PRACTICE EXAM 19: LIFE SCIENCE: BIOLOGY SIMULATION (50 QUESTIONS)

Instructions: Practice Exam 19 emphasizes scenario-based reasoning, experimental design analysis, and applied understanding across the New York Living Environment scope. Most questions require interpretation, comparison, or application of biological concepts rather than simple recall. Select the one best answer for each item.

1. A student is testing how light intensity affects the rate of photosynthesis in elodea plants. Which of the following would best serve as a controlled variable in this experiment?

A. The number of bubbles of oxygen produced by each plant per minute under different lighting conditions
B. The temperature of the water surrounding the elodea plant, kept constant throughout the entire experiment
C. The intensity of light shining on each elodea plant at the various points throughout the experimental trials
D. The species of plant used in the experiment, varied across each group to allow for a fuller comparison

2. A researcher concludes that a new fertilizer increases plant growth based on testing only three plants. The most significant weakness in this study is:

A. The sample size is too small to support a reliable conclusion about the effect of the fertilizer
B. The researcher tested actual plants instead of relying entirely on theoretical computer models of growth
C. The researcher used a fertilizer that is widely available in commercial agricultural supply stores
D. The researcher waited only a few weeks instead of testing the fertilizer over several full growing seasons

3. A drug company tests its new medication only on its own employees, who are paid to participate in the trial. The most likely source of bias in this study is:

A. The medication may have been manufactured at multiple different facilities, leading to chemical variation in samples
B. The drug company used standard double-blind procedures during the entire course of the medication trial protocol

C. The employees took the medication in different physical environments throughout the duration of the testing period
D. The participants may be motivated to report positive effects to please the employer who pays them for participation

4. A scientist observes that ice cream sales and drowning deaths both increase during the summer months. Which conclusion is best supported by this observation?

A. Eating ice cream directly causes drowning, since both events tend to increase during the same months each year
B. Drowning fatalities cause people to eat more ice cream as an emotional response while grieving their losses
C. A third factor, such as warm weather and outdoor recreation, likely causes both ice cream sales and drowning to increase
D. Ice cream sales and drowning deaths must always rise together regardless of any weather factor at all in summer

5. A research team modifies a cell membrane to remove all of its embedded protein channels. Which transport process would be most directly affected by this modification?

A. The facilitated diffusion of large polar molecules such as glucose, which requires specific protein channels to cross
B. The simple diffusion of dissolved oxygen and carbon dioxide gases across the phospholipid bilayer of cells
C. The osmosis of water molecules through the phospholipid bilayer of the cellular membrane in response to gradients
D. The diffusion of small lipid-soluble molecules across the phospholipid bilayer of the cellular membrane of cells

6. A spherical cell with a radius of 1 μm has a surface-area-to-volume ratio of 3. A spherical cell of the same shape with a radius of 2 μm has a surface-area-to-volume ratio of:

A. 6, because doubling the radius doubles the surface-area-to-volume ratio of the spherical cell directly each time
B. 1.5, because as the radius doubles, the surface-area-to-volume ratio of a sphere decreases by a factor of two
C. 3, because the surface-area-to-volume ratio remains constant regardless of the actual size of the cell tested
D. 12, because doubling the radius increases the surface-area-to-volume ratio of the sphere by a factor of four

7. A farmer accidentally applies too much fertilizer salt around the roots of his crops. The plants begin to wilt within hours of the application. The most likely explanation is:

A. The salt directly killed all of the plant cells by causing the cell membranes to burst from the inside outward rapidly

B. The salt blocked the openings in the cell walls of the root cells, preventing water uptake into the roots of the plants
C. The salty soil became hypertonic to the root cells, causing water to leave the root cells by osmosis into the soil
D. The salt converted the plant's stored glucose into starch, depriving the leaves of the energy needed for life support

8. Which of the following best describes a key difference between active transport and facilitated diffusion across a cell membrane?

A. Active transport involves only nonpolar molecules, while facilitated diffusion involves only large polar molecules in cells
B. Active transport occurs only in animal cells, while facilitated diffusion occurs only in plant and bacterial cells naturally
C. Active transport moves molecules through the lipid bilayer directly, while facilitated diffusion requires protein channels
D. Active transport uses ATP to move molecules against a concentration gradient, while facilitated diffusion does not use ATP

9. A student tests catalase activity by adding small disks of potato to hydrogen peroxide and timing how long it takes the disks to float on the bubbles produced. The independent variable in this experiment is most likely the:

A. Time required for each potato disk to float to the surface of the hydrogen peroxide solution measured in seconds
B. Volume of hydrogen peroxide solution placed in each test tube before adding the potato disks for the timing
C. Factor that the student deliberately changes between tubes, such as temperature, pH, or potato source for example
D. Color of the potato disks before and after being placed into the hydrogen peroxide test solution during each trial

10. A drug strongly resembles the substrate of an enzyme. When the drug is present, the reaction rate decreases, but adding much more substrate restores the rate to nearly normal. The drug is best classified as:

A. A competitive inhibitor, because it competes with the substrate for binding to the enzyme's active site directly
B. A noncompetitive inhibitor, because it binds at a site other than the enzyme's active site to alter the shape
C. An activator molecule, because it speeds up the reaction by stabilizing the enzyme's natural three-dimensional shape
D. A denaturing agent, because it permanently unfolds the enzyme and destroys its catalytic active site forever

