



Preparation Manual

Life Science 7–12 (238)

Overview and Exam Framework
Sample Selected-Response Questions
Sample Selected-Response Answers and Rationales

Preparation Manual

Section 3: Overview and Exam Framework Life Science 7–12 (238)

Exam Overview

Exam Name	Life Science 7–12
Exam Code	238
Time	5 hours
Number of Questions	100 selected-response questions
Format	Computer-administered test (CAT)

The TExES Life Science 7–12 (238) exam is designed to assess whether an examinee has the requisite knowledge and skills that an entry-level educator in this field in Texas public schools must possess. The 100 selected-response questions are based on the Life Science 7–12 exam framework. Questions on this exam range from grades 7–12. The exam may contain questions that do not count toward the score. Your final scaled score will be based only on scored questions.

The Standards

Standard I

The science teacher manages classroom, field and laboratory activities to ensure the safety of all students and the ethical care and treatment of organisms and specimens.

Standard II

The science teacher manages classroom, field and laboratory activities to ensure the safety of all students and the ethical care and treatment of organisms and specimens.

Standard III

The science teacher manages classroom, field and laboratory activities to ensure the safety of all students and the ethical care and treatment of organisms and specimens.

Standard IV

The science teacher manages classroom, field and laboratory activities to ensure the safety of all students and the ethical care and treatment of organisms and specimens.

Standard V

The science teacher knows the varied and appropriate assessments and assessment practices to monitor science learning.

Standard VI

The science teacher understands the history and nature of science.

Standard VII

The science teacher understands how science affects the daily lives of students and how science interacts with and influences personal and societal decisions.

Standard IX

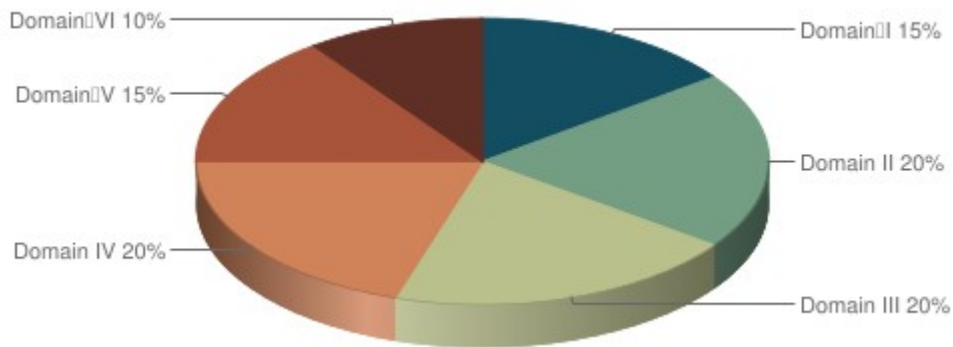
The science teacher knows and understands the science content appropriate to teach the statewide curriculum (Texas Essential Knowledge and Skills [TEKS]) in life science.

Standard XI

The science teacher knows unifying concepts and processes that are common to all sciences.

Domains and Competencies

Domain	Domain Title	Approx. Percentage of Exam	Standards Assessed
I	Scientific Inquiry and Processes	15%	Life Science 7–12 I–III, VI–VII, XI
II	Cell Structure and Processes	20%	Life Science 7–12 IX
III	Heredity and Evolution of Life	20%	Life Science 7–12 IX
IV	Diversity of Life	20%	Life Science 7–12 IX
V	Interdependence of Life and Environmental Systems	15%	Life Science 7–12 IX
VI	Science Learning, Instruction and Assessment	10%	Life Science 7–12 IV–V



The content covered by this exam is organized into broad areas of content called **domains**. Each domain covers one or more of the educator standards for this field. Within each domain, the content is further defined by a set of **competencies**. Each competency is composed of two major parts:

- The **competency statement**, which broadly defines what an entry-level educator in this field in Texas public schools should know and be able to do.
- The **descriptive statements**, which describe in greater detail the knowledge and skills eligible for testing.

Domain I—Scientific Inquiry and Processes

Competency 001—The teacher understands how to select and manage learning activities to ensure the safety of all students and the correct use and care of organisms, natural resources, materials, equipment and technologies.

The beginning teacher:

- A. Uses current sources of information about laboratory safety, including safety regulations and guidelines for the use of science facilities.
- B. Recognizes potential safety hazards in the laboratory and in the field and knows how to apply procedures, including basic first aid, for responding to accidents.
- C. Employs safe practices in planning, implementing and managing all instructional activities and designs and implements rules and procedures to maintain a safe learning environment.
- D. Understands procedures for selecting, maintaining and safely using chemicals, tools, technologies, materials, specimens and equipment, including procedures for the recycling, reuse and conservation of laboratory resources and for the safe handling and ethical treatment of organisms.
- E. Knows how to use appropriate equipment and technology (e.g., Internet, spreadsheet, calculator) for gathering, organizing, displaying and communicating data in a variety of ways (e.g., charts, tables, graphs, diagrams, maps, satellite images, written reports, oral presentations).
- F. Understands how to use a variety of tools, techniques and technology to gather, organize and analyze data; how to perform calculations; and how to apply appropriate methods of statistical measures and analyses.
- G. Knows how to apply techniques to calibrate measuring devices and understands concepts of precision, accuracy and error with regard to reading and recording numerical data from scientific instruments (e.g., significant figures).
- H. Uses the International System of Units (i.e., metric system) and performs unit conversions within and across measurement systems.

Competency 002—The teacher understands the nature of science, the process of scientific inquiry and the unifying concepts that are common to all sciences.

The beginning teacher:

- A. Understands the nature of science, the relationship between science and technology, the predictive power of science and limitations to the scope of science (i.e., the types of questions that science can and cannot answer).
- B. Knows the characteristics of various types of scientific investigations (e.g., descriptive studies, controlled experiments, comparative data analysis) and how and why scientists use different types of scientific investigations.

- C. Understands principles and procedures for designing and conducting a variety of scientific investigations — with emphasis on inquiry-based investigations — and how to communicate and defend scientific results.
- D. Understands how logical reasoning, verifiable observational and experimental evidence and peer review are used in the process of generating and evaluating scientific knowledge.
- E. Understands how to identify potential sources of error in an investigation, evaluate the validity of scientific data and develop and analyze different explanations for a given scientific result.
- F. Knows the characteristics and general features of systems; how properties and patterns of systems can be described in terms of space, time, energy and matter; and how system components and different systems interact.
- G. Knows how to apply and analyze the systems model (e.g., interacting parts, boundaries, input, output, feedback, subsystems) across the science disciplines.
- H. Understands how shared themes and concepts (e.g., systems, order and organization; evidence, models and explanation; change, constancy and measurements; evolution and equilibrium; and form and function) provide a unifying framework in science.
- I. Understands the difference between a theory and a hypothesis, how models are used to represent the natural world and how to evaluate the strengths and limitations of a variety of scientific models (e.g., physical, conceptual, mathematical).

Competency 003—The teacher understands the history of science, how science impacts the daily lives of students and how science interacts with and influences personal and societal decisions.

The beginning teacher:

- A. Understands the historical development of science, key events in the history of science and the contributions that diverse cultures and individuals of both genders have made to scientific knowledge.
- B. Knows how to use examples from the history of science to demonstrate the changing nature of scientific theories and knowledge (i.e., that scientific theories and knowledge are always subject to revision in light of new evidence).
- C. Knows that science is a human endeavor influenced by societal, cultural and personal views of the world, and knows that decisions about the use and direction of science are based on factors such as ethical standards, economics and personal and societal biases and needs.
- D. Understands the application of scientific ethics to the conducting, analyzing and publishing of scientific investigations.
- E. Applies scientific principles to analyze factors (e.g., diet, exercise, personal behavior) that influence personal and societal choices concerning fitness and health (e.g., physiological and psychological effects and risks associated with the use of substances and substance abuse).
- F. Applies scientific principles, the theory of probability and risk/benefit analysis to analyze the advantages of, disadvantages of or alternatives to a given decision or course of action.
- G. Understands the role science can play in helping resolve personal, societal and global issues (e.g., recycling, population growth, disease prevention, resource use, evaluating product claims).

Domain II—Cell Structure and Processes

Competency 004—The teacher understands the structure and function of biomolecules.

The beginning teacher:

- A. Identifies the chemical elements necessary for life and understands how these elements combine to form biologically important compounds.
- B. Relates the physical and chemical properties of water and carbon to the significance of these properties in basic life processes.
- C. Analyzes how a molecule's biological function is related to its shape (e.g., enzymes, tRNA, DNA, receptors, neurotransmitters, lipids).
- D. Understands the importance of chemical reactions in the synthesis and degradation of biomolecules.
- E. Identifies and compares the structures and functions of different types of biomolecules, including carbohydrates, lipids, proteins and nucleic acids.
- F. Explains how enzymes function in synthesis and degradation of biomolecules (e.g., DNA, food).

Competency 005—The teacher understands that cells are the basic structures of living things and have specialized parts that perform specific functions.

The beginning teacher:

- A. Differentiates among viruses, prokaryotic cells and eukaryotic cells (e.g., structure and function).
- B. Describes the basic components of prokaryotic and eukaryotic cells (e.g., cell membrane, cell wall, ribosomes, nucleus, mitochondrion, chloroplast) and the functions and relationships of the components.
- C. Identifies differences in cell structure and function in different types of organisms (e.g., differences in plant and animal cells).
- D. Analyzes specialization of structure and function in different types of cells in living organisms (e.g., skin, nerve and muscle cells in animals; root, stem and leaf cells in plants).

Competency 006—The teacher understands how cells carry out life processes.

The beginning teacher:

- A. Analyzes how cells maintain homeostasis (e.g., the effects of concentration gradients, rate of movement and ratio of surface area to volume).
- B. Understands processes by which cells transport water, nutrients and wastes across cell membranes (e.g., osmosis, diffusion, transport systems).
- C. Analyzes energy flow in the processes of photosynthesis and cellular respiration.
- D. Compares and contrasts anaerobic and aerobic respiration and their products.

Competency 007 —The teacher understands how specialized cells, tissues, organs, organ systems and organisms grow and develop.

The beginning teacher:

- A. Understands factors (e.g., hormones, cell size) that regulate the cell cycle and the effects of unregulated cell growth (e.g., cancer).
- B. Analyzes the role of cell differentiation in the development of tissues, organs, organ systems and living organisms.
- C. Analyzes factors (e.g., genetics, disease, nutrition, exposure to toxic chemicals) affecting cell differentiation and the growth and development of organisms.
- D. Identifies the different levels of organization in multicellular organisms and relates the parts to each other and to the whole.

Domain III—Heredity and Evolution of Life

Competency 008 — The teacher understands the structures and functions of nucleic acids in the mechanisms of genetics.

The beginning teacher:

- A. Relates the structure of DNA (e.g., bases, sugars, phosphates) to the nature, function and relationships of genes, chromatin and chromosomes.
- B. Relates the structures of DNA and RNA to the processes of replication, transcription, translation and genetic regulation.
- C. Compares and contrasts the organization and control of the genome in viruses, prokaryotic cells and eukaryotic cells.
- D. Understands the types, biological significance and causes of mutations.
- E. Identifies methods and applications of genetic identification and manipulation (e.g., production of recombinant DNA, cloning, PCR).
- F. Analyzes human karyotypes to identify chromosomal disorders and sex.

Competency 009—The teacher understands the continuity and variations of traits from one generation to the next.

The beginning teacher:

- A. Applies the laws of probability to determine genotypic and phenotypic frequencies in Mendelian inheritance (e.g., using Punnett squares, pedigree charts).
- B. Compares the processes of meiosis and mitosis (in plants and animals) and describes their roles in sexual and asexual reproduction.
- C. Recognizes factors influencing the transmission of genes from one generation to the next (e.g., linkage, position of genes on a chromosome, crossing-over, independent assortment).
- D. Understands how the genotype of an organism influences the expression of traits in its phenotype (e.g., dominant and recessive traits; monogenic, polygenic and polytypic inheritance; genetic disorders).
- E. Analyzes the effects of environmental factors (e.g., light, nutrition, moisture, temperature) on the expression of traits in the phenotype of an organism.

