PRACTICE EXAM 29: 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.

All animal cells maintain a high concentration of potassium ions (K^+) inside the cell and a high concentration of sodium ions (Na^+) outside the cell. This unequal distribution is maintained by a membrane protein called the sodium-potassium pump. The pump uses energy from ATP to move 3 Na^+ ions out of the cell and 2 K^+ ions into the cell with each cycle, against their concentration gradients. The resulting concentration difference is essential for many cellular processes, including the transmission of nerve impulses and the maintenance of cell volume.

1. The sodium-potassium pump moves ions against their concentration gradients. This process is best classified as:

A. Diffusion, in which molecules move down a concentration gradient through the cell membrane
B. Osmosis, in which water moves across a selectively permeable membrane to balance solute levels
C. Active transport, in which energy from ATP is used to move ions against a concentration gradient
D. Endocytosis, in which the cell membrane folds inward to bring large materials into the cell

2. The energy required by the sodium-potassium pump comes from:

A. Heat absorbed from the surrounding environment that surrounds the cell
B. Light energy captured by chlorophyll molecules located within the cell
C. Electrical energy generated by lightning in the surrounding atmosphere
D. ATP molecules produced primarily by the mitochondria of the cell

3. If a cell's ATP supply were severely reduced, what would most likely happen to the sodium-potassium pump?

A. The pump would speed up to compensate for the lack of available ATP for cellular work
B. The pump would slow down or stop, allowing ion concentrations to equalize over time
C. The pump would change shape to no longer require ATP for its function in the membrane
D. The pump would reverse direction and create a larger concentration gradient than normal

4. The high concentration of K^+ inside cells and Na^+ outside cells is especially important for:

A. The transmission of nerve impulses along the membranes of neurons in the body
B. The synthesis of glucose during the process of photosynthesis in plant cells
C. The breakdown of fats and proteins inside the digestive system of the human body
D. The duplication of DNA before the cell undergoes mitotic cell division

5. A cell that has been treated with a chemical that completely blocks the sodium-potassium pump would most likely:

A. Maintain its normal ion concentrations because the pump is not actually required
B. Increase its rate of cellular respiration to compensate for the loss of the pump
C. Begin producing new sodium-potassium pumps within seconds to replace the blocked pumps
D. Eventually lose the ion concentration differences across its membrane and stop functioning normally

Base your answers to questions 6 through 10 on the information below and on your knowledge of biology.

An enzyme inhibitor is a chemical that decreases enzyme activity. Inhibitors can be reversible (binding loosely and releasing the enzyme later) or irreversible (binding permanently or chemically modifying the enzyme so it can never function again). Researchers tested an enzyme with two different inhibitors. Inhibitor X reduced enzyme activity by 80%, but when the inhibitor was washed away by dialysis, enzyme activity returned to normal. Inhibitor Y also reduced activity by 80%, but when Inhibitor Y was washed away by dialysis, activity did not return.

6. Based on the results, Inhibitor X is best classified as:

A. An irreversible inhibitor, since it permanently damages the active site of the enzyme
B. A substrate, since it is broken down by the enzyme during the reaction tested
C. A reversible inhibitor, since enzyme activity returned after the inhibitor was removed
D. A coenzyme, since it activates the enzyme rather than slowing it down at any time

7. Inhibitor Y is best classified as:

A. An irreversible inhibitor, since enzyme activity did not return after the inhibitor was removed
B. A reversible inhibitor, since the enzyme can recover its function later in the experiment

C. A coenzyme, since it increases the enzyme's normal rate of catalytic activity
D. A substrate, since it is converted into product during the enzyme-catalyzed reaction

8. Many drugs and poisons act as enzyme inhibitors. An irreversible inhibitor like Inhibitor Y is sometimes a particularly serious health concern because:

A. The body can easily wash away irreversible inhibitors through urination after exposure
B. The enzyme cannot recover until the cell makes new enzyme molecules through translation
C. Irreversible inhibitors only affect bacterial enzymes, not human enzymes in the body
D. Irreversible inhibitors increase enzyme activity in human cells exposed to them

9. Aspirin is a drug that irreversibly inhibits an enzyme involved in inflammation. This means that:

A. Aspirin's effect wears off as soon as the patient takes a small amount of water
B. The enzyme can return to its normal function within minutes of aspirin exposure
C. The body must wait for the inhibitor to be metabolized by the liver before any effect
D. The body must produce new enzyme molecules to restore the enzyme's normal function

10. A reversible inhibitor's effect on an enzyme can be reduced by:

A. Heating the solution to a very high temperature so that the inhibitor evaporates
B. Adding more of the inhibitor to the reaction mixture so that the enzyme works again
C. Removing the inhibitor from the reaction mixture, allowing the enzyme to function again
D. Lowering the temperature of the solution to slow down the rate of the reaction

Base your answers to questions 11 through 15 on the information below and on your knowledge of biology.