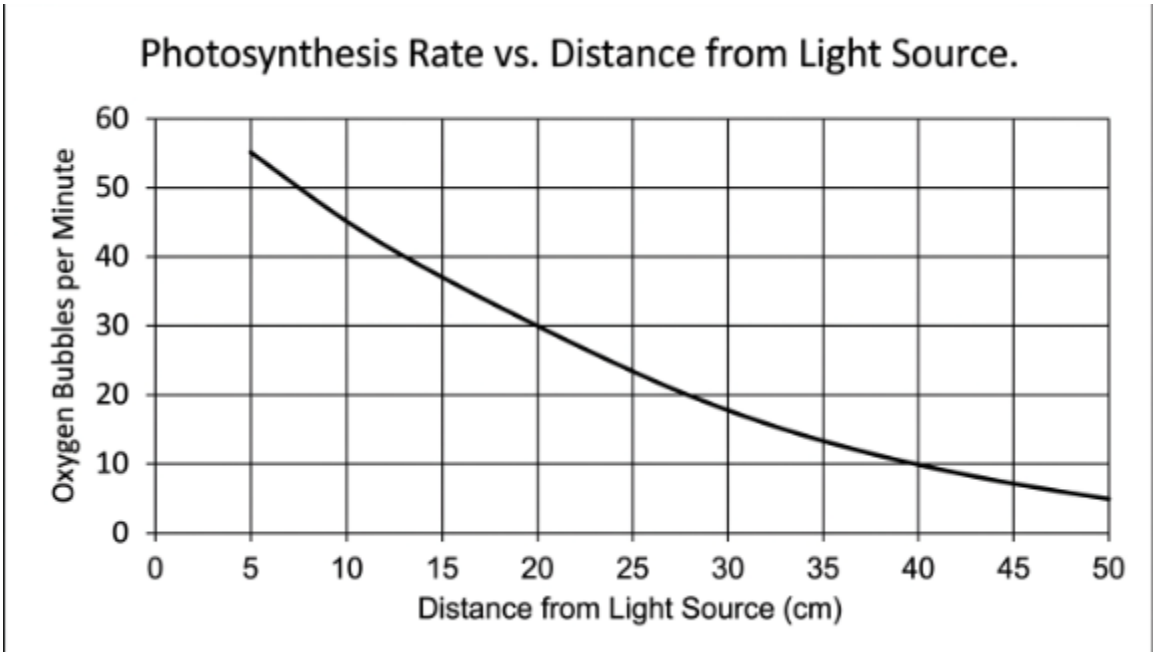
11. Phenylketonuria (PKU) is a genetic disorder in which a person lacks a functional enzyme needed to break down the amino acid phenylalanine. If untreated, this amino acid builds up in the blood. The molecular basis of this disorder best illustrates that:

A. Enzymes are needed only to digest food in the small intestine and have no role in cellular metabolism at any level
B. A defect in a single gene can disrupt an entire metabolic pathway and cause serious physiological problems for a person
C. Amino acids cannot be obtained from food sources and must be synthesized within the body's own cells from raw materials
D. Phenylalanine is the only amino acid used by humans, and lack of its breakdown immediately kills cells within the body

12. In living cells, the energy released by exergonic reactions such as the breakdown of glucose is captured by:

A. Building large new lipid molecules from smaller fatty acid subunits in the cellular cytoplasm directly during respiration
B. Converting one type of amino acid into another type within the body's tissues continuously each day in active cells
C. Synthesizing entirely new genetic material from raw atomic building blocks in the cellular nucleus each day of life
D. Phosphorylating ADP to form ATP, which then drives endergonic reactions throughout the cell when its bond is broken

13. A student varies the distance between a light source and an elodea plant submerged in water, then counts oxygen bubbles released per minute. The graph below shows the data.



Based on the graph, which conclusion is best supported by the data?

A. As distance from the light source increases, the rate of photosynthesis in elodea plants decreases steadily over the range
B. As distance from the light source increases, the rate of photosynthesis in elodea plants increases steadily over the range
C. The rate of photosynthesis remains constant across all of the various distances from the light source tested in this experiment
D. The rate of photosynthesis depends only on water temperature and not on the distance to the light source used in the test

14. A greenhouse manager notices that increasing light intensity beyond a certain level no longer increases plant growth, even though the plants still appear healthy and green. The most likely explanation is:

A. The plants have run out of chlorophyll and can no longer absorb any additional light from sources placed in the greenhouse
B. The plants have ceased respiring entirely and now rely only on stored sugar for daily energy production each hour
C. Another factor, such as carbon dioxide concentration or temperature, has become the limiting factor for further plant growth
D. The plants have begun to photosynthesize in reverse, producing carbon dioxide rather than oxygen during peak sunlight hours

15. Sugarcane (a C4 plant) and wheat (a C3 plant) are grown side by side in a hot, dry climate. The sugarcane grows much more vigorously than the wheat under these conditions. The most likely reason is that the sugarcane:

A. Has a much thicker cuticle on its leaf surfaces than the wheat plant has, reducing the loss of dissolved minerals in the heat
B. Concentrates carbon dioxide near the carbon-fixing enzyme, reducing wasteful photorespiration in the high heat of the area
C. Conducts photosynthesis at night when temperatures are cooler, while the wheat photosynthesizes only during the day
D. Does not need light energy and can grow through pure cellular respiration in cool soil throughout the entire day in heat

16. Cyanide poisoning blocks the final step of the electron transport chain in the mitochondria of human cells. The most direct and rapid consequence of cyanide poisoning is:

A. Increased glucose production in liver cells, as the body attempts to release stored energy from glycogen reserves continuously
B. Increased oxygen consumption in body tissues, as the body fights to overcome the effect of the poison and recover quickly
C. A rapid increase in body temperature, as the body burns more glucose to produce additional ATP for cellular activities

D. A sharp drop in ATP production, since the electron transport chain produces the majority of the cell's ATP under aerobic conditions

17. Both plant cells and animal cells perform cellular respiration. The primary purpose of cellular respiration in plant cells is to:

A. Produce glucose from atmospheric carbon dioxide using the energy provided by sunlight each day during photosynthesis
B. Convert oxygen gas into carbon dioxide so that the plant can then release oxygen to the atmosphere from its leaves
C. Release the chemical energy stored in glucose so that the plant cells can use it for cellular work throughout the plant
D. Eliminate excess carbon dioxide from the plant cells before it interferes with the photosynthesis pathway in the chloroplasts

18. In the alveoli of the lungs, oxygen moves from the air inside the alveoli into the blood capillaries surrounding them. This movement is best explained by:

A. Diffusion, with oxygen moving from higher concentration in the alveoli to lower concentration in the surrounding blood capillaries
B. Active transport, with oxygen molecules being pumped from the alveoli into the blood by ATP-driven carrier proteins
C. Osmosis, with water carrying the dissolved oxygen molecules across the alveolar membrane into the blood capillaries directly
D. Endocytosis, with oxygen engulfed by red blood cells through vesicles formed at the alveolar wall during inhalation each time

19. A drug used in cancer treatment blocks the formation of spindle fibers during cell division. This drug would most directly prevent:

A. Replication of the cell's DNA in the S phase of interphase before any cell division can even begin in the affected cell
B. The separation and movement of chromosomes to opposite poles during mitosis in the dividing cancer cell of the patient
C. The synthesis of proteins by ribosomes in the cytoplasm during the normal daily activity of the cell in many tissues
D. The breakdown of glucose by glycolysis in the cytoplasm during normal cellular respiration each minute of the day

20. Embryonic stem cells are described as pluripotent because they can:

A. Survive indefinitely in laboratory culture without ever requiring fresh nutrients or replacement of media in the dish
B. Reproduce by binary fission like prokaryotic cells, doubling rapidly with each successive division of the original cell
C. Carry out photosynthesis using light energy from the sun even though they originate from animal

embryos in the lab
D. Differentiate into almost any cell type found in the body, including muscle, nerve, skin, and many other tissue cells

21. Crossing over during meiosis is biologically significant because it:

A. Reduces the chromosome number of gametes from diploid to haploid, halving the genetic material in each gamete produced
B. Permanently damages the homologous chromosomes and prevents the formation of any viable offspring later on at all
C. Creates new combinations of alleles on chromosomes, increasing the genetic variation among the offspring produced
D. Ensures that all of the gametes produced from a single parent cell are genetically identical to each other afterward

22. During meiosis, the way one pair of chromosomes separates is independent of how other pairs separate. This principle of independent assortment:

A. Greatly increases the number of possible genetic combinations in the gametes produced by an individual organism
B. Reduces the genetic variation among the gametes by ensuring that maternal chromosomes stay together in one cell
C. Has no measurable effect on the genetic variation in the offspring produced by sexual reproduction at any time
D. Only applies to organisms with very small numbers of chromosomes in each of their cells throughout the body

23. A flower species shows codominance for petal color: red (RR) crossed with white (WW) produces flowers with both red and white petals on the same flower (RW). When two RW flowers are crossed, the expected phenotypic ratio of offspring is:

A. All of the offspring will have flowers with both red and white petals, identical to the parents in their appearance
B. Three red-and-white flowered plants to one white-flowered plant, in a typical Mendelian ratio for this single trait
C. Half red-flowered offspring and half white-flowered offspring, with no red-and-white flowered offspring at all in this cross
D. One red-flowered to two red-and-white flowered to one white-flowered offspring, a clear 1:2:1 phenotypic ratio

24. Two genes located very close together on the same chromosome tend to be inherited together rather than independently. These two genes are best described as:

A. Sex-linked genes, because they are both located on the X chromosome and follow that pattern of inheritance closely
B. Linked genes, because their physical closeness on the same chromosome makes them more likely to

stay together
C. Identical alleles, because they always specify the same trait in every single offspring of the same parent organism
D. Recessive alleles, because they appear only when no dominant allele is also present in the offspring's genotype

25. Hemophilia is a sex-linked recessive trait. A woman who is a carrier of the hemophilia allele marries a man without hemophilia. The probability that any one of their daughters will be a carrier of the trait is:

A. 0 percent, since carriers must inherit the recessive allele from both parents in this Mendelian cross between humans
B. 25 percent, since one out of every four daughters will be a carrier of the hemophilia allele on average across families
C. 50 percent, since half of the daughters will inherit the carrier mother's X chromosome with the recessive allele on it
D. 100 percent, since all daughters of a carrier mother will themselves be carriers regardless of the father's genotype

26. A trait appears in every generation of a family pedigree, affects males and females approximately equally, and is passed from one affected parent to roughly half of the children in each family. The trait is most likely:

A. Autosomal recessive, since the trait passes from carrier parents to homozygous recessive offspring in the next generation
B. Sex-linked recessive, since the trait is associated with the X chromosome and skips many generations of the family
C. Mitochondrial, since the trait is passed only from the affected mother to all of her children in every case of inheritance
D. Autosomal dominant, since one copy of the dominant allele is sufficient to produce the trait in an affected individual

27. Human skin color shows a continuous range of phenotypes from very light to very dark rather than a few discrete categories. This pattern is best explained by:

A. Polygenic inheritance, in which several different genes each contribute small effects to the overall observable phenotype
B. Sex-linked inheritance, in which the trait is carried on the X chromosome and varies dramatically between the sexes
C. Codominance, in which two alleles of a single gene are both fully expressed simultaneously in the heterozygote person
D. Incomplete dominance, in which the heterozygote shows a phenotype intermediate between the two homozygous phenotypes

28. Female mammals carry two X chromosomes, while males carry only one X chromosome. In each cell of a female mammal, one of the two X chromosomes is randomly inactivated early in development. This process best explains why:

A. Females and males develop the same secondary sex characteristics during the period of puberty in mammals around the world
B. Female mammals heterozygous for an X-linked trait can show a mixed (mosaic) pattern of expression across their tissues
C. All female mammals show identical patterns of gene expression in every cell of the body across their entire lifetimes from birth
D. Female mammals are unable to express any genes located on either of the two X chromosomes that they carry in their cells

29. After one round of DNA replication, a parent double helix has become two daughter double helices. Each daughter helix contains:

A. Two newly synthesized strands and no strands inherited from the original parent double helix of DNA in the cell at all
B. One strand of RNA paired with one strand of DNA, both newly synthesized during the replication of the original molecule
C. One strand from the original parent helix paired with one newly synthesized complementary strand of DNA in each daughter
D. Two strands inherited entirely from the original parent helix with no newly synthesized strands at all in the daughters

30. A single nucleotide change in the middle of a gene replaces one DNA base with a different DNA base. This kind of change is best classified as:

A. A chromosomal mutation, because it affects an entire chromosome rather than a single short DNA sequence on the gene
B. A point mutation, because it involves a change in a single nucleotide position within the DNA sequence of the gene
C. A frameshift mutation, because it shifts the reading frame of every codon downstream from the changed position
D. A whole-genome duplication, because it doubles the total amount of DNA contained within the cell's nucleus

31. In eukaryotic cells, the pre-mRNA transcribed from a gene undergoes several modifications before leaving the nucleus. One of these modifications removes intervening noncoding sequences called introns. This step is called:

A. Transcription, the process by which the original RNA copy of a DNA gene is first made within the nucleus of the cell
B. Translation, the process by which the mRNA is decoded into a polypeptide chain at the cell's ribosome in the cytoplasm
C. Replication, the process by which DNA molecules are copied exactly during the S phase of interphase in the nucleus
D. Splicing, the process by which introns are removed and the remaining exons are joined together to form a mature mRNA

32. At the ribosome, the order of amino acids added to a growing polypeptide chain is directly determined by:

A. The sequence of codons in the mRNA being read by the ribosome during the process of translation in the cell
B. The order in which tRNA molecules happen to drift toward the ribosome from the cytoplasm randomly each minute
C. The DNA sequence of the gene as the gene is being read directly by the ribosome of the cell during translation
D. The order in which amino acids are arranged in the cytoplasm of the cell at the moment of polypeptide synthesis

33. In a multicellular organism, every body cell contains the same complete set of genes, yet a muscle cell looks and functions very differently from a nerve cell. The best explanation for this difference is:

A. Each cell type contains a different complete genome that codes for that cell's specialized function alone in tissue
B. The genes of muscle and nerve cells have been physically rearranged through mutation during the embryo's development
C. Different cell types express different subsets of their genes, producing different proteins and cellular structures
D. Muscle cells and nerve cells are produced by entirely separate biological processes that share no genetic basis at all

34. Identical twins have the same DNA sequence, yet they sometimes develop different patterns of disease later in life. Recent research suggests that this difference is partly explained by:

A. Random rearrangement of the twins' DNA sequences over many years of cellular replication and ordinary division
B. Differences in chromosome number that develop as the twins age and accumulate cellular mutations gradually over time
C. The complete loss of one X chromosome in one of the twins shortly after their birth from one shared single zygote
D. Differences in patterns of gene expression caused by environmental factors and chemical modifications of the DNA

35. A population of butterflies shows a sudden shift in allele frequencies after the introduction of a new predator that selectively eats brightly colored butterflies. Which Hardy-Weinberg assumption has most clearly been violated in this scenario?

A. The assumption that the population is very small, leading to genetic drift effects in each generation of the butterflies
B. The assumption that no natural selection is acting on the population, since the predator now selects against bright color
C. The assumption that the population is reproducing sexually rather than through asexual reproduction in some way

D. The assumption that the population shows incomplete dominance for the color trait being measured in each generation

36. Over many generations, the average beak depth of medium ground finches on a Galapagos island has steadily increased due to ongoing drought conditions that favor finches able to crack larger seeds. This pattern of change is best classified as:

A. Directional selection, in which one extreme of a trait distribution is favored and the population mean shifts toward it
B. Stabilizing selection, in which intermediate values of a trait are favored over both of the two extreme values of the trait
C. Disruptive selection, in which both of the extreme values of a trait are favored over the intermediate values consistently
D. Random genetic drift, in which allele frequencies change purely by chance regardless of fitness effects on the trait values