Competency 010—The teacher understands the theory of biological evolution.

The beginning teacher:

- A. Understands stability and change in populations (e.g., Hardy-Weinberg equilibrium) and analyzes factors leading to genetic variation and evolution in populations (e.g., mutation, gene flow, genetic drift, recombination, nonrandom mating, natural selection).
- B. Analyzes the effects of natural selection on adaptations and diversity in populations and species.
- C. Understands the role of intraspecific and interspecific competition in evolutionary change.
- D. Compares and contrasts the different effects of selection (e.g., directional, stabilizing, diversifying) on a variable characteristic.
- E. Analyzes processes that contribute to speciation (e.g., natural selection, founder effect, reproductive isolation).
- F. Analyzes the development of isolating mechanisms that discourage hybridization between species (e.g., species' recognition marks, behavioral displays, ecological separation, seasonal breeding).

Competency 011 —The teacher understands evidence for evolutionary change during Earth's history.

The beginning teacher:

- A. Analyzes how fossils, DNA sequences, anatomical similarities, physiological similarities and embryology provide evidence of both common origin and change in populations and species.
- B. Understands the relationship between environmental change, mutations and adaptations of an organism over many generations.
- C. Identifies major developments in the evolutionary history of life (e.g., formation of organic molecules, self-replication, backbones, vascular tissue, colonization of the land).
- D. Understands theories regarding the causes of extinction of species and the pace and mode of evolutionary change (e.g., punctuated equilibrium, mass extinctions, adaptive radiation).

Domain IV—Diversity of Life

Competency 012—The teacher understands similarities and differences between living organisms and how taxonomic systems are used to organize and interpret the diversity of life.

The beginning teacher:

- A. Compares and contrasts structural and physiological adaptations of plants and animals living in various aquatic and terrestrial environments (e.g., freshwater and marine, forest and plain, desert and tundra).
- B. Understands the relationship between environmental changes in aquatic and terrestrial ecosystems and adaptive changes in organisms inhabiting those ecosystems.
- C. Explains the uses and limitations of classification schemes.
- D. Relates taxonomic classification to evolutionary history and knows how to distinguish between traits that are taxonomically useful (e.g., homologous traits) and those that are not (e.g., convergent traits).

- E. Analyzes relationships among organisms to develop a model of a hierarchical classification system and knows how to classify aquatic and terrestrial organisms at several taxonomic levels (e.g., species, phylum/division, kingdom) by using dichotomous keys.
- F. Identifies distinguishing characteristics of domains and kingdoms, including eubacteria, archaeobacteria, protists, fungi, plants and animals.

Competency 013—The teacher understands that, at all levels of nature, living systems are found within other living systems, each with its own boundaries and limits.

The beginning teacher:

- A. Identifies the basic requirements (e.g., nutrients, oxygen, water, carbon dioxide) necessary for various organisms to carry out life functions.
- B. Compares how various organisms obtain, transform, transport, release, eliminate and store energy and matter.
- C. Analyzes characteristics, functions and relationships of systems in animals, including humans (e.g., digestive, circulatory, nervous, endocrine, reproductive, integumentary, skeletal, respiratory, muscular, excretory, immune systems).
- D. Analyzes characteristics, functions and relationships of systems in plants (e.g., transport, control, reproductive, nutritional, structural systems).
- E. Identifies methods of reproduction, growth and development of various plants and animals.

Competency 014—The teacher understands the processes by which organisms maintain homeostasis.

The beginning teacher:

- A. Explains the importance of maintaining a stable internal environment.
- B. Describes the relationships among internal feedback mechanisms in maintaining homeostasis.
- C. Identifies anatomical structures and physiological processes in a variety of organisms that function to maintain homeostasis in the face of changing environmental conditions.
- D. Analyzes the importance of nutrition, environmental conditions and physical exercise on health in humans and other organisms.
- E. Analyzes the role of viruses and microorganisms in maintaining or disrupting homeostasis in different organisms (e.g., the role of bacteria in digestion, diseases of plants and animals).

Competency 015—The teacher understands the relationship between biology and behavior.

The beginning teacher:

- A. Understands how the behavior of organisms, including humans, is in response to internal and external stimuli.
- B. Recognizes that behavior in many animals is determined by a combination of genetic and learned factors.
- C. Identifies adaptive advantages of innate and learned patterns of behavior.

- D. Explains mediating factors in innate (e.g., imprinting, hormonal system) and learned (e.g., classical conditioning, play) behavior.
- E. Understands concepts linking behavior and natural selection (e.g., kin selection, courtship behavior, altruism).

Domain V—Interdependence of Life and Environmental Systems

Competency 016—The teacher understands the relationships between abiotic and biotic factors of terrestrial and aquatic ecosystems, habitats and biomes, including the flow of matter and energy.

The beginning teacher:

- A. Analyzes types, sources and flow of energy through different trophic levels (e.g., producers, consumers, decomposers) and between organisms and the physical environment in aquatic and terrestrial ecosystems.
- B. Analyzes the flow of energy and the cycling of matter through biogeochemical cycles (e.g., carbon, water, oxygen, nitrogen, phosphorus) in aquatic and terrestrial ecosystems.
- C. Understands the concept of limiting factors (e.g., light intensity, temperature, mineral availability) and the effects that they have on the productivity and complexity of different ecosystems (e.g., tropical forest versus taiga, continental shelf versus deep ocean).
- D. Explains the relationship among abiotic characteristics of different biomes and the adaptations, variations, tolerances and roles of indigenous plants and animals in those biomes.

Competency 017—The teacher understands the interdependence and interactions of living things in terrestrial and aquatic ecosystems.

The beginning teacher:

- A. Understands the concepts of ecosystem, biome, community, habitat and niche.
- B. Analyzes interactions of organisms, including humans, in the production and consumption of energy (e.g., food chains, food webs, food pyramids) in aquatic and terrestrial ecosystems.
- C. Understands interspecific interactions in aquatic and terrestrial ecosystems (e.g., predator-prey relationships, competition, parasitism, commensalism, mutualism) and how they affect ecosystem structure.
- D. Identifies indigenous plants and animals, assesses their roles in an ecosystem and describes their relationships in different types of environments (e.g., freshwater, continental shelf, deep ocean, forest, desert, plains, tundra).
- E. Analyzes how the introduction, removal or reintroduction of an organism may alter the food chain, affect existing populations and influence natural selection in terrestrial and aquatic ecosystems.
- F. Evaluates the importance of biodiversity in an ecosystem and identifies changes that may occur if biodiversity is increased or reduced in an ecosystem.
- G. Understands types and processes of ecosystem change over time in terrestrial and aquatic ecosystems (e.g., equilibrium, cyclical change, succession) and the effects of human activity on ecosystem change.
- H. Explains the significance of plants in different types of terrestrial and aquatic ecosystems.

Competency 018—The teacher understands the relationship between carrying capacity and changes in populations and ecosystems.

The beginning teacher:

- A. Identifies basic characteristics of populations in an ecosystem (e.g., age pyramid, density, patterns of distribution).
- B. Compares concepts of population dynamics, including exponential growth, logistic (i.e., limited) growth and cycling (e.g., boom-and-bust cycles).
- C. Relates carrying capacity to population dynamics, including human population growth.
- D. Analyzes the impact of density-dependent and density-independent factors (e.g., geographic locales, natural events, diseases, birth and death rates) on populations.
- E. Compares r- and K-selected reproductive strategies (e.g., survivorship curves).

Domain VI—Science Learning, Instruction and Assessment

Competency 019—The teacher understands research-based theoretical and practical knowledge about teaching science, how students learn science and the role of scientific inquiry in science instruction.

The beginning teacher:

- A. Knows research-based theories about how students develop scientific understanding and how developmental characteristics, prior knowledge, experience and attitudes of students influence science learning.
- B. Understands the importance of respecting student diversity by planning activities that are inclusive and selecting and adapting science curricula, content, instructional materials and activities to meet the interests, knowledge, understanding, abilities, possible career paths and experiences of all students, including English-language learners.
- C. Knows how to plan and implement strategies to encourage student self-motivation and engagement in their own learning (e.g., linking inquiry-based investigations to students' prior knowledge, focusing inquiry-based instruction on issues relevant to students, developing instructional materials using situations from students' daily lives, fostering collaboration among students).
- D. Knows how to use a variety of instructional strategies to ensure all students comprehend content-related texts, including how to locate, retrieve and retain information from a range of texts and technologies.
- E. Understands the science teacher's role in developing the total school program by planning and implementing science instruction that incorporates school-wide objectives and the state-wide curriculum as defined in the Texas Essential Knowledge and Skills (TEKS).
- F. Knows how to design and manage the learning environment (e.g., individual, small-group, whole-class settings) to focus and support student inquiries and to provide the time, space and resources for all students to participate in field, laboratory, experimental and nonexperimental scientific investigation.
- G. Understands the rationale for using active learning and inquiry methods in science instruction and how to model scientific attitudes such as curiosity, openness to new ideas and skepticism.

- H. Knows principles and procedures for designing and conducting an inquiry-based scientific investigation (e.g., making observations; generating questions; researching and reviewing current knowledge in light of existing evidence; choosing tools to gather and analyze evidence; proposing answers, explanations and predictions; communicating and defending results).
- I. Knows how to assist students with generating, refining, focusing and testing scientific questions and hypotheses.
- J. Knows strategies for assisting students in learning to identify, refine and focus scientific ideas and questions guiding an inquiry-based scientific investigation; to develop, analyze and evaluate different explanations for a given scientific result; and to identify potential sources of error in an inquiry-based scientific investigation.
- K. Understands how to implement inquiry strategies designed to promote the use of higher-level thinking skills, logical reasoning and scientific problem solving in order to move students from concrete to more abstract understanding.
- L. Knows how to guide students in making systematic observations and measurements.
- M. Knows how to sequence learning activities in a way that uncovers common misconceptions, allows students to build upon their prior knowledge and challenges them to expand their understanding of science.

Competency 020—The teacher knows how to monitor and assess science learning in laboratory, field and classroom settings.

The beginning teacher:

- A. Knows how to use formal and informal assessments of student performance and products (e.g., projects, laboratory and field journals, rubrics, portfolios, student profiles, checklists) to evaluate student participation in and understanding of inquiry-based scientific investigations.
- B. Understands the relationship between assessment and instruction in the science curriculum (e.g., designing assessments to match learning objectives, using assessment results to inform instructional practice).
- C. Knows the importance of monitoring and assessing students' understanding of science concepts and skills on an ongoing basis by using a variety of appropriate assessment methods (e.g., performance assessment, self-assessment, peer assessment, formal/informal assessment).
- D. Understands the purposes, characteristics and uses of various types of assessment in science, including formative and summative assessments, and the importance of limiting the use of an assessment to its intended purpose.
- E. Understands strategies for assessing students' prior knowledge and misconceptions about science and how to use those assessments to develop effective ways to address the misconceptions.
- F. Understands characteristics of assessments, such as reliability, validity and the absence of bias in order to evaluate assessment instruments and their results.
- G. Understands the role of assessment as a learning experience for students and strategies for engaging students in meaningful self-assessment.
- H. Recognizes the importance of selecting assessment instruments and methods that provide all students with adequate opportunities to demonstrate their achievements.
- I. Recognizes the importance of clarifying teacher expectations by sharing evaluation criteria and assessment results with students.

Preparation Manual

Section 4: Sample Selected-Response Questions Life Science 7–12 (238)

This section presents some sample exam questions for you to review as part of your preparation for the exam. To demonstrate how each competency may be assessed, sample questions are accompanied by the competency that they measure. While studying, you may wish to read the competency before and after you consider each sample question. Please note that the competency statements do not appear on the actual exam.

For each sample exam question, there is a correct answer and a rationale for each answer option. The sample questions are included to illustrate the formats and types of questions you will see on the exam; however, your performance on the sample questions should not be viewed as a predictor of your performance on the actual exam.