Students investigated how young plant roots respond to gravity. They germinated bean seeds and placed them in different orientations inside clear plastic boxes lined with damp paper. In some boxes, the seeds were oriented so that the root pointed downward; in others, the root pointed upward, sideways, or at an angle. After 3 days, students observed how each root had grown. In every case, regardless of the initial orientation, the roots had grown downward.

11. The downward growth of the roots in response to gravity is called:

A. Phototropism, the response of a plant to the direction of a light source
B. Gravitropism (also called geotropism), the response of a plant to the force of gravity
C. Thigmotropism, the response of a plant to physical contact with another object
D. Hydrotropism, the response of a plant to the presence of nearby water sources

12. Gravitropism in roots is described as a "positive" gravitropic response because:

A. Roots grow in the same direction as the force of gravity (downward into the soil)
B. Roots grow in the opposite direction of the force of gravity (upward into the air)
C. Roots grow perpendicular to the direction of the force of gravity (horizontally)
D. Roots grow at a 45-degree angle to the direction of the force of gravity at all times

13. Plant stems show a "negative" gravitropic response, meaning that they:

A. Grow horizontally regardless of the direction of the force of gravity in the ground
B. Grow in the same direction as the force of gravity, downward into the soil below
C. Grow in the opposite direction of gravity, upward away from the soil's surface
D. Grow randomly in any direction without responding to gravity at all

14. Like phototropism, gravitropism is mediated by the plant hormone:

A. Insulin, which regulates the concentration of sugars in the plant's phloem tissue
B. Adrenaline, which causes the plant to grow rapidly in response to environmental stress
C. Estrogen, which controls the timing of flower production in many flowering plants
D. Auxin, which causes differential growth of cells on different sides of the stem or root

15. Gravitropism is adaptive for plants because:

A. Roots growing downward find water and minerals in the soil, while stems growing upward find sunlight
B. Roots growing upward find the sunlight needed to perform photosynthesis efficiently
C. Stems growing downward avoid the harsh sunlight that could damage plant tissues
D. The downward growth of roots prevents the plant from being eaten by herbivorous animals

Base your answers to questions 16 through 19 on the information below and on your knowledge of biology.

Muscle contraction requires energy supplied directly by ATP. Inside muscle cells, two protein filaments — actin and myosin — slide past each other to shorten the muscle fiber. The myosin protein attaches to the actin, pulls it inward using energy from ATP, then releases and reattaches to repeat the cycle. Each cycle requires the hydrolysis of one ATP molecule. Without ATP, the myosin cannot release from actin, causing muscles to lock in a contracted position (this is what causes the stiffening called rigor mortis after death). Muscle cells produce ATP through cellular respiration in their many mitochondria.

16. The energy used by muscle cells to contract comes directly from:

A. Glucose molecules absorbed from the bloodstream into the muscle cell
B. ATP molecules produced by cellular respiration in the muscle cell

C. Oxygen molecules transported by red blood cells in the bloodstream
D. Sunlight energy captured by the muscle cells during daylight hours

17. Muscle contraction occurs when:

A. Actin and myosin filaments completely separate from each other and float free in the cell
B. Actin filaments break down into individual amino acids inside the muscle cell during contraction
C. The muscle cell takes in extra calcium ions from the surrounding tissue fluid only
D. Myosin attaches to actin and pulls it inward using energy released from ATP

18. After death, muscles stiffen into a contracted position (rigor mortis) because:

A. ATP production stops and myosin cannot release from actin without ATP being available
B. Calcium ions immediately leave the muscle cells and prevent any further contraction
C. The muscles continue contracting indefinitely without ATP being available in the cells
D. The brain stops sending signals, causing all of the muscles to relax completely at first

19. Muscle cells contain many mitochondria because:

A. Mitochondria help muscle cells absorb the nutrients they need from the bloodstream
B. Mitochondria store the calcium ions needed for muscle contractions to start and stop
C. Mitochondria contain the actin and myosin proteins needed for muscle contraction directly
D. Mitochondria produce the ATP needed to power the high energy demands of muscle contraction

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

DNA fingerprinting is a technique that uses variations in DNA sequence to identify individuals. Each person (except identical twins) has a unique pattern of DNA repeats at certain locations in the genome. To create a DNA fingerprint, a DNA sample is cut into fragments using special enzymes, and the fragments are separated by size using gel electrophoresis. In gel electrophoresis, DNA fragments are placed in a gel and an electric current is applied. Because DNA is negatively charged, fragments move toward the positive electrode. Smaller fragments move faster through the gel than larger fragments, creating a pattern of bands that can be compared between samples. DNA fingerprinting is used in criminal investigations, paternity testing, and identification of human remains.