37. Human birth weight tends to cluster around an average value, with very small or very large babies showing higher mortality rates than average-sized babies. This pattern is best classified as:

A. Directional selection, in which one extreme of a trait distribution is favored over the other in offspring across generations
B. Disruptive selection, in which both of the extremes of a trait distribution are favored over intermediate values over time
C. Stabilizing selection, in which intermediate values of a trait are favored over both extremes of the trait distribution
D. Genetic drift, in which random changes in allele frequencies occur regardless of any fitness effects on the trait values

38. A population of frogs becomes split into two groups when a river changes course through their habitat. After many generations, the two groups have evolved different mating calls and no longer interbreed even when artificially placed together. This is an example of:

A. Coevolution, in which two interacting species evolve traits in response to each other over many generations of contact
B. Convergent evolution, in which unrelated species independently evolve similar traits under similar selective pressures
C. Adaptive radiation, in which one ancestral species diversifies rapidly into many species filling different ecological niches
D. Reproductive isolation, in which behavioral differences prevent two formerly connected populations from successfully breeding

39. A phylogenetic tree is best described as a diagram that shows:

A. The proposed evolutionary relationships among different organisms, with branches indicating common ancestors of the groups
B. The detailed steps of cellular respiration in the mitochondria, with each branch showing a metabolic

pathway of the process
C. The geographic distribution of a single species across all of the major continents of the Earth in turn during its history
D. The genetic code in which each codon of mRNA specifies a particular amino acid in a polypeptide chain during translation

40. Modern classification systems group organisms based on shared derived characteristics that suggest descent from a common ancestor. This approach to classification is best called:

A. Lamarckism, the proposal that organisms inherit traits that their parents acquired during their own lifetimes through use
B. Cladistics, a method of biological classification based on shared derived traits indicative of evolutionary relationships
C. Convergent evolution, in which unrelated species develop similar traits under similar environmental conditions over time
D. Genetic engineering, the deliberate modification of DNA sequences in organisms through modern laboratory techniques

41. A small population of rabbits is introduced to an island with abundant food and no predators present. After several years, the population is increasing at an accelerating rate each year. This pattern of growth is best classified as:

A. Logistic growth, in which population growth slows as the population approaches the environment's carrying capacity over time
B. Linear growth, in which the population increases by the same number of individuals each year regardless of the population size
C. Exponential growth, in which the population's growth rate accelerates as more reproducing individuals are added to the group
D. Cyclic growth, in which the population rises and falls in regular repeated cycles over the course of several decades or years

42. Some species, such as oysters, produce thousands of offspring but provide essentially no parental care; most of their offspring die before reproducing. These species are best classified as:

A. r-selected species, characterized by high reproductive output and minimal parental care of each individual offspring produced
B. K-selected species, characterized by relatively few offspring and high parental investment in each of the few offspring produced
C. Keystone species, whose presence has effects on the ecosystem far out of proportion to their abundance in the ecosystem
D. Indicator species, whose presence or absence is used to assess the overall environmental health of a given ecosystem

43. In Yellowstone National Park, the reintroduction of wolves led to a reduction in the elk population, which in turn allowed willow and aspen trees to recover along streams, which in turn restored habitat for many other species. This chain of effects is best described as:

A. Habitat fragmentation, in which a single continuous habitat is broken into smaller and isolated patches over time and use
B. Coevolution, in which two interacting species evolve in response to each other over many evolutionary generations of contact
C. Niche partitioning, in which two species reduce direct competition by using different parts of a shared single resource
D. A trophic cascade, in which a change at one trophic level produces ripple effects through the other trophic levels above and below

44. Tropical rainforests have a much higher net primary productivity than tundra ecosystems do. The most important reason for this difference between the two biomes is that:

A. Tropical rainforests contain far fewer species and therefore each individual species produces much more biomass overall in the area
B. Tropical rainforests receive much more solar energy and have warmer temperatures and more water available year-round than tundra
C. Tropical rainforest soils are extremely fertile compared with the tundra soils where productivity is also high in summer months
D. Tundra ecosystems have too many decomposers, which compete with the producers for the limited sunlight available in the region

45. A bird species that can eat many different types of seeds, fruits, and insects, and can survive in many different habitats, is best described as a:

A. Generalist, a species with a broad niche that can use a wide variety of resources and habitats successfully across its range
B. Specialist, a species with a narrow niche that depends on a small set of resources or a single specific habitat type only
C. Keystone species, whose effect on the ecosystem is disproportionately large relative to its actual abundance there in the community
D. Pioneer species, the first species to colonize bare ground or rock after a major disturbance such as a retreating glacier

46. Large-scale deforestation contributes to climate change in part because cutting down and burning forests:

A. Decreases the atmospheric oxygen concentration so sharply that respiration becomes biologically impossible in the long term
B. Eliminates large numbers of decomposer bacteria and fungi from the global biosphere over the course of just a few years
C. Releases stored carbon as CO_2 and removes trees that would otherwise have absorbed CO_2 through photosynthesis each year
D. Causes the planet's overall albedo to decrease, leading to rapid global cooling rather than warming in the long-term climate

47. Plants play a key role in the global water cycle through transpiration. Transpiration is best described as:

A. The absorption of liquid water by plant cells, causing each individual cell to increase in size during the daytime hours
B. The conversion of liquid water into glucose molecules during the light-dependent reactions of photosynthesis each day in the leaf
C. The condensation of atmospheric water vapor onto the surfaces of leaves overnight in moist tropical environmental conditions
D. The release of water vapor from leaves into the atmosphere through small openings called stomata throughout the day

48. Wetlands provide many valuable ecosystem services to surrounding regions. Which of the following is one of the most important services provided by wetlands to nearby communities?

