PRACTICE EXAM 26: LIFE SCIENCE: BIOLOGY SIMULATION (50 QUESTIONS — MICROBIOLOGY, POPULATION METHODS, AND SPECIALIZED TOPICS)

Instructions: Practice Exam 26 emphasizes microbiology (viruses, bacteria, fungi, archaea), plant reproductive biology, population sampling techniques, the phosphorus and water cycles, sleep and aging, organ transplantation, and biotechnology applications. Each question is independent. Select the one best answer.

1. A virus differs from a bacterium in that a virus:

A. Has a true nucleus and membrane-bound organelles inside its cell body where many of its activities take place during reproduction B. Contains a cell wall composed of peptidoglycan that surrounds the entire outer surface of the cell during every life stage of the organism C. Is not made of cells and can only reproduce by entering a host cell and using the host's cellular machinery for the reproduction process D. Carries out cellular respiration within its own mitochondria to produce ATP for its many daily metabolic activities throughout its life

2. Bacteria are classified as prokaryotic organisms because they:

A. Are much larger than most eukaryotic cells and contain many more membrane-bound organelles in their cytoplasm than do eukaryotic cells B. Reproduce only through sexual reproduction, combining genetic material from two parent cells during each reproduction event in the cell C. Contain a true nucleus that is surrounded by a nuclear membrane separating the bacterial DNA from the rest of the cellular cytoplasm D. Lack a membrane-bound nucleus and instead contain DNA that floats freely within the cell's cytoplasm in a region called the nucleoid

3. A scientist studying the diversity of life on Earth divides all living organisms into three large groups called domains. The three domains of life are:

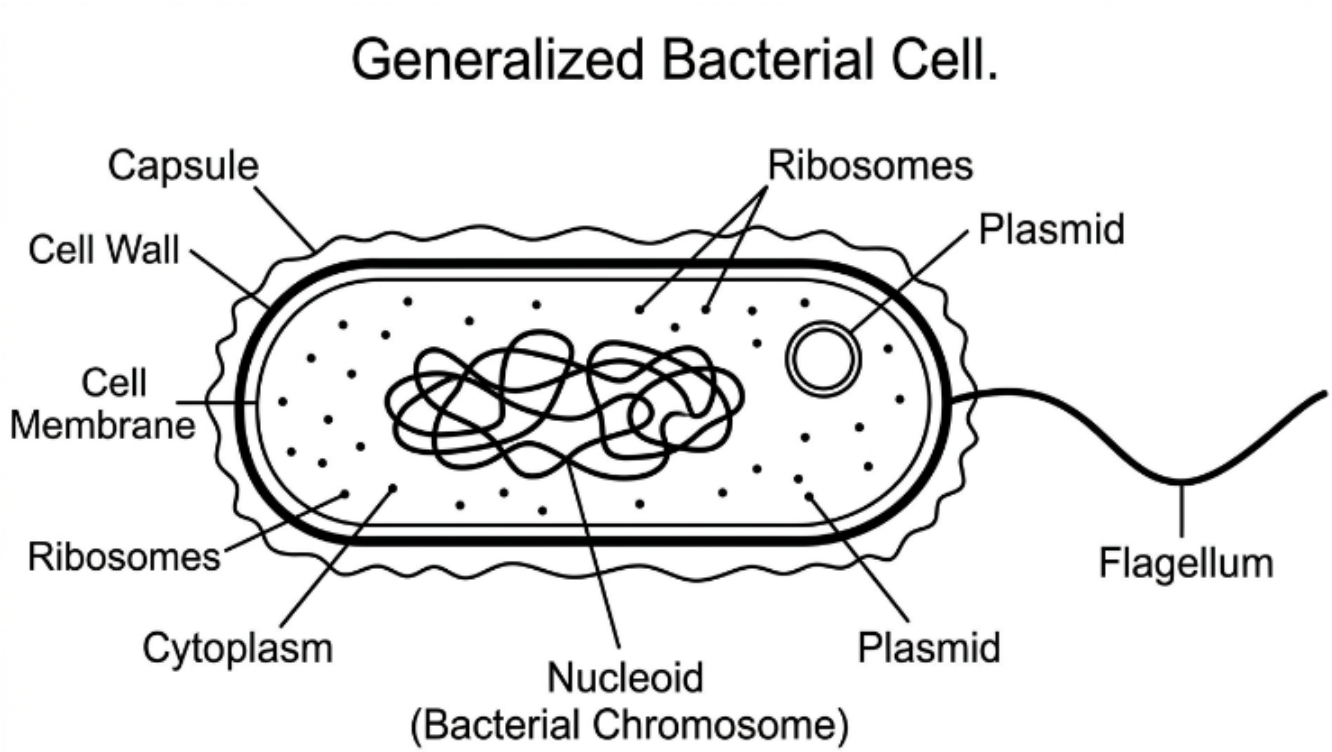
A. Bacteria, Archaea, and Eukarya, based on differences in cell structure, biochemistry, and genetic relationships among the major groups B. Animals, Plants, and Fungi, the three large groups of multicellular eukaryotes found across nearly every ecosystem worldwide on the planet C. Producers, Consumers, and Decomposers, the three functional roles that organisms play within their respective

ecosystems on every continent D. Prokaryotes, Protists, and Multicellular Organisms, based on the level of biological organization found across the tree of life on Earth

4. Kingdom Fungi differs from kingdom Plantae in that fungi:

A. Are autotrophs that produce their own food from sunlight, while plants are heterotrophs that consume other organisms for energy each day B. Are heterotrophs that absorb nutrients from their environment, while plants are autotrophs that produce food through photosynthesis daily C. Are exclusively single-celled organisms, while plants are exclusively multicellular organisms found in nearly every ecosystem on Earth D. Reproduce only by mitosis, while plants reproduce only through meiosis and the production of haploid gametes during sexual reproduction

5. The diagram below shows a typical bacterial cell.



Based on the diagram, which structure allows the bacterium to move through its surrounding fluid environment?

