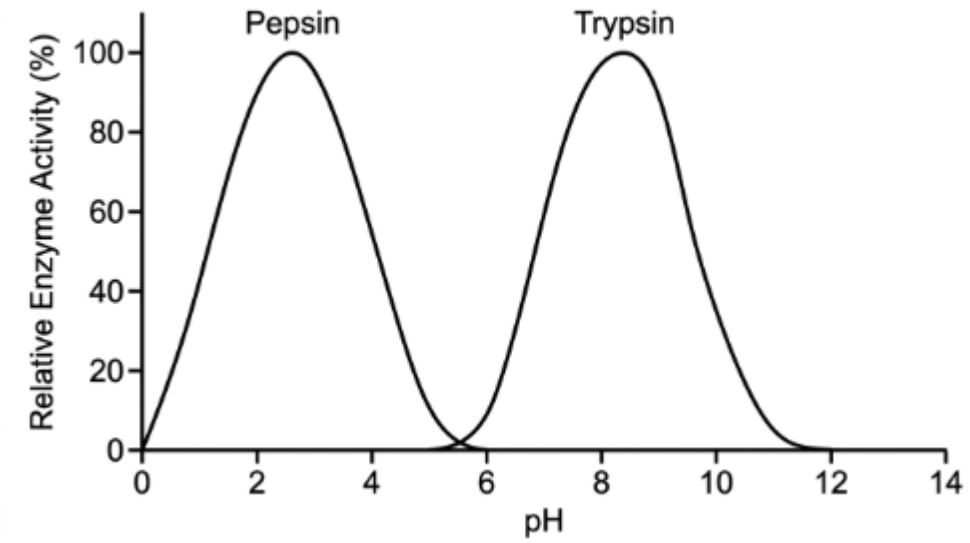
PRACTICE EXAM 36: LIFE SCIENCE: BIOLOGY SIMULATION (50 QUESTIONS — GRAPH & DIAGRAM-INTENSIVE COMPREHENSIVE REVIEW)

Instructions: Practice Exam 36 emphasizes data interpretation, graph reading, and analysis of biological figures (pedigrees, food webs, growth curves, gel electrophoresis, flow charts, action potentials). Each question is independent. Select the one best answer.

1. The graph below shows the activity of two human digestive enzymes, pepsin and trypsin, plotted against pH. Based on the graph, the most likely site at which pepsin operates effectively in the body is:



A. The mouth, where saliva maintains a slightly basic pH and begins the chemical breakdown of starches into smaller sugar molecules during chewing
B. The stomach, where hydrochloric acid produces a strongly acidic environment that matches the optimum pH for pepsin function in protein digestion
C. The small intestine, where bile and pancreatic secretions create a basic environment ideal for the breakdown of large protein molecules into amino acids
D. The large intestine, where bacteria break down remaining nutrients before solid waste materials are eliminated from the digestive system of the body

2. A scientist observes that glucose is moving into a cell against its concentration gradient, from a region of lower concentration outside the cell to higher concentration inside the cell. The transport process the cell must be using is best classified as:

A. Simple diffusion, which moves molecules down their concentration gradient without using any cellular energy at any point during the transport process across the membrane
B. Facilitated diffusion, which uses protein channels to allow molecules to cross the membrane down their concentration gradient without using any cellular energy of any kind
C. Osmosis, which involves the movement of water molecules across a selectively permeable membrane down a water concentration gradient established between the two sides
D. Active transport, which uses ATP to move molecules across the membrane against their concentration gradient through specific protein pumps embedded within the membrane

3. The phospholipid molecules that make up the cell membrane are arranged in a bilayer with their hydrophilic phosphate heads facing outward and their hydrophobic fatty acid tails facing inward. This arrangement is most directly explained by the fact that:

A. The phospholipid bilayer forms spontaneously in water because the polar heads interact favorably with water while the nonpolar tails are excluded from water and group together
B. The phospholipid heads contain large amounts of cholesterol that allow them to interact strongly with water molecules on either side of the membrane in the surrounding cytoplasm
C. The phospholipid tails are made up of single-stranded DNA molecules that bind tightly to the proteins embedded in the inner surface of the cell membrane in animal cells overall
D. Cellular ATP must be continuously expended to hold the phospholipid molecules in their bilayer arrangement throughout the entire lifetime of the cell each second of normal cell life

4. A red blood cell is placed into a beaker of pure distilled water. Compared with the inside of the red blood cell, the surrounding water is:

A. Hypertonic, meaning that water will move out of the cell by osmosis and cause the cell to shrink and shrivel up during the course of the experiment in the laboratory
B. Isotonic, meaning that there will be no net movement of water across the cell membrane in either direction throughout the entire course of the experiment over time
C. Hypotonic, meaning that water will move into the cell by osmosis and may cause the cell to swell and eventually burst from the increased internal pressure on the membrane
D. Anhydrous, meaning that the surrounding solution contains no water at all and that the red blood cell will dehydrate rapidly within a very short period of time of placement

5. The diagram below shows an animal cell during a particular phase of mitosis. Based on the position of the chromosomes shown, the cell is currently in:

[**Figure PQ-2:** Clean black-line technical diagram on white background.]

A. Prophase, the first stage of mitosis during which the chromosomes condense and the nuclear envelope begins to break down before any other events take place
B. Anaphase, the stage of mitosis during which sister chromatids separate and move toward opposite poles of the dividing cell as the spindle fibers shorten in the cell
C. Metaphase, the stage of mitosis during which chromosomes line up at the equator (center) of the cell before any movement of chromosomes toward the poles begins
D. Telophase, the final stage of mitosis during which two new nuclear envelopes form around the separated chromosomes at each pole of the cell at the end of mitosis

6. During DNA replication, each parental DNA strand serves as a template for the synthesis of a new complementary strand. If one segment of a parental DNA strand reads 5'-ATGCAT-3', the corresponding newly synthesized complementary strand will read:

A. 3'-TACGTA-5', following the rule that A pairs with T and G pairs with C, with the new strand running antiparallel to the parental template strand during replication
B. 3'-ATGCAT-5', since the new strand must be identical to the parental template strand in order to faithfully replicate the original genetic information stored in the DNA
C. 5'-AUGCAU-3', following the rule that A pairs with U and G pairs with C, since this is the pairing pattern used between mRNA and DNA during the process of replication
D. 3'-CGTACG-5', following the rule that each base in the parental strand pairs with a base of the same general type on the new strand during the process of DNA replication

7. An mRNA strand has the sequence 5'-AUG GCA UUU UAA UGC-3'. Translation begins at the start codon and proceeds in groups of three bases. The number of amino acids in the resulting polypeptide is:

A. 5 amino acids, because each codon is exactly three nucleotides long and there are 15 nucleotides total in the entire mRNA strand shown in the question stem above
B. 4 amino acids, because the first codon AUG is the start codon and is read normally as methionine before translation continues to the next codons in sequence through the strand
C. 1 amino acid, because the first three nucleotides AUG code only for methionine and translation stops

immediately after this single amino acid is added to the chain
D. 3 amino acids, because translation begins at the start codon AUG and continues until the stop codon UAA is reached, producing methionine, alanine, and phenylalanine

8. The pedigree below shows the inheritance of a single-gene trait through three generations of a family. Affected individuals are shown shaded; unaffected individuals are unshaded. Based on the pedigree, the trait is most likely inherited as:

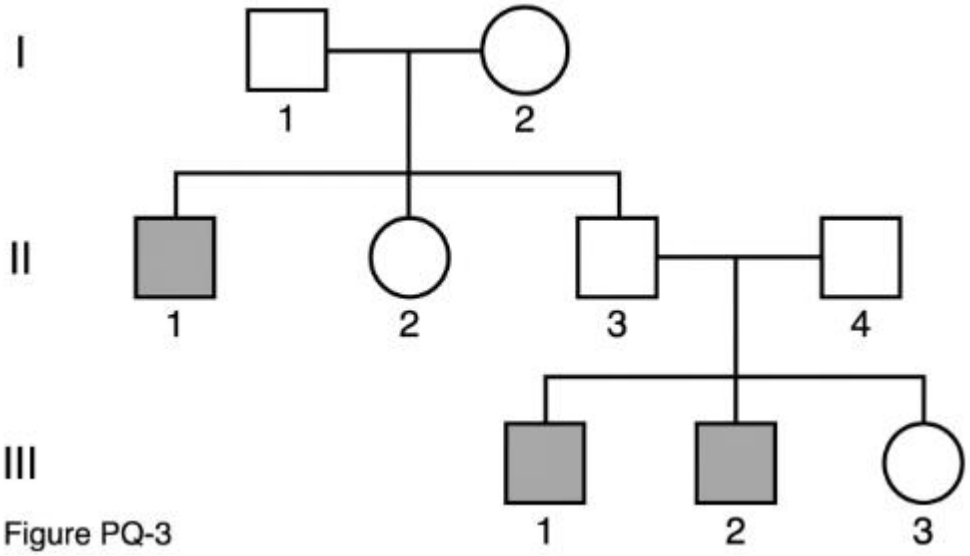


Figure PQ-3

A. Autosomal dominant, because the trait appears in every generation of the family and is passed from a single affected parent to about half of all of their children equally
B. Autosomal recessive, because the trait appears only in homozygous recessive individuals and skips entire generations in the family pedigree shown in this question
C. X-linked recessive, because the trait appears predominantly in males and is passed through unaffected carrier females to their affected sons in the next generation of the family
D. Y-linked inheritance, because the trait is passed from affected fathers directly to all of their sons but never appears in any of the daughters of affected fathers in the family