A. Producing the majority of the world's atmospheric oxygen through the photosynthesis of small aquatic algae floating in the water
B. Filtering pollutants from water and providing flood control by absorbing and then slowly releasing the excess water back to streams
C. Generating the strong winds responsible for circulating air around the planet during the warmest months of the year on Earth
D. Producing the majority of the world's iron and aluminum minerals through long-term geological processes over many centuries

49. Coral reef organisms threatened by rising ocean temperatures may persist over time through several possible biological responses. Which response is most likely to occur within a single human generation?

A. Speciation, in which a new species evolves with full tolerance to the higher water temperatures across many generations of corals
B. The development of completely new symbiotic algae species capable of surviving in much hotter waters across the world's oceans
C. Range shifts and possible acclimatization, in which existing corals move to cooler areas or adjust their physiological tolerances
D. The transformation of coral animals into fish that can swim away from areas of elevated water temperatures whenever needed

50. Conservation biologists often recommend protecting large, connected areas rather than several small isolated patches of habitat. The most important reason for this recommendation is:

A. Larger, connected habitats can support larger populations and allow individuals to disperse between areas safely over time
B. Smaller habitats are easier for endangered species to defend against predators that hunt them inside the patches each day
C. Smaller habitats receive more sunlight per unit area than larger habitats and so they produce more total plant biomass overall

D. Smaller habitats contain a wider variety of species per unit area than larger habitats with the same environmental conditions

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1. B — The temperature of the water surrounding the elodea plant, kept constant throughout the entire experiment. Controlled variables are factors held constant across all groups so they cannot confound the effect of the independent variable. Light intensity is the independent variable, oxygen bubbles are the dependent variable, and temperature must be controlled to isolate the effect of light.

2. A — The sample size is too small to support a reliable conclusion about the effect of the fertilizer. Three plants leave no way to distinguish a real fertilizer effect from random variation between individual plants. Larger sample sizes increase statistical power and reduce the chance of a misleading result.

3. D — The participants may be motivated to report positive effects to please the employer who pays them for participation. This is a classic source of response bias and conflict of interest, both of which can distort trial outcomes. Independent third-party participants and blinded study designs help minimize this bias in clinical trials.

4. C — A third factor, such as warm weather and outdoor recreation, likely causes both ice cream sales and drowning to increase. This is a textbook example of why correlation does not imply causation — a confounding variable (heat) drives both observed variables. Identifying lurking variables is essential to drawing valid conclusions from observational data.

5. A — The facilitated diffusion of large polar molecules such as glucose, which requires specific protein channels to cross. Large or charged molecules cannot pass through the hydrophobic lipid bilayer and depend on transport proteins for entry. Simple diffusion of small nonpolar molecules and water osmosis can still occur even when protein channels are absent.

6. B — 1.5, because as the radius doubles, the surface-area-to-volume ratio of a sphere decreases by a factor of two. The SA:V ratio of a sphere equals 3/r, so doubling r from 1 to 2 reduces the ratio from 3 to 1.5. This declining SA:V ratio is the geometric reason that cells stay small and divide rather than continuing to grow.

7. C — The salty soil became hypertonic to the root cells, causing water to leave the root cells by osmosis into the soil. With more solute outside the cells than inside, water moves down its concentration gradient out of the roots. The plants therefore lose turgor pressure and wilt despite having water in the soil — the classic "salt burn" effect.

8. D — Active transport uses ATP to move molecules against a concentration gradient, while facilitated diffusion does not use ATP. Both processes use membrane proteins, but only active transport requires

energy because it works against the gradient. Facilitated diffusion still moves molecules from high to low concentration, just with the help of a carrier or channel.

9. C — Factor that the student deliberately changes between tubes, such as temperature, pH, or potato source. The independent variable is the manipulated factor; the time-to-float is the dependent variable being measured. Identifying which variable is deliberately changed is the essential first step in analyzing any controlled experiment.

10. A — A competitive inhibitor, because it competes with the substrate for binding to the enzyme's active site directly. The hallmark of competitive inhibition is that excess substrate can overcome the inhibition by outcompeting the inhibitor for the active site. Noncompetitive inhibitors bind elsewhere and cannot be overcome by adding more substrate.

11. B — A defect in a single gene can disrupt an entire metabolic pathway and cause serious physiological problems for a person. PKU illustrates Garrod's "inborn error of metabolism" concept: a single faulty enzyme blocks one step, and substrates of that step accumulate to toxic levels. Early dietary restriction of phenylalanine prevents the intellectual disability that would otherwise result.

12. D — Phosphorylating ADP to form ATP, which then drives endergonic reactions throughout the cell when its bond is broken. Energy from exergonic processes such as glucose oxidation is captured in the high-energy phosphate bonds of ATP. Hydrolysis of those bonds then powers nearly every energy-requiring process in the cell.

13. A — As distance from the light source increases, the rate of photosynthesis in elodea plants decreases steadily over the range. The curve falls smoothly across the entire range tested, indicating an inverse relationship between distance and photosynthetic rate. This reflects the inverse-square law for light intensity, since intensity falls rapidly with distance.

