

PRACTICE EXAM 18: LIFE SCIENCE: BIOLOGY SIMULATION (50 QUESTIONS)

Instructions: This simulation exam mirrors the format of the New York State Regents Examination in Life Science: Biology. Questions are organized into stimulus-based clusters. Read each cluster's stimulus completely before answering any questions in that set. Select the one best answer for each question.

Base your answers to questions 1 through 5 on the information below and on your knowledge of biology.

Living things are organized into a hierarchy of levels. At the smallest level of living organization, individual cells perform the basic functions of life. Groups of similar cells working together form tissues; groups of different tissues form organs; and groups of organs working together form organ systems that carry out major functions in the body. A single living individual is an organism. Above the level of the organism, ecologists describe populations (groups of the same species in a place), communities (multiple populations sharing a habitat), ecosystems (communities plus their nonliving environment), and the biosphere (the global system of all ecosystems on Earth).

1. The smallest unit of life is:

- A. An organ system, which is a group of organs that work together inside the body
- B. A cell, which is the basic structural and functional unit of all known living things
- C. A tissue, which is a group of similar cells with a common function in the body
- D. An organism, which is a complete living individual of any species on Earth

2. Which sequence shows the correct order of biological organization from smallest to largest?

- A. Cell → tissue → organ → organ system → organism, in increasing complexity of structure
- B. Organism → organ system → organ → tissue → cell, in decreasing complexity of structure
- C. Tissue → cell → organ → organism → organ system, in this exact order of complexity
- D. Organ → organ system → tissue → cell → organism, in this exact order of complexity

3. A group of similar cells that perform a common function is called:

- A. An organ, which is a structure made of several tissues performing a specific function
- B. An organism, which is a complete living individual capable of all life functions in nature
- C. An organ system, which is a group of organs working together as one functional unit
- D. A tissue, which is a group of similar cells working together for one common function

4. The stomach, intestines, liver, and pancreas all work together as part of which organ system?

- A. The respiratory system, which moves oxygen into and out of the body each minute
- B. The circulatory system, which transports nutrients and gases throughout the body
- C. The digestive system, which breaks down food and absorbs the released nutrients
- D. The excretory system, which removes liquid and solid waste from the body cells

5. In ecology, a population is best defined as:

- A. A group of different species living together in the same geographic area at the same time
- B. The complete set of all individuals of every species that live within one ecosystem
- C. The combination of all living and nonliving components of one specific habitat
- D. A group of individuals of the same species living in the same geographic area

Base your answers to questions 6 through 9 on the information below and on your knowledge of biology.

The human excretory system removes metabolic waste from the body and helps maintain homeostasis of water, salt, and blood pH. The kidneys are the primary excretory organs. Each kidney contains roughly one million microscopic filtering tubules called nephrons. Each nephron filters water, salts, glucose, and small waste molecules out of the blood, then selectively reabsorbs water, glucose, and useful salts back into the blood. What remains is excreted as urine. One of the most important wastes removed by the kidneys is urea, a nitrogen-containing compound formed in the liver during the breakdown of amino acids.

6. The primary organs of the human excretory system are the:

- A. Lungs, which remove oxygen from the bloodstream during the process of breathing
- B. Kidneys, which filter waste products and excess water from the blood for excretion
- C. Stomach, which removes solid waste from undigested food after the digestive process
- D. Brain, which controls the release of all hormones produced in the body's tissues

7. The functional (filtering) unit of the kidney is the:

- A. Nephron, the microscopic filtering tubule that produces urine from blood plasma
- B. Alveolus, the small air sac in the lungs where gas exchange takes place by diffusion
- C. Villus, the small finger-like projection in the small intestine that absorbs nutrients
- D. Neuron, the nerve cell that carries electrical impulses throughout the entire body

8. One of the main nitrogen-containing waste products filtered from the blood by the kidneys is:
- A. Glucose, which is fully removed from the bloodstream by the kidneys after each meal
 - B. Hemoglobin, which is filtered out of the blood after red blood cells die in circulation
 - C. Urea, which is produced by the liver during the breakdown of amino acids in the body
 - D. Oxygen, which is filtered out of the bloodstream after diffusing across the lung surface
9. The kidneys help maintain homeostasis by regulating which of the following sets of variables?
- A. Body temperature alone, by releasing heat from the bloodstream during heavy exercise
 - B. Blood pH only, with no other physiological variables being controlled by the kidneys
 - C. Blood glucose levels by storing and releasing glycogen throughout the daily cycle
 - D. Water balance, salt concentrations, and blood pH within their narrow normal ranges

Base your answers to questions 10 through 14 on the information below and on your knowledge of biology.

Plants respond to changes in their environment through directional growth responses called tropisms. A tropism is a growth toward (positive) or away from (negative) a particular stimulus. Phototropism is a growth response to light. Gravitropism is a growth response to gravity. These responses are controlled by plant hormones. The most important hormone in phototropism and gravitropism is auxin, which is produced at the tips of stems and roots. When a shoot tip is illuminated from one side, auxin accumulates on the shaded side, causing the cells there to elongate more than the cells on the lighted side. The diagram below shows a young shoot bending toward a light source.