20. DNA fragments in gel electrophoresis move toward the positive electrode because:

A. DNA molecules contain a positive electrical charge that is attracted to the negative pole
B. DNA molecules contain a negative electrical charge due to their phosphate backbone
C. DNA molecules are heated by the electric current and travel away from the heat source
D. DNA molecules are dissolved by the gel and move randomly in all directions

21. During gel electrophoresis, smaller DNA fragments:

A. Move more slowly than larger fragments because they have less inertia overall
B. Stop moving entirely after only a short distance through the gel material
C. Move faster than larger fragments because they can pass more easily through the gel pores
D. Move in the opposite direction of larger fragments due to differences in their charge

22. DNA fingerprinting can identify individuals because:

A. All humans have identical DNA sequences except for the genes affecting eye color only
B. DNA fragments produced from any sample always result in the same number of bands
C. Identical twins have completely different DNA sequences from each other in the womb
D. Each person (except identical twins) has a unique pattern of DNA sequence variations

23. In a criminal investigation, DNA from a crime scene is compared with DNA from a suspect. A "match" between the two DNA fingerprints suggests that:

A. The two samples likely came from the same person or, very rarely, from identical twins
B. The two samples came from people who are genetically unrelated to each other
C. The samples must be from completely different individuals with no shared DNA at all
D. The DNA in one of the samples was damaged in the laboratory before testing

24. Paternity testing using DNA fingerprinting works because:

A. The mother and father always produce children with identical DNA fingerprints to their own
B. A child's DNA bands should match bands found in both the biological mother and biological father
C. Only the biological father contributes any DNA bands to a child's genetic fingerprint pattern
D. The mother and father have completely identical DNA fingerprints that combine in their child

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

A karyotype is a visual display of all the chromosomes of an individual, arranged in pairs by size and shape. A normal human karyotype shows 46 chromosomes in 23 pairs: 22 pairs of autosomes plus one pair of sex chromosomes (XX in females, XY in males). Sometimes, errors in cell division during meiosis (called nondisjunction) cause an individual to have an extra or missing chromosome. Down syndrome is caused by the presence of an extra copy of chromosome 21, resulting in three copies of chromosome 21 instead of the usual two. People with Down syndrome typically have 47 chromosomes total. This condition is also called "trisomy 21" because it involves three copies of chromosome 21.

25. A normal human body cell contains how many chromosomes?

A. 23 chromosomes, in 11 pairs of autosomes plus a single sex chromosome
B. 24 chromosomes, arranged in 12 pairs of autosomes and sex chromosomes
C. 46 chromosomes, in 22 pairs of autosomes plus one pair of sex chromosomes
D. 92 chromosomes, in 46 pairs of various autosomes and sex chromosomes

26. A person with Down syndrome has 47 chromosomes because of:

A. An extra copy of chromosome 21, resulting from nondisjunction during meiosis
B. A missing chromosome 21, leaving only one copy of that chromosome in the cell
C. A deletion of part of chromosome 21 during DNA replication in the parent's cell
D. A point mutation in the DNA sequence of chromosome 21 of the parent

27. Nondisjunction is the failure of chromosomes to separate properly during:

A. Mitosis only, since meiosis correctly separates chromosomes in every case
B. Fertilization, when the sperm cell joins with the egg cell of the parents
C. DNA replication, during which the DNA molecules are copied before cell division
D. Meiosis, when homologous chromosomes or sister chromatids fail to separate

28. A female human's karyotype would show which combination of sex chromosomes?

A. One X chromosome and one Y chromosome arranged together as a pair
B. Two X chromosomes arranged together as a pair in the karyotype display
C. Two Y chromosomes arranged together as a pair in the karyotype display
D. No sex chromosomes, just 22 pairs of autosomes in the karyotype

29. A karyotype is most useful for:

A. Identifying the exact sequence of every nucleotide in a person's entire genome
B. Determining the exact protein sequence produced from each gene in the body
C. Detecting changes in chromosome number or large changes in chromosome structure
D. Determining whether a particular gene is dominant or recessive in inheritance

Base your answers to questions 30 through 36 on the information below and on your knowledge of biology.

