

PRACTICE EXAM 28: LIFE SCIENCE: BIOLOGY SIMULATION (50 QUESTIONS — CELL SIGNALING, ANIMAL COMMUNICATION, DISEASE ECOLOGY, AND SPECIALIZED PHYSIOLOGY)

Instructions: Practice Exam 28 emphasizes cellular signaling and communication, plant defenses, animal communication, disease ecology, conservation biology, coevolution case studies, and specialized human physiology. Each question is independent. Select the one best answer.

1. Cells communicate with each other using chemical signals. A peptide hormone released by one cell binds to a specific receptor protein on another cell. The most likely location of this receptor protein is:
 - A. Inside the nucleus of the target cell, where it directly interacts with the cell's DNA and chromosomes throughout the day each second
 - B. Floating freely in the cytoplasm of the target cell, where it interacts with other proteins in the surrounding cellular fluid each minute
 - C. Embedded in the plasma membrane of the target cell, where it can detect signals arriving from outside the cell's outer surface boundary
 - D. Inside the mitochondria of the target cell, where it can directly influence the production of ATP for use throughout the cell each second
2. When a signal molecule binds to a receptor on the surface of a cell, the binding often triggers a chain of biochemical events inside the cell that ultimately affects the cell's behavior. This chain of events is best called:
 - A. Signal transduction, the conversion of an external signal into an internal cellular response through a series of biochemical steps
 - B. Active transport, the movement of substances across the cell membrane against the direction of their concentration gradient by pumps
 - C. Photosynthesis, the conversion of light energy into stored chemical energy through a series of enzyme-catalyzed reactions in chloroplasts
 - D. DNA replication, the copying of the cell's genetic material before the cell divides into two daughter cells of the same kind each time

3. In many animal tissues, neighboring cells communicate with each other through specialized channels that allow small ions and molecules to pass directly from one cell to another. These channels are best called:

- A. Plasmodesmata, the channels that connect plant cells through tiny openings in their cell walls between neighboring plant cells in tissues
- B. Synapses, the junctions between two neurons where chemical signals are passed from one neuron to the next neuron each second of activity
- C. Tight junctions, sealing junctions between epithelial cells that prevent the leakage of substances between adjacent body cells in tissues
- D. Gap junctions, channels between adjacent animal cells that allow direct passage of small molecules and ions between the connected cells

4. Many plants produce bitter or toxic chemicals such as alkaloids, tannins, and terpenes that discourage herbivores from eating them. These chemical compounds are best understood as:

- A. Photosynthetic pigments that capture light energy from the sun in order to drive the synthesis of glucose during the process of photosynthesis
- B. Chemical defenses produced by the plant to protect against herbivores, pathogens, and other biological threats from the surrounding environment
- C. Hormones that regulate the plant's response to changing light and temperature conditions during the various seasons of the year in the field
- D. Storage compounds that the plant uses as a long-term energy reserve to power its growth during the cold winter months in temperate regions

5. Many female moths release chemical signals called pheromones that attract males of their own species from long distances. Pheromones are best classified as a form of:

- A. Visual signaling, in which one organism uses bright colors and conspicuous body postures to communicate with another animal in the same area
- B. Auditory signaling, in which one organism produces and detects sound waves to communicate over a relatively short distance with other animals
- C. Chemical signaling, in which an organism releases molecules into the environment to communicate with other organisms at a distance from itself
- D. Tactile signaling, in which one organism uses physical touch and direct body contact to communicate with another animal at close range together

6. Honeybees returning to the hive perform a "waggle dance" that communicates the distance and direction of a food source to other bees in the colony. This behavior is best understood as:

- A. A form of animal communication that conveys specific information about the environment from one individual to others in a group of animals
- B. A series of random movements that have no specific biological meaning to other members of the bee colony at any time during the working day
- C. A defensive display intended to ward off predators that have entered the immediate vicinity of the hive at any moment of the day during foraging

D. A territorial display that warns other bee colonies to stay away from the honeybee's home territory and food sources nearby in the same area

7. Young songbirds typically learn their species-specific song by listening to adult males of their own species during a critical period in early development. The development of the song therefore depends on:

A. Genetic information alone, with no influence from the surrounding environment or auditory experience during the bird's early life on Earth

B. Environmental experience alone, with no genetic basis for the basic song structure or for the bird's ability to learn the song over its lifetime

C. Random vocalizations that have no underlying purpose or function in the bird's communication with members of its own species at any time

D. Both genetic predisposition and learning from adult tutors, an interaction between innate ability and environmental experience during early life

8. Mosquitoes are responsible for transmitting many human diseases, including malaria, dengue fever, and Zika virus. The role of the mosquito in these diseases is best described as:

A. The host of the disease, in which the disease-causing organism completes its full life cycle and replicates entirely inside the body each time

B. The reservoir of the disease, in which the disease-causing organism is stored long-term and from which it is only occasionally transmitted out

C. The vector of the disease, in which the mosquito transfers the disease-causing organism from one host to another during a blood meal cycle

D. The pathogen of the disease itself, since the mosquito is the actual organism that directly causes the disease in human patients each time

9. Lyme disease is caused by a bacterium (*Borrelia burgdorferi*) that is transmitted to humans by the bite of an infected tick. Cases of Lyme disease have increased in many regions over recent decades. One likely contributing factor is:

A. A sharp decline in human populations in affected regions, which has reduced the immune system strength of remaining human residents over the years

B. The expansion of tick populations and their host species (such as deer and white-footed mice) into areas with more human development and forest edges

C. A complete loss of the *Borrelia* bacterium from all natural environments outside of laboratory cultures used for medical research over the last decades

D. The introduction of antibiotic treatments that have made the *Borrelia* bacterium more virulent and more capable of infecting humans repeatedly each season

10. An "emerging infectious disease" is one that has appeared in a population for the first time or is rapidly increasing in incidence or geographic range. Examples include HIV, SARS, and COVID-19. The emergence of new infectious diseases in humans is most often associated with:

- A. Increased contact between humans and wildlife, which allows pathogens to spill over from animal reservoirs into human populations over time
- B. A decrease in the world's overall biodiversity of pathogenic bacteria and viruses across all of the major continents of the planet over the years
- C. The complete elimination of all vector species, such as mosquitoes and ticks, from large parts of every developed country worldwide today
- D. The discovery of new species of plants and animals whose chemical compounds have caused the emergence of unrelated human diseases worldwide

11. During the mid-20th century, the pesticide DDT was widely used and caused dramatic declines in populations of birds such as bald eagles. The most direct biological reason for this decline was that DDT:

- A. Killed adult eagles directly upon contact, as soon as the pesticide was sprayed in any area within the eagles' home range during each spring season
- B. Caused the eagles to lose their wing feathers, preventing them from flying south for the winter and reaching their breeding grounds in early spring
- C. Increased the supply of food available to the eagles, leading to overpopulation followed by mass starvation in the affected regions each year of use
- D. Accumulated in eagles through biomagnification and caused thinning of their eggshells, reducing the survival of their unhatched chicks each season

12. Methylmercury is a toxic compound that enters aquatic food webs and is more concentrated in the tissues of organisms at higher trophic levels than at lower trophic levels of the same ecosystem. This increase in concentration up the food chain is best classified as:

- A. Bioremediation, the use of living organisms to remove pollutants from contaminated environmental areas in the soil or in nearby waters of an area
- B. Bioaccumulation, the buildup of a contaminant within the body of a single individual organism over the course of its lifetime exposure to it
- C. Biomagnification, the increase in concentration of a pollutant at each successive higher trophic level of a food chain across an ecosystem
- D. Eutrophication, the buildup of excess nutrients in a body of water that causes algal blooms and depletes the oxygen in the water over time gradually

13. Certain lichens are extremely sensitive to air pollution, especially to sulfur dioxide and nitrogen oxides released by industrial sources. The absence of these lichens in an area is often used by scientists as an indicator of:

- A. Excellent air quality with very low levels of air pollutants in the surrounding area, since healthy lichens always indicate poor air quality in the area
- B. Poor air quality, since pollution-sensitive lichens cannot survive in places with high concentrations of certain harmful pollutants in the air locally
- C. Very high biodiversity of fungi in the surrounding region, since lichens are simple organisms that compete with all of the other fungi present in nature

D. Low rainfall and dry conditions in the local environment, since lichens cannot survive in regions that receive any significant precipitation each year

14. Lichens are sometimes called "bioindicators" because their presence or absence provides information about environmental quality. Bioindicators are most useful in environmental monitoring because they:

A. Respond predictably to environmental conditions, often showing changes long before chemical instruments can detect a measurable problem in the area

B. Provide a complete chemical analysis of every type of pollutant present in the environment at extremely high precision and accuracy levels each time

C. Are entirely independent of all environmental factors, allowing them to be used in any kind of measurement under any conditions on the entire planet

D. Produce large amounts of money for the local economy through ecotourism, especially in heavily polluted urban or industrial regions worldwide today

15. Amphibian populations worldwide have been declining sharply in recent decades. Multiple factors contribute to this decline. Which of the following is NOT generally identified as a major factor in amphibian declines?

A. Habitat destruction and pollution of the freshwater habitats where amphibians live during much of their life cycle in many regions of the world today

B. A fungal pathogen called *Batrachochytrium dendrobatidis* (chytrid fungus) that infects amphibian skin and disrupts their physiological functions

C. Climate change, which alters the timing of seasonal events such as breeding and the availability of water in amphibian breeding sites worldwide

D. A dramatic increase in the abundance of amphibian prey species, leading to overpopulation followed by mass starvation among the affected amphibians

16. A fungal disease called chytridiomycosis is caused by *Batrachochytrium dendrobatidis* (Bd) and has devastated frog populations on multiple continents. The chytrid fungus harms frogs primarily by:

A. Disrupting the frog's ability to lay eggs in freshwater ponds, completely preventing the frog from reproducing successfully throughout its life cycle

B. Eating the frog's internal organs from the inside out, killing the frog within just a few short hours after the initial infection occurs in the body of the frog

C. Infecting the skin of the frog and interfering with electrolyte balance and gas exchange across the skin's thin and permeable surface over time

D. Causing the frog's brain to swell rapidly, leading to immediate neurological symptoms and death soon after first exposure to the fungus in the wild

17. Conservation biologists working to protect endangered species have used many strategies. Wildlife corridors connecting separated habitat patches help endangered species primarily by:

A. Eliminating predators of the endangered species from the surrounding landscape, removing the major source of mortality for adult animals each year

B. Allowing individuals to move between isolated patches, increasing gene flow and reducing the

negative effects of small population sizes over time

C. Producing additional food sources directly within the corridor itself, completely supplying the nutritional needs of the endangered species locally

D. Permanently separating the endangered species from human development, ensuring complete isolation from human contact in every direction at all times

18. The cheetah population suffered a severe bottleneck event tens of thousands of years ago, which has left modern cheetahs with very low genetic diversity. The reduced genetic diversity in the modern cheetah population most directly increases the species' vulnerability to:

A. Disease outbreaks and other selective pressures, since populations with little genetic variation have few options for adaptive response over time

B. Direct competition with humans for food sources, since low genetic variation prevents cheetahs from being able to find food in human-modified environments

C. Climate change in the high mountains of Africa, since low genetic variation prevents cheetahs from living at any high altitudes on the African continent

D. Successful breeding in zoos, since zoos require populations with low genetic variation to maintain consistent breeding lines among captive animals globally

19. "Genetic rescue" is a conservation strategy in which a small number of individuals from one population are introduced into a second population that is suffering from inbreeding. The goal of genetic rescue is to:

A. Permanently increase the total size of the second population to a level greater than the carrying capacity of the surrounding habitat for many years to come

B. Replace the original second population entirely with the new individuals, so that the original second population's genes disappear completely from the area

C. Reduce the number of native predators in the second population's habitat, eliminating the main source of mortality for the affected species over time globally