9. In a population of butterflies, 4% of individuals show a recessive phenotype caused by a single autosomal recessive allele (q). Assuming the population is in Hardy-Weinberg equilibrium, the frequency of the recessive allele (q) in this population is:

A. 0.20, since the frequency of homozygous recessive individuals (q^2) is 0.04, and the square root of 0.04 equals 0.20 in this population under Hardy-Weinberg equilibrium
B. 0.40, since the frequency of homozygous recessive individuals (q^2) is 0.04, and that value multiplied by 10 gives 0.40 as the frequency of the recessive allele
C. 0.04, since the frequency of homozygous recessive individuals in the population is exactly 4%, and that value equals the recessive allele frequency directly
D. 0.96, since the frequency of homozygous recessive individuals (q^2) is 0.04, and 1 minus 0.04 equals 0.96 as the frequency of the recessive allele in this population

10. A group of ten individuals from a large mainland population colonizes a remote island. Over time, the island population becomes genetically distinct from the mainland source population in many of its allele frequencies. The most likely explanation for this divergence is:

A. Convergent evolution, in which two unrelated populations independently develop similar traits in response to similar environmental conditions over many generations of natural selection
B. The founder effect, a form of genetic drift in which a small founding population carries only a fraction of the genetic variation found in the original source population at the time
C. Coevolution, in which two interacting species develop reciprocal adaptations in response to each other over many generations of natural selection between two interacting species
D. Gene flow, in which migration of individuals between two populations causes their gene pools to become more genetically similar to one another over the course of time across generations

11. A river changes course and physically separates a single population of mice into two groups that cannot interbreed for thousands of years. Over time, the two groups become genetically distinct and can no longer produce fertile offspring even when brought back into contact. This pattern is best described as:

A. Sympatric speciation, in which new species arise within the same geographic area as the parent species without any physical barrier separating the diverging populations
B. Convergent evolution, in which unrelated species develop similar traits in response to similar environmental pressures over many generations of natural selection on each population
C. Adaptive radiation, in which one ancestral species rapidly diversifies into many descendant species filling different ecological niches in a single shared environment over time
D. Allopatric speciation, in which a physical geographic barrier separates two populations and allows them to diverge into different species over time through accumulated changes

12. On a Galápagos island, an extended drought reduced the supply of small soft seeds, leaving mostly large hard seeds for finches to eat. Over several years, the average beak depth of the finch population increased significantly. This change in average beak depth is best explained by:

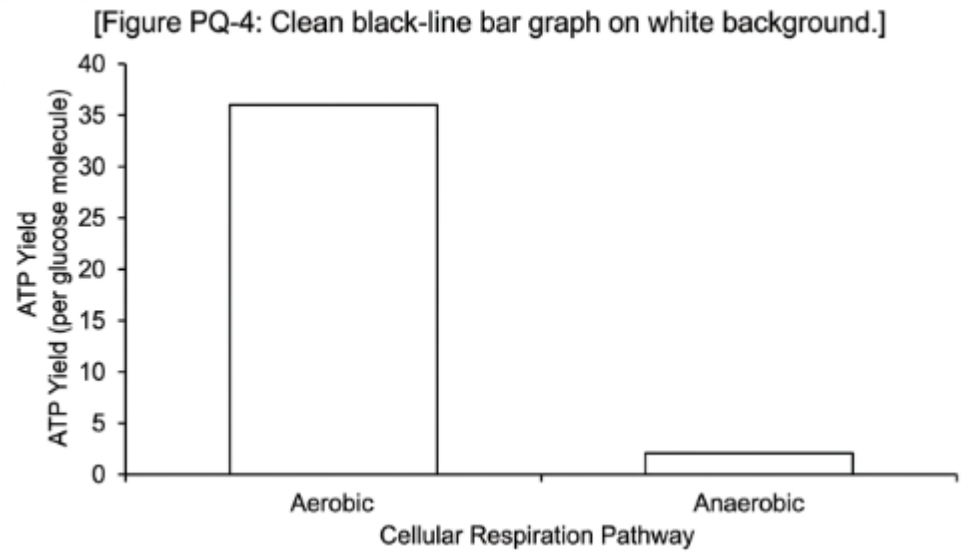
A. Inheritance of acquired characteristics, in which the act of repeatedly cracking large seeds physically enlarged the beaks of individual finches during the course of their lifetimes
B. Genetic drift, in which random changes in allele frequencies caused the average beak depth to increase over time even without any consistent selective pressure on beak depth at all
C. Natural selection, in which finches with larger beaks survived and reproduced more successfully during the drought than smaller-beaked finches, shifting average beak depth upward
D. The founder effect, in which a small group of large-beaked finches colonized the island and rapidly replaced the original finch population over the course of just a few years

13. The overall equation for photosynthesis is: $6CO_2 + 6H_2O + \text{light energy} \rightarrow C_6H_{12}O_6 + 6O_2$. Based on this equation and the known chemistry of the light-dependent reactions, the source of the oxygen atoms released as O_2 gas is:

A. The water molecules (H_2O), which are split during the light-dependent reactions of photosynthesis through the process of photolysis in the thylakoid membranes of chloroplasts

B. The carbon dioxide molecules (CO_2), which are split during the light-dependent reactions of photosynthesis and release oxygen as a byproduct in the stroma of chloroplasts in plants
C. The glucose molecules ($C_6H_{12}O_6$), which are broken down during the synthesis reactions of photosynthesis and release oxygen as a byproduct that then diffuses out of the chloroplast
D. The light energy itself, which generates oxygen gas molecules directly from photons absorbed by chlorophyll molecules in the thylakoid membranes throughout the daylight hours each day

14. The bar graph below compares the ATP yield from one molecule of glucose under aerobic and anaerobic conditions in human muscle cells. The most likely reason for the large difference shown is that:



A. Anaerobic respiration completely breaks glucose down to carbon dioxide and water, capturing nearly all of the available chemical energy stored in the glucose molecule itself
B. Aerobic respiration completely oxidizes glucose using the electron transport chain with oxygen as the final electron acceptor, capturing far more of the energy stored in glucose
C. Anaerobic respiration always occurs at higher temperatures than aerobic respiration, allowing for a slower release of energy from each glucose molecule over the course of time
D. Aerobic respiration occurs only in plant cells, while anaerobic respiration is the only form of cellular respiration that occurs in animal cells throughout normal daily activity

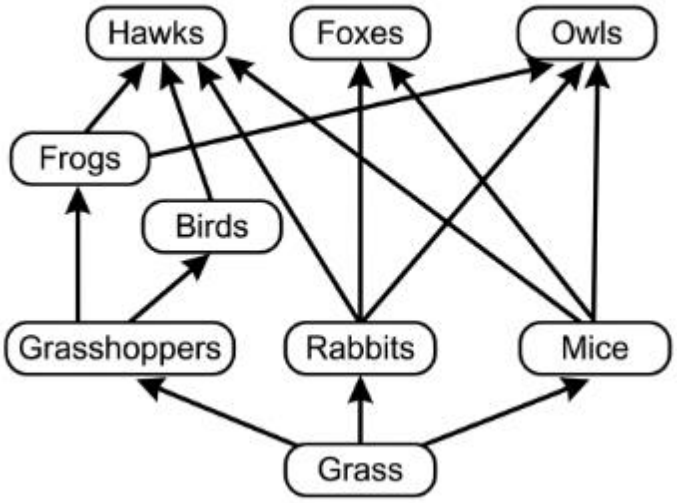
15. If the producers in an ecosystem capture 100,000 kcal of energy through photosynthesis, the amount of energy expected to be available to the secondary consumers of the same ecosystem is approximately:

A. 100,000 kcal, since energy is fully recycled in food webs and secondary consumers therefore receive nearly all of the energy originally captured by the producers of the ecosystem
B. 10,000 kcal, since approximately 10% of the energy at each trophic level is passed to the next trophic level above it in the food chain hierarchy of an ecosystem in nature
C. 50,000 kcal, since half of all energy is passed to the next trophic level and the other half is lost as heat to the surrounding environment over time during the energy flow process

D. 1,000 kcal, since approximately 10% of producer energy reaches primary consumers (10,000 kcal) and 10% of that reaches secondary consumers along the food chain in turn

16. The food web below shows feeding relationships in a meadow ecosystem. Arrows point in the direction of energy flow from prey to predator. Based on the food web, which of the following statements is true?