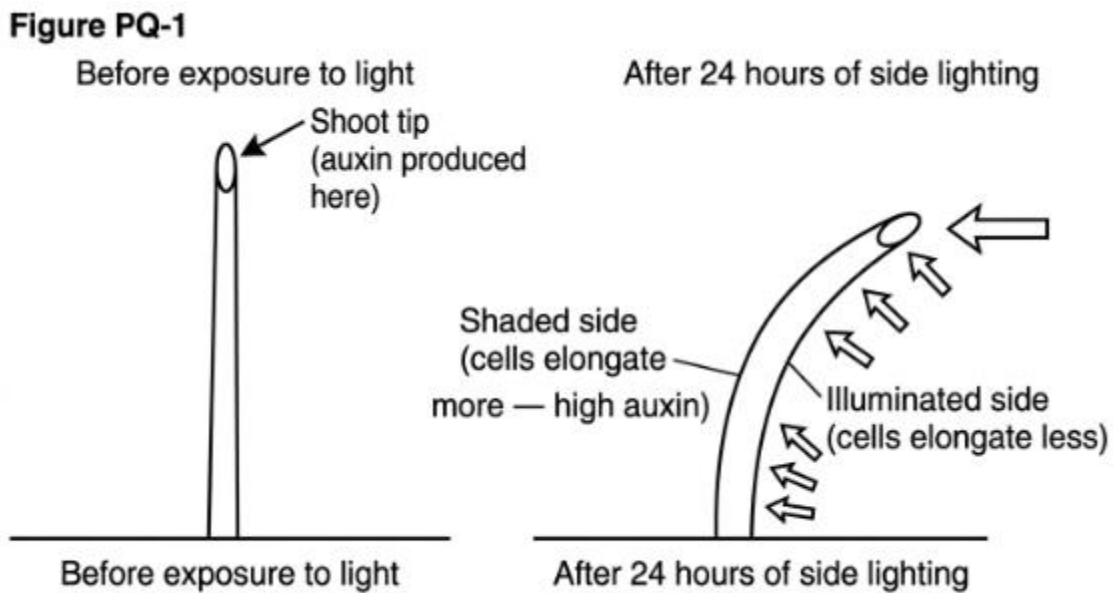


Figure PQ-1

10. A plant growing on a windowsill bends its stem toward a light source. This directional growth response is called:

- A. Phototropism, a growth response in which a plant grows toward or away from a light source
- B. Gravitropism, a growth response in which a plant grows in response to the force of gravity
- C. Thigmotropism, a growth response in which a plant grows in response to physical touch
- D. Hibernation, a state of inactivity during periods of unfavorable environmental conditions

11. Phototropism in plants is controlled primarily by a hormone called:

- A. Insulin, which lowers blood glucose levels in animals shortly after a meal is consumed
- B. Auxin, which is produced at shoot tips and causes plant cells to elongate during growth
- C. Adrenaline, which increases the heart rate and breathing rate during stress and exercise
- D. Thyroxine, which controls the metabolic rate in animals throughout the body's tissues

12. When a shoot tip is illuminated from one side, auxin moves to the shaded side of the shoot. As a result:

- A. The shaded cells produce more chlorophyll, turning the dark side a noticeably darker green
- B. The illuminated cells produce more chlorophyll, turning the bright side a darker green color
- C. The shaded cells elongate faster than the illuminated cells, bending the shoot toward the light
- D. The illuminated cells elongate faster than the shaded cells, bending the shoot away from light

13. A growing root tip placed horizontally will curve downward in response to gravity. This response is called:

- A. Positive gravitropism, in which the plant root grows in the direction of the pull of gravity
- B. Negative phototropism, in which the plant root grows away from a light source in soil
- C. Hibernation, a temporary period of inactivity during unfavorable growing conditions in roots
- D. Migration, a regular seasonal movement of an organism between two habitat regions

14. What is the main biological benefit of positive phototropism in the shoots of a plant?

- A. It allows the shoots to grow underground where the soil moisture is much more reliable
- B. It causes the shoots to grow directly away from sunlight, conserving water in dry climates
- C. It allows the plant to reproduce more often by producing more flowers in low-light environments
- D. It positions the leaves so that they can capture sunlight for photosynthesis more efficiently

Base your answers to questions 15 through 19 on the information below and on your knowledge of biology.

Bacteria are single-celled prokaryotic organisms found throughout Earth's environments. Unlike plant and animal cells, bacterial cells lack a membrane-bound nucleus and other membrane-bound organelles. Most bacteria reproduce asexually by binary fission, a process in which a single parent cell duplicates its

DNA and divides into two genetically identical daughter cells. Under favorable conditions, some bacterial species can complete binary fission in as little as 20 minutes, producing enormous populations very rapidly. This rapid reproduction also explains why bacterial populations can evolve antibiotic resistance unusually quickly.

15. Bacterial cells differ from plant and animal cells in that bacterial cells:

- A. Contain mitochondria and chloroplasts that produce ATP and store sugar within the cell
- B. Lack a membrane-bound nucleus and other membrane-bound organelles common in eukaryotes
- C. Are typically much larger than plant and animal cells in most known species of bacteria
- D. Cannot reproduce on their own and require a living host cell to make any new bacteria

16. Most bacteria reproduce asexually through the process of:

- A. Binary fission, in which a single parent cell divides into two genetically identical daughter cells
- B. Meiosis, which produces four genetically unique daughter cells from a single original parent cell
- C. Pollination, in which pollen is transferred from one organism to another to produce offspring
- D. Budding, in which the parent grows a smaller offspring as a small extension from the parent

17. A new bacterium produced by binary fission has which relationship to its parent cell?

- A. The new bacterium has half the genetic material of the parent cell, like a typical gamete
- B. The new bacterium has twice the genetic material of the parent cell, like a polyploid cell
- C. The new bacterium is genetically identical to the parent cell, like a clone of the parent
- D. The new bacterium has a randomly different genome from the parent cell, like a mutant

18. Under ideal conditions, a single bacterium can divide approximately every 20 minutes. Starting with one cell, how many bacteria will be present after 60 minutes?