Domain I—Scientific Inquiry and Processes

Competency 001—The teacher understands how to select and manage learning activities to ensure the safety of all students and the correct use and care of organisms, natural resources, materials, equipment and technologies.

1. A hamster kept as a class pet had a litter of 14 babies. Once the babies were one week old, the students monitored their growth by weighing them every other day and recording their individual masses to the nearest gram. The students also used calculators to determine the average mass of all the babies each time they were weighed. Many of the students reported the average mass to hundredths of grams. Which of the following best explains why the averages should have been reported only to the nearest gram?

- A. It is simpler to graph data points that are rounded to the nearest whole number.
- B. A calculation cannot appear to be more accurate than the original measurement.
- C. Rounding to the nearest whole number makes it easier to determine which students performed the most accurate measurements.
- D. The sample size was too small to justify averages in hundredths of grams.

Answer _____

2. In an effort to increase the number of students eating vegetables at lunch, the school cafeteria manager asked students to sample six different vegetables, with each vegetable presented both raw and cooked. The cafeteria personnel recorded the number of students who said that they would eat the vegetables if presented at lunch in each of the tested forms. Which of the following types of graph will most effectively show the data?

- A. Scatterplot
- B. Stem-and-leaf plot
- C. Line graph
- D. Bar graph

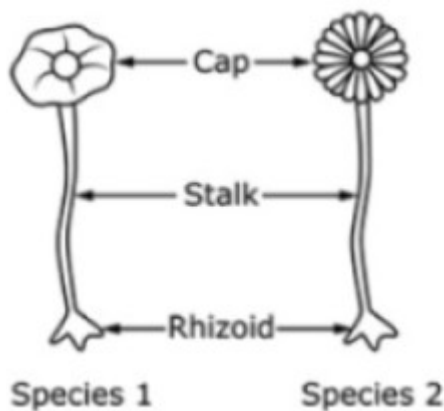
Answer _____

Competency 002—The teacher understands the nature of science, the process of scientific inquiry and the unifying concepts that are common to all sciences.

3. Researchers spent months in the field studying the behavior of monkeys in a particular population. In order to share their results with other scientists, the researchers should first do which of the following?

- A. Perform controlled experiments with the monkeys in the field to support their observations.
- B. Capture some of the monkeys to determine whether their behavior in the field is reproducible in a laboratory setting.
- C. Submit a paper describing their observations to a scientific journal for review by their peers.
- D. Invite an independent, unbiased group of scientists to observe the same population of monkeys.

Answer _____



4. *Acetabularia* is a genus of single-celled green algae that have a cap at one end that is attached to a stalk and a rootlike structure called a rhizoid. Two species are shown above. If the cap of a cell is removed, a new cap grows on the stalk and the detached cap degrades. If a stalk from species 2 is grafted onto a rhizoid from species 1, a new cap grows on the end of the stalk and resembles a species 1 cap. Similarly, grafting a species 1 stalk onto a species 2 rhizoid gives rise to a cap that resembles a species 2 cap. Which of the following is the best control for the grafting procedure?

- A. Remove the cap and stalk from an individual of species 1 and observe whether the rhizoid regrows at the base of the stalk.
- B. Remove the cap and stalk from an individual of species 1 and replace the same stalk to observe cap regrowth and morphology.
- C. Remove the cap and stalk from an individual of species 1, replace both parts with the stalk from a third species of *Acetabularia*, and observe cap morphology.
- D. Remove the cap and stalk from an individual of species 1, replace both parts with one stalk from each of species 1 and 2, and observe cap morphology.

Answer _____

Competency 003—The teacher understands the history of science, how science impacts the daily lives of students and how science interacts with and influences personal and societal decisions.

5. Prior to the 1940s and 1950s, it was generally accepted that heritable genetic material was composed of protein. It was known that chromosomes contain both DNA and proteins, the latter of which appeared to provide the complexity required

by genetic material. Experiments performed in the 1940s and 1950s confirmed that genetic material was actually DNA by demonstrating both its heritability and its importance in dictating the phenotype of an organism. Which of the following is best demonstrated by the scenario described?

- A. Hypotheses should not be proposed before knowing all the facts.
- B. Experimental data obtained before the middle of the twentieth century are unreliable.
- C. Scientific theories are subject to change in light of new data.
- D. A theory must be absolutely supported by data prior to its publication.

Answer _____

6. Individuals in many parts of the world are typically immunized against tuberculosis (TB), but immunization against TB in the United States is rare. Which TWO of the following are the most likely reasons why TB immunization in the United States is rare?

- A. Individuals worry about possible unintended effects of vaccines.
- B. The incidence of TB is relatively low in the United States.
- C. A TB skin test cannot be used to diagnose disease in an immunized individual because the results are always positive.
- D. The vaccine is prohibitively expensive in the United States.

Answer _____

Domain II—Cell Structure and Processes

Competency 004—The teacher understands the structure and function of biomolecules.

7. A virus infects only some types of cells in certain animal species. Which of the following is of greatest importance in determining the cell types that are infected?

- A. The structures of a ligand on the surface of a virus and a receptor on the surface of a cell
- B. The ratio between the concentration of virus and the number of cells of a particular type
- C. The pH and temperature environment around different cell types
- D. The availability to viruses of products secreted by different cell types

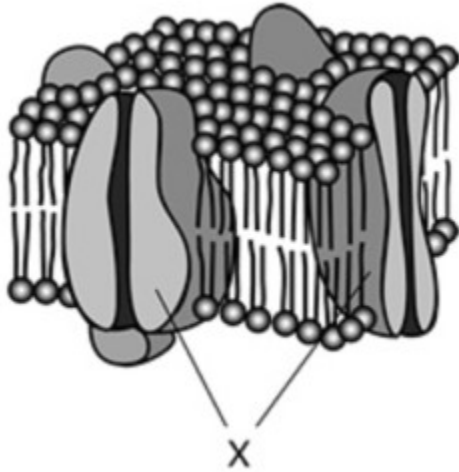
Answer _____

8. Which of the following is a property of carbon that makes this element basic to the chemistry of life?

- A. Carbon has many isotopes, two of which are stable.
- B. Carbon atoms are arranged in different ways in different crystalline structures.
- C. A carbon atom has four valence electrons and forms four covalent bonds with other atoms.
- D. A carbon atom has an equal number of protons and electrons.

Answer _____

Competency 005—The teacher understands that cells are the basic structures of living things and have specialized parts that perform specific functions.



9. A model of a eukaryotic cell membrane is shown above. Which of the following is the most likely function of the structures labeled X?

- A. Facilitating the exchange of O_2 and CO_2 by the cell
- B. Catalyzing the synthesis of molecules secreted by the cell
- C. Promoting the entry of hormones into the cell
- D. Enabling the movement of ions across the cell membrane

Answer _____

10. Which of the following properties best distinguishes prokaryotic and eukaryotic cells from viruses?

- A. Prokaryotes and eukaryotes divide by mitosis, whereas viruses do not.
- B. Prokaryotes and eukaryotes synthesize proteins on ribosomes, whereas viruses do not.
- C. Prokaryotes and eukaryotes are surrounded by a lipid bilayer, whereas viruses are not.
- D. Prokaryotes and eukaryotes have genomes of DNA, whereas viruses have genomes of RNA.

Answer _____

Competency 006—The teacher understands how cells carry out life processes.

11. The major source of energy for cellular respiration in plants is provided by which of the following?

- A. Sunlight
- B. CO_2 and water
- C. Nutrients absorbed from the soil
- D. Sugars synthesized by photosynthesis

Answer _____

12. In eukaryotes which of the following molecules is produced in anaerobic cellular respiration but not in aerobic cellular respiration?

- A. Lactic acid
- B. ATP
- C. Pyruvic acid
- D. H₂O

Answer _____

Competency 007—The teacher understands how specialized cells, tissues, organs, organ systems and organisms grow and develop.

13. Which of the following is most likely to trigger uncontrolled cell division and tumor formation?

- A. A mutation of a cyclin protein that interferes with the binding of cyclins and cyclin-dependent kinases (Cdk)
- B. A mutation to a cell surface receptor that causes continuous signaling in the absence of ligand binding
- C. An increase in the cytosolic concentration of second messengers such as cAMP and Ca²⁺
- D. An increase in the rate of cellular respiration and ATP production

Answer _____

14. The drugs used to treat some types of cancer are toxic to rapidly dividing cells. Which of the following best explains why patients whose bone marrow has been damaged by such drugs often receive bone marrow transplants?

- A. Bone marrow must be dense so that the bones can support the mass of an individual.
- B. Bone marrow contains stem cells that give rise to the red and white blood cells of an individual.
- C. Bone marrow contains adipose cells that store fat as a source of energy for an individual.
- D. Bone marrow must have cells around which to lay down a calcium-storing matrix in an individual.

Answer _____

Domain III—Heredity and Evolution of Life

Competency 008—The teacher understands the structures and functions of nucleic acids in the mechanisms of genetics.

15. If a single base pair is deleted from the coding region of gene X, which of the following describes a possible effect of the deletion on protein X?

- A. Protein X will be of normal sequence, because three sequential base pairs must be deleted to affect the protein sequence.
- B. Protein X will be of normal sequence, because one of every three base pairs is a wobble base that can be deleted without altering protein sequence.
- C. Protein X will differ from the normal sequence by the single amino acid coded in the region of the deletion.

- D. Protein X will be significantly shorter than the normal length, because a stop codon will be introduced downstream of the deletion.

Answer _____

16. For which of the following reasons is it better to clone cDNA rather than genomic DNA into bacteria if the bacteria are to synthesize a eukaryotic protein of the correct sequence?

- A. There are discrepancies between the genetic codes of prokaryotes and eukaryotes.
- B. The transcription factors of prokaryotes and eukaryotes differ.
- C. Bacteria cannot process mRNAs to remove introns.
- D. Bacteria cannot modify proteins in the same way that eukaryotes can.

Answer _____

Competency 009—The teacher understands the continuity and variations of traits from one generation to the next.

Genotype	Percent of Progeny
<i>RrTt</i>	39%
<i>Rrtt</i>	11%
<i>rrTr</i>	13%
<i>rrtt</i>	39%

17. In a particular species of fly, gene *R* can be found in two allelic forms: *R*, which is dominant, and *r*, which is recessive. Similarly, gene *T* can be found in two allelic forms: *T*, which is dominant, and *t*, which is recessive. A female fly of genotype *RrTt* is crossed with a male fly of genotype *rrtt*. The progeny are examined with respect to genes *R* and *T*, and their genotypes are determined. The results are shown in the table. Which of the following is most consistent with the data?

- A. Genes *R* and *T* are on different chromosomes that exhibit independent assortment.
- B. Genes *R* and *T* are linked on a single chromosome.
- C. Genes *R* and *T* are both on the X chromosome.
- D. Genes *R* and *T* are on different chromosomes that do not assort independently.

Answer _____

18. Siamese cats are white at birth, but as they mature, they become tan with much darker extremities, including the ears, nose, legs, and tail. Which of the following is the most likely explanation of the color pattern observed in adult Siamese cats?

- A. An allele of a gene required for pigment synthesis encodes a temperature-sensitive enzyme.
- B. An allele of a gene required for pigment synthesis is triggered by sex hormones.
- C. A gene required for pigment synthesis is located in mitochondrial DNA and is only expressed in cells of the extremities.
- D. A gene required for pigment synthesis in cells is activated by increased light exposure.

Answer _____

Competency 010—The teacher understands the theory of biological evolution.

19. Scientists have observed that when two species of stickleback fish occur in a single lake, they have distinct morphologies and niches. The species differ in size and shape and in the number and length of the gill rakers that are involved in food–particle retention. One species feeds in open water, and the other feeds at the lake bottom. When only one species of stickleback inhabits a lake, the species exhibits an intermediate morphology and niche. This scenario illustrates which of the following phenomena?