[Figure PQ-5]

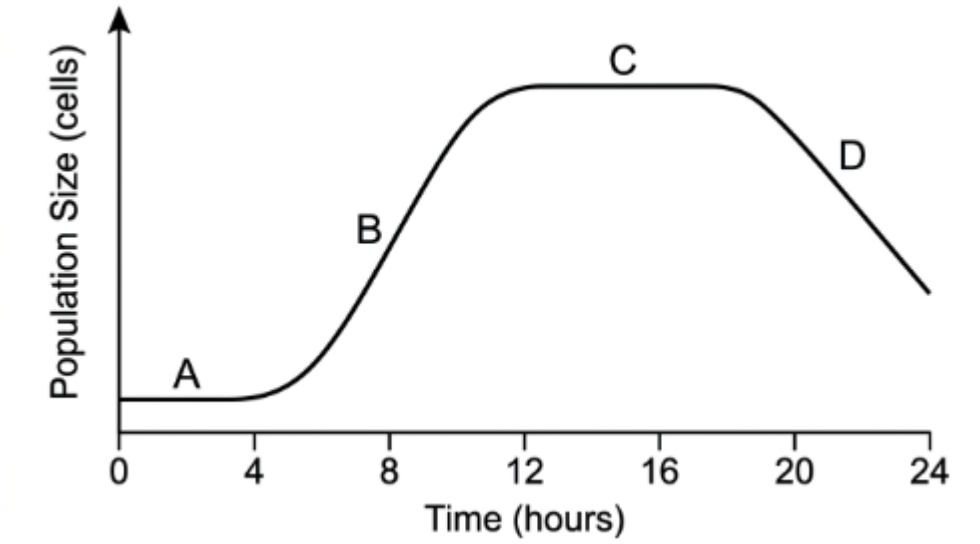


A. The grass is a primary consumer, since it is consumed by grasshoppers, rabbits, and mice throughout the meadow ecosystem at any given time during the course of the year
B. The hawks act only as secondary consumers, since they feed exclusively on herbivores such as rabbits and mice in the meadow ecosystem throughout each year of their lives
C. The hawks act as both secondary and tertiary consumers, since they feed on herbivores (rabbits, mice) and also on other carnivores (frogs, birds) within the same ecosystem
D. The owls and frogs share only a strictly competitive relationship for prey, since they both eat exactly the same single insect or rodent prey species in the meadow at all times

17. In a graph of population size over time, a population is said to be at its "carrying capacity" when:

A. The growth rate has slowed to approximately zero and the population size has stabilized near a level that the environment can support over the long term with available resources
B. The population is growing at its maximum possible exponential rate due to unlimited resources and the complete absence of any predators or competitors in the surrounding habitat
C. The population is decreasing rapidly because of a sudden environmental change that has greatly reduced the resources available to the organisms in the surrounding ecosystem
D. The population has gone completely extinct as a result of the gradual depletion of resources by previous generations of the same population in the same area over a long span of time

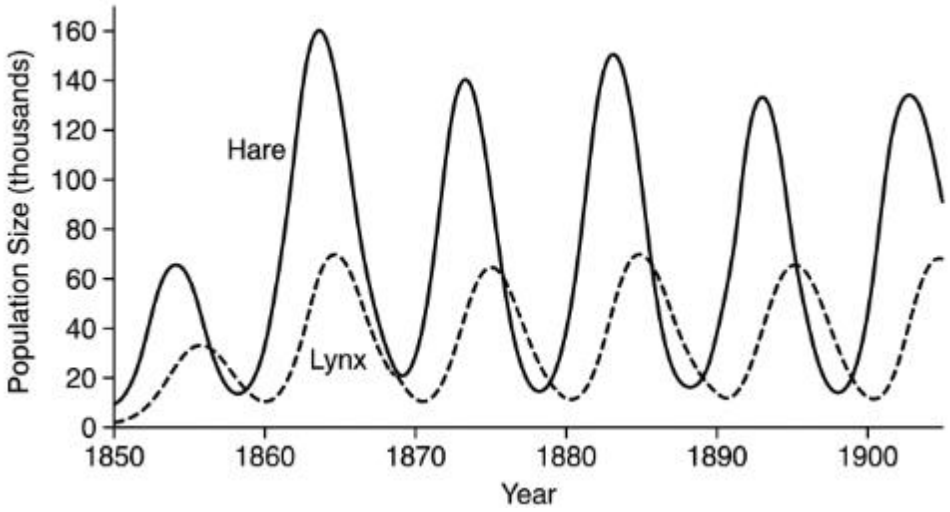
18. The graph below shows the growth of a bacterial population in a closed culture over a 24-hour period. Which lettered phase on the graph corresponds to the exponential (log) growth phase of the population?



A. Phase A, the initial period when the population size remains relatively constant before any significant cell division has occurred among the bacteria in the culture during incubation
B. Phase B, when the population grows rapidly with cell numbers doubling at regular intervals under conditions of abundant resources and minimal accumulated waste in the culture
C. Phase C, when the population size remains relatively constant because the rates of birth and death have become approximately balanced in the culture environment over time
D. Phase D, when the population size decreases steadily as a result of the depletion of available resources and the buildup of toxic waste products in the closed culture environment

19. The graph below shows the population sizes of a predator species (lynx) and its prey species (snowshoe hare) over a span of several decades. Based on the graph, which statement best describes the relationship between the two populations?

[Figure PQ-7]



A. The lynx population always peaks slightly before the hare population peaks during each cycle, indicating that the lynx population is actively driving the size of the hare population
B. The two populations are completely independent of each other and any pattern visible in the graph is purely random in nature and has no underlying biological meaning at all
C. The lynx population peaks slightly after the hare population peaks each cycle, indicating that the predator population responds to changes in prey availability with a brief time lag
D. Both populations decline together steadily over the course of the decades shown on the graph, indicating that both species are heading toward extinction in this particular region soon

20. Which of the following processes removes carbon dioxide from the atmosphere and incorporates the carbon into organic molecules?

A. Cellular respiration, in which living organisms break down glucose and release carbon dioxide as a byproduct of the chemical reactions that produce ATP for cellular work each day
B. Combustion of fossil fuels, in which carbon stored in coal and oil is released as carbon dioxide gas when the fuel is burned in power plants and engines for the production of energy
C. Decomposition of dead organisms, in which bacteria and fungi release carbon dioxide gas from organic molecules as they break down dead plant and animal material in the soil over time
D. Photosynthesis, in which plants and other autotrophs use atmospheric carbon dioxide and water to produce glucose, releasing oxygen as a byproduct of the chemical reactions in chloroplasts

21. Nitrogen-fixing bacteria found in the root nodules of legumes (such as soybeans and peas) play an important role in the nitrogen cycle by:

A. Converting atmospheric nitrogen gas (N_2) into ammonia (NH_3) that can be used by the plant to build amino acids, nucleic acids, and other essential nitrogen-containing molecules
B. Converting nitrates (NO_3^-) found in the soil back into atmospheric nitrogen gas (N_2) through the process of denitrification, which returns nitrogen to the atmosphere over time
C. Converting carbon dioxide from the atmosphere into glucose through a chemical process that is very similar to photosynthesis in the leaves of plants exposed to direct sunlight daily
D. Converting glucose produced by the legume host plants into ATP through the process of aerobic cellular respiration occurring within the cells of the surrounding root tissue at all times

22. A volcanic eruption covers a previously vegetated area with thick layers of ash and lava, leaving no soil and no living organisms in the affected area. Years later, lichens and mosses begin to grow on the bare rock surface. This colonization process is best classified as:

A. Secondary succession, in which an ecosystem recovers from a disturbance that left the existing soil intact and some living plant root systems alive within the soil after the event
B. A climax community, in which an ecosystem has reached a long-term stable composition of plant and animal species in equilibrium with the local climate and soil conditions
C. Primary succession, in which a new ecosystem forms in an area that had no previous soil and no surviving living organisms before colonization began on the bare rock surface
D. Eutrophication, in which excess nutrients build up in a body of water, leading to algal blooms and to eventual oxygen depletion in the deeper layers of the water over time

23. In Yellowstone National Park, the reintroduction of wolves led to changes throughout the entire ecosystem, including reduced elk populations, the recovery of riverside willow and aspen vegetation, and increases in beaver populations. The wolves in this case are best classified as:

A. An invasive species, since they were brought into the park from outside the area and quickly began to disrupt the existing balance of populations in the local ecosystem
B. A keystone species, since their presence has a disproportionately large effect on the structure and function of the entire ecosystem relative to their actual abundance in the park
C. A pioneer species, since they were the first species to colonize a barren landscape and helped to start the process of primary succession in the area at that particular time
D. A decomposer species, since their main ecological role is to break down dead organic matter and return nutrients to the soil throughout the surrounding park each year of their lives

24. A scientist examines a graph showing atmospheric CO_2 concentration and global average temperature over the past 150 years. Both curves show similar upward trends. The most well-supported scientific conclusion drawn from this data is:

A. Rising temperatures over the past 150 years have caused the increase in atmospheric CO_2 concentration by accelerating the rate of evaporation from the world's oceans throughout the period
B. The increase in atmospheric CO_2 concentration is entirely the result of changes in solar output over the past 150 years and is unrelated to any human activity in the world during the time
C. Both the atmospheric CO_2 concentration and the global temperature on Earth have remained essentially constant over the past 150 years despite human industrial activity worldwide
D. Increased atmospheric CO_2 from fossil fuel combustion and deforestation is enhancing the greenhouse effect, contributing to the rise in global average temperatures over the past 150 years

25. A nonnative species of plant introduced to a region has spread rapidly, outcompeted native plants for sunlight and water, and significantly reduced the biodiversity of the area. This species is best classified as:

A. An invasive species, a nonnative organism that has spread aggressively in its new environment and harmed the ecosystem by displacing native species and disrupting local food webs
B. A keystone species, a species that has a disproportionately large effect on its ecosystem and whose removal would cause major changes throughout the entire surrounding ecosystem
C. An indicator species, a species whose presence or abundance reflects the environmental conditions and the overall health of the ecosystem in which it lives in a particular region
D. A pioneer species, a species that is the first to colonize a barren or recently disturbed environment and begins the long process of ecological succession in the area over time

26. A tapeworm lives in the small intestine of a human host. The tapeworm absorbs nutrients from the host's digested food, while the host suffers nutritional deficiencies as a result of the infestation. This ecological relationship is best classified as:

A. Mutualism, an ecological relationship in which both species benefit from the close interaction between them over the course of their entire lives together in the same shared habitat
B. Commensalism, an ecological relationship in which one species benefits from the relationship while

the other species is essentially unaffected by it overall throughout the relationship
C. Parasitism, an ecological relationship in which one species (the parasite) benefits while the other species (the host) is harmed by the close interaction between them over time
D. Predation, an ecological relationship in which one species hunts, kills, and consumes another species as its primary source of nutrition each day in their shared ecosystem in nature

27. Which of the following statements is part of the modern cell theory?

A. All cells are surrounded by a rigid cell wall made of cellulose, which provides structural support and protection from the surrounding environment of the cell throughout the life of the cell
B. All living organisms are composed of one or more cells, and all cells arise from previously existing cells through the process of cell division each time new cells are produced
C. Cells are not the smallest unit of life because individual organelles inside the cell can function as completely independent living organisms outside of the cell in many cases overall
D. All cells contain exactly the same set of organelles regardless of the type of organism, and regardless of the specific function performed by that cell within its tissue or organ

28. Embryonic stem cells are classified as "pluripotent" because they can:

A. Divide only once or twice before they lose their ability to differentiate into any new cell types within the body of the developing organism after fertilization has occurred in the female
B. Differentiate only into red blood cells and white blood cells through the process of hematopoiesis in the bone marrow of the body throughout adulthood and into old age each year
C. Continue to function as fully differentiated adult body cells without ever needing to undergo any additional rounds of cell division throughout their entire life span in the body of the patient
D. Give rise to nearly any type of cell in the body, allowing them to develop into many specialized cell types during embryonic development of the organism after fertilization occurs

29. Cancer is most directly characterized by:

A. Uncontrolled cell division resulting from mutations in genes that normally regulate the cell cycle, allowing damaged cells to divide repeatedly and form tumors of abnormal tissue
B. A complete shutdown of all cell division throughout the body of the patient, leading to a gradual loss of body tissue and organ function over the course of the patient's life and over time
C. The replacement of all body cells with foreign bacterial cells that have invaded the body from the external environment through a wound or other break in the protective surface of the skin
D. The total loss of all genetic material from the affected cells in the body, resulting in the inability of those cells to perform any biological function whatsoever in the body throughout life

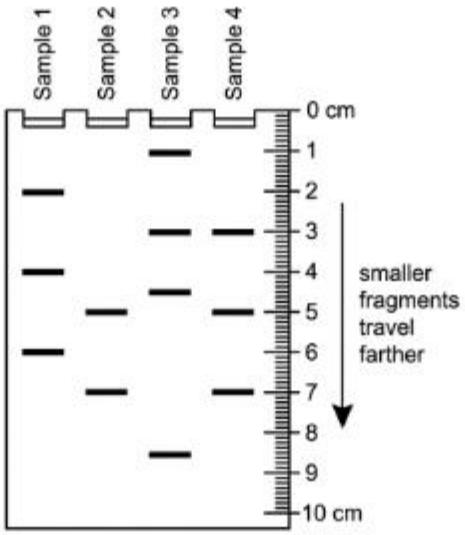
30. A mutation that changes a single nucleotide base in a gene's DNA sequence changes one amino acid in the resulting protein but does not change the total number of amino acids in the protein chain. This mutation is best classified as:

A. A frameshift mutation, in which the insertion or deletion of nucleotides shifts the entire downstream reading frame of the genetic code in the affected portion of the gene during translation
B. A silent mutation, in which the change in the nucleotide sequence does not change the amino acid

sequence of the resulting protein in the affected cell of the body of the patient overall
C. A point mutation of the missense type, in which a single nucleotide change results in the substitution of one amino acid for another amino acid in the resulting protein chain produced
D. A chromosomal mutation, in which the change involves a rearrangement of large segments of an entire chromosome and affects many genes simultaneously within the cell of the patient

31. The gel electrophoresis result below shows DNA fragments from four samples loaded into separate lanes. Smaller DNA fragments migrate farther from the wells than larger fragments. Based on the gel, which sample contains the smallest DNA fragments overall?

Figure PQ-8



A. Sample 1, since its bands are positioned closer to the top of the gel than the bands of the other three samples shown in the experiment above on the gel image
B. Sample 2, since all of its bands have traveled the greatest distance from the wells of any sample shown, indicating that Sample 2 contains the smallest DNA fragments overall
C. Sample 3, since its bands have traveled the shortest total distance from the wells of any sample shown, indicating that Sample 3 must contain the smallest DNA fragments overall
D. Sample 4, since its band distances fall in the middle range of the four samples on the gel, indicating an average fragment size in the experiment displayed in the figure shown

32. The polymerase chain reaction (PCR) is a laboratory technique used to:

A. Cut DNA molecules at specific recognition sequences in order to produce fragments of DNA that can then be separated and analyzed by gel electrophoresis in a forensic laboratory setting
B. Determine the order of amino acids in a protein by sequencing the genetic information stored in the DNA molecules found in a particular sample of human or animal tissue at the time
C. Transfer a gene from one organism into another organism's genome in order to produce a genetically modified organism that expresses a useful new trait in the recipient organism overall
D. Make many copies of a specific DNA segment through repeated cycles of heating and cooling using a heat-stable DNA polymerase enzyme and short primer sequences that bracket the target

33. A vaccine works by introducing a weakened or inactive form of a pathogen (or a piece of it) into the body. The body's immune response to a vaccine provides protection against future infection primarily by:

A. Permanently destroying all of the body's existing immune cells, forcing the body to develop a completely new set of immune cells over the course of the following several weeks after vaccination
B. Directly killing all copies of the pathogen that exist outside of the body of the patient, preventing them from ever reaching the patient's body in the first place after exposure of any kind
C. Stimulating the production of memory B cells and memory T cells that recognize the pathogen and mount a rapid and strong immune response upon future exposure to that same pathogen
D. Replacing the patient's normal red blood cells with new red blood cells that are resistant to all known pathogens that the patient might possibly be exposed to in the future of their life

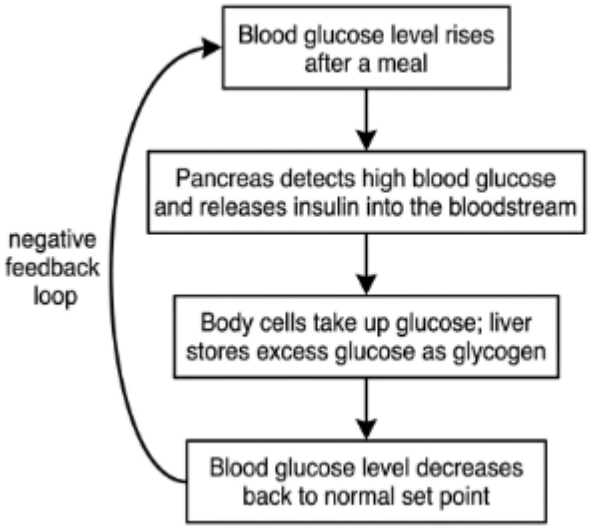
34. The human immunodeficiency virus (HIV) attacks the immune system by infecting and destroying:

A. Helper T cells ($CD4^+$ T cells), which are essential for coordinating the body's overall immune response, leaving the patient vulnerable to many opportunistic infections over time during AIDS
B. Red blood cells, which are responsible for transporting oxygen throughout the body to the cells of every organ system on a continuous basis each minute of life of the patient throughout life
C. Platelets in the blood, which are responsible for forming blood clots and stopping bleeding at the site of any wound or injury to the body of the patient throughout their daily life and activity
D. Neurons in the central nervous system, which are responsible for processing sensory input and generating motor output to muscles throughout the body of the patient each day of life

35. Type 1 diabetes is an autoimmune disease in which the immune system destroys the insulin-producing beta cells of the pancreas. As a result, individuals with type 1 diabetes have:

A. Excess production of the hormone insulin, leading to chronically low blood glucose levels that require frequent intake of dietary carbohydrates throughout each and every day to maintain
B. Little or no production of the hormone insulin, leading to chronically high blood glucose levels that require insulin injections to manage on a daily basis throughout the patient's life
C. Excessive production of the hormone glucagon, leading to the breakdown of muscle tissue to provide amino acids for gluconeogenesis throughout the body of the patient daily throughout life
D. Normal production of the hormone insulin but reduced sensitivity of body cells to that hormone, leading to chronically high blood glucose levels despite normal insulin secretion each day

36. The flow chart below shows the body's response to a rise in blood glucose levels after a meal. The pattern of regulation shown in this flow chart best illustrates which physiological principle?



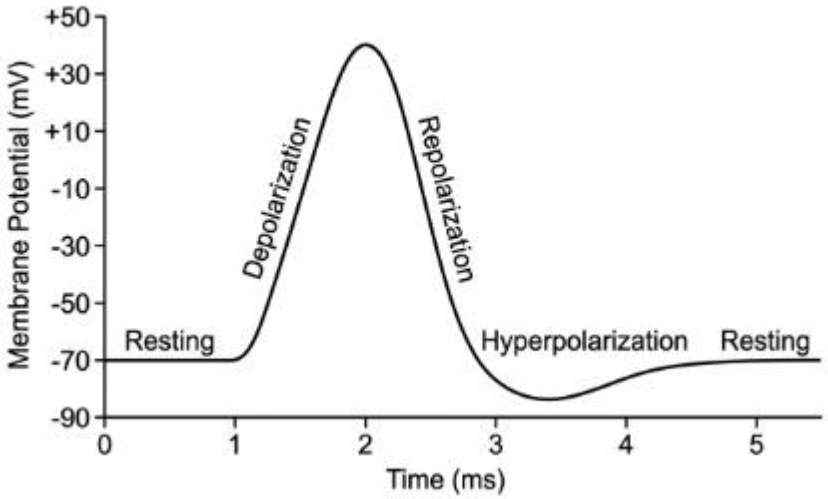
A. Positive feedback, in which the body's response to a stimulus amplifies the original stimulus and pushes the regulated variable further away from its initial set point over time during normal regulation
B. Genetic determinism, in which a single specific gene controls the body's overall metabolic response to changes in environmental conditions throughout the day after eating any kind of meal
C. Active transport, in which ATP energy is used to move glucose molecules against their concentration gradient across the plasma membranes of all of the body cells of the patient each day
D. Negative feedback, in which the body's response to a stimulus reverses the original change and returns the regulated variable back toward its normal set point over time during regulation

37. When body temperature rises above normal, sweat glands in the skin release sweat that evaporates and cools the body. When body temperature falls below normal, blood vessels in the skin constrict and skeletal muscles shiver to produce additional body heat. These coordinated responses together best illustrate:

A. Homeostasis, the maintenance of a relatively constant internal environment through coordinated physiological responses that counteract changes in conditions and restore the original set point
B. Mitosis, the process of cell division that produces two genetically identical diploid daughter cells from a single parent cell during the normal growth and repair of body tissues in the patient overall
C. Photosynthesis, the conversion of light energy into stored chemical energy through a series of enzyme-catalyzed reactions occurring within the chloroplasts of plant cells exposed to sunlight each day
D. Translation, the process by which the information in messenger RNA is decoded by ribosomes to produce specific proteins inside the cells of the body of the patient each day of their normal life

38. The graph below shows the membrane potential (voltage) of a neuron during the firing of a single action potential. During the phase of the graph labeled "Depolarization", what happens at the neuron's membrane?

[Figure PQ-10]



A. Potassium ions (K^+) rapidly flow out of the neuron through specific potassium ion channels in the membrane, making the inside of the neuron more negative than it was during the resting state
B. The neuron actively pumps sodium ions out of the cell and potassium ions back into the cell using the sodium-potassium pump, gradually restoring the resting membrane potential of the cell
C. Sodium ions (Na^+) rapidly flow into the neuron through voltage-gated sodium channels in the membrane, making the inside of the neuron more positive than it was during the resting state
D. The neuron releases neurotransmitters at the synapse, causing the next neuron in the pathway to also depolarize within the next several milliseconds and continue propagating the nerve signal

39. When a person accidentally touches a hot stove, the hand is pulled away before the person is consciously aware of the pain. This rapid protective response is best explained by:

A. A long-distance hormonal signal traveling through the bloodstream from the brain to the muscles of the arm, causing them to contract within just a few seconds of the initial contact with the heat
B. A spinal reflex arc in which sensory neurons signal the spinal cord, which directly activates motor neurons to contract the arm muscles without first involving the brain in the response cycle
C. A conscious decision made by the cerebral cortex of the brain to remove the hand from the source of the heat, transmitted to the arm muscles through motor neurons in the arm of the patient
D. The release of adrenaline from the adrenal glands of the body, which rapidly causes the heart rate to increase and the muscles of the arm to contract in a coordinated way throughout the body

40. Which of the following best describes a fundamental difference between the nervous system and the endocrine system in coordinating responses in the body?