Coevolution is the process by which two species each evolve in response to the other over time. Classic examples include flowering plants and their pollinators, predators and prey, and parasites and their hosts. For example, certain orchid species have evolved long, narrow flower tubes that can only be reached by a particular moth species with a very long tongue. The moth, in turn, has evolved its long tongue specifically to feed on the nectar of these flowers. Each species exerts selective pressure on the other, and the two evolve in tandem. Coevolution often produces highly specialized relationships, but it can also lead to "evolutionary arms races" between predators and prey or between parasites and hosts.

30. An "evolutionary arms race" between predator and prey species refers to:

A. Reciprocal evolutionary adaptations in both species over time, as each evolves in response to the other
B. The use of weapons by predators to hunt prey species in their natural environments
C. The introduction of new species into ecosystems where they have no natural predators
D. The deliberate breeding of stronger predators by humans to control prey populations

31. The orchid with a long flower tube and the moth with a long tongue are an example of:

A. Convergent evolution, in which two unrelated species independently develop similar physical traits
B. Coevolution, in which two species each evolve in response to changes in the other species
C. Sexual selection, in which mate choice drives changes in physical traits of one sex over generations
D. Genetic drift, in which random changes in allele frequencies occur in small isolated populations

32. The specialized relationship between the orchid and the moth could be considered:

A. Parasitism, since the moth feeds on the orchid without giving anything in return at all
B. Predation, since the moth consumes the orchid completely during the feeding process
C. Commensalism, since only the moth benefits and the orchid is unaffected by the moth visit
D. Mutualism, since the moth gets food (nectar) and the orchid gets pollinated by the moth

33. If the moth species suddenly went extinct, the orchid species would most likely:

A. Increase its production of nectar to attract a wide variety of other insect species rapidly
B. Continue to reproduce as well as before because pollination would not be affected at all
C. Decline in numbers because it would lose its specialized pollinator and reproduction would suffer
D. Evolve the ability to pollinate itself within just one or two generations after the moth was lost

34. An example of host–parasite coevolution might involve:

A. A parasite evolving better defenses against the host's immune system, while the host evolves stronger immune responses
B. A parasite and a host living together for many generations without affecting each other in any way
C. A host species deliberately weakening itself to allow parasites to flourish within its body tissues
D. A parasite evolving to be completely beneficial to its host within a single generation of evolution

35. Coevolution depends on the fact that:

A. Two interacting species must have completely identical DNA in order to evolve together over time
B. The traits in each species that affect the interaction must be heritable and subject to selection
C. One species in a coevolving pair must remain genetically unchanged across many generations
D. Coevolution can only occur in animal species and is impossible between plants of different kinds

36. Coevolution often leads to highly specialized interactions, which can be:

A. Permanently fixed in the genome and unaffected by any future environmental change
B. Completely independent of changes in the surrounding ecosystem and environment
C. Vulnerable to disruption if one of the species is lost or its population declines significantly
D. Unaffected by the loss of one of the partner species in the coevolutionary relationship

Base your answers to questions 37 through 41 on the information below and on your knowledge of biology.

A biome is a large geographic region characterized by a particular climate and the communities of plants and animals adapted to that climate. Major terrestrial biomes include tropical rainforest, temperate deciduous forest, taiga (boreal forest), tundra, grassland, and desert. Climate factors — primarily temperature and precipitation — largely determine where each biome is found. For example, the tundra biome occurs at high latitudes (near the poles) and high altitudes, where temperatures are cold and precipitation is low. The tropical rainforest biome occurs near the equator, where temperatures are warm year-round and rainfall is abundant. Each biome supports a distinctive community of organisms adapted to its specific conditions.

37. The biome characterized by warm temperatures, abundant rainfall, and the greatest biodiversity on Earth is:

A. Tundra, the cold biome found at high latitudes near the poles of Earth
B. Desert, the dry biome with low precipitation found in subtropical regions
C. Temperate deciduous forest, the biome with mild seasons and trees that drop their leaves yearly
D. Tropical rainforest, the biome found near the equator with warm temperatures and high rainfall

38. The two climate factors that most strongly determine the distribution of biomes are:

A. Temperature and precipitation, which together determine which organisms can survive
B. Elevation and longitude, which determine the exact position of the biome on Earth
C. Soil color and rock type, which affect the visible appearance of the biome's surface
D. The number of human inhabitants and the technology used in the surrounding regions