14. C — Another factor, such as carbon dioxide concentration or temperature, has become the limiting factor for further plant growth. Photosynthesis depends on multiple inputs, and once light is no longer scarce, some other resource becomes the bottleneck. Greenhouse operators routinely raise CO_2 levels for exactly this reason once lighting is optimized.

15. B — Concentrates carbon dioxide near the carbon-fixing enzyme, reducing wasteful photorespiration in the high heat of the area. C4 plants use a two-step pathway that pumps CO_2 to bundle-sheath cells, keeping RuBisCO saturated with CO_2 even when stomata are partly closed. This adaptation gives them a clear productivity advantage over C3 plants in hot, dry conditions.

16. D — A sharp drop in ATP production, since the electron transport chain produces the majority of the cell's ATP under aerobic conditions. Blocking cytochrome c oxidase halts the ETC, collapses the proton gradient, and shuts down oxidative phosphorylation. Because tissues such as the brain and heart depend on rapid ATP production, cyanide poisoning is rapidly fatal without treatment.

17. C — Release the chemical energy stored in glucose so that the plant cells can use it for cellular work throughout the plant. Plants need ATP just like animals do — for growth, transport, biosynthesis, and

active uptake of minerals at the roots. Photosynthesis stores energy in glucose; cellular respiration releases it for use.

18. A — Diffusion, with oxygen moving from higher concentration in the alveoli to lower concentration in the surrounding blood capillaries. The thin alveolar and capillary walls, combined with the steep oxygen concentration gradient, allow rapid passive movement across the membranes. No ATP is expended on this gas exchange.

19. B — The separation and movement of chromosomes to opposite poles during mitosis in the dividing cancer cell of the patient. Spindle fibers attach to chromosomes at the kinetochore and pull sister chromatids apart during anaphase. Spindle-targeting drugs such as the taxanes and vinca alkaloids exploit the high division rate of cancer cells to halt them at this step.

20. D — Differentiate into almost any cell type found in the body, including muscle, nerve, skin, and many other tissue cells. Pluripotency is the defining feature of embryonic stem cells, making them powerful research and potential therapeutic tools. Adult stem cells, in contrast, are usually multipotent and limited to a narrower range of cell types.

21. C — Creates new combinations of alleles on chromosomes, increasing the genetic variation among the offspring produced. Crossing over recombines maternal and paternal alleles on the same chromosome, producing combinations not present in either parent. Together with independent assortment and random fertilization, this is one of the major engines of genetic diversity in sexual reproduction.

22. A — Greatly increases the number of possible genetic combinations in the gametes produced by an individual organism. With independent assortment, n chromosome pairs can produce 2^n different gamete chromosome combinations — over 8 million for humans (2^{23}). This is a major reason siblings differ genetically from each other and from their parents.

23. D — One red-flowered to two red-and-white flowered to one white-flowered offspring, a clear 1:2:1 phenotypic ratio. In codominance, each genotype produces its own distinct phenotype, so the 1:2:1 genotypic ratio of RR:RW:WW also becomes the phenotypic ratio. This contrasts with the 3:1 phenotypic ratio of classical complete dominance.

24. B — Linked genes, because their physical closeness on the same chromosome makes them more likely to stay together. Genes that lie close together on a chromosome are rarely separated by crossing over and tend to be inherited as a unit. Linkage was a key discovery by Morgan that extended and refined Mendel's principle of independent assortment.

25. C — 50 percent, since half of the daughters will inherit the carrier mother's X chromosome with the recessive allele on it. The carrier mother (X^HX^h) passes X^H or X^h to each daughter with equal probability, while the unaffected father always passes X^H to a daughter. Half of daughters therefore become X^HX^h carriers and half become X^HX^H non-carriers.

26. D — Autosomal dominant, since one copy of the dominant allele is sufficient to produce the trait in an affected individual. Appearance in every generation, equal frequency in both sexes, and roughly 50%

transmission from an affected heterozygous parent are the classic hallmarks of autosomal dominant inheritance. Huntington disease is a familiar example of this pattern.

27. A — Polygenic inheritance, in which several different genes each contribute small effects to the overall observable phenotype. When many genes each add a small contribution to a single trait, the result is a continuous, often bell-shaped distribution of phenotypes. Human height and skin color are classic polygenic traits.

28. B — Female mammals heterozygous for an X-linked trait can show a mixed (mosaic) pattern of expression across their tissues. Because X-inactivation is random and occurs early in development, different cells silence different X chromosomes; clones of cells inherit that same pattern. Calico cats are the most famous visible example of X-inactivation mosaicism.

29. C — One strand from the original parent helix paired with one newly synthesized complementary strand of DNA in each daughter. This is the semiconservative mechanism of DNA replication, confirmed by the Meselson–Stahl experiment using density-gradient centrifugation. Each daughter helix is half old, half new — preserving the parental sequence with high fidelity.

30. B — A point mutation, because it involves a change in a single nucleotide position within the DNA sequence of the gene. Point mutations include substitutions (silent, missense, nonsense) and may or may not change the encoded amino acid. Frameshift mutations, by contrast, involve insertions or deletions that shift the reading frame.

31. D — Splicing, the process by which introns are removed and the remaining exons are joined together to form a mature mRNA. Splicing is carried out by the spliceosome and, along with 5' capping and 3' polyadenylation, completes mRNA processing before export to the cytoplasm. Alternative splicing of the same pre-mRNA can produce different proteins from a single gene.