A. The capsule, the outer layer surrounding the cell wall that provides additional protection from environmental damage in many bacteria B. The plasmid, a small circular piece of DNA separate from the main bacterial chromosome that can be transferred between bacterial cells C. The nucleoid, the region of the cytoplasm that contains the bacterium's main circular chromosome carrying most of its essential genes D. The flagellum, a long whip-like extension that rotates and propels the bacterium through its surrounding fluid environment by spinning

6. Some bacteria contain small circular DNA molecules called plasmids in addition to their main chromosome. Plasmids are particularly important in biotechnology because they:

A. Provide the bacterial cell with all of the energy it needs to carry out its normal daily metabolic activities each second of its life cycle B. Contain all of the bacterium's essential genes, including the genes for the production of its membrane proteins each day of its existence C. Can be used as vectors to carry foreign genes into bacterial cells during the process of genetic engineering in the laboratory setting D. Replace the function of the main bacterial chromosome whenever the chromosome is damaged or temporarily lost from the bacterial cell

7. Antibiotics are drugs that kill bacteria or stop their growth. Most antibiotics are ineffective against viral infections because:

A. Viruses lack the cellular structures, such as ribosomes and cell walls, that most antibiotics specifically target during a course of treatment B. Viruses are much larger than bacteria and so antibiotic molecules cannot effectively diffuse into them during the course of medical treatment C. Viruses have a thick outer cell wall made of peptidoglycan that prevents most antibiotics from reaching their internal targets in viral cells D. Viruses produce a special protein that inactivates every antibiotic molecule immediately upon contact with the antibiotic in the human body

8. The flu vaccine must be reformulated nearly every year. The most likely reason for this annual reformulation is that:

A. The vaccine loses its potency in storage, and a fresh version must therefore be manufactured before each new flu season begins every year B. Influenza viruses mutate rapidly, causing changes in their surface proteins that may not match previous versions of the vaccine each year C. The human immune system completely loses all memory of the previous year's influenza virus over a period of just a few short months D. Federal regulations require that all vaccines be reformulated annually, regardless of any biological change in the underlying pathogen organism

9. A flower's reproductive organs include the male stamen and the female pistil. The structure within the stamen that produces pollen is called the:

A. Stigma, the sticky surface at the top of the pistil where pollen grains land during the process of pollination on a flowering plant each season B. Style, the narrow tube of the pistil that connects the stigma above to the ovary below at the base of the female reproductive structure C. Petal, the colored leaf-like part of the flower that attracts pollinators such as bees, butterflies, and certain bird species each day in nature D. Anther, the part of the stamen that contains pollen sacs in which pollen grains are produced through the process of meiosis in flowering plants

10. During fertilization in a typical flowering plant, a sperm nucleus from a pollen grain travels through the style of the pistil and fuses with an egg cell located in the:

A. Stamen, the male reproductive structure that produces pollen grains during the early reproductive cycle of the flower each growing season B. Petal, the colored leaf-like part of the flower that primarily functions to attract pollinators to land on the flower surface for pollination C. Ovary, the female

reproductive structure at the base of the pistil that contains the ovules with their female egg cells inside each ovule D. Sepal, the small green leaf-like part of the flower that protects the developing flower bud before the flower opens fully into a bloom

11. After fertilization in a flowering plant, the ovary develops into the:

A. New sepal of the plant, which then forms a protective leaf-like structure around the next developing bud of the next growing season B. Fruit of the plant, which surrounds the developing seeds and helps to protect and disperse them away from the parent plant in nature C. Stigma of the plant, the sticky structure at the top of the female reproductive system that catches pollen grains in the wind each season D. Vegetative root system of the plant, which then anchors the new plant in the soil and absorbs water and minerals daily during growth

12. Some flowering plants are pollinated by wind rather than by animal pollinators. Wind-pollinated flowers are often:

A. Small, drab in color, and without strong scents, since they do not need to attract animal pollinators with showy visual or olfactory displays B. Large, brightly colored, and strongly scented, since they need to attract a wide variety of animal pollinators across great distances each season C. Completely absent of any pollen entirely, since wind cannot carry pollen grains effectively over long distances between flowering plants D. Unable to reproduce successfully in normal conditions, since wind is generally too unreliable to deliver pollen to other flowers in the wild

13. A scientist wants to estimate the number of fish in a small lake. She catches 50 fish, tags them, and releases them back into the lake. One week later, she catches a new sample of 60 fish, of which 12 are tagged. Using the mark-recapture method, the best estimate of the total fish population is approximately:

A. 60 fish, calculated by simply counting the number of fish caught in the second sample of the population during the second catch attempt B. 110 fish, calculated by adding together the number of fish caught in the first sample and the number caught in the second sample of fish C. 250 fish, calculated by multiplying the first sample (50) by the second sample (60) and dividing by the recaptured tagged fish (12) overall D. 720 fish, calculated by multiplying the first sample by the second sample and dividing by the number of recaptured fish times two for accuracy

14. A scientist studying the diversity of plants in a forest uses a method that involves laying out small square plots of fixed size at random locations and counting all the plant species inside each plot. This sampling method is best described as:

A. Mark-recapture sampling, in which animals are captured, tagged, and released so that they can be recaptured during a later sampling effort B. Direct census sampling, in which every single individual organism within the entire study area is individually counted and identified each time C. Behavioral observation, in which the researcher carefully watches the actions of individual organisms over a long period of careful study time D. Quadrat sampling, in which fixed-size sample plots are used to estimate species diversity or abundance across a larger area being studied

15. A population ecologist measures the population growth rate of a deer herd in a forest. After many years, the population grows quickly at first and then slows down as it approaches an upper limit. The most likely explanation for the slowing of growth is that:

A. Density-dependent limiting factors, such as competition for food and the spread of disease, are now reducing the population growth rate B. The deer have suddenly stopped reproducing entirely because of unknown random changes in their reproductive biology during this period C. All of the deer in the herd have lived exactly the same number of years and are now beginning to die together at the same time naturally D. The forest has begun to expand its boundaries, providing the deer with more resources than they had previously needed to access in the past

16. A scientist studying carbon storage in a forest finds that most of the carbon in a mature forest is stored in:

A. Atmospheric carbon dioxide molecules contained directly above the forest in a thin layer just above the forest canopy at all times of year B. The wood and other living biomass of the trees, along with the carbon stored in the soil beneath the forest's standing trees and underbrush C. The bodies of the animals living within the forest, especially the large mammals such as deer, elk, and other major herbivores in the area D. The mineral salts dissolved in the groundwater that flows beneath the forest floor toward nearby rivers and freshwater lakes through soil

17. The phosphorus cycle differs from the carbon and nitrogen cycles in that the phosphorus cycle:

A. Includes a major atmospheric gas reservoir, similar to atmospheric carbon dioxide that is shared by all terrestrial ecosystems worldwide B. Only occurs in tropical rainforests and has no significant role in the ecosystems of temperate or polar regions of the world overall C. Has no significant atmospheric gas phase, with phosphorus cycling mainly through rocks, soil, water, and living organisms over time D. Operates only inside human-made systems such as agricultural fertilizers and has no role at all in the natural environment of any ecosystem

18. The water cycle includes processes such as evaporation, transpiration, condensation, and precipitation. The major source of energy that drives the water cycle is:

A. Solar energy, which evaporates water from oceans, lakes, and other surfaces and drives the entire water cycle on Earth throughout each year B. Energy from the breakdown of organic molecules by decomposers in the soil throughout the year in every climate zone of the entire world C. Heat energy released from Earth's interior through volcanic activity along the major continental plate boundaries throughout the world D. Energy stored in the chemical bonds of glucose molecules within the leaves of plants during the photosynthesis process each day in the sun

19. A new organ transplanted from a donor into a recipient is sometimes rejected by the recipient's body. This rejection most directly involves:

A. Hormonal regulation, in which hormones released by the transplanted organ trigger a physical attack on the surrounding host body cells over time B. The pumping action of the heart, which physically pushes the transplanted organ out of the body during the early days after surgery is performed C. The

digestive system, which produces enzymes that break down the transplanted organ tissue from the inside outward through enzymatic action D. The immune system, which recognizes the transplanted tissue as foreign and attacks it as it would attack any invading pathogen in the body

20. A doctor prescribes immunosuppressant medications to a patient who has recently received a kidney transplant. The primary purpose of these medications is to:

A. Stimulate the recipient's immune system so it can vigorously fight off any infections that may enter the body after the transplant surgery B. Suppress the recipient's immune response so that it does not attack and reject the transplanted kidney as a foreign tissue inside the body C. Speed up the production of new kidney cells in the transplanted organ to help it grow to its normal full size more rapidly after the surgery D. Replace the function of the kidneys directly until the new transplanted kidney is fully connected to the recipient's bloodstream after surgery

21. During a typical 24-hour day, humans cycle between periods of sleep and wakefulness. The brain structure most directly responsible for regulating this sleep-wake cycle is the:

A. Cerebellum, which coordinates voluntary muscle movements and helps the body maintain its balance during physical activity each day in life B. Medulla oblongata, which regulates many essential involuntary functions such as breathing rate and heart rate every minute throughout the day C. Hypothalamus, which regulates many homeostatic functions including the body's circadian sleep-wake cycle throughout the day and night D. Cerebral cortex, which is the site of higher mental functions such as conscious thinking, learning, and memory throughout each day of life

22. During REM sleep, the brain shows electrical activity similar to that seen during wakefulness, and most vivid dreaming occurs during this stage. The other major category of sleep is best called:

A. Non-REM sleep, which includes several deeper stages of sleep with progressively slower brain wave patterns during the night each evening B. Daytime sleep, which only occurs during the bright daylight hours when most people are normally awake and active each day in their lives C. Pre-sleep wakefulness, the period of relaxation that immediately precedes the actual onset of sleep each night before bed in normal sleep D. Conscious dreaming, in which the sleeper is fully aware of the surrounding environment despite being deeply asleep at the time of the dream

23. As humans age, certain physiological changes typically occur over time. Which of the following is generally an expected change associated with normal human aging?

A. A significant increase in the speed of nerve impulse conduction over time across all parts of the central nervous system continuously each year B. A dramatic increase in immune function and resistance to infectious diseases throughout the entire lifespan of an aging individual person over time C. An increase in the rate of cell division in nearly every tissue of the body throughout the entire lifespan of an older adult person continuously D. A gradual loss of muscle mass and bone density along with a slower metabolic rate that reduces overall daily energy needs in older adults

24. Telomeres are repetitive DNA sequences at the ends of chromosomes that shorten slightly with each round of cell division in normal somatic cells. Telomere shortening is associated with:

A. The complete prevention of any cell aging across the entire lifespan of an organism's body throughout its long life span in nearly every species B. A continuous increase in the number of cell divisions that a given cell can undergo before reaching its lifetime limit of divisions in the body C. Cellular aging and the eventual limit on the number of times a normal somatic cell can divide before reaching senescence and cell-cycle arrest D. The production of new chromosomes from the cytoplasm during the early stages of mitotic cell division in adult body tissues throughout life

25. A specific kind of cell in the body produces large amounts of a particular protein and exports that protein outside the cell. Cells that produce and export large amounts of protein generally contain especially large amounts of:

A. Lysosomes, which contain digestive enzymes that break down old cellular structures and engulfed food particles in the cell over time during life B. Rough endoplasmic reticulum and Golgi apparatus, which together synthesize, modify, and package proteins for export from the cell each second C. Mitochondria, which produce ATP that is used to power the routine metabolic activities of nearly every type of cell daily throughout the body D. Chloroplasts, which capture sunlight and produce glucose used by the cell to power its many cellular activities each day of life on Earth

26. The complete differentiation of cells during embryonic development requires precise regulation of gene expression in each cell type. A key mechanism that controls which genes are expressed in a particular cell type involves:

A. Transcription factors, proteins that bind to specific DNA sequences and either activate or repress the transcription of specific genes in the cell B. Permanent loss of DNA from cells that no longer need certain genes, leaving only the genes needed for that cell's specific adult function in life C. Random and ongoing mutation of all the genes that the cell does not actively need for its specific adult biological function throughout life D. Increased intake of food and dietary nutrients by cells that need to express more genes throughout their entire lifetime in the human body

27. Cells that have a haploid (n) chromosome number include:

A. Skin cells produced by mitosis in the deep layers of the skin throughout the lifespan of the human body for ordinary tissue repair and growth B. Muscle cells produced by mitosis during the growth of the body's various muscle tissues during normal childhood and adolescent development C. Liver cells produced by mitosis throughout the lifespan of the body to maintain the liver's many important metabolic functions for life every day D. Sperm cells and egg cells produced by meiosis to combine genetic material from two parents during sexual reproduction in humans and other animals

28. The diploid (2n) chromosome number is restored in a developing human embryo at which event?

A. The first cell division of the zygote that produces two cells from the original fertilized egg cell at the start of embryo development in the womb B. The release of an egg cell from the ovary into the fallopian tube during ovulation midway through the menstrual cycle of the adult female human C. Fertilization, in which the haploid sperm cell fuses with the haploid egg cell to form the diploid zygote at the start of pregnancy in the female D. The implantation of the developing embryo into the wall of the uterus several days after fertilization has already occurred in the woman's body

29. Identical twins are produced when a single fertilized egg divides into two separate cells that each develop into a complete embryo. Identical twins are also called:

A. Monozygotic twins, since they originate from a single zygote that divides early in development to produce two genetically identical embryos B. Dizygotic twins, since they originate from two different zygotes produced by the fertilization of two separate egg cells by two separate sperm C. Triplet twins, since they share three copies of the same genome distributed across the two developing embryos in this same pregnancy event D. Fraternal twins, since they originate from two separately fertilized eggs that happen to develop into two embryos in the same uterus together