- A. Müllerian mimicry
- B. Character displacement
- C. Facilitation
- D. Competitive exclusion

Answer _____

20. Which of the following scenarios best illustrates disruptive selection?

- A. Female widowbirds preferentially mate with male widowbirds with longer tails.
- B. Water boatmen occur in three distinct shades of brown; when a population includes all three shades, predatory fish eat a disproportionately large number of the most common form and reduce its frequency in the population.
- C. Guppies that are preyed on by fish that prefer large, mature guppies reproduce at a smaller size and younger age than more-rapidly growing guppies that are preyed on by fish that prefer small, juvenile guppies.
- D. Under drought conditions, a population of cactus finches includes individuals with short, deep bills and others with long, shallow bills but few with bills of intermediate shape, as are common with normal rainfall.

Answer _____

Competency 011—The teacher understands evidence for evolutionary change during Earth’s history.

21. Recent evidence suggests that the segmented body plan of several protostome phyla arose independently in the phyla, rather than from a common ancestor. The evidence suggests convergent evolution of segmentation in Annelida (segmented worms), Arthropoda (arthropods), and Onychophora (velvet worms). Which of the following most likely provided the evidence?

- A. Analyses of ribosomal RNA (rRNA) sequences and mitochondrial DNA sequences
- B. Studies of newly uncovered fossils from several geologic periods
- C. Comparison of interactions among cells in different body segments
- D. Comparison of chromosome numbers among organisms in the three phyla

Answer _____

22. Which of the following adaptations is most directly linked to the diversity of angiosperms?

- A. The variation in photoperiods among species
- B. The presence of vascular tissue

- C. The ability to reproduce asexually
- D. The ability to perform photosynthesis

Answer _____

Domain IV—Diversity of Life

Competency 012—The teacher understands similarities and differences between living organisms and how taxonomic systems are used to organize and interpret the diversity of life.

23. Which of the following adaptations is more likely to be enhanced in a desert mammal than in a mammal living in the northern boreal forest?

- A. Ability to burrow into the ground
- B. Avoidance of predators
- C. Ability to retain water
- D. Complex mating behavior

Answer _____

24. Which of the following best distinguishes the structure of bacteria from the structure of archaeans?

- A. Genomes of bacteria are located in nucleoids, whereas those of archaeans are located in nuclei.
- B. Cell walls of bacteria contain peptidoglycan, whereas those of archaeans lack peptidoglycan.
- C. Chromosomes of bacteria are circular, whereas those of archaeans are linear.
- D. Chlorophyll in bacteria is located in infoldings of the plasma membrane, whereas chlorophyll in archaeans is located in chloroplasts.

Answer _____

25. Which of the following pieces of information would be most useful to include in a dichotomous key for students identifying Texas wildflowers?

- A. Ribosomal RNA (rRNA) sequences
- B. Germination times
- C. Petal colors
- D. Chromosome numbers

Answer _____

Competency 013—The teacher understands that, at all levels of nature, living systems are found within other living systems, each with its own boundaries and limits.

26. Which of the following best describes the mechanism by which vaccination provides protection from pathogens?

- A. The lymphatic system carries pathogens more rapidly to lymphoid organs after pre-exposure to a similar vaccine.
- B. The vaccine remains in the body and competes with the real pathogen for cells to infect.

- C. Memory lymphocytes are produced that rapidly respond upon subsequent encounter with a pathogen resembling a vaccine.
- D. There is an increase in the number of phagocytic cells that can find and ingest pathogens resembling a vaccine.

Answer _____

27. Mutation of a protein specific to which of the following cell types is most likely to interfere with the transport of sugars in angiosperms?

- A. Sclereids
- B. Tracheids
- C. Collenchyma cells
- D. Sieve-tube elements

Answer _____

Competency 014—The teacher understands the processes by which organisms maintain homeostasis.

28. In the flipper of a dolphin, each artery is surrounded by several veins. Which of the following is the best explanation for the arrangement of blood vessels?

- A. Cool blood in the veins receives heat from arterial blood as the venous blood returns to the animal's core.
- B. Oxygen-poor blood in the veins absorbs oxygen from the artery as the blood returns to the animal's core.
- C. The artery is protected from trauma by the surrounding veins.
- D. Flipper movement ensures that the rate of blood flow in the veins equals the rate of flow in the artery.

Answer _____

29. Which THREE of the following best explain how small mammals can survive long periods of hibernation without ingesting food or water?

- A. The production of enzymes that hydrolyze the triglycerides of stored fat in the mammals increases.
- B. The pH of the mammals' blood significantly decreases, except for blood that circulates to the brain.
- C. The heart rate and breathing rate of the mammals decrease.
- D. The core temperature of the mammals decreases.

Answer _____

Competency 015—The teacher understands the relationship between biology and behavior.

30. Which of the following best demonstrates that some behaviors involve both an innate and a learned component?

- A. A pheromone produced by a queen honeybee attracts workers to the queen in the hive.
- B. The females of some cichlid fish species hold fertilized eggs in their mouths until the eggs hatch.
- C. Male weaver birds build similar but not identical nests, and individual birds modify their technique from one nest to the next.
- D. A rat that presses a lever in a box and routinely receives a food reward will continue to press the lever.

Answer _____

Domain V—Interdependence of Life and Environmental Systems

Competency 016—The teacher understands the relationships between abiotic and biotic factors of terrestrial and aquatic ecosystems, habitats and biomes, including the flow of matter and energy.

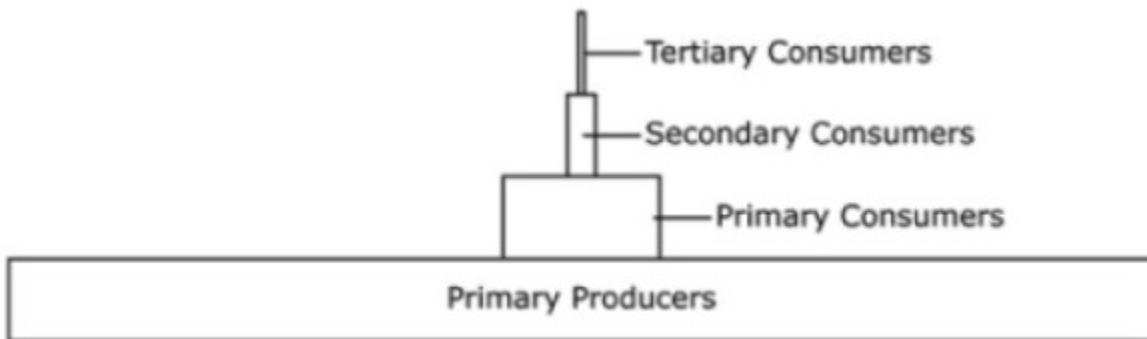
31. The primary productivity of coral reefs is substantially greater than the primary productivity of the open ocean. Which of the following best explains the high primary productivity of coral reefs?
- A. Corals grow in relatively deep water with a low salt concentration and a high concentration of dissolved CO_2 .
 - B. Corals grow in warm water that contains a high plankton count and has a high concentration of nutrients.
 - C. Corals grow in shallow, cold water with abundant sunlight and a high concentration of dissolved O_2 .
 - D. Corals grow in relatively shallow, nutrient-poor water that is easily penetrated by sunlight.

Answer _____

32. If the energy available from all secondary consumers to the next trophic level in a terrestrial food web is $90 \text{ kcal} / \text{m}^2 / \text{year}$, then the net primary productivity of the food web is most likely closest to
- A. $0.9 \text{ kcal} / \text{m}^2 / \text{year}$
 - B. $9 \text{ kcal} / \text{m}^2 / \text{year}$
 - C. $900 \text{ kcal} / \text{m}^2 / \text{year}$
 - D. $9,000 \text{ kcal} / \text{m}^2 / \text{year}$

Answer _____

Competency 017—The teacher understands the interdependence and interactions of living things in terrestrial and aquatic ecosystems.



33. Which of the following best explains why each level of a standing crop biomass pyramid such as that shown above is so much smaller than the level immediately below it?
- A. Organisms at higher levels die more rapidly than organisms at lower levels do.
 - B. Inefficient energy transfers between levels support fewer organisms at higher levels.

- C. Organisms at higher levels typically require more nutrients per unit mass than organisms at lower levels do.
- D. Recycling of organic matter and essential chemical elements occurs less efficiently at higher levels.

Answer _____

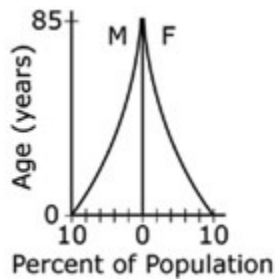
34. Truffles are fungi that grow underground. Truffles produce chemicals with an aroma that attracts pigs and helps them detect the truffles. The pigs sometimes eat the truffles they find. Which of the following best describes why the relationship between a pig and a truffle can be considered mutualistic?

- A. The pig eats the truffle and gains chemical energy from it.
- B. The pig eats the truffle, and the truffle remnants benefit scavengers in the soil.
- C. The pig eats the truffle, and the pig's feces contain digested components that decomposers return to the soil.
- D. The pig eats the truffle and spreads fungal spores as it digs the truffle out of the ground.

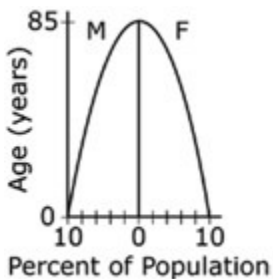
Answer _____

Competency 018—The teacher understands the relationship between carrying capacity and changes in populations and ecosystems.

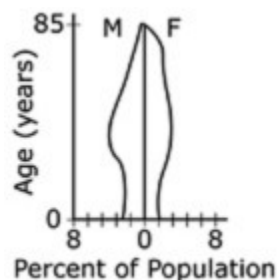
35. Assuming that no emigration, immigration, or catastrophic event occurs, which of the following graphs best illustrates a human population that is likely to decrease in size over the next 25 years?



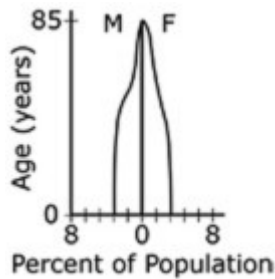
A.



B.



C.



D.

Answer _____

36. The reproductive strategies of organisms are often described as being primarily *r*-selected or *K*-selected. Organisms with *r*-selected reproductive strategies often have shorter life expectancies and produce many more offspring than organisms with *K*-selected reproductive strategies do. Which of the following is more likely to be true of a population of organisms with a *K*-selected reproductive strategy than of a population with an *r*-selected reproductive strategy?

- A. The population size is near the carrying capacity of the environment.
- B. The population lives in an unstable environment.
- C. The population lives in an environment with a temperate climate.
- D. The population is made up of organisms that are keystone species.

Answer _____

Domain VI—Science Learning, Instruction and Assessment

Competency 019—The teacher understands research-based theoretical and practical knowledge about teaching science, how students learn science and the role of scientific inquiry in science instruction.

37. Which of the following procedures is most likely to engage and motivate students to learn about regulation of cell growth?

- A. Playing a game in which teams of students compete to see who can correctly answer the most questions about organelle function in cell growth
- B. Directing students to Internet sites on which they can watch animations of cells as they grow and divide
- C. Having students read short biographies of scientists who are engaged in research about cell-growth regulation
- D. Having students use a microscope to examine cultured cells before and after they add substances to the cells that affect cell growth and division

Answer _____

38. Students in a biology laboratory class will work in groups using the enzyme catalase to study factors that affect the activity of enzymes. Which of the following strategies by the teacher is the most effective inquiry-based learning approach?

- A. Ask the students first to develop a hypothesis related to catalysis and then to design and perform an experiment with catalase to investigate the hypothesis.
- B. Give the students several hypotheses about factors that affect catalase activity and help them to design a single experiment that addresses all the hypotheses.

- C. Give the students a protocol that has been used to investigate catalysis by catalase and ask them to carefully follow and then evaluate the protocol.
- D. Tell the students to read research papers about catalase and its activity, then have them select one paper and attempt to reproduce the methods and results.