39. The tundra biome supports relatively few species because:

A. The biome receives too much sunlight, which damages most living organisms in the tundra
B. The biome contains too many predators, leaving few prey species alive in the region
C. Cold temperatures, low precipitation, and a short growing season limit the organisms that can survive
D. The biome's soils are too acidic to support most plants and the animals that eat them

40. Desert plants such as cacti often have thick, fleshy stems and small or absent leaves. These features are adaptations for:

A. Capturing more sunlight to support rapid photosynthesis during cool nights in the desert
B. Storing water and reducing water loss through evaporation in the hot, dry environment

C. Protecting the plant from the predators that hunt larger desert herbivores at night
D. Producing more oxygen for the surrounding atmosphere of the desert during the day

41. As global temperatures rise due to climate change, the boundaries of biomes are most likely to:

A. Remain in exactly the same locations they have occupied for thousands of years now
B. Move toward the equator as cold regions expand outward from the polar regions
C. Disappear entirely, leaving Earth with a single uniform biome covering all land
D. Shift toward the poles and to higher altitudes as warmer conditions expand poleward

Base your answers to questions 42 through 45 on the information below and on your knowledge of biology.

An ocean "dead zone" is an area of the ocean with extremely low dissolved oxygen, often too low to support most marine life. Dead zones can form when excess nutrients (mainly nitrogen and phosphorus from agricultural runoff and sewage) enter coastal waters. These nutrients fuel rapid blooms of algae and phytoplankton near the surface. When the algae die, they sink to the bottom, where decomposer bacteria break them down using oxygen. The resulting depletion of bottom-water oxygen — a condition called hypoxia — can kill fish, shellfish, and other marine organisms, or force them to flee the area. One of the largest dead zones in the world forms each summer in the Gulf of Mexico, near the mouth of the Mississippi River.

42. Ocean dead zones form when excess nutrients enter coastal waters because:

A. The nutrients chemically react with seawater to release toxic gases into the ocean water
B. The nutrients cause fish to immediately stop reproducing in the affected coastal waters
C. The nutrients fuel algal blooms whose decomposition depletes dissolved oxygen in the water
D. The nutrients raise the temperature of the water so high that all marine life is killed

43. The primary source of the excess nutrients causing the Gulf of Mexico dead zone is:

A. Agricultural runoff from farms in the Mississippi River basin draining fertilizers into the river
B. Underwater volcanic eruptions in the Gulf releasing chemicals from beneath the seafloor
C. Natural processes that have always produced large dead zones in the same locations
D. Direct dumping of fertilizers into the Gulf of Mexico by industrial fishing vessels

44. The low-oxygen condition that defines a dead zone is called:

A. Anaerobic respiration, the process by which cells produce ATP without using any oxygen
B. Hypoxia, a condition in which dissolved oxygen is too low to support most marine life
C. Eutrophication, a condition in which excess nutrients cause algal blooms in surface waters
D. Photosynthesis, the process by which plants produce oxygen from carbon dioxide and water

45. One way to reduce the size of ocean dead zones is to:

A. Increase the use of fertilizers in agriculture to fertilize the ocean ecosystem better
B. Remove all the algae from the ocean surface using large mechanical equipment regularly
C. Reduce nutrient runoff by improving farm practices and treating sewage before release
D. Allow more sewage to be released directly into rivers flowing into the ocean

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

The human skeletal system consists of approximately 206 bones that provide structural support, protect internal organs, and serve as attachment points for muscles. Bones are connected to other bones at joints, many of which allow movement. The skeletal system works closely with the muscular system to enable movement. Skeletal muscles are attached to bones by tough connective tissues called tendons. When a muscle contracts, it pulls on the bone, producing movement at a joint. Muscles can only pull, not push, so they typically work in opposing pairs (such as the biceps and triceps in the upper arm), with one muscle bending the joint and the other straightening it.

46. Skeletal muscles are attached to bones by:

A. Ligaments, which connect bones to other bones at the joints of the skeleton
B. Cartilage, which provides smooth surfaces at the ends of bones at the joints
C. Skin, which covers the bones and protects them from external damage and injury
D. Tendons, which are tough fibrous connective tissues that attach muscles to bones

47. The biceps and triceps of the upper arm function as opposing muscles because:

A. Muscles can only pull, not push, so one muscle bends the elbow while the other straightens it
B. Muscles work most efficiently when they are paired with other muscles doing the same job
C. Each muscle alone is too weak to produce any noticeable movement of the human arm
D. The two muscles work together to produce a single, identical pulling movement of the elbow