- A. 2 bacteria, since the population only doubles once during the 60-minute period
- B. 4 bacteria, since the population doubles twice during the 60-minute period
- C. 6 bacteria, since one new cell appears every 20 minutes for a total of three new cells
- D. 8 bacteria, since the population doubles three times during the 60-minute period

19. The fact that bacterial populations evolve antibiotic resistance unusually quickly is most directly related to:

- A. Their ability to perform sexual reproduction much faster than other living organisms can
- B. Their very rapid reproduction rate, which produces many generations in a short period of time
- C. Their possession of multiple chloroplasts, which directly protect them against most antibiotics
- D. Their large body size, which dilutes the effective dose of any administered antibiotic drug

Base your answers to questions 20 through 24 on the information below and on your knowledge of biology.

A virus is a small infectious particle consisting of genetic material (DNA or RNA) enclosed in a protein coat called a capsid. Some viruses also have an outer envelope made of lipid membrane. Unlike living cells, viruses cannot carry out metabolism on their own and cannot reproduce without infecting a living host cell. After a virus enters a host cell, it can take over the cell's machinery to make many copies of itself. In the lytic cycle, the host cell is destroyed (lysed) as new virus particles are released. Many of the most common human infectious diseases — including the common cold, influenza, COVID-19, and chickenpox — are caused by viruses.

20. A virus is best described as:

- A. A non-living particle of genetic material (DNA or RNA) surrounded by a protein coat called a capsid
- B. A single-celled organism that lives inside the cells of other organisms as a typical parasite
- C. A complex multicellular organism that lacks all of the typical organelles of eukaryotic cells
- D. A small bacterium that has lost the ability to reproduce on its own without a suitable host

21. Viruses are considered non-living by most biologists primarily because they:

- A. Are too small to be seen with any kind of optical or electron microscope under any condition
- B. Contain no genetic material of any kind in their internal structures or outer protein coat
- C. Cannot survive outside of any host cell for any length of time under any conditions
- D. Cannot reproduce on their own and must infect a living cell in order to make more viruses

22. In the lytic cycle of viral infection, what happens to the host cell?

- A. The host cell continues to live and produces antibodies that destroy the virus particles
- B. The host cell uses the viral genetic material to its own benefit and becomes stronger overall
- C. The host cell makes new virus particles and then bursts (lyses), releasing many viruses
- D. The host cell engulfs the virus and digests it in lysosomes before any infection can occur

23. Which of the following best explains why antibiotics are not effective against viral infections?

- A. Antibiotics destroy white blood cells, preventing the body from fighting off the virus particles
- B. Antibiotics target bacterial cell structures and processes that viruses simply do not possess
- C. Antibiotics are too large to enter a host cell where the virus is reproducing inside the cell
- D. Antibiotics chemically combine with the virus and form a more aggressive new viral particle

24. Which of the following is a common viral disease in humans?

- A. Influenza (flu), which is caused by an RNA virus that infects the respiratory system tissues
- B. Strep throat, which is caused by Streptococcus bacteria infecting the throat lining tissues

- C. Tuberculosis, which is caused by *Mycobacterium tuberculosis* bacteria infecting the lungs
- D. Tetanus, which is caused by *Clostridium tetani* bacteria contaminating a deep open wound

Base your answers to questions 25 through 29 on the information below and on your knowledge of biology.

Cystic fibrosis is a genetic disorder caused by a recessive allele of the CFTR gene on chromosome 7. Because the gene is located on an autosome (not a sex chromosome), cystic fibrosis is described as an autosomal recessive disorder. Affected individuals (genotype cc) inherit one recessive allele from each parent. Heterozygous individuals (Cc) are unaffected carriers — they do not show symptoms but can pass the recessive allele to their children. Two unaffected carriers can have an affected child even when neither parent has the disease.

25. Two unaffected parents have a child diagnosed with cystic fibrosis. Which of the following is the most likely explanation?

- A. Both parents recently developed the disease themselves but did not show any symptoms yet
- B. The child inherited the disease from a grandparent who was directly carrying the trait
- C. Both parents are heterozygous carriers of the recessive allele but do not show the disease
- D. One parent has the disease while the other parent has no recessive allele at all in their DNA

26. Two carrier parents ($Cc \times Cc$) have a child. What is the probability that the child will be homozygous recessive (cc) and therefore affected by cystic fibrosis?

- A. 0%, since neither parent shows the disease and cannot pass the recessive allele to the offspring
- B. 50%, since each parent has a one-in-two chance of passing the recessive allele to the offspring
- C. 75%, since most offspring will inherit at least one recessive allele from one of the parents
- D. 25%, since each parent has a one-in-two chance of passing the recessive allele to the offspring

27. Two carrier parents ($Cc \times Cc$) have a child. What is the probability that the child will be a heterozygous carrier (Cc) but unaffected by the disease?