Answer _____

Competency 020—The teacher knows how to monitor and assess science learning in laboratory, field and classroom settings.

39. Students perform a laboratory exercise to investigate how cell membranes regulate the movement of materials into and out of cells. They expose both live cells and artificial membranes to several different solutions and monitor the effects of the solutions on the cells and membranes. Which of the following methods will best allow the teacher to assess understanding by each student of the significance of the results?

- A. After completing the exercise, have the students write individual reports in which they use their results to propose mechanisms by which various materials cross cell membranes.
- B. As they perform the exercise, have the students work in pairs and discuss the procedure and data with each other.
- C. After completing the exercise, select several volunteers to stand up and summarize the significance of the results to the rest of the class.
- D. After completing the exercise, give the students a multiple-choice quiz with questions about the procedure and the results they obtained.

Answer _____

40. Which of the following is the best example of a summative assessment?

- A. Asking students who have presented independent experiments at a science fair to describe their science fair experiences to their classmates
- B. Asking students at the end of a physiology unit to identify and give the function of structures identified by flags in dissected organisms
- C. Asking students who worked in assigned groups for an activity to evaluate the work of the other members of the group
- D. Asking students at the beginning of a unit on ecology to describe the biological basis for succession and niche partitioning

Answer _____

Preparation Manual

Section 4: Sample Selected-Response Answers and Rationales

Life Science 7–12 (238)

This section presents some sample exam questions for you to review as part of your preparation for the exam. To demonstrate how each competency may be assessed, sample questions are accompanied by the competency that they measure. While studying, you may wish to read the competency before and after you consider each sample question. Please note that the competency statements do not appear on the actual exam.

For each sample exam question, there is a correct answer and a rationale for each answer option. The sample questions are included to illustrate the formats and types of questions you will see on the exam; however, your performance on the sample questions should not be viewed as a predictor of your performance on the actual exam.

Domain I—Scientific Inquiry and Processes

Competency 001—The teacher understands how to select and manage learning activities to ensure the safety of all students and the correct use and care of organisms, natural resources, materials, equipment and technologies.

1. A hamster kept as a class pet had a litter of 14 babies. Once the babies were one week old, the students monitored their growth by weighing them every other day and recording their individual masses to the nearest gram. The students also used calculators to determine the average mass of all the babies each time they were weighed. Many of the students reported the average mass to hundredths of grams. Which of the following best explains why the averages should have been reported only to the nearest gram?

- A. It is simpler to graph data points that are rounded to the nearest whole number.
- B. A calculation cannot appear to be more accurate than the original measurement.
- C. Rounding to the nearest whole number makes it easier to determine which students performed the most accurate measurements.
- D. The sample size was too small to justify averages in hundredths of grams.

Answer

Option B is correct because significant figures rules state that there cannot be more significant figures in a calculation than in the data used for the calculation. **Option A is incorrect** because the ability to graph is irrelevant to the calculation of averages. **Option C is incorrect** because the question asks nothing about comparing the students' results, and results can be compared equally well with more figures. **Option D is incorrect** because significant figures, rather than sample size, determine the number of figures in the averages.

2. In an effort to increase the number of students eating vegetables at lunch, the school cafeteria manager asked students to sample six different vegetables, with each vegetable presented both raw and cooked. The cafeteria personnel recorded the number of students who said that they would eat the vegetables if presented at lunch in each of the tested forms. Which of the following types of graph will most effectively show the data?

- A. Scatterplot
- B. Stem-and-leaf plot

- C. Line graph
- D. Bar graph

Answer

Option D is correct because each form of each vegetable is a discrete variable that can be indicated on the x-axis and form the basis for a bar. The absolute number of students who responded positively to each vegetable determines the height of each bar. To determine which vegetables are most likely to be consumed, the heights of the 12 bars can be easily compared. **Option A is incorrect** because there is no absolute x-axis variable to plot. **Option B is incorrect** because a stem-and-leaf plot is used to examine the distribution of a series of numerical observations within a single data set, such as the amount of one particular vegetable eaten by individual students. **Option C is incorrect** because there is no absolute x-axis variable to plot and so no points to connect into a line.

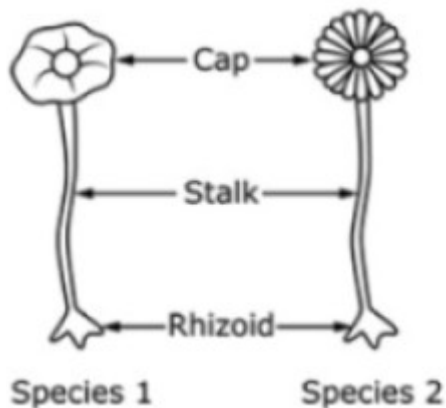
Competency 002—The teacher understands the nature of science, the process of scientific inquiry and the unifying concepts that are common to all sciences.

3. Researchers spent months in the field studying the behavior of monkeys in a particular population. In order to share their results with other scientists, the researchers should first do which of the following?

- A. Perform controlled experiments with the monkeys in the field to support their observations.
- B. Capture some of the monkeys to determine whether their behavior in the field is reproducible in a laboratory setting.
- C. Submit a paper describing their observations to a scientific journal for review by their peers.
- D. Invite an independent, unbiased group of scientists to observe the same population of monkeys.

Answer

Option C is correct because a major route by which scientific findings are shared is by publication in a peer-reviewed journal. **Option A is incorrect** because field observations are frequently impossible to test in controlled experiments. **Option B is incorrect** because wild animals brought into a laboratory generally do not behave as they do in the field. **Option D is incorrect** because although another group of scientists may observe the same population of monkeys, such a practice is not instrumental in sharing results with the greater scientific community.



4. *Acetabularia* is a genus of single-celled green algae that have a cap at one end that is attached to a stalk and a rootlike structure called a rhizoid. Two species are shown above. If the cap of a cell is removed, a new cap grows on the stalk and the detached cap degrades. If a stalk from species 2 is grafted onto a rhizoid from species 1, a new cap grows on the end of the stalk and resembles a species 1 cap. Similarly, grafting a species 1 stalk onto a species 2 rhizoid gives rise to a cap that resembles a species 2 cap. Which of the following is the best control for the grafting procedure?

- A. Remove the cap and stalk from an individual of species 1 and observe whether the rhizoid regrows at the base of the stalk.
- B. Remove the cap and stalk from an individual of species 1 and replace the same stalk to observe cap regrowth and morphology.
- C. Remove the cap and stalk from an individual of species 1, replace both parts with the stalk from a third species of *Acetabularia*, and observe cap morphology.
- D. Remove the cap and stalk from an individual of species 1, replace both parts with one stalk from each of species 1 and 2, and observe cap morphology.

Answer

Option B is correct because the procedure evaluates whether a cap and stalk can be removed from *Acetabularia* and the stalk replaced without a loss of algal viability or a change to the morphology, and whether the cap that regrows is identical to the original. **Option A is incorrect** because it involves no grafting and additionally tests the regrowth of the rhizoid rather than the regrowth of the cap and stalk. **Option C is incorrect** because it introduces the variable of an additional species. **Option D is incorrect** because it introduces the variable of two species' stalks grafted onto a single rhizoid.

Competency 003—The teacher understands the history of science, how science impacts the daily lives of students and how science interacts with and influences personal and societal decisions.

5. Prior to the 1940s and 1950s, it was generally accepted that heritable genetic material was composed of protein. It was known that chromosomes contain both DNA and proteins, the latter of which appeared to provide the complexity required by genetic material. Experiments performed in the 1940s and 1950s confirmed that genetic material was actually DNA by demonstrating both its heritability and its importance in dictating the phenotype of an organism. Which of the following is best demonstrated by the scenario described?

- A. Hypotheses should not be proposed before knowing all the facts.
- B. Experimental data obtained before the middle of the twentieth century are unreliable.
- C. Scientific theories are subject to change in light of new data.
- D. A theory must be absolutely supported by data prior to its publication.

Answer

Option C is correct because the experiments to determine what molecule contained genetic material took place over many years and continuously built on prior experiments. As technology improved and as more data were generated, the theory describing the nature of heritable genetic material changed. **Option A is incorrect** because hypotheses are based on logical analysis of available data and then are further tested to be eventually accepted, discarded, or modified. **Option B is incorrect** because much experimental data obtained early in the twentieth century have proven to be very reliable. In many cases, further experimentation with more modern techniques has upheld previous data and conclusions. **Option D is incorrect** because theories based on experiments that have received peer reviews are deemed to be logical and worthy of further investigation and are published with supporting data in scientific journals. This allows the theories to be tested further by the same or many other investigators.

6. Individuals in many parts of the world are typically immunized against tuberculosis (TB), but immunization against TB in the United States is rare. Which TWO of the following are the most likely reasons why TB immunization in the United States is rare?

- A. Individuals worry about possible unintended effects of vaccines.
- B. The incidence of TB is relatively low in the United States.
- C. A TB skin test cannot be used to diagnose disease in an immunized individual because the results are always positive.
- D. The vaccine is prohibitively expensive in the United States.

Answer

Options B and C are correct because, in contrast to some other countries, there is a relatively insignificant number of TB infections in the United States, and the medical community wants to preserve skin testing as a quick and inexpensive way to test for TB. Once an individual is immunized, the skin test will be positive, requiring a more expensive test, such as a chest x-ray. **Option A is incorrect** because there is no evidence that the vaccine is associated with any unintended effects. **Option D is incorrect** because the vaccine is used in other countries that are financially less well off than the United States is, so the cost of the vaccine is not a problem in this country.

Domain II—Cell Structure and Processes

Competency 004—The teacher understands the structure and function of biomolecules.

7. A virus infects only some types of cells in certain animal species. Which of the following is of greatest importance in determining the cell types that are infected?

- A. The structures of a ligand on the surface of a virus and a receptor on the surface of a cell
- B. The ratio between the concentration of virus and the number of cells of a particular type
- C. The pH and temperature environment around different cell types
- D. The availability to viruses of products secreted by different cell types

Answer

Option A is correct because the specificity of interaction between the amino acids of the ligand on the surface of a virus and the amino acids and carbohydrates of a receptor molecule on the surface of a cell determines both host range and tissue-type specificity of virus binding. **Option B is incorrect** because the ratio of virus to cell number might influence the number of cells infected, but it will not determine which cells are infected. **Option C is incorrect** because pH and temperature should be relatively constant in the body, and these factors are unlikely to alter viral specificity. **Option D is incorrect** because products secreted by the cells are unlikely to affect viral specificity.

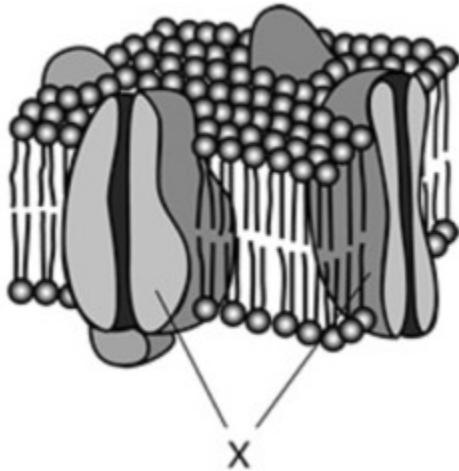
8. Which of the following is a property of carbon that makes this element basic to the chemistry of life?

- A. Carbon has many isotopes, two of which are stable.
- B. Carbon atoms are arranged in different ways in different crystalline structures.
- C. A carbon atom has four valence electrons and forms four covalent bonds with other atoms.
- D. A carbon atom has an equal number of protons and electrons.

Answer

Option C is correct because the atom's ability to make four covalent bonds allows it to form large, complex molecules. **Option A is incorrect** because the number of isotopes does not influence carbon's role in the chemistry of life. **Option B is incorrect** because carbon's ability to form different kinds of crystalline structures does not influence carbon's role in the chemistry of life. **Option D is incorrect** because, while this statement is true, the number of protons is typically identical to the number of electrons in any uncharged atom.

Competency 005—The teacher understands that cells are the basic structures of living things and have specialized parts that perform specific functions.