30. The diagram below shows two different DNA samples being separated using gel electrophoresis.

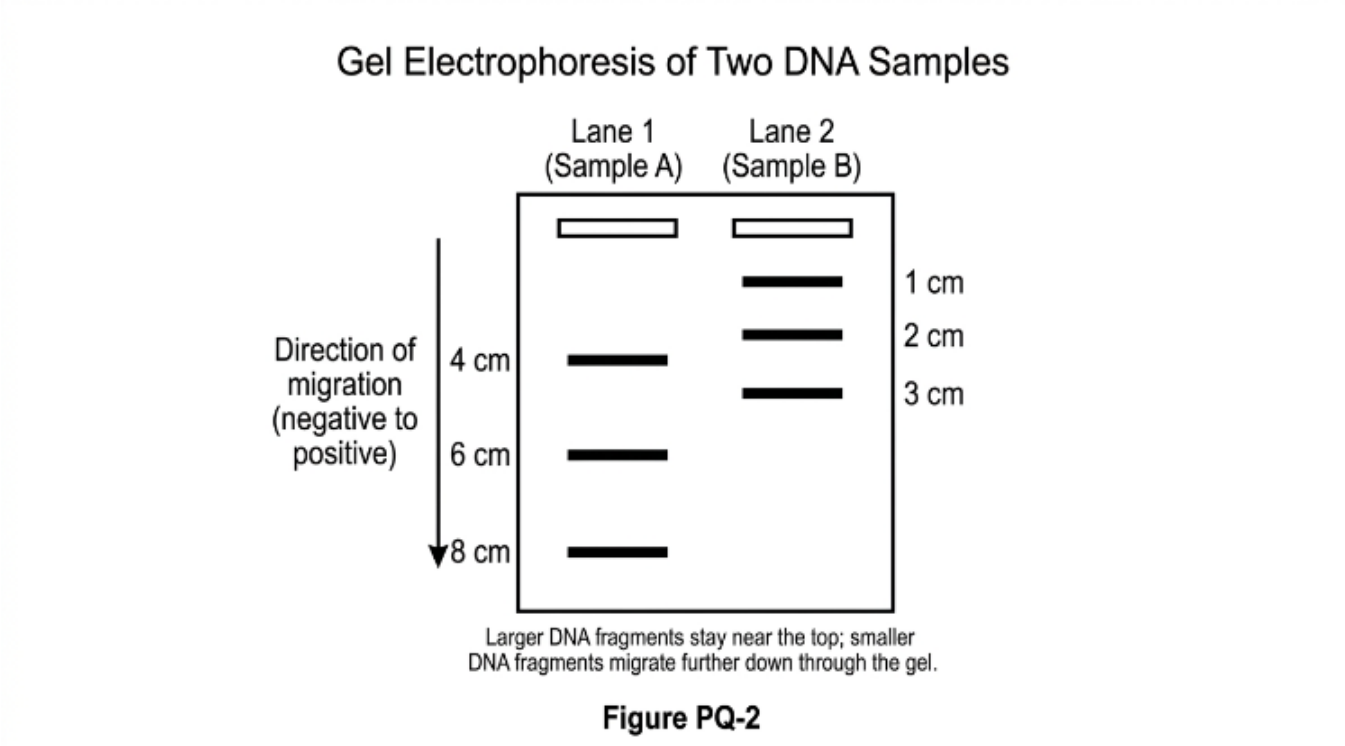


Figure PQ-2

Based on the diagram, which conclusion is best supported?

A. Sample A contains DNA fragments that are all larger in size than every fragment in Sample B at every distance position shown on the gel B. Sample A contains DNA fragments that are all smaller in size than every fragment in Sample B at every distance position shown on the gel C. Both samples contain exactly the same DNA fragments, just sorted in two different orders within the gel based on chance alone each time D. Sample A and Sample B both contain three fragments, but each fragment in Sample A is slightly larger than the corresponding fragment in Sample B

31. A scientist studies populations of a beetle species in two different forests. In Forest 1, all the beetles are red. In Forest 2, all the beetles are green. When the two populations are placed together in the laboratory, they do not interbreed even though they are physically capable of mating. The two populations are best classified as:

A. Members of the same species, since they look similar and are physically capable of mating with each other when placed in close contact by humans B. Two unrelated species that just happen to look similar to each other due to convergent evolution in two different forest environments over time C. Two different ages of the same species that simply differ in their adult coloration patterns by chance among the studied beetles in the laboratory D. Separate biological species, since reproductive isolation prevents gene flow between them despite their physical ability to mate in the laboratory

32. Two species of finches on a Galapagos island have very similar diets and beak shapes when they first colonize the island. Over many generations, one species begins to feed on larger seeds while the other species begins to feed on smaller seeds, which reduces competition between the two species. This process is best classified as:

A. Resource partitioning, in which two species divide a shared resource so that they can coexist together with reduced direct competition between them B. Convergent evolution, in which two unrelated species independently evolve similar physical traits over many generations of time in similar environments C. Adaptive radiation, in which one ancestral species rapidly diversifies into many descendant species filling different ecological niches in a habitat D. Genetic drift, in which random changes in allele frequencies cause one population to become noticeably different from another over time by chance

33. The fossil record contains many examples of intermediate forms between major groups of organisms. For example, the fossil Tiktaalik shows features of both fish and early amphibians in its anatomy. The most direct interpretation of such transitional fossils is that they:

A. Prove that evolution does not occur, since organisms with mixed features could not survive in the natural environment over long time periods on Earth B. Represent organisms that were created in their final forms with no relationship at all to any other organisms in the planet's long history of life forms C. Provide evidence of evolutionary change between major groups, showing intermediate forms that share features of two related lineages over time D. Are simply unusual variants of modern fish that happened to be preserved due to particular environmental conditions in the deep past on Earth

34. Two species of organisms have very similar limb bone structures, even though one species uses its limb for swimming and the other species uses its limb for digging. The similar bone arrangement is best classified as:

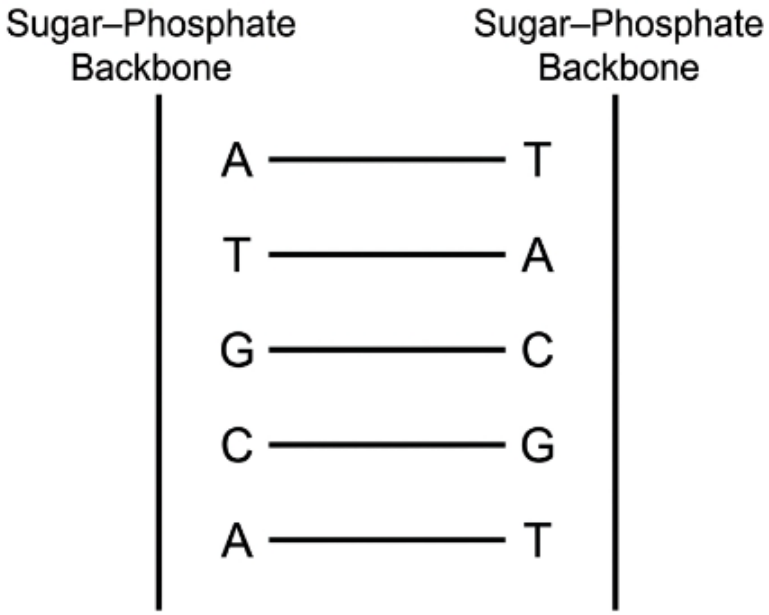
A. Vestigial structures, the reduced or unused remnants of structures that were functional in the species' evolutionary ancestors over time on Earth B. Homologous structures, similar in underlying anatomy because of inheritance from a common ancestor, even though now used for different functions C. Analogous structures, similar in function only and not in underlying anatomy, having evolved independently in two unrelated species over time on Earth D. Convergent structures, identical in both form and function due to identical genetic mutations occurring simultaneously in both lineages today on Earth

35. The wings of a butterfly and the wings of a bird are both used for flight, yet they evolved independently from completely different ancestral structures. The wings of these two organisms are best classified as:

A. Vestigial structures, the reduced or unused remnants of structures that were functional in the species' evolutionary ancestors over time on Earth B. Homologous structures, similar in underlying anatomy because of inheritance from a common ancestor, even though now used for different functions C. Convergent structures, identical in both form and function due to identical genetic mutations occurring simultaneously in both lineages today on Earth D. Analogous structures, similar in function but not in underlying anatomy, having evolved independently in two unrelated species under similar pressures

36. The diagram below shows a portion of a DNA molecule drawn in linear ladder form.

Figure PQ-3: Portion of a DNA Molecule



Based on the diagram, the base pairs A-T and G-C illustrate which structural principle of DNA?

A. The two strands of the DNA double helix run in the same direction, with both strands oriented from the 5' to the 3' end on each strand of DNA B. All base pairs in DNA are held together by exactly the same number of identical hydrogen bonds between the bases on each strand of the DNA C. Adenine always pairs with thymine, and guanine always pairs with cytosine, due to the specific shapes and hydrogen bonding of the four bases D. Adenine pairs with guanine, and thymine pairs with cytosine, due to the specific shapes and hydrogen bonding of the four bases in DNA molecules

37. The principle of complementary base pairing in DNA is essential for the accurate replication of DNA molecules because:

A. Each strand of the original DNA serves as a template for the synthesis of a new strand with a precisely predictable sequence of bases each time B. The double helix structure prevents the strands from separating during the replication process, keeping the original DNA intact at all times daily C. Each base on a single strand of DNA can pair with any of the other three bases, allowing many different

copies to be made each time replication occurs D. Only the dominant alleles can be replicated, while recessive alleles are skipped during the DNA replication process throughout the cell cycle each time

38. A scientist studying the genetics of a population of plants notices that certain alleles are far more common than others, despite no apparent selective advantage. The population has remained small and isolated for many generations. The most likely cause of this allele frequency pattern is:

A. Strong natural selection that has favored those alleles over many generations of the plant population growing in this isolated location every year B. Genetic drift, in which random sampling effects in a small population have caused certain allele frequencies to change purely by chance over time C. Gene flow, in which alleles have been transferred between populations through the movement of pollen or seeds over a large geographic area D. Recent mutations that have appeared in many individual plants of the population simultaneously over the past few growing seasons of the species

39. A population of insects has 1,000 individuals, of which 360 are homozygous recessive for a particular trait. Assuming the population is in Hardy-Weinberg equilibrium, the approximate frequency of the recessive allele (q) is:

A. 0.36, calculated directly from the proportion of homozygous recessive insects in this particular insect population studied by the scientist each year B. 0.18, calculated by dividing the proportion of homozygous recessive insects by two for this particular insect population studied in the field each year C. 0.60, calculated as the square root of the proportion of homozygous recessive insects in this insect population under Hardy-Weinberg assumptions D. 0.80, calculated by adding the proportion of homozygous recessive insects to the proportion of heterozygous insects in this population each year

40. Continuing the scenario from the previous question, the approximate frequency of the dominant allele (p) in this same insect population is:

A. 0.36, calculated directly from the proportion of homozygous recessive insects in this insect population under the same Hardy-Weinberg assumptions B. 0.60, calculated as the same value as the recessive allele frequency in this particular insect population studied in this particular scenario each year C. 0.50, calculated by averaging the recessive and dominant allele frequencies in this insect population studied throughout this particular scenario D. 0.40, calculated by subtracting the recessive allele frequency (0.60) from 1 in this particular insect population studied in this same scenario

41. The genetic disorder phenylketonuria (PKU) is caused by an enzyme deficiency that prevents the breakdown of the amino acid phenylalanine. Babies are routinely tested for PKU shortly after birth so that affected babies can be:

A. Given regular blood transfusions to dilute the high levels of phenylalanine that build up in their blood throughout their lifetime each day of life B. Placed on a low-phenylalanine diet that prevents the buildup of toxic levels of phenylalanine and protects developing brain tissue from damage C. Given the missing enzyme by mouth daily, since this enzyme can be readily synthesized in a laboratory and absorbed unchanged from food each day D. Cured of the genetic mutation through standard gene therapy treatments that are widely available at most major hospitals worldwide today

42. Color blindness is a recessive sex-linked trait carried on the X chromosome. A color-blind father and a non-carrier mother have several children together. Their daughters will all be:

A. Carriers of the color-blindness allele but unaffected, since they inherit one normal X from the mother and one recessive X from the affected father B. Affected with color blindness because they inherit the recessive allele directly from the father on their single X chromosome at fertilization C. Unaffected and noncarriers, since their mother does not carry the color-blindness allele and they did not inherit one from her either at fertilization D. Carriers if female and affected if male, in equal proportions across the daughters of this particular pair of parents in this family of children

43. A patient with sickle cell anemia has red blood cells that take on a curved, sickle-like shape under low oxygen conditions. These misshapen cells are LEAST likely to cause which of the following problems?