A. The endocrine system uses electrical signals to coordinate responses, while the nervous system uses chemical signals released into the bloodstream throughout the body to coordinate its activity each day
B. The nervous system has effects that last for hours or days at a time, while the endocrine system produces effects that last for only a few milliseconds at a time during normal use of the body's systems
C. The nervous system and the endocrine system have no important functional differences and produce identical responses through identical mechanisms within the body throughout the entire lifespan of life

D. The nervous system uses fast electrical signals for rapid, short-lasting responses, while the endocrine system uses slower hormonal signals for longer-lasting, more sustained responses throughout the body

41. The functional unit of the kidney is the nephron. The first step in the formation of urine within a single nephron is:

A. Filtration of blood plasma through the walls of the glomerulus into Bowman's capsule, where water and small dissolved solutes are forced out of the blood by the high pressure within the capillaries
B. Reabsorption of glucose, amino acids, and water from the kidney tubules back into the bloodstream through active and passive transport mechanisms in the cells of the tubules in the kidney structure
C. Secretion of waste molecules such as drugs and hydrogen ions from the bloodstream into the kidney tubules through specific transport proteins in the cells of the tubules throughout the kidney structure
D. Excretion of the final urine product from the body of the patient through the ureters, bladder, and urethra after passing through the entire kidney structure during processing of the original blood plasma

42. The enzyme pepsin is found in the stomach and begins the chemical digestion of proteins. Pepsin functions effectively in the stomach because:

A. The stomach maintains a very basic pH environment (approximately pH 10), which is the optimal pH for the function of the pepsin enzyme in the chemical digestion of proteins in the body of the patient
B. The temperature inside the stomach is far below normal body temperature, which allows pepsin to maintain its three-dimensional shape and function properly during the digestion of proteins each day
C. The stomach contains hydrochloric acid that maintains a very acidic pH (approximately pH 2), which is the optimal pH for pepsin to effectively digest proteins into smaller peptide fragments
D. The stomach is the only organ in the entire human body that contains any pepsin enzyme molecules, which makes it the only possible site of chemical protein digestion in the entire digestive system

43. During a normal heartbeat, blood follows a specific path through the four chambers of the heart and through the lungs. The correct sequence of blood flow through the human heart and lungs is:

A. Left atrium → left ventricle → pulmonary artery → lungs → pulmonary vein → right atrium → right ventricle → aorta → body, repeating in this same continuous cycle with each new heartbeat
B. Right ventricle → right atrium → aorta → body → vena cava → left ventricle → left atrium → pulmonary artery → lungs → pulmonary vein, repeating in this same continuous cycle with each beat
C. Aorta → right atrium → right ventricle → pulmonary vein → lungs → pulmonary artery → left atrium → left ventricle → vena cava, repeating in this same continuous cycle of blood flow with each beat
D. Vena cava → right atrium → right ventricle → pulmonary artery → lungs → pulmonary vein → left atrium → left ventricle → aorta → body, repeating in this same continuous cycle with each beat

44. The alveoli of the lungs are well-adapted for the rapid exchange of gases between the air and the blood. The structural feature of alveoli that most directly contributes to efficient gas exchange is:

A. A thick, multilayered epithelium that protects the alveolar tissue from physical damage caused by the rapid movement of air through the lungs during breathing throughout each day of the patient's life
B. A large total surface area combined with extremely thin walls (a single cell layer thick), allowing

oxygen and carbon dioxide to diffuse rapidly between the alveolar air and the surrounding capillary blood
C. A muscular wall that actively contracts and relaxes to push gas molecules across the alveolar membrane between the air and the blood at the rate needed by the body during physical exertion of the patient
D. A dense layer of pigment-producing cells that absorb light energy and convert it into the chemical energy needed for gas exchange between the alveolar air and the surrounding capillary blood each minute

45. The elbow joint allows the lower arm to move toward and away from the upper arm in essentially one direction only, similar to the motion of a door hinge swinging open and closed. This type of joint is best classified as:

A. A hinge joint, which allows movement in primarily one plane only and is found at locations such as the elbow and the knee in the human body throughout the lifespan of the individual person
B. A ball-and-socket joint, which allows movement in multiple planes including rotation, and is found at locations such as the shoulder and the hip joints of the human body of an adult patient each year
C. A pivot joint, which allows one bone to rotate around another bone, and is found at locations such as the joint between the first two vertebrae of the neck near the base of the skull of an adult patient
D. A gliding joint, which allows two bones to slide past each other with a limited range of motion, and is found at locations such as within the wrist and ankle of the body of an adult patient throughout life

46. The skin is the largest organ of the human body and serves many important functions. The skin's central role in homeostasis is best illustrated by:

A. Its ability to absorb light energy from the sun and to convert that energy into chemical energy used by the body's various organ systems during the daylight hours of every single day throughout life of the patient
B. Its ability to produce digestive enzymes that break down food molecules into smaller molecules that can then be absorbed by the cells of the body for nutrition and growth in the patient throughout life
C. Its role in regulating body temperature through sweating and changes in blood flow to the skin's surface, and its function as a protective barrier against pathogens and dehydration throughout the patient's daily life
D. Its role in producing all of the body's red blood cells in specialized bone marrow tissue located within the deeper layers of the skin's dermis throughout the entire body of the adult patient each day of life

47. Meiosis differs from mitosis in that meiosis:

A. Produces two diploid daughter cells that are genetically identical to the parent cell, providing for the repair and growth of body tissues throughout the body of the adult patient each day of life and growth
B. Produces four haploid daughter cells that contain unique combinations of genetic material as a result of crossing over and independent assortment occurring during the two divisions of the meiosis process
C. Occurs in every type of cell throughout the body during normal growth and tissue repair, producing the genetic variation that is necessary for normal body function throughout the lifespan of the adult patient
D. Involves a single round of DNA replication followed by a single round of cell division, with no

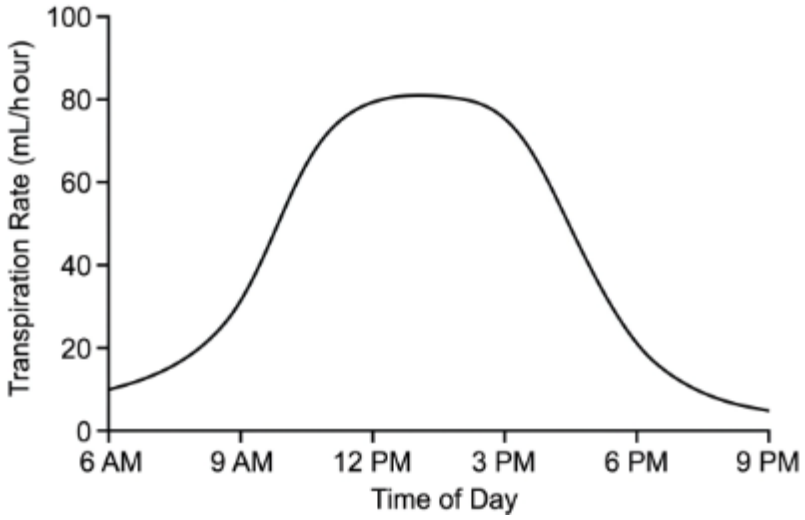
genetic recombination occurring during the entire process of meiosis at any point in the cell cycle of the patient

48. During early embryonic development, the fertilized egg (zygote) undergoes a series of cell divisions and rearrangements that produce a complex multicellular embryo. The correct sequence of these early developmental stages is:

A. Gastrula → blastula → cleavage → zygote → organogenesis, with each stage building structurally on the one before it during the normal embryonic development of the human being in the uterus
B. Zygote → organogenesis → blastula → gastrula → cleavage, with each stage involving more complex cellular interactions than the previous stages during normal embryonic development of the body
C. Blastula → gastrula → zygote → cleavage → organogenesis, with each stage involving an increasing degree of complexity in the organization of the cells of the developing embryo over the course of time
D. Zygote → cleavage → blastula → gastrula → organogenesis, with each stage representing an increasingly complex level of cellular organization in the developing embryo from fertilization onward

49. The graph below shows the rate of water loss through transpiration in a typical plant over the course of a single day. Based on the graph, the most likely explanation for the pattern shown is:

[Figure PQ-11]



A. Transpiration rates are highest during the night because the stomata of the plant open at night to release water and gases to the surrounding cool environment outside the leaves of the plant throughout the night
B. Transpiration rates remain essentially constant throughout the entire day because the stomata of the plant are open at all times during the entire 24-hour daily period throughout the lifespan of the plant overall
C. Transpiration rates are highest during the daytime because the stomata of the plant open in response to light to allow the gas exchange needed for photosynthesis, but this also allows large amounts of water to escape
D. Transpiration rates are completely independent of the time of day because water loss from plants is

controlled only by the temperature of the surrounding air at the time and not by any other environmental factor

50. A young plant growing on a sunny windowsill bends toward the source of light, with the cells on the shaded side of the stem elongating more than the cells on the lighted side of the stem during the bending response. This growth response is best explained by:

A. The plant hormone auxin accumulating on the shaded side of the stem, causing the cells on that side to elongate more rapidly than the cells on the lighted side, which bends the stem toward the light source
B. The plant consciously turning its stem toward the source of light in order to maximize the total amount of photosynthesis that can be performed by all of the leaves of the plant during each day of the year
C. The accumulation of additional chlorophyll molecules on the shaded side of the stem, which causes the cells on that side to undergo cell division more rapidly than the cells on the lighted side of the stem
D. The breakdown of the cell walls on the lighted side of the stem due to direct exposure to sunlight, which causes the plant to bend away from the source of light in the surrounding environment of the plant

Practice Exam 36: Life Science: Biology Simulation – Answer Key with Explanations

1. B — pH 2 is the optimum for pepsin, shown by its activity peak on the graph at strongly acidic conditions. Parietal cells in the stomach lining secrete HCl that maintains this acidic environment, perfectly suited for pepsin's protein-digesting function. Pepsin denatures and stops working when food moves into the alkaline small intestine, where trypsin takes over.