- A. 50%, since half of the offspring of two heterozygous carriers are themselves carriers of the allele
- B. 25%, since one in four of the offspring of two carriers are typically homozygous dominant for the trait
- C. 75%, since most offspring of two carrier parents will inherit at least one recessive allele on average
- D. 100%, since all of the offspring of two carrier parents will inherit the recessive allele from one parent

28. A pedigree of a family with cystic fibrosis shows that the disease can skip generations and appears in both females and males at roughly equal frequencies. This pattern is most consistent with:

- A. X-linked dominant inheritance, in which an affected father passes the trait to all of his daughters
- B. Autosomal recessive inheritance, in which two unaffected carriers can have affected children

- C. Autosomal dominant inheritance, in which one affected parent always has affected children
- D. Y-linked inheritance, in which the trait passes only from father to all sons but never to daughters

29. Cystic fibrosis is caused by a change in the CFTR gene that alters a single amino acid in the resulting protein. This kind of change is best classified as:

- A. A whole-chromosome duplication, in which an entire extra chromosome is added during meiosis
- B. A frameshift mutation, in which a nucleotide is added or removed from the middle of a gene
- C. A chromosomal translocation, in which segments of one chromosome attach to a different chromosome
- D. A point mutation, specifically a base substitution that changes a single amino acid in the protein

Base your answers to questions 30 through 35 on the information below and on your knowledge of biology.

Genetic drift is a change in the allele frequencies of a population caused entirely by chance rather than by natural selection. Two important types of genetic drift are the bottleneck effect and the founder effect. A bottleneck effect occurs when a population experiences a sharp reduction in size — for example, after a natural disaster — leaving a small surviving population with reduced genetic variation. A founder effect occurs when a small group of individuals leaves a larger population and establishes a new isolated colony. Genetic drift acts more strongly in small populations, where random events can change allele frequencies dramatically from one generation to the next.

30. Genetic drift is best described as:

- A. The deliberate selection of certain alleles by humans during artificial breeding programs over time
- B. The directional change in allele frequencies caused by differential survival of carriers of an allele
- C. A random change in allele frequencies due to chance events in a population over generations
- D. The constant maintenance of allele frequencies through perfect non-random mating among individuals

31. Genetic drift has the greatest effect on:

- A. Small populations, where random events can change allele frequencies significantly over generations
- B. Large populations, where the sheer number of individuals amplifies the effect of chance events strongly
- C. Populations consisting of only one sex, where reproduction cannot continue at all in any case
- D. Populations that are exactly equally divided between two competing alleles at every gene locus

32. The "bottleneck effect" is a type of genetic drift that occurs when:

- A. A new mutation suddenly appears in a single individual and rapidly spreads through the population
- B. A population is sharply reduced in size, randomly losing many of its original alleles in the process
- C. A small group of individuals leaves a larger population to establish a new colony in a new location
- D. Individuals in a population deliberately choose mates with rare alleles to balance the gene frequencies

33. The "founder effect" is a type of genetic drift that occurs when:

- A. A new mutation suddenly appears in many individuals at once across an entire large population
- B. A population is sharply reduced in size, randomly losing many of its original alleles in the process
- C. Two previously isolated populations merge into a single combined population in a new habitat area
- D. A small group of individuals leaves a larger population to establish a new colony in a new location

34. The modern cheetah population shows very low genetic diversity throughout its range. This is most likely the result of:

- A. A historical population bottleneck that drastically reduced the species' overall genetic variation
- B. Strong natural selection favoring the loss of genetic variation in modern cheetahs over recent time
- C. Random mating between members of completely unrelated species in the wild today on the savanna
- D. The recent appearance of many new mutations that quickly overwhelmed older genetic diversity

35. Low genetic diversity in a population is concerning to conservation biologists because:

- A. Low diversity always increases the population's ability to adapt to future environmental change
- B. Low diversity increases the carrying capacity of the environment for that species over time
- C. Low diversity reduces the population's ability to adapt to new diseases and environmental change
- D. Low diversity speeds up the rate at which beneficial mutations are introduced into the gene pool

Base your answers to questions 36 through 40 on the information below and on your knowledge of biology.

Water moves continuously between Earth's oceans, atmosphere, land, and living organisms in a global cycle. Solar energy drives evaporation of water from oceans, lakes, and soil into the atmosphere. Plants release additional water vapor to the atmosphere through transpiration. In the atmosphere, water vapor cools and condenses into clouds, then returns to Earth's surface as precipitation (rain, snow, sleet, or hail). Water that falls onto the land may flow over the surface as runoff into streams and lakes, or soak into the soil through infiltration to become groundwater. The diagram below summarizes the main processes of the global water cycle.