D. Introduce new genetic variation into the inbred population, restoring genetic diversity and improving the population's long-term viability over the years

20. Many species of hummingbirds and tubular flowers have evolved together so that the shape of the hummingbird's beak and the depth of the flower's nectar tube are closely matched. This reciprocal evolutionary change between two species is best called:

A. Convergent evolution, in which unrelated species independently evolve similar physical traits under similar selective pressures over many generations of time

B. Adaptive radiation, in which one ancestral species rapidly diversifies into many descendant species filling different ecological niches in habitats across regions

C. Coevolution, in which two interacting species evolve in response to each other over many generations of reciprocal selective pressure between species

D. Genetic drift, in which random changes in allele frequencies cause one population to become noticeably different from another over time by pure chance alone

21. Many fig species are pollinated by tiny wasps, and the wasps reproduce only inside fig fruits. Each fig species depends on a specific wasp species, and each wasp species depends on its specific fig species. This relationship is best classified as:

- A. Mutualism, an ecological interaction in which both interacting species benefit from the close relationship they have evolved with each other over time
- B. Parasitism, in which one species benefits directly at the expense of the other species, harming the host over the course of the interaction over time
- C. Predation, in which one species hunts and consumes another species for nutrition within their shared ecological habitat in any given location each day
- D. Competition, in which two species struggle for the same limited resource in their shared habitat, with one species typically displacing the other species

22. A remora fish attaches itself to a shark using a sucker-like organ on its head and feeds on scraps from the shark's meals. The shark is neither helped nor noticeably harmed by the remora's presence. This relationship is best classified as:

- A. Mutualism, in which both species in the close ecological relationship benefit from the interaction with one another over time in their shared habitat
- B. Commensalism, in which one species benefits and the other is essentially unaffected by the close ecological interaction between them over time in nature
- C. Parasitism, in which one species benefits directly at the expense of the other species, causing measurable harm to the host over time during the relationship
- D. Predation, in which one species hunts and consumes another species for nutrition within their shared ecological habitat in the marine environment each day

23. Bacteria in a hospital have become resistant to multiple antibiotics over the past several decades, even as new antibiotics have been introduced. The evolution of multidrug-resistant bacteria is best explained by:

- A. Random mutation alone, in which all of the surviving bacteria suddenly developed identical mutations during the use of one single antibiotic at a time
- B. The bacteria's conscious decision to develop new mechanisms of resistance in response to antibiotic exposure as a direct survival behavior of bacteria
- C. The deliberate engineering of resistance traits by scientists studying antibiotic resistance in laboratory research settings around the world each year
- D. Natural selection acting on heritable variation, in which bacteria carrying resistance alleles survive antibiotic exposure and reproduce more successfully

24. In 19th-century industrial England, the peppered moth population shifted from mostly light-colored to mostly dark-colored as soot blackened tree bark. After air quality improved in the 20th century, the population shifted back toward lighter colors. These observations best illustrate:

- A. Convergent evolution, in which different species independently evolve the same trait under similar environmental conditions across many generations on Earth
- B. Genetic drift, in which random changes in allele frequencies cause populations to diverge from each

other in small populations over many generations by chance

C. Natural selection responding to changing environmental conditions, with allele frequencies shifting as the relative camouflage value of each color changes

D. Inheritance of acquired characteristics, in which the soot directly caused the moths to change color and pass that change on to their offspring genetically each generation

25. In adult humans, the ability to digest lactose (the sugar in milk) is much more common in populations that have a long history of dairy farming than in populations without such a history. This pattern is best explained by:

A. Direct learning, in which humans in dairy-farming cultures consciously train their digestive systems to process the sugar in milk over many years of practice

B. Natural selection favoring the persistence of the lactase enzyme into adulthood in human populations where milk has been an important food source over time

C. Genetic drift alone, with no relationship between the dietary practices of these populations and the frequency of lactose tolerance in adults of the populations

D. Inheritance of acquired characteristics, in which children who drink large amounts of milk pass that acquired tolerance directly to their offspring each generation

26. Many new plant species have arisen through a process in which a single ancestral species produces offspring with double the normal number of chromosomes. These polyploid offspring are usually reproductively isolated from the original parent species. This is best classified as:

A. Sympatric speciation, in which new species arise in the same geographic area as the parent species without any physical barrier separating them at all

B. Allopatric speciation, in which a physical geographic barrier separates two populations and allows them to diverge into different species over time on Earth

C. Convergent evolution, in which two unrelated species independently develop similar traits under similar environmental conditions over the years on Earth

D. Adaptive radiation, in which one ancestral species rapidly diversifies into many descendant species filling different ecological niches in many habitats across continents

27. Two closely related plant species cannot interbreed because their flowers are pollinated by different species of insects that are physically incapable of cross-pollinating between the two plant species in nature. This is best classified as:

A. Behavioral isolation, in which differences in courtship behaviors prevent two animal species from successfully mating with each other in nature throughout the year

B. Temporal isolation, in which two species reproduce at different times of the year and therefore do not encounter each other during the breeding seasons of either species

C. Postzygotic isolation, in which fertilization occurs but the resulting hybrid offspring are inviable or sterile and cannot reproduce themselves over the course of their life

D. Mechanical isolation, in which physical or structural differences prevent fertilization between the two species through a pollinator or anatomical mismatch in nature

28. When two closely related species occasionally interbreed in a region where their ranges overlap, the area where hybrids occur is best called a:

- A. Climax community, an area in which an ecosystem has reached a long-term stable balance among the species that live within the area for many years on end
- B. Bottleneck, an area in which the population size has been dramatically reduced because of a major catastrophic environmental event of some kind in the recent past
- C. Hybrid zone, a region where two closely related species meet, mate, and produce at least some hybrid offspring of variable fitness or fertility each season
- D. Allopatric range, a geographic area in which two populations of the same species are separated by a physical barrier such as a river or a mountain on either side