48. A major function of the skeletal system, besides supporting the body, is to:

A. Produce the hormones that regulate growth and reproduction in the human body
B. Filter waste products out of the blood that circulates through the body's vessels
C. Protect vital internal organs such as the brain, heart, and lungs from physical damage
D. Digest the food that enters the body through the mouth and stomach during meals

49. A joint that allows movement, such as the knee or the elbow, is best classified as:

A. An immovable joint, similar to the bones of the human skull that do not move
B. A movable joint, which allows the bones to move relative to each other in various ways
C. A bone-to-bone fusion, in which the two bones gradually grow together permanently over time
D. A muscle, which is responsible for producing all movement in the human body

50. An athlete who suddenly experiences pain in the lower leg while running may have torn a tendon. A torn tendon would:

A. Disrupt the connection between a muscle and the bone it normally moves, causing weakness
B. Cause an immediate increase in the strength of the affected muscle by removing tension
C. Have no effect on the body since tendons are not involved in any kind of movement
D. Cause the bones at the nearest joint to fuse together permanently within just a few hours

PRACTICE EXAM 29 – EXPLAINED ANSWER KEY (Q1–Q50)

1. C — Active transport is defined as the movement of substances against a concentration gradient using cellular energy. The sodium-potassium pump fits this definition exactly: it pushes Na^+ and K^+ "uphill" using ATP. Passive processes like diffusion and osmosis cannot move ions against their gradients.

2. D — ATP is the cell's universal energy currency, and the sodium-potassium pump hydrolyzes ATP to power each ion-pumping cycle. The ATP is produced primarily by mitochondria through cellular respiration. Without a steady ATP supply, the pump cannot function.

3. B — The sodium-potassium pump strictly depends on ATP, so depleting ATP causes the pump to slow or stop. Once pumping stops, Na^+ and K^+ slowly leak across the membrane and the concentration gradient dissipates. This is why ATP depletion is rapidly lethal to cells.

4. A — The Na^+/K^+ gradient sets up the resting membrane potential that allows neurons to fire action potentials. When a neuron is stimulated, gated channels open and ions flow down these gradients, generating the electrical signal. Nerve impulses would be impossible without the pump's work.

5. D — Blocking the pump halts the maintenance of the Na^+ and K^+ gradients, so the ions gradually equalize across the membrane. With the gradients lost, the cell cannot generate normal electrical signals or maintain proper volume. Many cardiac and nerve poisons act this way.

6. C — A reversible inhibitor binds the enzyme loosely, so removing it (here, by dialysis) restores normal enzyme activity. The 100% recovery seen with Inhibitor X is the hallmark of reversibility. Many medicines work this way so that their effect wears off as the drug is cleared.

7. A — An irreversible inhibitor binds permanently or chemically modifies the enzyme, so removing it does not restore activity. The fact that enzyme function did not return after dialysis is the defining evidence for irreversibility. Many toxins and a few important drugs act through this mechanism.

8. B — Once an irreversible inhibitor inactivates an enzyme, that enzyme is permanently nonfunctional and cannot be reactivated. The cell must transcribe and translate new enzyme molecules to restore activity. This is why irreversible inhibitor effects often last much longer than the drug's presence in the body.

9. D — Aspirin permanently acetylates its target enzyme (cyclooxygenase), so the enzyme cannot recover. Function returns only when the cell synthesizes new enzyme molecules through transcription and translation. This is why a single low-dose aspirin can affect platelets for their entire ~10-day lifespan.

10. C — Because reversible inhibitors are not chemically bound to the enzyme, simply removing them allows the enzyme to resume normal activity. Dialysis, dilution, or competition with substrate all work for reversible inhibitors. The behavior of Inhibitor X in the experiment confirms this principle.

11. B — Gravitropism (also called geotropism) is the growth response of plants to gravity. Roots consistently grow downward regardless of how the seed is oriented, which is the textbook example of positive gravitropism. The other tropisms involve light, touch, or water rather than gravity.

12. A — A "positive" tropic response means growth toward the stimulus, and for roots the stimulus is gravity pulling downward. Roots grow in the same direction as the gravitational force, so they exhibit positive gravitropism. This response steers roots into the soil where water and minerals are available.

13. C — Stems grow away from the gravitational pull, which makes their response "negative" gravitropism. This upward growth carries leaves into sunlight for photosynthesis. The opposite directional responses of roots and stems are coordinated by the same hormone signal, auxin.