A. Blockage of small blood vessels, leading to severe pain and tissue damage when oxygen cannot reach the surrounding tissues during a crisis B. Reduced ability of the red blood cells to carry oxygen, leading to fatigue and weakness in the affected patient especially during exercise activity C. Premature destruction of the red blood cells by the spleen, leading to severe anemia and other symptoms throughout the patient's lifetime D. Permanent and unfixable damage to the DNA of every body cell in the patient, leading to multiple unrelated cancers throughout the patient's life

44. The human gene for insulin has been successfully inserted into bacteria, which then produce human insulin that can be used to treat diabetes. This biotechnology application is most directly classified as an example of:

A. Cross-pollination, the natural transfer of pollen between two different plant species during the normal reproductive process of flowering plants B. Selective breeding, the deliberate choice of which individual organisms to breed in order to produce desired traits in future generations of organisms C. Genetic engineering, the deliberate transfer of a gene from one organism into another organism using modern biotechnology techniques in a laboratory D. Cloning, the production of multiple genetically identical copies of a single original donor organism through laboratory techniques used today widely

45. CRISPR-Cas9 is a powerful gene-editing tool that allows researchers to make precise changes to specific locations in an organism's DNA. The most important advantage of CRISPR-Cas9 over earlier gene-editing methods is its:

A. Ability to permanently delete the entire genome of an organism in a single quick step, leaving the affected organism with no DNA at all afterward B. Ability to target specific DNA sequences with high precision, allowing researchers to make exact edits at predetermined locations in the genome C. Use of bacterial viruses that destroy bacterial cells completely without leaving any cellular DNA behind in the affected organism after the treatment D. Ability to change the DNA of an organism only during the embryonic stages of development before any cells have differentiated into adult tissue

46. A scientist proposes that human activities are causing a significant decline in global biodiversity. Which line of evidence would most directly support this hypothesis?

A. Data showing increased rates of extinction of species in regions of intense human activity, such as habitat destruction and widespread pollution B. Data showing that human populations have grown rapidly over the last several centuries to billions of individuals worldwide today across the globe C. Data showing that humans have built large cities throughout many parts of the world over the past several thousand years of human history overall D. Data showing the deep evolutionary history of major animal groups since the origin of life on Earth several billion years ago overall in the past

47. A coral reef ecosystem provides many services to coastal communities, including breaking the force of incoming ocean waves and supporting commercial fisheries. These benefits provided by natural ecosystems to humans are best called:

A. Cultural rituals, since human communities often hold ceremonies that celebrate the importance of coral reefs to the local cultures around the world B. Economic mineral resources, since coral reefs produce mineral substances such as iron and copper that humans extract for industrial use directly C. Genetic engineering products, since most modern medical drugs are now produced by genetically modifying coral organisms in a laboratory setting D. Ecosystem services, the benefits provided by healthy natural ecosystems to humans, including provisioning, regulating, and cultural service categories

48. Climate change driven by human activities is predicted to have widespread effects on ecosystems. Which of the following is the most likely effect of rising global temperatures on coral reefs?

A. Coral reefs will rapidly expand into colder polar waters where they previously could not survive because of the cold ocean temperatures up north B. Coral reefs will become more productive and host an even greater diversity of species than they currently do under present conditions worldwide C. Coral bleaching will become more common and more severe, leading to widespread loss of coral reef ecosystems in many tropical waters worldwide D. Coral reefs will be completely unaffected by rising water temperatures, since corals can tolerate any temperature change without significant distress

49. A wildlife biologist is concerned about the long-term survival of a particular endangered species. Which of the following conservation strategies would best help protect that species over the long term?

A. Capturing all of the remaining wild individuals and keeping them in cages without any further breeding or reintroduction efforts at all later B. Protecting the species' natural habitat from destruction and disturbance so that the population can survive and reproduce in the wild for years C. Introducing many predator species into the species' habitat in order to reduce the population to a more manageable size for the biologists studying it D. Eliminating all other species from the endangered species' habitat in order to reduce all competition between the populations completely each year

50. A river that flows through both a heavily forested area and a heavily farmed area shows significantly higher levels of dissolved nitrogen in the section flowing through the farmed area. The most likely explanation for this difference is that:

A. Fertilizer runoff from the farmland is adding additional nitrogen to the river, raising the dissolved nitrogen levels in the water in that area B. The forested section of the river contains organisms that consume all dissolved nitrogen before it can be detected in the water samples each year C. The farmed section of the river is exposed to less sunlight, which causes the river's nitrogen levels to rise sharply in

that section over time D. Forested rivers naturally lose all of their nitrogen content within a few short hours of flowing through any forested area each year worldwide

Practice Exam 26: Life Science: Biology Simulation — Answer Key with Explanations

1. C — Is not made of cells and can only reproduce by entering a host cell and using the host's cellular machinery. Viruses are acellular particles consisting of a protein coat surrounding genetic material, lacking the cytoplasm, ribosomes, and metabolic machinery of true cells. This obligate intracellular dependence is the central reason viruses are usually considered to lie at the border between living and nonliving.

2. D — Lack a membrane-bound nucleus and instead contain DNA that floats freely within the cell's cytoplasm in a region called the nucleoid. The absence of a nuclear envelope is the defining structural feature of prokaryotes; "pro-karyote" literally means "before the nucleus." Prokaryotes also lack other membrane-bound organelles such as mitochondria, ER, and Golgi.

3. A — Bacteria, Archaea, and Eukarya, based on differences in cell structure, biochemistry, and genetic relationships among the major groups. Carl Woese established this three-domain system in the 1970s based on ribosomal RNA sequence comparisons. Archaea were once classified with bacteria but are now recognized as a separate domain that, surprisingly, shares some molecular features with eukaryotes.

4. B — Are heterotrophs that absorb nutrients from their environment, while plants are autotrophs that produce food through photosynthesis daily. Fungi secrete digestive enzymes into their surroundings and absorb the resulting small molecules — a mode of nutrition called absorptive heterotrophy. Plants, in contrast, build their own organic molecules using sunlight, water, and CO_2.

5. D — The flagellum, a long whip-like extension that rotates and propels the bacterium through its surrounding fluid environment by spinning. Bacterial flagella rotate like a propeller, driven by a molecular motor in the cell membrane. This swimming ability allows many bacteria to perform chemotaxis — moving toward nutrients and away from harmful substances.

6. C — Can be used as vectors to carry foreign genes into bacterial cells during the process of genetic engineering in the laboratory setting. Researchers cut plasmids with restriction enzymes, insert a gene of interest, then reintroduce the recombinant plasmid into a bacterium. The bacterium then replicates the plasmid and expresses the inserted gene, allowing production of human insulin, growth hormone, and many other useful proteins.

7. A — Viruses lack the cellular structures, such as ribosomes and cell walls, that most antibiotics specifically target during a course of treatment. Antibiotics work by attacking bacterial-specific features (such as the peptidoglycan cell wall or 70S ribosomes) that viruses simply do not possess. This is why antiviral drugs use entirely different mechanisms and why antibiotics are useless against the common cold or flu.