2. D — Active transport is the only mechanism that moves solutes against their concentration gradient, and it requires ATP energy to power membrane protein pumps. Glucose moving from low concentration outside to high concentration inside cannot occur by diffusion (which only goes down gradients) and must use pumps such as the sodium-glucose cotransporter. The cell pays an energetic cost for this uphill movement.

3. A — Phospholipid bilayers self-assemble in water because the polar phosphate heads form favorable interactions with water while the nonpolar fatty acid tails cluster together to avoid water. This hydrophobic effect drives bilayer formation without requiring cellular energy. The same principle explains why soap bubbles form and why oil and water do not mix.

4. C — Distilled water has no dissolved solutes, so it is hypotonic compared with the cytoplasm of the red blood cell. Water moves down its concentration gradient by osmosis from the surrounding water into the cell, causing the cell to swell and eventually burst — hemolysis. This is why intravenous fluids are typically isotonic saline rather than pure water.

5. B — Anaphase is the only phase of mitosis during which sister chromatids actively separate and move toward opposite poles of the cell. The V-shape of each chromatid in the diagram reflects the centromere

being pulled poleward while the arms trail behind. This separation ensures that each daughter cell receives one complete copy of each chromosome.

6. A — DNA strands run antiparallel and follow complementary base pairing (A with T, G with C). The complement of 5'-ATGCAT-3' is therefore 3'-TACGTA-5', with the 3' end of the new strand aligned to the 5' end of the template. This complementarity is what makes DNA replication so accurate.

7. D — Reading the mRNA in codons from the start: AUG (methionine), GCA (alanine), UUU (phenylalanine), then UAA (stop). Translation halts at UAA without adding an amino acid, so the polypeptide contains three amino acids. Recognizing stop codons (UAA, UAG, UGA) is essential for counting amino acids in any mRNA sequence.

8. C — The trait appears almost exclusively in males, skips the unaffected carrier daughter, and reappears in her sons — the classic pattern of X-linked recessive inheritance. Females need two recessive X-linked alleles to be affected, while males need only one because they carry a single X chromosome. Hemophilia and red-green colorblindness follow this same inheritance pattern.

9. A — Under Hardy-Weinberg equilibrium, the frequency of the homozygous recessive genotype equals q^2. Setting $q^2 = 0.04$ and taking the square root gives $q = 0.20$ for the recessive allele frequency. This allows scientists to estimate allele frequencies from phenotype data without genotyping every individual in the population.

10. B — The founder effect is a form of genetic drift in which a small group establishing a new population carries only a random subset of the original gene pool. With only ten colonists, certain alleles are overrepresented and others lost entirely, producing rapid divergence from the source population. This is well-documented in isolated human populations such as the Amish and Tristan da Cunha.

11. D — Allopatric speciation requires a geographic barrier that separates populations and prevents gene flow long enough for accumulated genetic differences to produce reproductive isolation. The new river course is exactly such a barrier, and the inability to produce fertile offspring after reunion confirms speciation is complete. This is the most common mode of speciation in animals.

12. C — Natural selection requires heritable variation, differential survival or reproduction based on that variation, and a resulting shift in population trait frequencies — all three are present in this drought scenario. Finches with larger beaks could crack the remaining hard seeds, survived, and reproduced, passing the alleles to offspring. The Grants' decades-long study on Daphne Major documented this exact shift in real time.

13. A — Isotope-tracking experiments by Ruben in the 1940s showed that the oxygen released as O_2 during photosynthesis comes entirely from H_2O, not from CO_2. During photolysis in photosystem II of the thylakoid membrane, water molecules are split to provide electrons, protons, and oxygen. The carbon and oxygen from CO_2 end up in glucose and water rather than in O_2.

14. B — Aerobic respiration runs glucose breakdown to completion: glycolysis, the Krebs cycle, and the electron transport chain together extract roughly 36–38 ATP per glucose molecule. Anaerobic fermentation stops after glycolysis with a net of only 2 ATP because without O_2 as the final electron

acceptor the ETC cannot operate. This is why aerobic metabolism is essential for sustained energy demands such as endurance exercise.

15. D — Roughly 10% of the energy at each trophic level is transferred to the next, with the rest lost as metabolic heat. Producers (100,000 kcal) → primary consumers (10,000 kcal) → secondary consumers (1,000 kcal). This rapid energy loss is why food chains rarely exceed four or five trophic levels in nature.

16. C — Hawks eat rabbits and mice (herbivores), making them secondary consumers in those interactions, and they also eat frogs and birds (which are themselves secondary consumers), making them tertiary consumers in those interactions. Many top predators occupy multiple trophic positions simultaneously through different feeding choices. Trophic level is therefore best thought of as a property of a feeding link rather than of a species as a whole.

17. A — Carrying capacity (K) is the population size that the environment's resources can sustain indefinitely, the point at which birth rate and death rate balance and the growth curve flattens. Below K, the logistic growth curve rises; above K, the population crashes back toward K. This concept is central to population ecology and to managing wildlife and fisheries.

18. B — The exponential (log) phase of bacterial growth is the steeply rising segment of the curve, during which cells divide at their maximum rate while nutrients remain abundant and waste has not yet accumulated. Each generation produces double the previous number, giving the curve its rapidly ascending shape. This phase is when antibiotics that target cell-wall synthesis are most effective.

19. C — In a classic predator-prey cycle, the prey population peaks first, then the predator population peaks slightly later because the abundant prey allows more predators to survive and reproduce. As the predators continue consuming prey, the prey population crashes, followed soon after by a predator crash from starvation. The lynx-hare data from Hudson's Bay Company fur records is the textbook example of this lagged cycling.

20. D — Photosynthesis is the major biological process that removes CO_2 from the atmosphere, fixing carbon into glucose through the Calvin cycle in chloroplasts. Cellular respiration, combustion, and decomposition all release CO_2 back into the atmosphere. The balance between photosynthesis and these CO_2-releasing processes governs atmospheric CO_2 levels and, through the greenhouse effect, global climate.

21. A — Nitrogen-fixing bacteria such as Rhizobium living in legume root nodules possess the nitrogenase enzyme, which converts atmospheric N_2 (which most organisms cannot use) into ammonia (NH_3), which plants can incorporate into amino acids. This is why legumes enrich the soil with nitrogen and why farmers rotate them with other crops. Almost all biologically usable nitrogen on Earth originally enters the biosphere through this fixation process.

22. C — Primary succession begins on bare rock or other lifeless substrate with no preexisting soil, as is the case after a fresh lava flow. Pioneer species such as lichens and mosses break down rock to begin soil formation, slowly allowing other species to establish over time. Secondary succession, in contrast, occurs where soil remains intact, such as after a fire or on abandoned farmland.

23. B — A keystone species exerts an effect on its ecosystem far greater than would be predicted from its abundance, and removing or restoring it triggers cascading changes throughout the food web. Yellowstone wolves limit elk grazing, which lets willows and aspens recover, which provides materials and habitat for beavers and songbirds. This is one of the most cited examples of a trophic cascade in modern ecology.

24. D — The scientific consensus, supported by decades of climate research, is that human burning of fossil fuels and deforestation has raised atmospheric CO_2 from roughly 280 ppm in 1850 to over 420 ppm today. The added CO_2 traps additional outgoing infrared radiation, enhancing the natural greenhouse effect and warming the planet. Multiple independent lines of evidence (isotope ratios, ice cores, ocean acidification) confirm the human source.

25. A — An invasive species is a nonnative organism that spreads aggressively and causes ecological or economic harm in its new range. Common features include rapid reproduction, broad tolerance of conditions, and the absence of natural predators or pathogens in the new environment. Familiar examples include zebra mussels, kudzu, Burmese pythons, and emerald ash borers.

26. C — Parasitism is a symbiotic relationship in which one species (the parasite) benefits while the other (the host) is harmed, but typically not killed outright. Tapeworms absorb predigested nutrients through their tegument, lacking a digestive system of their own, while depriving the host of those nutrients. Successful parasites often evolve to keep their host alive long enough to support reproduction.