14. D — Auxin redistribution along a stem or root drives the differential cell elongation that produces tropic bending. In roots, auxin accumulates on the lower side and inhibits elongation there, so the root curves downward. The other listed hormones are animal hormones with no role in plant tropisms.

15. A — Gravitropism puts each plant organ in the right place for its function: roots go down to anchor the plant and absorb water and minerals, stems go up to reach sunlight for photosynthesis. This adaptive orientation is essential to plant survival. Seedlings that cannot detect gravity rarely establish themselves.

16. B — ATP supplies the chemical energy that drives the myosin power stroke during muscle contraction. Glucose and oxygen are inputs to cellular respiration, but they must first be converted to ATP before the muscle can use them. ATP is the immediate energy source for every contraction cycle.

17. D — In the sliding-filament model, myosin heads bind to actin, pivot to pull actin inward, and then detach using ATP. This cycle shortens the sarcomere and contracts the muscle fiber. Without myosin pulling on actin, no contraction occurs.

18. A — When cellular respiration stops at death, ATP production ends and the existing ATP is rapidly consumed. Myosin requires ATP to release from actin, so without ATP the cross-bridges remain locked and the muscles stiffen. This biochemical fact is why rigor mortis appears within a few hours of death.

19. D — Mitochondria are the site of aerobic ATP production, and muscle cells have very high ATP demands during contraction. Packing many mitochondria into each muscle fiber ensures that ATP can be made fast enough to sustain activity. Endurance training measurably increases mitochondrial number in muscle cells.

20. B — The sugar-phosphate backbone of DNA carries a net negative charge because of the phosphate groups. In an electric field, negatively charged molecules migrate toward the positive electrode. This is the fundamental basis of DNA gel electrophoresis.

21. C — Gel electrophoresis sieves DNA through a porous matrix, and small fragments slip through the pores more easily than large ones. As a result, smaller fragments migrate farther in a given time and travel faster. This size-dependent separation produces the characteristic ladder of bands.

22. D — Outside of identical twins, every person carries a unique combination of variable DNA sequences (such as short tandem repeats). Cutting and sizing these regions produces band patterns that differ between unrelated people. This individual uniqueness is what makes DNA fingerprinting useful for identification.

23. A — Because each person's DNA pattern is essentially unique, matching band patterns between a crime-scene sample and a suspect's sample is strong evidence they came from the same person. Identical twins are the only known exception. This is why DNA evidence is so powerful in court.

24. B — A child inherits half of their DNA from each parent, so every band in the child's fingerprint should be present in either the mother's or the father's fingerprint. If a man's bands account for all the paternal bands in the child, he is very likely the biological father. Missing matches usually rule a man out.

25. C — Normal human somatic cells contain 46 chromosomes, organized as 22 pairs of autosomes plus one pair of sex chromosomes. This diploid number ($2n = 46$) is the standard reference for karyotypes. Gametes, by contrast, contain only 23 chromosomes (n).

26. A — Down syndrome (trisomy 21) is caused by the presence of three copies of chromosome 21 instead of two, giving a total of 47 chromosomes. The extra chromosome typically results from nondisjunction during meiosis in one of the parents. This is the most common chromosomal trisomy compatible with live birth.

27. D — Nondisjunction is the failure of homologous chromosomes (meiosis I) or sister chromatids (meiosis II) to separate properly. The resulting gametes carry an extra or missing chromosome, which produces aneuploid offspring after fertilization. Maternal nondisjunction in meiosis I accounts for most cases of Down syndrome.

28. B — Human females are typically XX, with two X chromosomes paired together in the karyotype. Males are typically XY, with one X and one Y. The sex chromosomes are conventionally placed at position 23 in a standard karyotype.

29. C — Karyotypes are made at low resolution and show whole chromosomes, so they reveal numerical abnormalities (trisomies and monosomies) and large structural changes (deletions, duplications, translocations). They cannot detect single-gene mutations or read DNA sequence. This is why karyotypes are paired with molecular tests in clinical genetics.

30. A — An evolutionary arms race describes reciprocal adaptations between two species: as one evolves a new offense or defense, the other evolves a counter-adaptation. The pattern arises because each species exerts selective pressure on the other. Predator–prey and host–parasite systems are the classic examples.

31. B — Coevolution occurs when two species evolve in response to each other over generations. The orchid's flower depth and the moth's tongue length are mutually shaped by their interaction. This is one of the most famous examples in evolutionary biology, originally predicted by Darwin himself.

32. D — Both partners benefit from the relationship: the moth obtains nectar, and the orchid achieves pollination. This is the defining feature of mutualism. Pollinator–plant relationships are among the most common examples of mutualism in nature.