Figure PQ-2

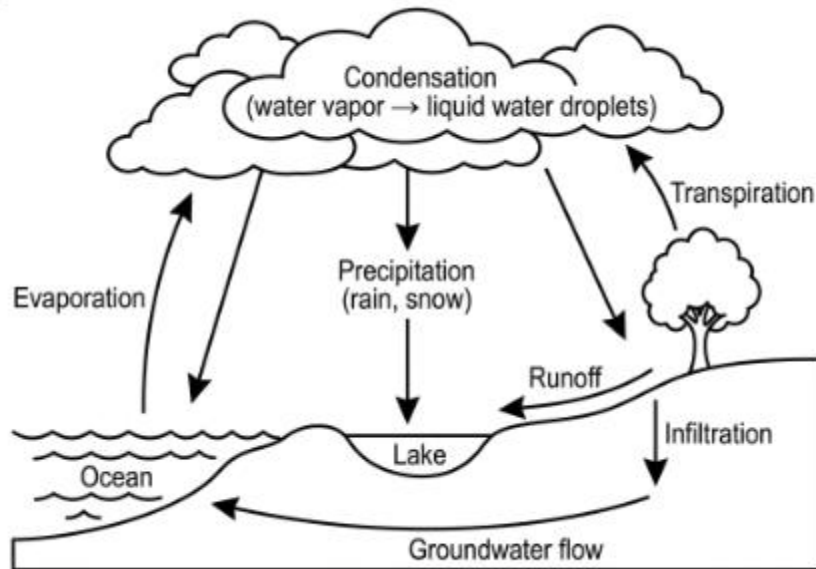


Figure PQ-2

36. Which process moves water from Earth's surface (oceans, lakes, soil) into the atmosphere?
- A. Condensation, in which water vapor cools and changes back into liquid water in the air
 - B. Evaporation, in which liquid water absorbs energy and changes into water vapor in the air
 - C. Precipitation, in which water in clouds falls to Earth as rain, snow, sleet, or hail
 - D. Infiltration, in which water on the surface of the soil moves down into the ground below
37. The process by which plants release water vapor through pores in their leaves is called:
- A. Photosynthesis, in which plants produce glucose from carbon dioxide and water in the leaves
 - B. Respiration, in which plants release energy stored in glucose for the cell's various activities
 - C. Condensation, in which water vapor cools and changes back into liquid water in the air above
 - D. Transpiration, in which plants release water vapor through small pores on the leaf surface
38. Water vapor in the atmosphere returns to the surface of the Earth mainly through:
- A. Transpiration, when plants release additional water vapor through pores in their leaf surfaces
 - B. Evaporation, when energy from the sun converts liquid water into more water vapor in the air
 - C. Precipitation, when water in clouds falls back to Earth's surface as rain, snow, sleet, or hail
 - D. Decomposition, when bacteria release water as they break down dead organisms in forest soil
39. When precipitation falls and then moves over the surface of the land instead of soaking into the soil, the process is called:
- A. Runoff, which can carry sediment, dissolved nutrients, and pollutants into nearby streams and lakes
 - B. Infiltration, in which water moves downward through the soil to reach the groundwater table below
 - C. Condensation, in which water vapor cools and forms small liquid water droplets inside the clouds
 - D. Photosynthesis, in which water molecules combine with carbon dioxide inside plant leaves directly

40. Why is the water cycle considered a closed system on a global scale?

- A. Water is constantly being created by chemical reactions occurring in the upper atmosphere of Earth
- B. The total amount of water on Earth remains nearly constant; it is continuously cycled, not destroyed
- C. Water is regularly delivered to Earth from comets and meteorites that strike the planet's surface
- D. Water is destroyed when it evaporates and is then recreated by photosynthesis in plant leaves

Base your answers to questions 41 through 45 on the information below and on your knowledge of biology.

A niche is the role and resource use of a species within its ecosystem, including how it interacts with both living and nonliving components of the environment. According to the competitive exclusion principle, two species cannot occupy exactly the same niche in the same place for an extended time — eventually one will outcompete the other or one will shift its niche slightly. When two similar species coexist, they often divide shared resources in different ways through a process called resource partitioning. Some species are generalists, using a wide variety of resources, while others are specialists, using only a narrow range of resources. Specialist species are typically more vulnerable to environmental change than generalist species.

41. An organism's niche is best defined as:

- A. The geographic area in which a species is naturally found within its larger habitat range
- B. The total population of one species in a single specific habitat within an ecosystem in the wild
- C. The community of all species that share a single habitat with one another within an ecosystem
- D. The role and resource use of a species in its ecosystem, including its interactions with others

42. The "competitive exclusion principle" states that:

- A. Two species cannot occupy exactly the same niche in the same place for an extended period of time
- B. Two species that occupy the same niche will always cooperate to share the available resources fairly
- C. Two species that have very similar niches must merge into a single new species over many years
- D. Two species can occupy the same niche indefinitely whenever the available resources are abundant

43. When two species that use overlapping resources evolve slightly different specializations over time, the pattern is best described as:

- A. Mutualism, in which both species benefit by sharing the same resources in the same niche over time
- B. Mimicry, in which one species closely resembles another species to gain a survival advantage
- C. Resource partitioning, in which species divide a shared resource in ways that reduce competition
- D. Parasitism, in which one species lives on or in another species and harms it during the interaction

44. A "specialist" species is best described as one that:

- A. Eats a very wide variety of food types and can live in many different habitat types successfully
- B. Has very specific food and habitat requirements and is sensitive to environmental change in its niche
- C. Reproduces only one time in its lifetime and then dies of old age soon after producing offspring
- D. Has only a single living individual representing the entire species in nature on Earth today

45. Which of the following is most likely to be more vulnerable to habitat destruction in its environment?

- A. A generalist species, which can use many different food sources in many different types of habitats
- B. A widely distributed species, which has populations established on multiple continents at the same time
- C. A long-lived species, which can wait out short-term disturbances and then resume reproduction later
- D. A specialist species, which depends on a narrow range of food sources in one specific type of habitat

Base your answers to questions 46 through 50 on the information below and on your knowledge of biology.