8. B — Influenza viruses mutate rapidly, causing changes in their surface proteins that may not match previous versions of the vaccine each year. Antigenic drift in hemagglutinin and neuraminidase proteins means that last year's antibodies may not recognize this year's strain. Each year's flu vaccine is therefore designed based on epidemiological surveillance of which strains are likely to circulate.

9. D — Anther, the part of the stamen that contains pollen sacs in which pollen grains are produced through the process of meiosis in flowering plants. The stamen consists of a slender filament topped by the pollen-producing anther. Each pollen grain is a tiny haploid structure that carries the plant's male gametes (sperm nuclei) to the female reproductive organs of another flower.

10. C — Ovary, the female reproductive structure at the base of the pistil that contains the ovules with their female egg cells inside each ovule. After pollination, the sperm nucleus travels down a pollen tube through the style to reach the ovary. Fertilization within the ovule produces a zygote that develops into the embryo of a seed.

11. B — Fruit of the plant, which surrounds the developing seeds and helps to protect and disperse them away from the parent plant in nature. The ovary wall ripens into the fruit tissue, while each fertilized ovule develops into a seed inside the fruit. Fleshy fruits often attract animals that eat them and disperse the seeds in their droppings, an important coevolutionary partnership.

12. A — Small, drab in color, and without strong scents, since they do not need to attract animal pollinators with showy visual or olfactory displays. Wind-pollinated plants instead produce vast quantities of small, lightweight pollen grains to maximize the chance that some will reach receptive flowers. Grasses, oaks, and many conifers are well-known wind-pollinated species.

13. C — 250 fish, calculated by multiplying the first sample (50) by the second sample (60) and dividing by the recaptured tagged fish (12) overall. The mark-recapture (Lincoln-Petersen) estimate is $N = (M \times C) / R$, giving $(50 \times 60) / 12 = 250$. This method assumes a closed population, complete mixing of marked individuals, and no tag loss.

14. D — Quadrat sampling, in which fixed-size sample plots are used to estimate species diversity or abundance across a larger area being studied. Quadrats are used widely in plant ecology and benthic studies where organisms do not move. Multiple randomly placed quadrats allow ecologists to extrapolate from sample plots to estimate populations across an entire habitat.

15. A — Density-dependent limiting factors, such as competition for food and the spread of disease, are now reducing the population growth rate. As population density rises, individuals share resources and are more likely to transmit disease, lowering birth rates and raising death rates. This produces the characteristic logistic growth curve that levels off near carrying capacity.

16. B — The wood and other living biomass of the trees, along with the carbon stored in the soil beneath the forest's standing trees and underbrush. Tree trunks contain enormous amounts of carbon stored in cellulose and lignin, and forest soils contain additional carbon in decomposing organic matter. This is why deforestation is such a significant source of atmospheric CO_2 — burning and decay release the long-term forest carbon stocks.

17. C — Has no significant atmospheric gas phase, with phosphorus cycling mainly through rocks, soil, water, and living organisms over time. Phosphorus exists primarily as phosphate ions and is released from rock through weathering, taken up by plants, and returned to soil through decomposition. The slow pace of weathering often makes phosphorus a limiting nutrient in many ecosystems.

18. A — Solar energy, which evaporates water from oceans, lakes, and other surfaces and drives the entire water cycle on Earth throughout each year. Sunlight provides the energy that lifts water into the atmosphere as vapor, where it then condenses and falls as precipitation. Without solar input, the water cycle and the climate patterns it supports would not function.

19. D — The immune system, which recognizes the transplanted tissue as foreign and attacks it as it would attack any invading pathogen in the body. The recipient's T cells recognize foreign MHC (HLA) markers on the donor tissue as non-self and mount a cell-mediated attack. Tissue matching and immunosuppressive drugs reduce but do not eliminate this rejection response.

20. B — Suppress the recipient's immune response so that it does not attack and reject the transplanted kidney as a foreign tissue inside the body. Drugs such as cyclosporine and tacrolimus dampen T-cell activity enough to allow tolerance of the donor organ. The tradeoff is increased vulnerability to infection and certain cancers, requiring careful long-term medical monitoring.

21. C — Hypothalamus, which regulates many homeostatic functions including the body's circadian sleep-wake cycle throughout the day and night. The suprachiasmatic nucleus of the hypothalamus serves as the body's master clock, taking light cues from the eyes and orchestrating hormone release and sleep timing. Disruption of this system underlies jet lag and shift-work sleep disorders.

22. A — Non-REM sleep, which includes several deeper stages of sleep with progressively slower brain wave patterns during the night each evening. Non-REM (NREM) sleep makes up roughly 75–80% of total sleep time and includes the deepest restorative stages. The cycle between NREM and REM repeats roughly every 90 minutes throughout a normal night's sleep.

23. D — A gradual loss of muscle mass and bone density along with a slower metabolic rate that reduces overall daily energy needs in older adults. Sarcopenia (muscle loss) and osteopenia (bone loss) are well-documented features of normal aging, along with a decline in basal metabolic rate. Resistance exercise and adequate nutrition can slow but not entirely prevent these changes.

24. C — Cellular aging and the eventual limit on the number of times a normal somatic cell can divide before reaching senescence and cell-cycle arrest. Each replication shortens telomeres until they reach a critical length, triggering the Hayflick limit on cell division. This contributes to age-related decline in tissue regeneration capacity.

25. B — Rough endoplasmic reticulum and Golgi apparatus, which together synthesize, modify, and package proteins for export from the cell each second. Ribosomes on the rough ER synthesize secretory proteins, which then move through the ER lumen to the Golgi for sorting and packaging into transport vesicles. Cells specialized in secretion, such as pancreatic acinar cells and plasma cells, are particularly rich in these organelles.

26. A — Transcription factors, proteins that bind to specific DNA sequences and either activate or repress the transcription of specific genes in the cell. Different cell types contain different combinations of transcription factors, leading to expression of different gene sets and therefore different phenotypes. This combinatorial control is the basis of cellular differentiation.

27. D — Sperm cells and egg cells produced by meiosis to combine genetic material from two parents during sexual reproduction in humans and other animals. Gametes carry n = 23 chromosomes in humans, half the somatic cell number, so that fertilization can restore the normal 2n = 46. All other listed cells are somatic cells produced by mitosis and remain diploid.

28. C — Fertilization, in which the haploid sperm cell fuses with the haploid egg cell to form the diploid zygote at the start of pregnancy in the female. The two sets of 23 chromosomes combine into a single 46-chromosome nucleus. This restoration of diploidy reestablishes the species-specific chromosome number for the new individual.

29. A — Monozygotic twins, since they originate from a single zygote that divides early in development to produce two genetically identical embryos. Because both embryos arise from the same zygote, they carry identical DNA and are typically of the same sex and very similar in appearance. Dizygotic (fraternal) twins, in contrast, arise from two separate zygotes and are no more genetically similar than ordinary siblings.