9. A model of a eukaryotic cell membrane is shown above. Which of the following is the most likely function of the structures labeled X?

- A. Facilitating the exchange of O_2 and CO_2 by the cell
- B. Catalyzing the synthesis of molecules secreted by the cell
- C. Promoting the entry of hormones into the cell
- D. Enabling the movement of ions across the cell membrane

Answer

Option D is correct because the structures labeled X appear to be integral membrane proteins with channels running through them. Ions in solution are hydrated by water and are too large to pass between membrane lipids. They require channel proteins, with different proteins specific to each type of ion. **Option A is incorrect** because O_2 and CO_2 can pass between membrane lipids. **Option B is incorrect** because molecules secreted by a eukaryotic cell are synthesized by cellular organelles rather than by channel proteins. **Option C is incorrect** because most protein hormones bind to cell membrane receptors and do not enter the cell, while lipid hormones simply pass between the membrane lipids to enter.

10. Which of the following properties best distinguishes prokaryotic and eukaryotic cells from viruses?

- A. Prokaryotes and eukaryotes divide by mitosis, whereas viruses do not.
- B. Prokaryotes and eukaryotes synthesize proteins on ribosomes, whereas viruses do not.

- C. Prokaryotes and eukaryotes are surrounded by a lipid bilayer, whereas viruses are not.
- D. Prokaryotes and eukaryotes have genomes of DNA, whereas viruses have genomes of RNA.

Answer

Option B is correct because viruses do not contain ribosomes to synthesize proteins but are dependent on the ribosomes of the prokaryotes and eukaryotes they infect for synthesis of viral proteins. **Option A is incorrect** because only eukaryotes divide by mitosis; neither prokaryotes nor viruses do so. **Option C is incorrect** because enveloped animal viruses are surrounded by a lipid layer that is usually derived from the plasma membrane of the cells they infect. Naked capsid viruses have no such lipid layer. **Option D is incorrect** because only some viruses have genomes of RNA; many viruses, including all bacteriophages, have genomes of DNA.

Competency 006—The teacher understands how cells carry out life processes.

11. The major source of energy for cellular respiration in plants is provided by which of the following?
- A. Sunlight
 - B. CO₂ and water
 - C. Nutrients absorbed from the soil
 - D. Sugars synthesized by photosynthesis

Answer

Option D is correct because plants use photosynthesis to produce three-carbon sugars that can be converted to glucose. The energy stored in glucose is then released by glycolysis in the cytosol and the citric acid cycle in the mitochondria of plant cells. **Option A is incorrect** because sunlight provides energy for photosynthesis but not for cellular respiration. **Option B is incorrect** because CO₂ and water are not energy sources. CO₂ is released during cellular respiration and fixed in photosynthesis; H₂O is produced during cellular respiration and provides a source of electrons for noncyclic photophosphorylation in photosynthesis. **Option C is incorrect** because no nutrients that are absorbed from the soil provide energy for cellular respiration.

12. In eukaryotes which of the following molecules is produced in anaerobic cellular respiration but not in aerobic cellular respiration?
- A. Lactic acid
 - B. ATP
 - C. Pyruvic acid
 - D. H₂O

Answer

Option A is correct because lactic acid is a product of fermentation, which is a common form of anaerobic cellular respiration. **Option B is incorrect** because ATP is produced in both anaerobic and aerobic respiration. **Option C is incorrect** because pyruvic acid is the final breakdown product of glucose in glycolysis, the initial metabolic pathway of both anaerobic and aerobic respiration in eukaryotes. **Option D is incorrect** because H₂O is released when oxygen is reduced during oxidative phosphorylation of aerobic respiration.

Competency 007—The teacher understands how specialized cells, tissues, organs, organ systems and organisms grow and develop.

13. Which of the following is most likely to trigger uncontrolled cell division and tumor formation?

- A. A mutation of a cyclin protein that interferes with the binding of cyclins and cyclin-dependent kinases (Cdk)
- B. A mutation to a cell surface receptor that causes continuous signaling in the absence of ligand binding
- C. An increase in the cytosolic concentration of second messengers such as cAMP and Ca^{2+}
- D. An increase in the rate of cellular respiration and ATP production

Answer

Option B is correct because binding of a ligand such as a cellular growth factor to a cell surface receptor is the normal way by which intracellular signaling is triggered. Mutations to such receptors often induce conformational changes to the receptors that cause the receptors to initiate signaling in the absence of ligand binding. **Option A is incorrect** because blocking interaction between cyclins and cyclin-dependent kinases blocks cell cycle progression and cell division. **Option C is incorrect** because cAMP and Ca^{2+} are ubiquitous second messengers, so increasing their concentrations is likely to cause so many metabolic problems in a cell that the cell will die. **Option D is incorrect** because increased cellular respiration and ATP production are likely to be a consequence of, rather than a cause of, increased cell division.

14. The drugs used to treat some types of cancer are toxic to rapidly dividing cells. Which of the following best explains why patients whose bone marrow has been damaged by such drugs often receive bone marrow transplants?

- A. Bone marrow must be dense so that the bones can support the mass of an individual.
- B. Bone marrow contains stem cells that give rise to the red and white blood cells of an individual.
- C. Bone marrow contains adipose cells that store fat as a source of energy for an individual.
- D. Bone marrow must have cells around which to lay down a calcium-storing matrix in an individual.

Answer

Option B is correct because the hematopoietic stem cells that give rise to red blood cells and white blood cells are found in the bone marrow. These cells divide rapidly and so are typically killed by drugs that are used to kill rapidly dividing cancer cells. **Option A is incorrect** because the density and strength of bone are derived from collagen fibers and deposits of mineral salts in the compact bone that surrounds the softer marrow. **Option C is incorrect** because the adipose cells in the bone marrow store an insignificant amount of energy. **Option D is incorrect** because calcium is not stored in the bone marrow.

Domain III—Heredity and Evolution of Life

Competency 008—The teacher understands the structures and functions of nucleic acids in the mechanisms of genetics.

15. If a single base pair is deleted from the coding region of gene X, which of the following describes a possible effect of the deletion on protein X?
- A. Protein X will be of normal sequence, because three sequential base pairs must be deleted to affect the protein sequence.
 - B. Protein X will be of normal sequence, because one of every three base pairs is a wobble base that can be deleted without altering protein sequence.
 - C. Protein X will differ from the normal sequence by the single amino acid coded in the region of the deletion.
 - D. Protein X will be significantly shorter than the normal length, because a stop codon will be introduced downstream of the deletion.

Answer

Option D is correct because each codon specifying an amino acid is three bases, so the loss of a single base pair in the DNA will alter the entire amino acid coding sequence past the deletion (that is, will alter the translation reading frame). Because three codons of the genetic code are translation stop codons rather than amino acid–dictating codons, one of the altered codons may be a stop codon, causing a shorter protein to be produced. **Option A is incorrect** because the deletion of one base pair alters the translation reading frame. **Option B is incorrect** because only the third base of many codons is a wobble base whose alteration does not alter the amino acid encoded, and the question does not indicate that the third base is the one that is deleted. Additionally, the third base of some codons is not a wobble base, so changing the third base of such codons does alter which amino acid is encoded. **Option C is incorrect** because the deletion of one base pair alters the entire translation reading frame and not just a single amino acid.

16. For which of the following reasons is it better to clone cDNA rather than genomic DNA into bacteria if the bacteria are to synthesize a eukaryotic protein of the correct sequence?
- A. There are discrepancies between the genetic codes of prokaryotes and eukaryotes.
 - B. The transcription factors of prokaryotes and eukaryotes differ.
 - C. Bacteria cannot process mRNAs to remove introns.
 - D. Bacteria cannot modify proteins in the same way that eukaryotes can.

Answer

Option C is correct because cDNA, a double-stranded DNA copy of an mRNA, does not contain introns, but genomic DNA does. Bacteria do not have the molecules necessary to process pre-mRNAs and remove the introns before translation. The only way to translate a protein of correct amino acid sequence is to clone a cDNA that lacks introns. **Option A is incorrect** because the genetic codes of prokaryotes and eukaryotes are essentially identical. **Option B is incorrect** because transcription factors are irrelevant to pre-mRNA processing. **Option D is incorrect** because it refers to protein modifications, but the difference between a cDNA and genomic DNA is the lack or presence, respectively, of introns.

Competency 009—The teacher understands the continuity and variations of traits from one generation to the next.

Genotype	Percent of Progeny
<i>RrTt</i>	39%
<i>Rrtt</i>	11%
<i>rrTr</i>	13%
<i>rrtt</i>	39%

17. In a particular species of fly, gene *R* can be found in two allelic forms: *R*, which is dominant, and *r*, which is recessive. Similarly, gene *T* can be found in two allelic forms: *T*, which is dominant, and *t*, which is recessive. A female fly of genotype *RrTt* is crossed with a male fly of genotype *rrtt*. The progeny are examined with respect to genes *R* and *T*, and their genotypes are determined. The results are shown in the table. Which of the following is most consistent with the data?

- A. Genes *R* and *T* are on different chromosomes that exhibit independent assortment.
- B. Genes *R* and *T* are linked on a single chromosome.
- C. Genes *R* and *T* are both on the X chromosome.
- D. Genes *R* and *T* are on different chromosomes that do not assort independently.

Answer

Option B is correct because the expected data, if genes *R* and *T* are completely unlinked, should show 25% of each genotype of progeny. The genotype of the gamete from the male fly can only be *rt* and, if the genes are unlinked, there is a 25% chance of gametes with each of the following genotypes being produced by the female fly: *RT*, *Rt*, *rT*, *rt*. The data suggest that (1) the female fly, with genotype *RrTt*, is the result of a pairing between *RT* and *rt* gametes and (2) the *R* and *T* or *r* and *t* alleles are close enough on the chromosome that relatively little crossing-over occurred between them during formation of gametes by the female fly. **Option A is incorrect** because 25% of each genotype of progeny is expected if the genes are on different chromosomes and assorting independently. **Option C is incorrect** because there is no information to suggest that male and female progeny differ in their expression of the genes, as would be the case with X-linkage. **Option D is incorrect** because different chromosomes do assort independently of each other.

18. Siamese cats are white at birth, but as they mature, they become tan with much darker extremities, including the ears, nose, legs, and tail. Which of the following is the most likely explanation of the color pattern observed in adult Siamese cats?

- A. An allele of a gene required for pigment synthesis encodes a temperature-sensitive enzyme.
- B. An allele of a gene required for pigment synthesis is triggered by sex hormones.
- C. A gene required for pigment synthesis is located in mitochondrial DNA and is only expressed in cells of the extremities.
- D. A gene required for pigment synthesis in cells is activated by increased light exposure.

Answer

Option A is correct because the extremities of a cat are cooler than the core, and if an enzyme that is required for pigment synthesis or deposition has a different conformation and exhibits greater activity at a lower temperature, then only the extremities of an adult cat will be dark. **Option B is incorrect** because it is highly improbable that sex hormones will activate a gene associated with pigment deposition only in cells of the extremities. **Option C is incorrect** because most mitochondrial genes encode products required for mitochondrial function and are not expected to differentially affect pigment production or deposition. **Option D is incorrect** because other parts of the animal are exposed to light to the same degree as the extremities.

Competency 010—The teacher understands the theory of biological evolution.

19. Scientists have observed that when two species of stickleback fish occur in a single lake, they have distinct morphologies and niches. The species differ in size and shape and in the number and length of the gill rakers that are involved in food–particle retention. One species feeds in open water, and the other feeds at the lake bottom. When only one species of stickleback inhabits a lake, the species exhibits an intermediate morphology and niche. This scenario illustrates which of the following phenomena?

- A. Müllerian mimicry
- B. Character displacement
- C. Facilitation
- D. Competitive exclusion

Answer

Option B is correct because character displacement refers to the tendency for traits to be more divergent in sympatric populations of two species than in allopatric populations of the same species. **Option A is incorrect** because Müllerian mimicry refers to a resemblance between two or more unpalatable species that generally have a common predator, but the stickleback fish described differ in appearance and occupy different niches that probably have different predators. **Option C is incorrect** because facilitation refers to the positive effect of one species on the survival and reproduction of another species, but the two stickleback species have separate niches. **Option D is incorrect** because competitive exclusion refers to the greater success of one species when two species compete for the same resources, but the two stickleback species have separate niches and do not compete.