33. C — Highly specialized mutualisms are fragile because each partner depends on the other. If the only pollinator disappears, the orchid loses its means of sexual reproduction and is likely to decline. This vulnerability is one reason coevolved specialists are often the first to suffer when ecosystems are disturbed.

34. A — In host–parasite coevolution, parasites evolve to better exploit and evade their hosts while hosts evolve stronger or more specific immune defenses. This back-and-forth produces an ongoing evolutionary arms race. Pathogen escape from immunity is a real-world example seen with influenza viruses.

35. B — Evolution by natural selection requires heritable variation that affects survival or reproduction. For coevolution, the interacting traits in each species must be heritable so selection can shape them across generations. Without heritability, no evolutionary response — and no coevolution — is possible.

36. C — Specialization narrows a species' interactions to a small number of partners, so the loss of even one partner can be devastating. Generalists are buffered against partner loss; specialists are not. This is why coevolved specialists are disproportionately represented on endangered-species lists.

37. D — Tropical rainforests have warm temperatures year-round and very high rainfall, creating conditions that support more species than any other terrestrial biome. They cover only a small fraction of Earth's land yet contain more than half of its species. Their high productivity is also a major driver of their biodiversity.

38. A — Climate diagrams plotting biome distribution show that biomes sort out almost entirely by temperature and precipitation. Together these two factors set the conditions plants must tolerate, and plant communities in turn shape the animal communities. This is why biome maps look so similar to climate maps.

39. C — Tundra has very low temperatures, low precipitation, and a growing season of only a few weeks, all of which severely limit which organisms can survive. The result is a biome of low productivity and low species diversity. Permafrost in the soil adds another constraint on rooting depth.

40. B — Thick fleshy stems store water, and reduced or absent leaves cut down on transpiration in hot, dry air. Many cacti also have a waxy cuticle and specialized photosynthesis (CAM) that further reduce water loss. These adaptations let cacti thrive where most plants would dehydrate quickly.

41. D — As Earth warms, climate zones suitable for each biome shift toward the poles and upward in elevation. Many species are observed migrating in these same directions to track suitable conditions. Species that cannot move fast enough — or that have nowhere left to go — face increased extinction risk.

42. C — Excess nitrogen and phosphorus fuel large algal blooms; when the algae die, decomposers consume oxygen as they break the biomass down. The resulting drop in dissolved oxygen suffocates fish, shellfish, and other organisms. This nutrient-driven oxygen depletion is the core mechanism of every dead zone.

43. A — The Mississippi River drains a vast agricultural region where heavy fertilizer use produces nitrogen- and phosphorus-rich runoff. These nutrients are carried to the Gulf, fueling the annual dead zone near the river mouth. Reducing upstream fertilizer use is the main strategy for shrinking it.

44. B — Hypoxia is the technical term for low dissolved oxygen, the defining condition of a dead zone. Eutrophication is the broader nutrient-enrichment process that leads to hypoxia. Distinguishing the two terms is important: eutrophication is the cause, hypoxia is the consequence.

45. C — The most effective approach is to cut the nutrient pollution at its source — for example, by improving fertilizer management, planting buffer strips along waterways, and treating sewage before release. Reducing inputs prevents the algal blooms that drive oxygen depletion. This is why "nutrient management" is the centerpiece of dead-zone policy.

46. D — Tendons are tough, fibrous connective tissues specifically built to anchor muscle to bone. Ligaments, in contrast, connect bone to bone at joints. Distinguishing tendons from ligaments is a common point of confusion that the question tests directly.

47. A — Skeletal muscles generate force only by shortening — they pull, never push. Bending a joint and straightening it are therefore opposite movements that require two different muscles, one for each direction. The biceps/triceps pair at the elbow is the textbook antagonistic arrangement.

48. C — The skull protects the brain, the rib cage protects the heart and lungs, and the vertebrae protect the spinal cord. This protective role is one of the major functions of the skeletal system, alongside support, movement, blood-cell production, and mineral storage. The other listed functions belong to different organ systems.

49. B — Joints that allow movement, including the knee and elbow, are classified as movable (synovial) joints. They are distinguished from immovable joints such as the sutures of the adult skull. Most of the joints involved in everyday motion are synovial joints of various types.

50. A — A tendon physically links a muscle to the bone it moves, so a tear breaks that mechanical connection. Even if the muscle can still contract, the force is no longer transmitted to the bone, producing weakness and loss of normal movement. Surgical repair is often needed for major tendon injuries.