29. Cacti in North American deserts and certain euphorbia plants in African deserts both have thick, succulent, water-storing stems and reduced or absent leaves, even though they are not closely related to each other. This similarity is best explained by:

- A. Coevolution, in which two interacting species evolve traits in response to each other over many generations of reciprocal natural selection between the two species
- B. Convergent evolution, in which unrelated species independently evolve similar traits under similar environmental selective pressures over time on different continents
- C. Recent common ancestry, in which the two plant groups share a very recent ancestor that already possessed the water-storing succulent body plan in its tissues
- D. Genetic drift, in which random changes in allele frequencies cause two unrelated populations to develop similar physical features over time by pure chance alone

30. A comparison of early embryonic development in fish, reptiles, birds, and mammals shows striking similarities, including the presence of gill pouches and a long tail in the early embryos of each group. These embryological similarities are best interpreted as evidence that:

- A. These vertebrate groups share a common ancestor and inherited similar developmental genes that are still expressed during early embryonic stages today
- B. The developmental stages of these groups are completely unrelated, and any observed similarities are pure coincidence with no biological significance at all
- C. All vertebrate species develop directly from the same single ancestral fertilized egg cell that was first produced billions of years ago on planet Earth long ago
- D. The environmental conditions during embryonic development always produce identical embryos regardless of species, due to physical constraints alone in nature

31. A person who has chronic obstructive pulmonary disease (COPD) has alveoli that have lost much of their elasticity and surface area. The most direct consequence of these changes is:

- A. An increase in the amount of oxygen that can be transported into the bloodstream during each individual breath taken by the affected patient each minute
- B. A decrease in the patient's resting heart rate, since the heart no longer needs to pump blood as forcefully through the lungs as it did before the illness began
- C. A decrease in the efficiency of gas exchange, leading to lower blood oxygen levels and difficulty

breathing during physical activity throughout the day

D. A complete loss of the patient's ability to detect smells, since the olfactory receptors in the nose are connected to the alveoli of the lungs in adult humans

32. Blood pressure is highest in which type of blood vessel just after blood leaves the heart with each beat?

A. The veins, which carry blood back from the body's tissues to the heart after blood has flowed through the body's many capillary beds in the tissues

B. The capillaries, which are the smallest blood vessels in the body and which allow exchange of materials between the blood and the surrounding body tissues

C. The venules, the small blood vessels that lie between the capillaries and the larger veins of the body's overall circulatory system structure overall

D. The arteries, which carry blood under high pressure away from the heart and toward the body's various organs and tissues during each heartbeat in life

33. A nephron is the functional unit of the kidney. As blood passes through the glomerulus of a nephron, fluid is forced from the blood into the surrounding capsule. The major driving force for this filtration is:

A. Active transport of fluid by ATP-driven pumps in the wall of the glomerulus, which selectively pump water and small solutes out of the bloodstream actively

B. Blood pressure, which forces water and small dissolved molecules out of the capillaries of the glomerulus and into the surrounding Bowman's capsule rapidly

C. Osmosis driven by salt gradients in the surrounding kidney tissue, with water moving from the bloodstream into the capsule down its concentration gradient

D. Diffusion of large protein molecules from the blood into the capsule, where they then form the basic structure of the urine produced by the nephron in the kidney

34. Cortisol is a hormone released by the adrenal glands in response to long-term stress. Chronically elevated cortisol levels are associated with:

A. Suppressed immune function, increased blood sugar, and weight gain, all of which can have long-term negative effects on health over many years of life

B. Improved immune function, lower blood sugar, and consistent weight loss, all of which generally improve a person's health throughout their life over time

C. No measurable physiological effect at all on the body, since cortisol is a hormone with very little impact on the body's daily metabolic activities each day

D. A direct increase in red blood cell production by the bone marrow, leading to dramatic increases in the body's ability to carry oxygen throughout the body

35. The pituitary gland is often called the "master gland" of the endocrine system because it:

A. Produces all of the body's hormones in a single central location near the base of the brain, supplying every hormone needed by the body each day of life

B. Filters waste products out of the bloodstream and produces urine for excretion through the urinary system of the body each day after meals are eaten

- C. Produces hormones that regulate the activity of many other endocrine glands throughout the body, including the thyroid, adrenals, and gonads
- D. Pumps blood through the body's circulatory system, distributing nutrients and oxygen to every tissue throughout the body each minute of normal life

36. Some neurotransmitters in the nervous system have an inhibitory effect on the neurons that receive them, making the receiving neuron less likely to fire an action potential. An inhibitory neurotransmitter most directly works by:

- A. Permanently destroying the receiving neuron so that it can never fire an action potential again throughout the rest of the person's life on Earth
- B. Stimulating the receiving neuron to fire many action potentials in rapid succession, sending repeated signals throughout the surrounding nervous tissue
- C. Increasing the size of the receiving neuron dramatically, causing it to absorb large amounts of nutrients and grow rapidly within hours of release at the synapse
- D. Causing changes in the receiving neuron's membrane that make it harder to depolarize and reach the threshold needed for an action potential at the cell

37. GABA (gamma-aminobutyric acid) is a major inhibitory neurotransmitter in the brain. Many anti-anxiety medications enhance the effects of GABA on neurons throughout the brain. The most likely overall effect of these medications on brain activity is:

- A. A dramatic increase in the overall electrical activity of brain neurons, leading to greatly heightened alertness and rapid information processing in the brain
- B. A general reduction in the overall electrical activity of brain neurons, leading to feelings of relaxation and reduced anxiety in the patient over time
- C. A complete loss of all sensory function, since GABA receptors are located only in the sensory regions of the brain throughout the entire human body
- D. A targeted activation of only the motor neurons of the brain, producing involuntary muscle contractions throughout the body during the time of use

38. Multiple sclerosis (MS) is an autoimmune disease in which the body's immune system attacks the myelin sheaths surrounding the axons of certain neurons. The most direct effect of this damage on nerve impulse conduction is:

- A. Slowed or interrupted conduction of action potentials along the affected neurons, leading to symptoms such as muscle weakness and coordination problems
- B. A dramatic increase in the speed of action potential conduction, leading to overactive muscle responses and improved sensory function throughout the body
- C. The complete loss of any ability of neurons to produce action potentials, leading to immediate paralysis of the entire body within just hours of onset of the disease
- D. Increased production of new neurons by the brain to replace those that have been damaged by the autoimmune response in MS patients each day of life

39. A doctor tests a patient's knee-jerk reflex by tapping the tendon below the kneecap with a small rubber hammer. The leg kicks slightly. The pathway of this reflex involves:

- A. Tapping → brain → conscious decision to kick → motor neuron → leg muscle, requiring the patient's conscious choice to move the leg in response to the tap
- B. Tapping → motor neuron → leg muscle, with no involvement of any sensory neurons or the spinal cord at any point during the entire reflex response in the body
- C. Tapping → sensory neuron → brain → motor neuron → leg muscle, with the signal passing through the brain before causing the muscle to briefly contract once
- D. Tapping → sensory neuron → spinal cord → motor neuron → leg muscle, bypassing the brain so that the response occurs very rapidly to protect the body from harm

40. The three major types of muscle tissue in the human body are skeletal, cardiac, and smooth muscle. Smooth muscle differs from skeletal muscle in that smooth muscle:

- A. Is found attached to bones throughout the body and is used to produce all voluntary movements of the limbs during normal daily activities each day of life
- B. Is striated and under voluntary control, similar to skeletal muscle in both its appearance under the microscope and its method of nervous control over contractions
- C. Is non-striated and under involuntary control, found in the walls of internal organs such as the intestines, blood vessels, and reproductive organs of the body
- D. Contains no actin or myosin filaments and contracts through a completely different mechanism than the sliding filament model seen in skeletal muscle tissue

41. The sliding filament theory describes how muscles contract at the molecular level. According to this theory, muscle contraction occurs when:

- A. The entire actin and myosin filaments shorten by a substantial amount during the process of contraction throughout the muscle fiber each second of contraction
- B. Myosin heads attach to actin filaments, pull them past the myosin, and then release, repeating this cycle to shorten the muscle fiber over the course of contraction
- C. Actin and myosin filaments grow longer during contraction, which is what shortens the muscle as it contracts in response to nerve stimulation each second of life
- D. New actin and myosin filaments are synthesized during contraction, providing the muscle fiber with the additional protein it needs to contract over the time period

42. A person with osteoporosis has bones that are weaker than normal and more likely to fracture. The primary cause of osteoporosis is:

- A. A decrease in bone density caused by an imbalance between bone formation by osteoblasts and bone resorption by osteoclasts over the years of an adult's life
- B. A complete loss of all calcium from the bones of the affected person within just a few days of the initial diagnosis of the disease by a physician at the hospital
- C. An increase in bone density above normal levels, making the bones brittle because they have become too hard to absorb impact during normal physical activity
- D. The replacement of bone tissue throughout the skeleton with fat tissue, which has no structural function in supporting the body's overall framework during life

43. The shoulder joint allows the arm to move in many different directions, including rotation. This type of joint is best classified as:

- A. A hinge joint, which allows movement primarily in one direction only, such as the joint found at the elbow connecting the upper and lower arm bones in the body
- B. A pivot joint, which allows one bone to rotate around another bone, such as the joint between the first two vertebrae of the neck near the base of the skull
- C. A gliding joint, which allows the bones to slide past one another with a limited range of motion, such as the joints found within the wrist and the ankle of the body
- D. A ball-and-socket joint, which allows movement in many directions including rotation, such as the joint found at the shoulder and at the hip joint of the body

44. The skin is composed of multiple layers, including the outer epidermis and the deeper dermis. Compared with the epidermis, the dermis contains:

- A. Mostly dead, flattened cells filled with the protein keratin, which provide a barrier against water loss and against entry by foreign organisms into the body
- B. Multiple layers of densely packed pigment-producing cells called melanocytes that protect the deeper layers of the body from sunlight damage over the years
- C. Blood vessels, nerve endings, hair follicles, and sweat glands, all embedded in a layer of connective tissue rich in collagen and elastic fibers in the skin
- D. A thick layer of fat cells that insulate the body and store energy, found primarily below the dermis in a layer called the subcutaneous tissue of the human body

45. When the skin is cut, a complex healing process begins. The early inflammatory phase of healing is characterized by redness, warmth, swelling, and pain at the site. These signs of inflammation are most directly caused by:

- A. The complete absence of any blood flow to the injured area, which prevents oxygen and nutrients from reaching the surrounding tissues during the healing process
- B. Increased blood flow to the area along with the release of signaling molecules that make blood vessels leaky, allowing immune cells to reach the injured site
- C. The immediate and total cessation of all activity by the body's white blood cells, which normally provide protection against bacterial infections at injury sites
- D. A direct nerve signal from the brain commanding the affected tissue to become red and swollen as a conscious protective response to the injury of the skin

46. The innate immune system provides the body's first line of defense against pathogens. Innate immunity differs from adaptive immunity in that innate immunity:

- A. Responds rapidly and in the same general way to many different types of pathogens, without producing a memory of specific previous infections of the body
- B. Responds very slowly over a period of weeks, producing specific antibodies and memory cells that target one particular pathogen at a time in the body's tissues
- C. Is found only in vertebrate animals, while adaptive immunity is found in all of the major groups of organisms across the entire tree of life on planet Earth today

D. Requires previous exposure to a specific pathogen in order to mount any response at all, similar to the way that vaccination works in humans throughout their life

47. Histamine is a chemical released by mast cells in response to certain triggers, such as exposure to allergens. The release of histamine during an allergic reaction causes the symptoms of allergies primarily by:

A. Permanently destroying the cells of the immune system that would otherwise produce antibodies in response to the allergen during the entire reaction in the body

B. Increasing the body's overall blood pressure to dangerously high levels, which causes the rapid swelling seen during the allergic response over the time period

C. Causing increased blood vessel permeability, smooth muscle contraction, and mucus secretion, leading to itching, swelling, sneezing, and other symptoms of allergy