20. Which of the following scenarios best illustrates disruptive selection?

- A. Female widowbirds preferentially mate with male widowbirds with longer tails.
- B. Water boatmen occur in three distinct shades of brown; when a population includes all three shades, predatory fish eat a disproportionately large number of the most common form and reduce its frequency in the population.
- C. Guppies that are preyed on by fish that prefer large, mature guppies reproduce at a smaller size and younger age than more-rapidly growing guppies that are preyed on by fish that prefer small, juvenile guppies.
- D. Under drought conditions, a population of cactus finches includes individuals with short, deep bills and others with long, shallow bills but few with bills of intermediate shape, as are common with normal rainfall.

Answer

Option D is correct because disruptive selection is a form of natural selection in which individuals with extreme phenotypes survive and reproduce with greater success than do individuals with intermediate phenotypes. **Option A is incorrect** because the scenario illustrates sexual selection. **Option B is incorrect** because the scenario illustrates frequency-dependent selection, in which the frequency of different phenotypes is maintained at approximately equal levels by the reduction of the most common phenotype, in this instance because of the greater likelihood of being eaten. **Option C is incorrect** because the scenario illustrates directional selection in which there is a shift, under certain predator conditions, toward more-rapidly maturing guppies that can reproduce before being eaten.

Competency 011—The teacher understands evidence for evolutionary change during Earth’s history.

21. Recent evidence suggests that the segmented body plan of several protostome phyla arose independently in the phyla, rather than from a common ancestor. The evidence suggests convergent evolution of segmentation in Annelida (segmented worms), Arthropoda (arthropods), and Onychophora (velvet worms). Which of the following most likely provided the evidence?

- A. Analyses of ribosomal RNA (rRNA) sequences and mitochondrial DNA sequences
- B. Studies of newly uncovered fossils from several geologic periods
- C. Comparison of interactions among cells in different body segments
- D. Comparison of chromosome numbers among organisms in the three phyla

Answer

Option A is correct because comparing the similarities or dissimilarities of rRNA sequences and mitochondrial DNA sequences in different organisms has been shown to be a reliable way of analyzing possible relationships. Such technologies were not available in the early days of phylogeny construction. **Option B is incorrect** because discovery of a few fossils in these rather diverse phyla is unlikely to demonstrate the origin of segmentation. **Option C is incorrect** because interactions among cells might provide data on cell signaling, but the interactions will not provide data on the origin of segmentation. **Option D is incorrect** because chromosome numbers provide no indication about the similarities or dissimilarities of gene sequences or the evolution of segmentation.

22. Which of the following adaptations is most directly linked to the diversity of angiosperms?

- A. The variation in photoperiods among species
- B. The presence of vascular tissue
- C. The ability to reproduce asexually
- D. The ability to perform photosynthesis

Answer

Option B is correct because the evolution of vascular tissue first allowed plants to colonize land. The evolution of flowers and the ability to transport water through the vascular system then allowed angiosperms to adapt to a wide range of terrestrial biomes. **Option A is incorrect** because the variation in photoperiods is not linked to the diversity of angiosperms. **Option C is incorrect** because only a fraction of angiosperms reproduce asexually through such means as the production of runners. **Option D is incorrect** because all plants perform photosynthesis, not just angiosperms.

Domain IV—Diversity of Life

Competency 012—The teacher understands similarities and differences between living organisms and how taxonomic systems are used to organize and interpret the diversity of life.

23. Which of the following adaptations is more likely to be enhanced in a desert mammal than in a mammal living in the northern boreal forest?

- A. Ability to burrow into the ground
- B. Avoidance of predators
- C. Ability to retain water
- D. Complex mating behavior

Answer

Option C is correct because water is far more plentiful in the northern boreal forest than in the desert. Desert mammals have evolved mechanisms for conserving water that include more efficient water extraction from the oxidation of macromolecules in their food and production of more concentrated urine. **Option A is incorrect** because some species of mammals in both regions burrow into the ground. **Option B is incorrect** because mammals in both regions try to avoid predators. **Option D is incorrect** because mammals in both regions exhibit complex mating behaviors.

24. Which of the following best distinguishes the structure of bacteria from the structure of archaeans?

- A. Genomes of bacteria are located in nucleoids, whereas those of archaeans are located in nuclei.
- B. Cell walls of bacteria contain peptidoglycan, whereas those of archaeans lack peptidoglycan.
- C. Chromosomes of bacteria are circular, whereas those of archaeans are linear.
- D. Chlorophyll in bacteria is located in infoldings of the plasma membrane, whereas chlorophyll in archaeans is located in chloroplasts.

Answer

Option B is correct because the presence or absence of peptidoglycan is a major structural distinction between bacteria and archaeans. **Option A is incorrect** because both bacteria and archaeans have nucleoids; nuclei are a characteristic of eukarya only. **Option C is incorrect** because the chromosomes of both bacteria and archaeans are generally circular. **Option D is incorrect** because some bacteria perform photosynthesis using chlorophyll embedded in infoldings of the plasma membrane, but neither chlorophyll nor photosynthesis has been demonstrated in any archaeans.

25. Which of the following pieces of information would be most useful to include in a dichotomous key for students identifying Texas wildflowers?

- A. Ribosomal RNA (rRNA) sequences
- B. Germination times
- C. Petal colors
- D. Chromosome numbers

Answer

Option C is correct because a dichotomous key is typically used to allow visual identification of plants or animals. Selection from a series of features such as leaf shape, petal number, and petal color allow an individual to identify a wildflower. **Options A, B, and D are incorrect** because rRNA sequences, germination times, and chromosome numbers do not aid in visual identification of an organism and are thus not included in dichotomous keys.

Competency 013—The teacher understands that, at all levels of nature, living systems are found within other living systems, each with its own boundaries and limits.

26. Which of the following best describes the mechanism by which vaccination provides protection from pathogens?
- A. The lymphatic system carries pathogens more rapidly to lymphoid organs after pre-exposure to a similar vaccine.
 - B. The vaccine remains in the body and competes with the real pathogen for cells to infect.
 - C. Memory lymphocytes are produced that rapidly respond upon subsequent encounter with a pathogen resembling a vaccine.
 - D. There is an increase in the number of phagocytic cells that can find and ingest pathogens resembling a vaccine.

Answer

Option C is correct because vaccination produces clones of lymphocytes specific to the introduced material, and many of the lymphocytes are memory cells that are activated much more rapidly than naïve cells upon subsequent encounter with a pathogen similar to the material in the vaccine. **Option A is incorrect** because vaccination has no effect on the rate at which material is carried through the lymphatic system. **Option B is incorrect** because the vaccine is typically completely cleared from the body within a few weeks. **Option D is incorrect** because phagocytic cell populations do not expand upon pre-exposure to a vaccine, and the cells exhibit no memory.

27. Mutation of a protein specific to which of the following cell types is most likely to interfere with the transport of sugars in angiosperms?
- A. Sclereids
 - B. Tracheids
 - C. Collenchyma cells
 - D. Sieve-tube elements

Answer

Option D is correct because sieve-tube elements are the cells that conduct sugars and other organic nutrients in the phloem of angiosperms. The sieve-tube elements are alive but lack most organelles, as this leaves maximal space for nutrient passage through the cells. **Option A is incorrect** because sclereids are cells with very thick secondary cell walls that provide support to a plant or to its products, such as seed coats, and are often dead at maturity. **Option B is incorrect** because tracheids are cells of the xylem that extend in the direction of water movement and possess pits to allow water movement among the cells. **Option C is incorrect** because collenchyma cells are flexible cells that are alive at maturity and provide support to a plant, especially to new growth.

Competency 014—The teacher understands the processes by which organisms maintain homeostasis.

28. In the flipper of a dolphin, each artery is surrounded by several veins. Which of the following is the best explanation for the arrangement of blood vessels?

- A. Cool blood in the veins receives heat from arterial blood as the venous blood returns to the animal's core.
- B. Oxygen-poor blood in the veins absorbs oxygen from the artery as the blood returns to the animal's core.
- C. The artery is protected from trauma by the surrounding veins.
- D. Flipper movement ensures that the rate of blood flow in the veins equals the rate of flow in the artery.

Answer

Option A is correct because this is an example of a countercurrent heat exchanger. To conserve body heat, venous blood that has cooled in the flipper and is returning to the body core absorbs heat from arterial blood directed to the flipper. **Option B is incorrect** because there is no gas exchange between blood in the artery and the veins. **Option C is incorrect** because veins do not have strong muscular walls and thus are too soft to provide protection for an artery. **Option D is incorrect** because while flipper movement does help blood flow in veins, it does not ensure a flow rate equal to that of the flow in the artery, and it does not explain the particular arrangement of the vessels.

29. Which THREE of the following best explain how small mammals can survive long periods of hibernation without ingesting food or water?

- A. The production of enzymes that hydrolyze the triglycerides of stored fat in the mammals increases.
- B. The pH of the mammals' blood significantly decreases, except for blood that circulates to the brain.
- C. The heart rate and breathing rate of the mammals decrease.
- D. The core temperature of the mammals decreases.

Answer

Options A, C, and D are correct because all describe physiological processes that occur during hibernation. There is an increase in the production of enzymes that hydrolyze the triglycerides of the fat stores accumulated by the animal before the start of hibernation. Additionally, the heart rate, breathing rate, and core temperature all decrease in association with a decrease in metabolic rate during hibernation. **Option B is incorrect** because a decrease in the pH of the blood during hibernation would have an adverse effect on the cells of the animal.

Competency 015—The teacher understands the relationship between biology and behavior.

30. Which of the following best demonstrates that some behaviors involve both an innate and a learned component?

- A. A pheromone produced by a queen honeybee attracts workers to the queen in the hive.
- B. The females of some cichlid fish species hold fertilized eggs in their mouths until the eggs hatch.
- C. Male weaver birds build similar but not identical nests, and individual birds modify their technique from one nest to the next.
- D. A rat that presses a lever in a box and routinely receives a food reward will continue to press the lever.

Answer

Option C is correct because a bird initially uses instinct to build a nest that is generally characteristic of the species in terms of location and structure. However, there must also be a learned component to nest building because the structure of the nests can improve and become more elaborate with each subsequent nest built by birds of certain species, as exemplified by the nests built by male weaver birds. **Option A is incorrect** because attraction to a pheromone is strictly innate. **Option B is incorrect** because a cichlid does not learn to hold eggs and fry in its mouth but is exhibiting an innate behavior. **Option D is incorrect** because pressing a lever with the expectation of a reward is an example of operant conditioning, in which a behavior may be changed by a consequence; lever-pressing behavior by the rat is reinforced by a food reward.

Domain V—Interdependence of Life and Environmental Systems

Competency 016—The teacher understands the relationships between abiotic and biotic factors of terrestrial and aquatic ecosystems, habitats and biomes, including the flow of matter and energy.

31. The primary productivity of coral reefs is substantially greater than the primary productivity of the open ocean. Which of the following best explains the high primary productivity of coral reefs?

- A. Corals grow in relatively deep water with a low salt concentration and a high concentration of dissolved CO_2 .
- B. Corals grow in warm water that contains a high plankton count and has a high concentration of nutrients.
- C. Corals grow in shallow, cold water with abundant sunlight and a high concentration of dissolved O_2 .
- D. Corals grow in relatively shallow, nutrient-poor water that is easily penetrated by sunlight.