Recombinant DNA technology is a set of laboratory techniques used to combine DNA from different sources into a single molecule. Specific restriction enzymes are used to cut DNA at recognition sequences, isolating the desired gene. The gene is then inserted into a carrier (often a plasmid) and introduced into a host organism — often a bacterium. The host then expresses the new gene, producing the protein encoded by it. Recombinant DNA technology is now used to produce human insulin from bacteria, to develop genetically modified crops, and to make a wide variety of medical and industrial products. The technology raises important ethical, ecological, and regulatory questions.

46. Recombinant DNA technology is best described as:

- A. The natural process by which DNA is exchanged between homologous chromosomes during meiosis
- B. The process by which mutations occur spontaneously during the normal replication of DNA in cells
- C. A set of laboratory techniques in which DNA from different sources is combined into one molecule
- D. The natural transfer of DNA from a parent cell to a daughter cell during the process of mitosis

47. Restriction enzymes are used in genetic engineering to:

- A. Cut DNA at specific recognition sequences, allowing the desired DNA segment to be isolated
- B. Synthesize complete copies of any DNA sequence quickly and without using any template strand
- C. Translate DNA sequences directly into proteins without going through any mRNA intermediate
- D. Repair all damaged DNA inside cells, preventing any mutations from being passed to offspring

48. One important medical application of recombinant DNA technology is:

- A. The production of synthetic atoms that do not occur naturally anywhere on Earth's surface
- B. The production of human insulin by genetically engineered bacteria for use in treating diabetes
- C. The complete elimination of all bacteria from human bodies and the surrounding environment
- D. The deliberate creation of new chemical elements through nuclear reactions in the laboratory

49. Which of the following is a possible concern about the use of genetically modified organisms (GMOs) in agriculture?

- A. GMOs cannot reproduce, so they must be created fresh in laboratories every growing season
- B. GMOs contain only artificial sequences that no naturally occurring organism could ever possess
- C. GMOs always produce toxic substances that are harmful to humans within the first generation
- D. GMO traits could spread to wild populations and could affect non-target organisms in ecosystems

50. When evaluating the trade-offs of genetic engineering applications, scientists and policy makers must consider:

- A. Only the cost of producing the modified organism in U.S. dollars during the first year of use
- B. Only the number of new species that can be created by the new genetic technology each year
- C. Effectiveness, safety, ecological impact, ethical concerns, and long-term consequences for society
- D. Only the visual appearance of the genetically modified organism as observed in laboratory experiments

Practice Exam 18 – Full Explained Answer Key

1. B — The cell is the smallest unit that can carry out all the basic functions of life, including metabolism, growth, and reproduction. Tissues, organs, and organ systems are progressively larger arrangements of cooperating cells. This is a central tenet of cell theory.

2. A — Biological organization scales upward from cells, which combine into tissues, which form organs, which work together as organ systems, which together make up the organism. Each level is built from the structures of the level below it. Recognizing this hierarchy is fundamental to understanding how the body functions.

3. D — A tissue is by definition a group of similar cells working together to perform a common function — examples include epithelial, connective, muscle, and nervous tissue. Tissues are the building blocks of organs. The defining feature is the cooperation of similar cells.

4. C — The stomach, small and large intestines, liver, and pancreas all participate in breaking down food and absorbing nutrients, which is the defining function of the digestive system. Each organ performs a distinct step in this overall process. Together they form an integrated digestive organ system.

5. D — A population in ecology consists of all the individuals of a single species living in a defined geographic area at the same time. Multiple populations make up a community. This species-and-place definition is the starting point for population ecology.

- 6. B** — The kidneys are the primary excretory organs; they filter blood plasma to remove water, salts, urea, and other dissolved wastes, producing urine. Other organs participate (lungs exhale CO₂, skin sweats) but the kidneys handle the bulk of nitrogenous waste. They are also the chief regulators of blood composition.
- 7. A** — A nephron is the microscopic filtering tubule that performs the kidney's actual work; each kidney contains roughly a million nephrons. Filtration, reabsorption, and secretion all occur along its length. Identifying the nephron as the functional unit is essential for understanding renal physiology.
- 8. C** — Urea is the principal nitrogen-containing waste produced by the liver during amino acid breakdown and is excreted in the urine after filtration through the kidneys. Hemoglobin, glucose, and oxygen are not normal urinary wastes in a healthy individual. Urea levels in blood are a routine indicator of kidney function.
- 9. D** — Beyond removing wastes, the kidneys actively regulate the body's water content, salt concentrations, and acid–base balance by varying how much water, sodium, and bicarbonate are reabsorbed or excreted. This makes them central to homeostasis well beyond simple waste removal. Kidney failure disrupts each of these variables.
- 10. A** — Phototropism is the directional growth response of a plant to a light source — typically positive in shoots, which grow toward the light. The response depends on differential cell elongation across the stem. This is the textbook example of a plant tropism.
- 11. B** — Auxin (indole-3-acetic acid) is the plant hormone produced at shoot tips that stimulates elongation of the cells in the zone just below the tip. Differences in auxin distribution drive the bending response. It is also central to apical dominance and several other growth responses.
- 12. C** — Light causes auxin to redistribute laterally toward the shaded side of the shoot; the higher auxin concentration there makes those cells elongate faster than the cells on the lighted side. The asymmetric elongation bends the shoot toward the light. This is the classic Cholodny-Went explanation of phototropism.
- 13. A** — Positive gravitropism is growth in the direction of gravity; plant roots respond this way so they grow downward into the soil to reach water and anchor the plant. Shoots, in contrast, show negative gravitropism by growing upward. Both responses involve auxin redistribution in response to gravity.
- 14. D** — By bending shoots toward the light, phototropism positions the leaves to intercept more sunlight, increasing photosynthetic energy capture. More light absorbed means more glucose produced. This adaptive advantage explains why phototropism is so widespread among plants.
- 15. B** — Bacteria are prokaryotes; their DNA sits free in the cytoplasm in a nucleoid region, and they lack the membrane-bound nucleus, mitochondria, chloroplasts, ER, and Golgi found in eukaryotic cells. This is the defining structural distinction between prokaryotes and eukaryotes. The absence of these organelles is fundamental to all bacterial biology.