D. Producing a long-term immunity to the allergen so that the person never reacts to the same allergen again at any time in the future of their life after first exposure

48. "Herd immunity" refers to a situation in which a high percentage of a population is immune to a particular infectious disease, which provides indirect protection to those who are not immune. Herd immunity is most important for protecting:

A. People who are already immune to the disease, providing them with an additional layer of protection against future infection by the same pathogen over the years

B. People who choose not to be vaccinated for personal reasons, by allowing them to receive immunity from the surrounding community without any effort on their part

C. Domestic livestock animals from human diseases that might cross over to them from the surrounding human population in the community each year during outbreaks

D. Individuals who cannot be vaccinated themselves, such as infants, immunocompromised patients, and people with certain medical conditions or severe allergies

49. Most chemotherapy drugs used to treat cancer work by interfering with cell division. These drugs are effective against cancer because cancer cells:

A. Have completely stopped dividing and are in a permanent resting phase, leaving them more vulnerable to drugs that target the cell membrane directly each cycle

B. Divide much more rapidly than most normal body cells, making them more sensitive to drugs that interfere with the cell division process in the affected tissue

C. Contain large amounts of an enzyme that breaks down chemotherapy drugs faster than normal cells do, leading to greater drug accumulation in cancer cells overall

D. Have completely lost the ability to repair DNA damage, but their division rate is identical to that of normal cells found in healthy tissues each second of life

50. Excessive exposure to ultraviolet (UV) radiation from the sun is a major risk factor for skin cancer. UV radiation causes cancer primarily by:

A. Damaging DNA in skin cells, leading to mutations in genes that control cell division and potentially producing cancer cells over time after sustained exposure

- B. Heating the skin to extremely high temperatures, which directly destroys the proteins inside skin cells and causes immediate cell death in the affected tissue
- C. Stimulating the production of additional melanin in the skin, which interferes with the skin's normal ability to perform cellular respiration each day of life
- D. Causing the immediate release of histamine from mast cells in the skin, which directly triggers cancer cell formation within minutes of sun exposure each time

Practice Exam 28: Life Science: Biology Simulation – Answer Key with Explanations

1. **C** — Peptide hormone receptors sit in the plasma membrane because peptide hormones are hydrophilic and cannot cross the lipid bilayer. They bind extracellular receptors that then trigger intracellular signaling cascades. This contrasts with steroid hormones, which are lipid-soluble and bind to receptors inside the cell.
2. **A** — Signal transduction is the process by which a cell converts an external chemical signal into an internal cellular response through a chain of biochemical steps. Receptor binding typically activates intracellular relay proteins and second messengers that amplify the message. This amplification is why a few hormone molecules can produce a large cellular response.
3. **D** — Gap junctions are protein channels between adjacent animal cells that allow small molecules and ions to pass directly from cell to cell. They enable rapid coordinated activity in tissues such as cardiac muscle, where electrical signals must spread quickly across many cells at once. Plasmodesmata serve a similar role in plants but pass through cell walls.
4. **B** — Alkaloids, tannins, and terpenes are secondary metabolites that defend plants against herbivores, fungi, and bacteria by being bitter, toxic, or otherwise deterring consumption. Familiar examples include nicotine, caffeine, and the latex of milkweeds. These chemical defenses are products of long coevolutionary arms races between plants and their consumers.
5. **C** — Pheromones are chemical molecules released into the environment that influence the behavior of other members of the same species. Female moth sex pheromones can be detected by males at distances of more than a kilometer because male antennae carry highly specific receptor proteins. This long-distance chemical signaling is more efficient than visual or auditory cues for locating scattered mates.
6. **A** — The waggle dance is a symbolic form of animal communication that encodes the distance and direction of a food source relative to the sun. The angle of the waggle run inside the hive represents the angle to the food outside, and the duration encodes the distance. This makes honeybee dance language one of the most sophisticated examples of non-human communication.
7. **D** — Songbirds inherit a genetic template for their song but must hear a tutor's song during a critical period to develop normal adult song. Birds raised in isolation produce abnormal, simplified songs, demonstrating the genetic component, while birds raised hearing the wrong species' song often learn that

one, demonstrating the learned component. Song learning is a classic example of nature and nurture interacting in behavior.

8. C — A vector is an organism that transmits a pathogen from one host to another without itself being the disease. Mosquitoes pick up Plasmodium, dengue virus, or Zika virus from one host during a blood meal and inject the pathogen into the next host. Vector control through bed nets and insecticides is one of the most effective public health strategies against these diseases.

9. B — Lyme disease range and incidence have expanded as suburban development reaches into forest habitats and as deer and small-mammal populations have grown in those edge environments. Black-legged ticks need these hosts at different life stages, so habitat changes that favor the hosts also favor the ticks. Warming winters have also allowed ticks to survive in regions that were previously too cold.

10. A — Most emerging infectious diseases are zoonoses that spilled over from animal reservoirs into humans. Increased human encroachment on wildlife habitats through deforestation, wildlife trade, and bushmeat hunting raises the rate of contact and the chance of spillover. HIV (chimpanzees), SARS (bats via civets), and COVID-19 (bats) are all leading examples.

11. D — DDT and its breakdown product DDE concentrate up the food chain through biomagnification and interfere with calcium deposition in eggshells. Eagles, ospreys, and pelicans laid eggs so thin they cracked under brooding parents, causing reproductive failure. Banning DDT in 1972 allowed these populations to recover dramatically.

12. C — Biomagnification is the increase in pollutant concentration at successively higher trophic levels, occurring because each predator consumes many contaminated prey items and concentrates the chemical in its tissues. Methylmercury is especially prone to biomagnification because it binds tightly to proteins and accumulates over a lifetime. Top predators such as tuna and swordfish therefore carry the highest mercury loads in marine food webs.

13. B — Many lichen species are extremely sensitive to sulfur dioxide and nitrogen oxides because their tissues absorb gases and dissolved pollutants directly from the air. The absence of these sensitive lichens therefore signals that pollution levels exceed their tolerance. Lichen surveys have been used to map air pollution since the 19th century.