Answer

Option D is correct because corals primarily live around islands and along the edges of some continents in a zone of water that exhibits great clarity. The abundant sunlight promotes the growth of photosynthetic algae that live in a symbiotic relationship with the corals, a relationship that contributes to the great productivity of the reefs. Most corals live in warm water, and all appear to be very sensitive to a high concentration of nutrients and have in fact declined in areas exposed to sewage and fertilizer runoff. **Option A is incorrect** because most corals do not live in deep water, where the Sun does not penetrate, and deep water is unlikely to be low in salt and high in CO_2 . **Option B is incorrect** because high nutrient concentrations that often promote plankton growth kill corals. **Option C is incorrect** because the vast majority of corals grow in warm water, and a very few grow in cool—but not cold—water.

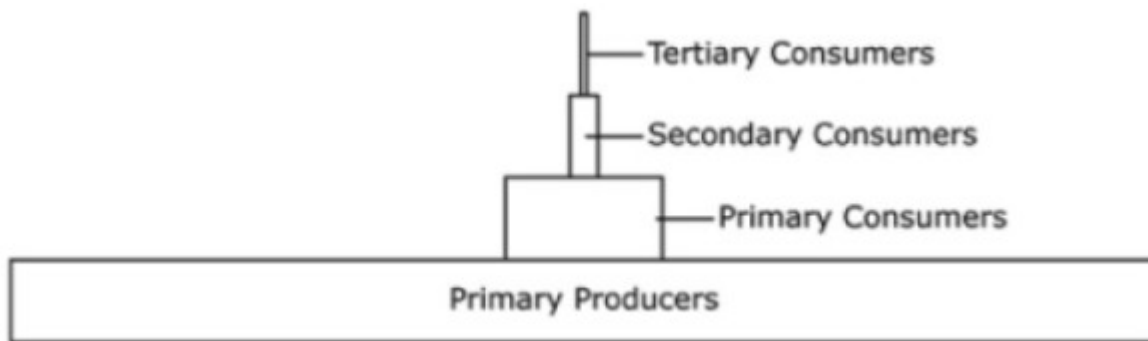
32. If the energy available from all secondary consumers to the next trophic level in a terrestrial food web is $90 \text{ kcal} / \text{m}^2 / \text{year}$, then the net primary productivity of the food web is most likely closest to

- A. $0.9 \text{ kcal} / \text{m}^2 / \text{year}$
- B. $9 \text{ kcal} / \text{m}^2 / \text{year}$
- C. $900 \text{ kcal} / \text{m}^2 / \text{year}$
- D. $9,000 \text{ kcal} / \text{m}^2 / \text{year}$

Answer

Option D is correct because $90 \text{ kcal} / \text{m}^2 / \text{year}$ is 1% of $9,000 \text{ kcal} / \text{m}^2 / \text{year}$. It is estimated that approximately 10% of the energy at any trophic level is available to the next trophic level. If the net primary productivity of the food web is closest to $9,000 \text{ kcal} / \text{m}^2 / \text{year}$, then the energy available to primary consumers (herbivores) is approximately $900 \text{ kcal} / \text{m}^2 / \text{year}$, and the energy available to secondary consumers is approximately $90 \text{ kcal} / \text{m}^2 / \text{year}$. **Options A, B, and C are incorrect** because $90 \text{ kcal} / \text{m}^2 / \text{year}$ is not 1% of the value in any of those options.

Competency 017—The teacher understands the interdependence and interactions of living things in terrestrial and aquatic ecosystems.



33. Which of the following best explains why each level of a standing crop biomass pyramid such as that shown above is so much smaller than the level immediately below it?

- A. Organisms at higher levels die more rapidly than organisms at lower levels do.
- B. Inefficient energy transfers between levels support fewer organisms at higher levels.
- C. Organisms at higher levels typically require more nutrients per unit mass than organisms at lower levels do.
- D. Recycling of organic matter and essential chemical elements occurs less efficiently at higher levels.

Answer

Option B is correct because trophic efficiencies generally range from 5% to 20%. Energy is lost between trophic levels through respiration and feces as well as through energy in the lower trophic level that is not consumed by organisms in the next trophic level. **Option A is incorrect** because organisms at higher trophic levels often live as long as or longer than organisms at lower trophic levels. **Option C is incorrect** because organisms at higher trophic levels typically do not require more nutrients per unit mass than organisms at lower trophic levels do. **Option D is incorrect** because recycling occurs with about the same efficiency at all trophic levels, but there is simply less energy to recycle at higher levels.

34. Truffles are fungi that grow underground. Truffles produce chemicals with an aroma that attracts pigs and helps them detect the truffles. The pigs sometimes eat the truffles they find. Which of the following best describes why the relationship between a pig and a truffle can be considered mutualistic?

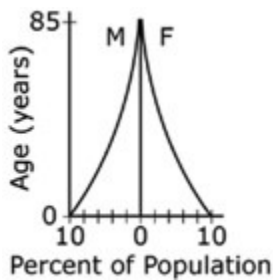
- A. The pig eats the truffle and gains chemical energy from it.
- B. The pig eats the truffle, and the truffle remnants benefit scavengers in the soil.
- C. The pig eats the truffle, and the pig's feces contain digested components that decomposers return to the soil.
- D. The pig eats the truffle and spreads fungal spores as it digs the truffle out of the ground.

Answer

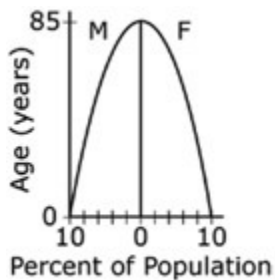
Option D is correct because both the pig and truffle benefit: the pig gains a source of chemical energy when it eats the truffle, and the spores of the truffle are dispersed by the pig, facilitating the growth of more truffles. **Option A is incorrect** because this activity benefits the pig but not the truffle. **Options B and C are incorrect** because both activities benefit the pig and other organisms but do not directly benefit the truffle.

Competency 018—The teacher understands the relationship between carrying capacity and changes in populations and ecosystems.

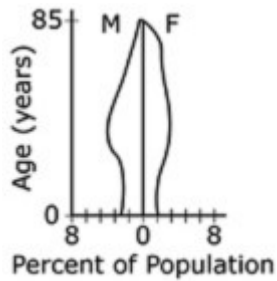
35. Assuming that no emigration, immigration, or catastrophic event occurs, which of the following graphs best illustrates a human population that is likely to decrease in size over the next 25 years?



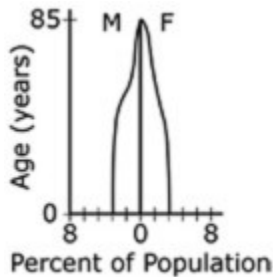
A.



B.



C.



D.

Answer

Option C is correct because the size of the child-bearing population in 25 years will be smaller than the size of the current child-bearing population. **Option A is incorrect** because the population is heavily weighted toward individuals who will be of child-bearing age in 25 years. **Option B is incorrect** because there are more individuals who will be of child-bearing age in 25 years than are currently of child-bearing years. **Option D is incorrect** because the number of individuals of child-bearing age is fairly constant for the next 25 years and is greater than the current older population; the population will probably grow slowly over the next 25 years.

36. The reproductive strategies of organisms are often described as being primarily *r*-selected or *K*-selected. Organisms with *r*-selected reproductive strategies often have shorter life expectancies and produce many more offspring than organisms with *K*-selected reproductive strategies do. Which of the following is more likely to be true of a population of organisms with a *K*-selected reproductive strategy than of a population with an *r*-selected reproductive strategy?

- A. The population size is near the carrying capacity of the environment.
- B. The population lives in an unstable environment.
- C. The population lives in an environment with a temperate climate.
- D. The population is made up of organisms that are keystone species.

Answer

Option A is correct because the population size of organisms with a *K*-selected reproductive strategy is typically close to the carrying capacity of the environment. **Option B is incorrect** because organisms with a *K*-selected reproductive strategy typically live in a stable environment. **Option C is incorrect** because organisms with a *K*-selected reproductive strategy are found in a variety of climates. **Option D is incorrect** because organisms with a *K*-selected reproductive strategy need not be keystone species.

Domain VI—Science Learning, Instruction and Assessment

Competency 019—The teacher understands research-based theoretical and practical knowledge about teaching science, how students learn science and the role of scientific inquiry in science instruction.

37. Which of the following procedures is most likely to engage and motivate students to learn about regulation of cell growth?
- A. Playing a game in which teams of students compete to see who can correctly answer the most questions about organelle function in cell growth
 - B. Directing students to Internet sites on which they can watch animations of cells as they grow and divide
 - C. Having students read short biographies of scientists who are engaged in research about cell-growth regulation
 - D. Having students use a microscope to examine cultured cells before and after they add substances to the cells that affect cell growth and division

Answer

Option D is correct because students who use microscopes to observe the effects of adding substances to cells are likely to be engaged and motivated to learn more about factors that can affect cell growth. **Option A is incorrect** because competing to see who can answer the most questions about organelle function is less engaging than observing cells through a microscope. **Option B is incorrect** because watching animations is passive rather than engaging. **Option C is incorrect** because reading biographies of scientists is also passive.

38. Students in a biology laboratory class will work in groups using the enzyme catalase to study factors that affect the activity of enzymes. Which of the following strategies by the teacher is the most effective inquiry-based learning approach?
- A. Ask the students first to develop a hypothesis related to catalysis and then to design and perform an experiment with catalase to investigate the hypothesis.
 - B. Give the students several hypotheses about factors that affect catalase activity and help them to design a single experiment that addresses all the hypotheses.
 - C. Give the students a protocol that has been used to investigate catalysis by catalase and ask them to carefully follow and then evaluate the protocol.
 - D. Tell the students to read research papers about catalase and its activity, then have them select one paper and attempt to reproduce the methods and results.

Answer

Option A is correct because asking the students to develop a hypothesis as well as perform an experiment that they design to investigate the hypothesis is a learning approach that is entirely inquiry based. **Option B is incorrect** because giving the students hypotheses and helping them to design an experiment does not provide much opportunity to develop independent-inquiry skills. **Option C is incorrect** because giving the students a protocol to follow and evaluate provides little opportunity to develop independent-inquiry skills. **Option D is incorrect** because reproducing published methods to obtain published results does not provide much opportunity to develop independent-inquiry skills.

Competency 020—The teacher knows how to monitor and assess science learning in laboratory, field and classroom settings.

39. Students perform a laboratory exercise to investigate how cell membranes regulate the movement of materials into and out of cells. They expose both live cells and artificial membranes to several different solutions and monitor the effects of the solutions on the cells and membranes. Which of the following methods will best allow the teacher to assess understanding by each student of the significance of the results?

- A. After completing the exercise, have the students write individual reports in which they use their results to propose mechanisms by which various materials cross cell membranes.
- B. As they perform the exercise, have the students work in pairs and discuss the procedure and data with each other.
- C. After completing the exercise, select several volunteers to stand up and summarize the significance of the results to the rest of the class.
- D. After completing the exercise, give the students a multiple-choice quiz with questions about the procedure and the results they obtained.

Answer

Option A is correct because the ability to write a report and, based on the experimental results, propose mechanisms by which materials, including some the student did not test, cross cell membranes suggests that a student truly understands the significance of the results. **Option B is incorrect** because it is difficult to determine how much the students understand if they are only talking with one another. **Option C is incorrect** because the process does not assess the understanding of all students but only of those few who volunteer to speak to the class. **Option D is incorrect** because a quiz on the procedure and results, particularly a multiple-choice quiz, does not allow the students to describe the broader significance of the results.

40. Which of the following is the best example of a summative assessment?

- A. Asking students who have presented independent experiments at a science fair to describe their science fair experiences to their classmates
- B. Asking students at the end of a physiology unit to identify and give the function of structures identified by flags in dissected organisms
- C. Asking students who worked in assigned groups for an activity to evaluate the work of the other members of the group
- D. Asking students at the beginning of a unit on ecology to describe the biological basis for succession and niche partitioning

Answer

Option B is correct because testing student knowledge at the end of a unit or course is a summative assessment. **Option A is incorrect** because asking students to describe science fair experiences does not directly assess knowledge or skills. **Option C is incorrect** because asking students to evaluate the work of other group members is a peer assessment. **Option D is incorrect** because assessing prior knowledge at the beginning of a unit is typically part of a formative assessment.