16. A — Binary fission is the asexual reproductive process used by bacteria: the cell replicates its single circular chromosome, elongates, and divides into two daughter cells. The two daughters are genetically identical to the parent. This simple division allows extremely rapid population growth under favorable conditions.

17. C — Because binary fission involves only DNA replication followed by division — with no mixing of genomes from two parents — the daughter cells are clones of the parent. Variation arises mainly from later mutations or horizontal gene transfer. The clonal nature of binary fission is essential for understanding bacterial evolution.

18. D — A 20-minute doubling time means three doublings in 60 minutes: $1 \rightarrow 2 \rightarrow 4 \rightarrow 8$ cells. Each interval doubles the population, so the formula is $N = 1 \times 2^3 = 8$. This kind of geometric growth is why bacterial populations can become enormous very quickly.

19. B — Because bacterial generations may be only minutes long, many divisions occur in a short period, giving natural selection many opportunities to act on resistance mutations that already exist or that arise. The result is that resistant strains can dominate a population very rapidly under antibiotic pressure. This rapid generation time is the central biological reason for the antibiotic-resistance crisis.

20. A — A virus is a tiny infectious particle made of genetic material — either DNA or RNA — enclosed in a protein coat called a capsid (some viruses also have a lipid envelope). It is not a cell. This minimal architecture distinguishes viruses from all forms of cellular life.

21. D — Viruses lack the machinery of cellular metabolism and cannot make copies of themselves; they can replicate only by commandeering the synthetic apparatus of a host cell. This dependence is the main reason most biologists exclude viruses from the category of living organisms. It also explains why antiviral therapy is so much harder than antibacterial therapy.

22. C — In the lytic cycle, viral genes hijack the host's machinery to make new viral genomes and capsid proteins; the newly assembled viruses then rupture (lyse) the host cell as they are released. The host cell is destroyed. This is the cycle responsible for many acute viral illnesses.

23. B — Antibiotics work by disrupting bacterial structures and processes — cell-wall synthesis, ribosomal protein synthesis, folate metabolism — that viruses simply do not have, because viruses are not cells and rely entirely on host machinery instead. Antiviral drugs require different targets, such as viral enzymes or surface proteins. Misuse of antibiotics for viral illnesses fuels antibiotic resistance.

24. A — Influenza is caused by an RNA virus (the influenza virus) that infects the cells lining the respiratory tract. Strep throat, tuberculosis, and tetanus are all caused by bacteria. Distinguishing viral from bacterial causes is essential for choosing appropriate treatment.

25. C — Cystic fibrosis is autosomal recessive: a child can be affected only if both parents pass on the recessive allele, which means each unaffected parent must be a heterozygous carrier (Cc). Carriers show no symptoms because their dominant allele produces enough functional protein. This is a classic illustration of recessive inheritance from carrier parents.

26. D — A Punnett square for $Cc \times Cc$ gives 1 CC : 2 Cc : 1 cc — so 25 percent of offspring are expected to be cc (affected). Each parent has a 50 percent chance of transmitting the recessive allele, and the joint probability is $0.5 \times 0.5 = 0.25$. This 1-in-4 ratio is the hallmark outcome of a heterozygote \times heterozygote cross.

27. A — From the same $Cc \times Cc$ Punnett square, two of the four outcomes are Cc , giving 50 percent heterozygous (carrier but unaffected) offspring. This is why most children of carrier parents end up as unaffected carriers themselves. It also explains how the allele persists hidden in families.

28. B — Autosomal recessive disorders typically skip generations (because carriers are unaffected) and appear with roughly equal frequency in females and males because the gene is on an autosome rather than a sex chromosome. X-linked, Y-linked, and dominant patterns each produce different telltale features. Recognizing this combination of clues is the standard way to identify autosomal recessive inheritance.

29. D — A point mutation is a change at a single nucleotide; a base substitution specifically replaces one base with another, which can change one codon and therefore one amino acid in the resulting protein (a missense mutation). The most common cystic fibrosis allele, $\Delta F508$, is a small deletion but the broader class of single-nucleotide changes belongs to point mutations. Recognizing the substitution category is core mutation-classification knowledge.

30. C — Genetic drift is the random fluctuation of allele frequencies from one generation to the next caused by chance events in finite populations, independent of fitness. It contrasts with natural selection, which acts on differences in survival and reproduction. Drift is one of the four major mechanisms of evolution.