14. A — Bioindicators are valuable because living organisms integrate exposure over time and respond to cumulative effects that brief chemical measurements may miss. They can also reveal pollution at biologically relevant levels too low for instruments to detect reliably, since they respond to bioavailable rather than total pollutant concentration. This makes them a powerful complement to direct chemical monitoring.

15. D — Overabundance of prey and mass starvation is not a recognized cause of amphibian decline; the major documented drivers are habitat destruction, chytrid fungus, climate change, pollution, and UV-B exposure. Many populations have collapsed even in protected wilderness areas, pointing to disease and climate as widespread causes. The amphibian crisis is one of the most severe documented vertebrate declines.

16. C — Bd colonizes the keratinized skin of frogs and disrupts the skin's role in electrolyte balance and gas exchange. Because amphibian skin is essential for breathing and ion regulation, the resulting cardiac arrest from electrolyte imbalance can kill an infected frog within weeks. This single pathogen has been linked to declines or extinctions of more than 500 amphibian species worldwide.

17. B — Wildlife corridors restore landscape connectivity between otherwise isolated habitat patches, allowing animals to move, find mates, and recolonize areas. Increased gene flow counters the inbreeding and drift that plague small fragmented populations. Corridors are now a standard component of conservation planning for wide-ranging species such as wolves and big cats.

18. A — Low genetic diversity reduces a population's ability to evolve in response to new selective pressures, including novel diseases. Modern cheetahs accept skin grafts from unrelated individuals, indicating remarkably uniform MHC genotypes that leave the species particularly vulnerable to epidemics. Inbreeding depression and reduced sperm quality also affect reproduction.

19. D — Genetic rescue introduces new alleles from a healthier source population, increasing heterozygosity and counteracting inbreeding depression. The classic example is the Florida panther, in which Texas cougars were introduced and dramatically improved health, fertility, and survival within a few generations. The strategy works best when the source population is genetically similar enough that local adaptation is preserved.

20. C — Coevolution occurs when two species exert reciprocal selective pressure on each other, leading to closely matched adaptations. The long curved beak of a hummingbird and the deep curved corolla of its preferred flower are a classic mutualistic coevolutionary pair. Such tight matching can leave both species vulnerable if either partner declines.

21. A — Mutualism is a symbiotic relationship in which both partners benefit; in the fig-wasp system, the fig gets pollinated and the wasp gets food and a protected place to reproduce. Each fig species typically has its own specialist wasp pollinator, making the relationship obligate on both sides. This is one of the most ancient and specialized mutualisms in nature.

22. B — In commensalism, one partner benefits while the other is essentially unaffected. The remora gains food, transportation, and protection from the shark's presence, while the shark experiences little measurable cost or benefit. Other commensal relationships include barnacles on whales and many epiphytic plants on tree branches.

23. D — Antibiotic resistance evolves through natural selection: random mutation and horizontal gene transfer generate heritable variation, and antibiotic exposure favors the survival and reproduction of resistant strains. Misuse and overuse of antibiotics in medicine and agriculture have accelerated this process worldwide. Hospital settings concentrate antibiotic use and create especially strong selective pressure on bacterial populations.

24. C — Industrial melanism in peppered moths is a textbook example of natural selection responding to changing environmental conditions. When tree bark darkened with soot, dark moths had better camouflage from bird predators, and when air quality improved and bark lightened, the selection reversed. The bidirectional shift is strong evidence against Lamarckian inheritance of acquired characteristics.

25. B — Lactase persistence is a recent evolutionary adaptation: in dairying populations, individuals who could digest milk into adulthood had a nutritional advantage and left more descendants. The trait has arisen independently at least four times through different mutations in European and African populations, a textbook example of recent human evolution. Without this adaptation, most adult humans worldwide remain lactose intolerant.

26. A — Polyploidy creates instant reproductive isolation in the same geographic area as the parent population because tetraploid offspring usually cannot produce viable seeds when crossed back to diploids. This makes polyploid speciation a major form of sympatric speciation, particularly common in flowering plants. Wheat, cotton, and many cultivated crops are polyploid species.

27. D — Mechanical isolation occurs when physical or structural differences prevent successful fertilization between two species. Different pollinator species attracted to flowers of different shape or size is a classic prezygotic isolating mechanism in plants. This isolation prevents gene flow even when the two species grow side by side.

28. C — A hybrid zone is the geographic region where the ranges of two closely related species overlap and produce hybrid offspring. The fate of the hybrid zone depends on hybrid fitness — if hybrids are unfit, reinforcement strengthens isolation, but if hybrids are fit, the species may eventually merge. Hybrid zones are natural laboratories for studying speciation in action.

29. B — Convergent evolution produces similar adaptations in unrelated lineages exposed to similar selective pressures. Cacti (family Cactaceae, Americas) and stem-succulent euphorbias (Euphorbiaceae, Africa) independently evolved fleshy water-storing stems with reduced leaves as adaptations to desert conditions. Their similar appearance masks completely different evolutionary origins on separate continents.

30. A — Shared embryological features such as pharyngeal arches and a post-anal tail reflect common developmental genetic programs inherited from a shared vertebrate ancestor. These features may later be modified into gills in fish or middle-ear bones in mammals, but the early embryonic pattern remains highly conserved. This deep developmental conservation is one of the strongest pieces of evidence for common descent.

31. C — Loss of alveolar surface area and elasticity in COPD reduces the area available for diffusion of O₂ and CO₂ between air and blood. The resulting drop in arterial oxygen, combined with the work of breathing through damaged airways, produces shortness of breath especially on exertion. Smoking cessation slows but does not reverse the structural damage to alveoli.

32. D — Arteries receive blood directly from the ventricles during systole and therefore experience the highest pressure in the circulatory system. Their thick muscular walls withstand and propagate the pressure wave we feel as the pulse. Blood pressure falls progressively through the arterioles, capillaries, venules, and veins back to the heart.