30. B — Sample A contains DNA fragments that are all smaller in size than every fragment in Sample B at every distance position shown on the gel. Smaller DNA fragments migrate further through the gel, so the bands deeper in the gel represent smaller fragments. Since all of Sample A's bands are deeper than all of Sample B's bands, every fragment in Sample A must be smaller than every fragment in Sample B.

31. D — Separate biological species, since reproductive isolation prevents gene flow between them despite their physical ability to mate in the laboratory. Under the biological species concept, what defines species boundaries is the absence of successful interbreeding in nature, regardless of physical capacity to mate. Behavioral isolation is one of the most common prezygotic isolating mechanisms.

32. A — Resource partitioning, in which two species divide a shared resource so that they can coexist together with reduced direct competition between them. By exploiting different parts of the same resource, two species avoid the competitive exclusion that would otherwise occur. This partitioning is a common evolutionary outcome of sustained interspecific competition.

33. C — Provide evidence of evolutionary change between major groups, showing intermediate forms that share features of two related lineages over time. Transitional fossils such as Tiktaalik (fish-to-tetrapod) and Archaeopteryx (dinosaur-to-bird) reveal the gradual nature of evolutionary change between major groups. These fossils were predicted by evolutionary theory before their discovery, strengthening confidence in the theory.

34. B — Homologous structures, similar in underlying anatomy because of inheritance from a common ancestor, even though now used for different functions. The forelimbs of mammals — including whale flippers, bat wings, and human arms — all share the same underlying bone plan inherited from a common tetrapod ancestor. Homology is one of the strongest lines of evidence for common descent.

35. D — Analogous structures, similar in function but not in underlying anatomy, having evolved independently in two unrelated species under similar pressures. Insect wings and bird wings serve the same function (flight) but evolved from entirely different ancestral structures and have very different anatomy. Analogous structures result from convergent evolution rather than shared ancestry.

36. C — Adenine always pairs with thymine, and guanine always pairs with cytosine, due to the specific shapes and hydrogen bonding of the four bases. This complementary base pairing is the structural basis of DNA's faithful replication and repair. The two A–T hydrogen bonds and three G–C hydrogen bonds also help stabilize the double helix.

37. A — Each strand of the original DNA serves as a template for the synthesis of a new strand with a precisely predictable sequence of bases each time. Because A pairs only with T and G only with C, each parental strand specifies exactly which nucleotides will be added to the new strand. This complementarity is what gives DNA its remarkable replication fidelity, typically with fewer than one error per billion base pairs.

38. B — Genetic drift, in which random sampling effects in a small population have caused certain allele frequencies to change purely by chance over time. Drift acts most strongly in small populations because random variation has a larger relative effect when fewer individuals are sampled each generation. The lack of any selective advantage rules out natural selection as the primary explanation.

39. C — 0.60, calculated as the square root of the proportion of homozygous recessive insects in this insect population under Hardy-Weinberg assumptions. Under Hardy-Weinberg, q^2 equals the homozygous recessive frequency, so $q^2 = 360/1000 = 0.36$ and $q = \sqrt{0.36} = 0.60$. This formula lets researchers estimate allele frequencies from phenotype data without genotyping every individual.

40. D — 0.40, calculated by subtracting the recessive allele frequency (0.60) from 1 in this particular insect population studied in this same scenario. Because the two alleles must add to 1 in a two-allele system, $p = 1 - q = 1 - 0.60 = 0.40$. This is a foundational relationship in Hardy-Weinberg analysis.

41. B — Placed on a low-phenylalanine diet that prevents the buildup of toxic levels of phenylalanine and protects developing brain tissue from damage. Dietary restriction starting in infancy is the standard treatment for PKU and prevents the intellectual disability and other complications that otherwise result. Newborn screening for PKU is mandatory in all U.S. states.

42. A — Carriers of the color-blindness allele but unaffected, since they inherit one normal X from the mother and one recessive X from the affected father. The father (X^cY) passes his X^c to every daughter, while the non-carrier mother (X^BX^B) passes a normal X^B. All daughters are therefore X^BX^c carriers but phenotypically unaffected.

43. D — Permanent and unfixable damage to the DNA of every body cell in the patient, leading to multiple unrelated cancers throughout the patient's life. Sickle cell anemia affects red blood cells and the tissues they supply, but it does not damage the DNA of other body cells or cause widespread cancer. The blockages, anemia, and premature RBC destruction listed in the other options are all well-documented complications of the disease.

44. C — Genetic engineering, the deliberate transfer of a gene from one organism into another organism using modern biotechnology techniques in a laboratory. The bacterial production of human insulin is one of the earliest and most successful examples of recombinant DNA technology. It replaced the previous use of insulin extracted from pig and cow pancreases.

45. B — Ability to target specific DNA sequences with high precision, allowing researchers to make exact edits at predetermined locations in the genome. Earlier gene-editing tools were slower, more expensive, and less precise than CRISPR-Cas9, which uses an easily customized guide RNA to direct cutting. This precision and accessibility have transformed biomedical research within the past decade.

46. A — Data showing increased rates of extinction of species in regions of intense human activity, such as habitat destruction and widespread pollution. Direct extinction-rate data linked to human-driven habitat loss provide the most relevant test of the hypothesis. The other choices may be background information but do not directly measure changes in biodiversity.

47. D — Ecosystem services, the benefits provided by healthy natural ecosystems to humans, including provisioning, regulating, and cultural service categories. Ecosystem services are typically classified into four groups: provisioning (food, water), regulating (climate, water purification), supporting (nutrient cycling), and cultural (recreation, spiritual). Recognition of these services has become central to modern conservation economics.

48. C — Coral bleaching will become more common and more severe, leading to widespread loss of coral reef ecosystems in many tropical waters worldwide. Elevated sea temperatures disrupt the symbiosis between corals and their zooxanthellae, causing the corals to expel the algae and lose their color. Repeated or prolonged bleaching events can kill corals outright, threatening one of the most biodiverse ecosystems on Earth.

49. B — Protecting the species' natural habitat from destruction and disturbance so that the population can survive and reproduce in the wild for years. Habitat preservation addresses the leading cause of biodiversity loss and supports all life-history stages of the species. The other strategies listed are either harmful or would not promote long-term population viability.

50. A — Fertilizer runoff from the farmland is adding additional nitrogen to the river, raising the dissolved nitrogen levels in the water in that area. Agricultural fertilizers contain large amounts of nitrogen compounds, which run off into nearby waterways during rain events. This nitrogen enrichment is a well-known cause of downstream eutrophication and dead zones, including the large Gulf of Mexico hypoxic zone fed by the Mississippi River basin.