27. B — The modern cell theory has three core tenets: all living organisms are composed of cells, the cell is the basic unit of life, and all cells arise from preexisting cells through cell division. The last principle, established by Virchow in 1855 ("omnis cellula e cellula"), refuted spontaneous generation and underpins all of modern biology. This unifying theory connects organisms as diverse as bacteria and whales.

28. D — Pluripotent cells can give rise to nearly any cell type found in the body — all three germ layers (ectoderm, mesoderm, endoderm) — but typically cannot form extraembryonic tissues such as the placenta. Embryonic stem cells from the inner cell mass of the blastocyst are the classic example and form the basis of much regenerative medicine research. Totipotent cells (the zygote and early cleavage cells) can additionally form extraembryonic tissues.

29. A — Cancer arises from accumulated mutations in proto-oncogenes (which become oncogenes when mutated) and tumor suppressor genes, causing loss of normal cell-cycle regulation. The affected cells divide uncontrollably, ignore stop signals, evade apoptosis, and may invade other tissues. This dysregulated proliferation forms a tumor and may eventually metastasize through the bloodstream or lymphatic system.

30. C — A missense point mutation changes a single nucleotide and substitutes one amino acid for another in the resulting protein, without changing the total amino acid count. Sickle-cell anemia is the textbook example: a single A→T change replaces glutamic acid with valine at position 6 of β-globin. Frameshift mutations, in contrast, shift the reading frame and typically alter many downstream amino acids.

31. B — Smaller DNA fragments encounter less resistance moving through the gel matrix and migrate farther from the wells. Sample 2's bands at 5, 7, and 9 cm have traveled the greatest distance of any sample,

indicating that all of its fragments are smaller than those of any other sample. This size-based separation is the foundation of DNA fingerprinting, restriction mapping, and PCR-product analysis.

32. D — PCR amplifies a target DNA region through repeated cycles of denaturation (heating to separate strands), annealing (cooling to allow primer binding), and extension (a heat-stable polymerase synthesizes new strand). Each cycle doubles the target DNA, so 30 cycles can produce over a billion copies from a single starting molecule. PCR is fundamental to forensics, diagnostics, and molecular biology research.

33. C — Vaccines train the adaptive immune system by exposing it to harmless versions of pathogen antigens, prompting clonal expansion of B and T lymphocytes. Some of these become long-lived memory cells that recognize the pathogen on future exposure and mount a rapid, strong secondary response before disease can develop. This is the principle behind virtually all vaccines, including those for measles, polio, and COVID-19.

34. A — HIV's surface glycoprotein gp120 binds the CD4 receptor on helper T cells, allowing the virus to enter and ultimately destroy them. Because helper T cells coordinate both antibody-mediated and cell-mediated immune responses, their depletion cripples the entire immune system. Once CD4 counts drop below 200 cells/μL, the opportunistic infections that define AIDS appear (such as Pneumocystis pneumonia and Kaposi's sarcoma).

35. B — In type 1 diabetes, autoimmune destruction of pancreatic beta cells eliminates the body's ability to produce insulin, leading to dangerously high blood glucose. Lifelong insulin injections or pump therapy are required for survival because no oral medication can replace absent insulin production. This contrasts with type 2 diabetes, in which insulin is produced but tissues are resistant to its effects.

36. D — Negative feedback opposes the original change to restore the regulated variable to its set point, the defining feature of homeostatic control. Insulin lowers high blood glucose, and glucagon raises low blood glucose — both bring the variable back toward normal. Positive feedback, in contrast, amplifies a change and is rarer in physiology, with childbirth contractions and blood clotting as the main examples.

37. A — Homeostasis is the maintenance of a relatively stable internal environment despite external changes, achieved through coordinated physiological responses that counteract deviations from set points. Sweating and shivering are textbook thermoregulatory mechanisms operating through negative feedback. Other examples include blood glucose regulation, blood pH balance, and osmotic balance of body fluids.

38. C — Depolarization occurs when voltage-gated Na^+ channels open and Na^+ rushes into the neuron down its electrochemical gradient, driving the membrane potential from −70 mV toward +40 mV. The inflow of positive charge briefly makes the inside of the neuron positive relative to the outside, which is what the curve's sharp upstroke shows. Repolarization that follows is driven by K^+ efflux through delayed-rectifier K^+ channels.

39. B — A spinal reflex arc routes sensory information from receptors to the spinal cord, where it synapses directly onto motor neurons that contract the appropriate muscles — without first traveling to the brain. The withdrawal of the hand happens within milliseconds, faster than conscious perception of pain, which arrives later through ascending pathways. This bypass protects the body from continued tissue damage while the brain catches up.

40. D — The nervous system uses rapid electrical signals (action potentials) and produces short-lasting, precisely targeted effects through synaptic transmission. The endocrine system uses hormones traveling through the bloodstream, producing slower onset but longer-lasting and more diffuse effects on many tissues. Together they coordinate the body's responses across multiple time scales.

41. A — Glomerular filtration is the first step of urine formation: the high hydrostatic pressure of blood inside the glomerular capillaries forces water and small dissolved molecules across the filtration barrier into Bowman's capsule. Larger proteins and blood cells are retained in the blood by the size selectivity of the barrier. The resulting filtrate is then progressively modified through reabsorption and secretion as it flows along the tubule.

42. C — Pepsin's optimal pH is approximately 2, matching the strongly acidic environment created by parietal cells secreting HCl in the stomach. At this pH, pepsin's active site is in the correct conformation to cleave peptide bonds adjacent to specific amino acids in food proteins. When the acidic chyme enters the small intestine and is neutralized by bicarbonate, pepsin denatures and trypsin takes over.

43. D — Deoxygenated blood returns from the body through the vena cava to the right atrium, passes to the right ventricle, is pumped through the pulmonary artery to the lungs for gas exchange, returns via the pulmonary vein to the left atrium, passes to the left ventricle, and is pumped through the aorta to the body. The right side handles pulmonary circulation and the left side handles systemic circulation. The double-loop design is what allows the high pressures required for systemic flow.

44. B — Alveoli have an enormous combined surface area (about 70 m^2 in adult humans) and walls only one cell thick, so the diffusion distance between alveolar air and capillary blood is minimal. These features satisfy Fick's law of diffusion, which states that gas exchange rate is proportional to surface area and inversely proportional to thickness. Emphysema destroys alveolar walls, reducing surface area and impairing gas exchange.

45. A — Hinge joints permit flexion and extension in a single plane, much like the swing of a door, and are found at the elbow, knee, and the joints between phalanges of the fingers and toes. The bony architecture and ligament arrangement restrict movement to one axis. Other joint types — ball-and-socket, pivot, gliding — allow different ranges and types of motion.

46. C — The skin contributes to homeostasis primarily by regulating body temperature (through sweating and adjusting blood flow at the surface), serving as a physical and chemical barrier against pathogens, and preventing dehydration through its keratinized epidermis. It also synthesizes vitamin D, houses sensory receptors, and supports resident immune cells. As the largest organ, it integrates multiple homeostatic functions simultaneously.

47. B — Meiosis produces four genetically unique haploid daughter cells from a single diploid parent cell through two rounds of division. Crossing over in prophase I and independent assortment in metaphase I generate the genetic variation that drives evolutionary potential and underlies the diversity of offspring in sexual reproduction. Mitosis, in contrast, produces two diploid clones for growth and tissue repair.

48. D — Embryonic development proceeds from a single-celled zygote through cleavage (rapid mitotic divisions without growth between divisions) to form the blastula, then through gastrulation (folding that

produces the three primary germ layers), and finally into organogenesis (formation of organs from the germ layers). Each stage builds in complexity on the previous one. Understanding this sequence is foundational for developmental biology and for interpreting birth defects.

49. C — Stomata open during daylight to permit CO_2 entry for photosynthesis, but their opening also allows water vapor to escape from the moist internal leaf surfaces, producing the daytime transpiration peak shown on the graph. At night, stomata close, photosynthesis stops, and transpiration falls sharply. Plants face an inescapable trade-off between carbon gain and water loss through this same stomatal opening.

50. A — Auxin (indoleacetic acid) is produced in the shoot tip and redistributes laterally away from the light source, accumulating on the shaded side of the stem. There, auxin promotes cell elongation by acidifying the cell wall and loosening it, so cells on the shaded side grow longer than those on the lit side and the stem bends toward the light. This phototropic mechanism was first characterized by Charles and Francis Darwin and later confirmed by Boysen-Jensen and Went.