33. B — Glomerular filtration is a pressure-driven process: blood entering the glomerulus is under high hydrostatic pressure, which forces water and small solutes through the filtration barrier into Bowman's

capsule. Larger proteins and blood cells are retained in the blood by the size selectivity of the filtration barrier. A drop in blood pressure quickly reduces urine output, a key clinical indicator of kidney function.

34. A — Chronically elevated cortisol suppresses immune function by inhibiting lymphocyte activity, raises blood glucose through gluconeogenesis, and promotes visceral fat deposition. These actions evolved to support short-term fight-or-flight responses but become harmful when stress is sustained. Cushing's syndrome shows the clinical picture of long-term cortisol excess at its extreme.

35. C — The anterior pituitary releases tropic hormones (TSH, ACTH, FSH, LH, GH) that regulate the thyroid, adrenal cortex, gonads, and growth respectively. The hypothalamus controls the pituitary itself, but it is the pituitary's outputs that orchestrate most downstream endocrine glands. This hierarchical control is why the pituitary is called the "master gland" of the endocrine system.

36. D — Inhibitory neurotransmitters typically open Cl^- or K^+ channels in the postsynaptic membrane, hyperpolarizing the cell or making it more difficult to depolarize. This raises the threshold for firing an action potential and reduces overall neuronal excitability. GABA and glycine are the main inhibitory transmitters in the central nervous system.

37. B — Enhancing GABA's effect increases inhibition throughout the central nervous system, reducing overall neuronal firing and producing anxiolytic and sedative effects. Benzodiazepines such as diazepam bind to the GABA-A receptor at a site that amplifies GABA's response. This mechanism is also why these drugs cause drowsiness and impair coordination at higher doses.

38. A — Myelin acts as an electrical insulator that enables saltatory conduction, in which action potentials jump rapidly between nodes of Ranvier. When immune attack strips myelin in MS, conduction slows, becomes erratic, or fails along the affected axons. The result is variable symptoms — weakness, numbness, vision changes — depending on which tracts are demyelinated.

39. D — The patellar reflex is a monosynaptic spinal reflex: stretch receptors in the quadriceps activate sensory neurons that synapse directly onto motor neurons in the spinal cord, which fire and contract the muscle. Because the signal does not travel up to the brain and back, the response is extremely fast. Reflex arcs protect the body more quickly than conscious decisions can.

40. C — Smooth muscle lacks the regular striped pattern of skeletal muscle because its actin and myosin are not organized into sarcomeres. It is controlled by the autonomic nervous system and operates without conscious control. Smooth muscle lines the walls of internal organs such as the gut, blood vessels, bladder, and reproductive tract.

41. B — In the sliding filament model, myosin cross-bridges bind actin, undergo a power stroke that pulls the actin filament past the myosin, then detach and reset using ATP. The filaments themselves do not shorten; the sarcomere shortens as the thin and thick filaments slide past each other. Repeated cycles produce the gross shortening of the whole muscle.

42. A — Osteoporosis develops when osteoclasts resorb bone faster than osteoblasts replace it, gradually thinning the bone matrix and reducing density. Postmenopausal estrogen loss, inadequate calcium and

vitamin D, and a sedentary lifestyle all accelerate this imbalance. Weight-bearing exercise and bisphosphonate medications can slow or partially reverse the loss.

43. D — Ball-and-socket joints fit a spherical bone head into a cup-shaped socket, allowing flexion, extension, abduction, adduction, and rotation. The shoulder (glenohumeral) and hip joints are the two main examples in the human body. This freedom of movement comes with greater susceptibility to dislocation, especially at the shoulder.

44. C — The dermis is a thick layer of connective tissue containing blood vessels, sensory nerve endings, hair follicles, sebaceous glands, and sweat glands embedded in a matrix of collagen and elastic fibers. The epidermis above is mostly avascular epithelial cells. This is why a paper cut to the epidermis does not bleed, but a deeper cut into the dermis does.

45. B — Inflammation is driven by chemical signals such as histamine, prostaglandins, and cytokines that dilate local blood vessels and increase their permeability. The resulting increased blood flow brings warmth and redness, while leaky vessels allow plasma and immune cells to enter the tissue and produce swelling. These changes deliver immune defenders to the wound and clear debris.

46. A — Innate immunity is rapid, non-specific, and pre-programmed; barriers, phagocytes, complement, and inflammation respond within minutes to hours of infection. It does not retain memory of past pathogens, so the response strength is similar with every encounter. Adaptive immunity, by contrast, is slower but pathogen-specific and improves with re-exposure through memory cells.

47. C — Histamine binds receptors on smooth muscle and blood vessels, increasing vascular permeability (swelling, hives), contracting bronchial smooth muscle (wheezing), and stimulating mucus production (runny nose). Antihistamines block H1 receptors and relieve these symptoms. In severe cases, massive histamine release causes the life-threatening drop in blood pressure characteristic of anaphylaxis.

48. D — Herd immunity matters most for people who cannot generate their own immune response — newborns too young to vaccinate, chemotherapy patients, transplant recipients, and people with immunodeficiencies. When most of the surrounding population is immune, the pathogen cannot spread efficiently and these vulnerable individuals are indirectly protected. This is the public-health justification for maintaining high vaccination coverage in a population.

49. B — Chemotherapy agents target processes essential to cell division, such as DNA replication, microtubule function, or mitotic checkpoints. Because cancer cells divide more frequently than most healthy cells, they are disproportionately affected. The side effects of chemotherapy — hair loss, bone marrow suppression, GI distress — reflect collateral damage to other rapidly dividing tissues in the body.

50. A — UV photons damage DNA primarily by forming pyrimidine dimers, and accumulated mutations in tumor-suppressor and proto-oncogenes (such as TP53 in squamous cell carcinoma) drive skin cells toward unregulated division. Melanin pigment and DNA repair systems usually cope, but lifetime accumulated damage progressively raises cancer risk. This is why sunscreen, protective clothing, and avoiding burns reduce melanoma and other skin cancers.