32. A — The sequence of codons in the mRNA being read by the ribosome during the process of translation in the cell. Each three-nucleotide codon specifies one amino acid, and the ribosome moves along the mRNA in 5'→3' direction adding amino acids in that order. The DNA sequence determines the mRNA sequence, but it is the mRNA that the ribosome directly reads.

33. C — Different cell types express different subsets of their genes, producing different proteins and cellular structures. All somatic cells in an individual share the same DNA, but selective gene expression — controlled by transcription factors and epigenetic marks — generates the specialized phenotypes of muscle, nerve, blood, and other cell types. This differential gene expression underlies the entire process of cell differentiation.

34. D — Differences in patterns of gene expression caused by environmental factors and chemical modifications of the DNA. Epigenetic changes such as DNA methylation and histone modification can be influenced by diet, stress, and other environmental factors, altering gene expression without changing the underlying sequence. This explains how genetically identical twins can diverge phenotypically over time.

35. B — The assumption that no natural selection is acting on the population, since the predator now selects against bright color. Hardy-Weinberg equilibrium assumes that all genotypes have equal survival

and reproduction; predator-driven selection violates this directly. Sudden allele-frequency shifts after a new selective pressure are a hallmark of active natural selection.

36. A — Directional selection, in which one extreme of a trait distribution is favored and the population mean shifts toward it. When environmental conditions favor one end of a phenotypic range, the average trait value moves in that direction over generations. The classic Galapagos finch beak-depth shifts during droughts are well-documented examples studied by the Grants.

37. C — Stabilizing selection, in which intermediate values of a trait are favored over both extremes of the trait distribution. When both extremes are at a fitness disadvantage, selection reduces variation around an optimal intermediate value. Human birth weight is one of the most thoroughly documented examples of stabilizing selection in our species.

38. D — Reproductive isolation, in which behavioral differences prevent two formerly connected populations from successfully breeding. Once gene flow between populations stops because they no longer recognize each other as mates, the two groups can diverge into separate species. Mating-call differences are a common prezygotic behavioral isolating mechanism in frogs.

39. A — The proposed evolutionary relationships among different organisms, with branches indicating common ancestors of the groups. Each branching point on a phylogenetic tree represents the most recent common ancestor of the lineages above it. Trees are constructed from molecular, morphological, and fossil evidence and are central to modern evolutionary biology.

40. B — Cladistics, a method of biological classification based on shared derived traits indicative of evolutionary relationships. Cladistics uses synapomorphies (shared derived traits) to identify monophyletic groups (clades) that include all descendants of a common ancestor. This approach has largely replaced traditional Linnaean classification in modern taxonomy.

41. C — Exponential growth, in which the population's growth rate accelerates as more reproducing individuals are added to the group. When resources are unlimited and mortality is low, populations grow at a rate proportional to their current size, producing a J-shaped curve. This pattern continues only until some density-dependent factor begins to limit growth.

42. A — r-selected species, characterized by high reproductive output and minimal parental care of each individual offspring produced. r-selected species rely on numbers and rapid reproduction to ensure that some offspring survive in unpredictable environments. K-selected species, by contrast, produce few offspring and invest heavily in each one.

43. D — A trophic cascade, in which a change at one trophic level produces ripple effects through the other trophic levels above and below. The Yellowstone wolf reintroduction is one of the best-documented trophic cascades, showing how a top predator can reshape vegetation, geomorphology, and biodiversity. Such effects highlight the importance of preserving keystone predators in ecosystems.

44. B — Tropical rainforests receive much more solar energy and have warmer temperatures and more water available year-round than tundra. Productivity depends on light, warmth, and water — all abundant

in the tropics and severely limited in the tundra. The result is dramatically higher net primary productivity in tropical forests, which support the highest biodiversity on land.

45. A — A generalist, a species with a broad niche that can use a wide variety of resources and habitats successfully across its range. Generalists tolerate environmental variability and often do well in disturbed habitats, including those affected by human activity. Specialists, in contrast, have narrow niches and are more vulnerable when their preferred resources disappear.

46. C — Releases stored carbon as CO_2 and removes trees that would otherwise have absorbed CO_2 through photosynthesis each year. Deforestation thus delivers a double climate impact: an immediate pulse of CO_2 from burning and decay, plus a long-term loss of carbon sequestration capacity. Tropical deforestation accounts for a substantial fraction of global anthropogenic CO_2 emissions.

47. D — The release of water vapor from leaves into the atmosphere through small openings called stomata throughout the day. Transpiration also creates the negative pressure that pulls water and dissolved minerals upward from the roots through xylem. Together with evaporation from soil and water bodies, transpiration is a major driver of the global hydrologic cycle.

48. B — Filtering pollutants from water and providing flood control by absorbing and then slowly releasing the excess water back to streams. Wetlands also support exceptional biodiversity, sequester carbon, and serve as nurseries for fish and shellfish. These ecosystem services have an estimated economic value in the trillions of dollars per year worldwide.

49. C — Range shifts and possible acclimatization, in which existing corals move to cooler areas or adjust their physiological tolerances. Evolutionary responses such as speciation take far too long to help within a single human generation, while range shifts and physiological adjustments can occur much more quickly. Even so, these short-term responses may not keep pace with the rate of current ocean warming.

50. A — Larger, connected habitats can support larger populations and allow individuals to disperse between areas safely over time. Larger habitats reduce extinction risk by maintaining genetic diversity and buffering populations against random events, while corridors permit gene flow between subpopulations. This principle underlies many modern reserve design strategies in conservation biology.