31. A — In small populations, chance events can dramatically alter allele frequencies in a single generation because each individual represents a larger share of the gene pool. In large populations the same chance events are statistically averaged out. This is why drift is most evident on islands, in endangered species, and in small isolates.

32. B — A bottleneck effect occurs when a population undergoes a sharp size reduction (from disaster, disease, or hunting), and the surviving subset carries only a sample of the original alleles. The post-bottleneck population is genetically depleted relative to the original. Northern elephant seals and northern cheetahs are classic real-world examples.

33. D — A founder effect occurs when a small group of individuals leaves a parent population to establish a new colony, taking with them only a subset of the original allele frequencies — and possibly some rare alleles in high frequency. The new population's gene pool reflects the founders, not the source. Several human populations (e.g., the Amish for certain genetic conditions) illustrate the founder effect.

34. A — Cheetah populations across Africa show remarkably uniform DNA, consistent with one or more historical bottleneck events — possibly during the late Pleistocene — that drastically reduced their numbers and genetic variation. The species has never recovered the diversity lost in those events. This makes the modern population especially vulnerable to disease and environmental change.

35. C — Genetic variation is the raw material for adaptation; populations with low diversity have fewer allele combinations available to respond to new pathogens, climate shifts, or other selective pressures. Reduced adaptive potential increases extinction risk. Maintaining genetic diversity is therefore a central goal of conservation biology.

36. B — Evaporation is the phase change from liquid water to water vapor driven by solar energy at the surface of oceans, lakes, soils, and other water bodies. It is the main mechanism that moves water from Earth's surface into the atmosphere. Without evaporation, the rest of the water cycle could not proceed.

37. D — Transpiration is the release of water vapor from plants, primarily through stomata on the undersides of leaves. It accounts for a substantial fraction of atmospheric water vapor over land. Together with evaporation, it is sometimes called "evapotranspiration."

38. C — Once water vapor cools and condenses into clouds, it returns to the surface as precipitation — rain, snow, sleet, or hail — depending on temperature and atmospheric conditions. Precipitation is the only major pathway by which atmospheric water reaches the land and oceans again. It is the major surface-water input that drives runoff and infiltration.

39. A — Runoff is the portion of precipitation that flows across the land surface to streams, rivers, lakes, and ultimately the ocean rather than infiltrating the soil. It transports sediment, nutrients, and pollutants, sometimes causing erosion and water quality problems. Managing runoff is central to stormwater engineering and watershed protection.

40. B — The hydrologic cycle is essentially closed at the planetary scale: water molecules are continually recycled among reservoirs but their total amount on Earth changes only negligibly. No significant new water is created or destroyed by the cycle. This conservation explains why pollution and overuse in one place ultimately affect water elsewhere.

41. D — An ecological niche encompasses everything a species does in its environment — what it eats, where it lives, how it reproduces, and how it interacts with other species and abiotic factors. The niche is the species' role, not just its address. Distinguishing niche from habitat is a core ecological concept.

42. A — The competitive exclusion principle, often attributed to Gause, states that two species cannot indefinitely occupy identical niches in the same place because one will outcompete the other or one must change. Coexistence requires niche differentiation. This principle organizes much of community ecology.

43. C — Resource partitioning is the evolutionary outcome by which competing species divide a shared resource — by time of day, feeding location, prey size, or other dimensions — so that direct competition is reduced. It allows similar species to coexist by occupying slightly different niches. MacArthur's warblers in spruce trees are a textbook example.

44. B — A specialist species has narrow ecological requirements — specific foods, specific habitats, specific climatic conditions — and therefore tends to be sensitive to environmental change. Generalists, by contrast, tolerate a wider range of conditions. Specialization is often a successful strategy in stable environments but risky in changing ones.

45. D — Because specialists depend on a narrow set of resources or conditions, the loss of even part of their habitat or food supply can drive them toward local extinction. Generalists can usually shift to alternative resources. This is why specialists (such as the koala or giant panda) figure so prominently among species of conservation concern.

46. C — Recombinant DNA technology refers to laboratory techniques that join DNA segments from two or more different sources — different organisms or species — into a single new DNA molecule. The combined molecule can then be replicated and expressed in a host. This concept underlies most modern biotechnology applications.

47. A — Restriction enzymes (restriction endonucleases) are bacterial proteins that recognize specific short DNA sequences and cut the DNA at or near those sites, often leaving "sticky ends" that facilitate joining to other DNA cut by the same enzyme. They are the molecular scissors of genetic engineering. Their discovery made recombinant DNA technology practical.

48. B — Human insulin produced by genetically engineered *E. coli* and yeast was one of the first major medical applications of recombinant DNA technology and now supplies essentially the entire global insulin market. The technology replaced animal-derived insulin with a human-identical product. This is a benchmark example of recombinant biology benefitting medicine.

49. D — One major concern with GMOs in agriculture is gene flow: engineered traits — herbicide resistance, insecticidal proteins, or others — can spread to wild relatives through pollination or escape, and may also affect non-target organisms in the surrounding ecosystem. Such ecological side effects are central to GMO regulation. The risk is one of several factors weighed against the technology's benefits.

50. C — Responsible evaluation of any genetic engineering application requires weighing how well it works (effectiveness), whether it is safe for humans and ecosystems, its environmental impact, the ethical issues it raises, and its long-term consequences. Optimizing any single factor ignores the rest. This kind of multidimensional analysis is central to bioethics and science policy.