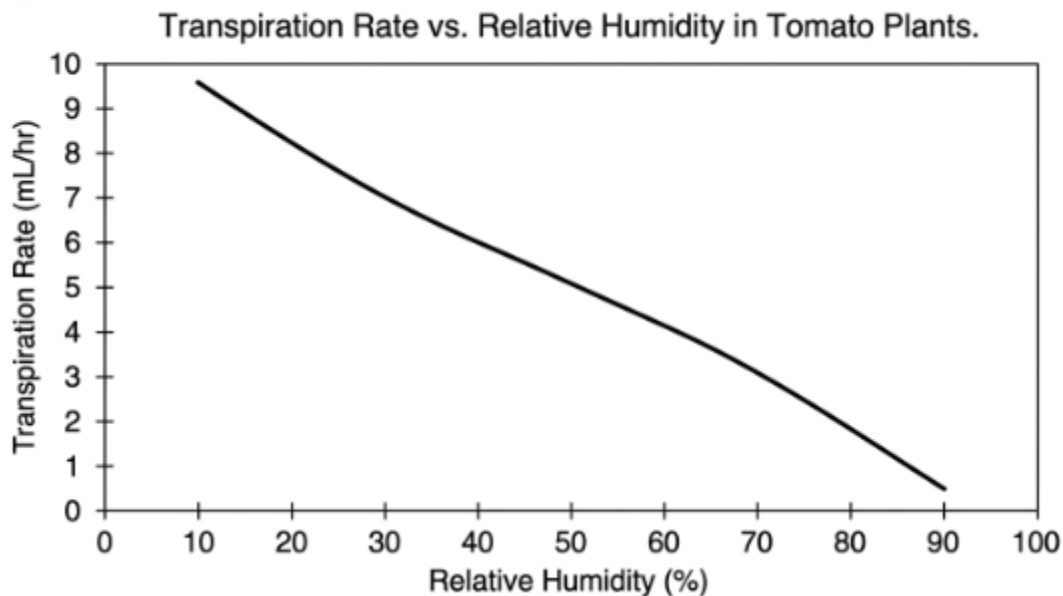


PRACTICE EXAM 15: LIFE SCIENCE: BIOLOGY SIMULATION (50 QUESTIONS)

Instructions: Practice Exam 15 emphasizes plant biology, animal behavior, evolutionary mechanisms beyond basic natural selection, ecological interactions, biotechnology, the endocrine system, and embryonic development within the New York Living Environment scope. Each question is independent. Select the one best answer for each item.

1. A biology class measured the rate of water loss (transpiration) from potted tomato plants in greenhouses set to different relative humidity levels. The results are shown in the graph below.

Figure PQ-1



Based on the graph, what is the relationship between humidity and transpiration rate?

- A. As humidity increases, transpiration rate increases steadily across the entire range of humidity values
- B. As humidity increases, transpiration rate decreases steadily across the entire range of humidity values

- C. Humidity has no measurable effect on the transpiration rate of the tomato plants at any humidity level
- D. As humidity increases, transpiration first decreases and then sharply increases at very high humidity
2. Stomata are small pores on the surfaces of plant leaves. Their primary function is to:
- A. Conduct sugars produced during photosynthesis from leaves down to the roots through the phloem tissue
- B. Anchor the plant firmly to the soil and absorb water from the surrounding soil through small openings
- C. Produce flowers and fruits during the plant's reproductive growth phase at the end of each season
- D. Allow gas exchange and release of water vapor between the leaf interior and the surrounding atmosphere
3. A potted houseplant placed on a windowsill bends toward the window over several days. This response is best classified as:
- A. Phototropism, the directional growth of a plant in response to a light source coming from one side
- B. Gravitropism, the directional growth of a plant in response to the downward pull of Earth's gravity
- C. Hydrotropism, the directional growth of a plant's roots in response to a moisture gradient in the soil
- D. Thigmotropism, the directional growth of a plant in response to physical touch or contact with an object
4. Xylem tissue in vascular plants is primarily responsible for:
- A. Transporting sugars produced during photosynthesis from the leaves down to the roots of the plant
- B. Storing starch reserves for the plant during the cold winter months between active growth seasons
- C. Transporting water and dissolved minerals upward from the roots to the leaves of the plant body

D. Protecting the plant from herbivores by producing bitter chemicals along the surfaces of all leaves

5. The part of a typical flower that develops into a fruit after fertilization is the:

A. Stamen, the male reproductive structure that produces pollen grains containing the sperm cells

B. Ovary, the female reproductive structure that contains the ovules and develops into the fruit

C. Petal, the colorful outer structure that attracts pollinators such as bees, butterflies, and birds

D. Sepal, the small green leaf-like structure that protects the developing flower bud before it opens

6. A newly hatched sea turtle immediately crawls toward the ocean without any teaching or prior experience. This behavior is best classified as:

A. Innate behavior, a genetically programmed behavior that does not require prior learning from experience

B. Learned behavior, a behavior acquired through repeated experience over the organism's own lifetime

C. Conditioned response, a behavior trained by repeated association with a particular stimulus over time

D. Cultural transmission, a behavior passed from older individuals to younger ones within a population

7. Imprinting is a type of learning in which:

A. An organism gradually associates a previously neutral stimulus with a meaningful stimulus over time

B. An organism modifies its behavior based on the rewarding or punishing consequences of past actions

C. An organism suddenly solves a new problem by recognizing a relationship among objects in its surroundings

D. A young animal forms a strong attachment to the first moving object it sees during a critical early period

8. The seasonal migration of birds southward in autumn is best understood as a behavior that:

- A. Was deliberately taught by older birds to the younger birds within a single migrating flock each year
 - B. Increases survival by allowing the birds to escape cold conditions and reach areas of more abundant food
 - C. Provides no real biological advantage to the birds and continues only out of historical habit over time
 - D. Originated only after humans first introduced these bird species to new continents in recent centuries
9. A random change in allele frequencies within a population due to chance events, rather than to selection, is best described as:
- A. Natural selection, in which heritable traits that increase survival and reproduction become more common
 - B. Gene flow, in which alleles move between populations when individuals migrate from one area to another
 - C. Genetic drift, in which allele frequencies change randomly from one generation to the next by chance
 - D. Mutation pressure, in which new alleles are constantly being added to the population by random mutation
10. A volcanic eruption kills nearly all of the beetles in a population, leaving only a small group of survivors whose allele frequencies happen to differ noticeably from the original population. This event is best described as:
- A. The bottleneck effect, a sharp reduction in population size that alters the surviving allele frequencies
 - B. The founder effect, in which a few individuals start a new population in a previously unoccupied area
 - C. Natural selection, in which beetles with adaptive traits survived the volcanic eruption preferentially
 - D. Coevolution, in which two interacting species adapt in response to each other over many generations

11. A small group of finches from a mainland population is blown onto a remote island, where they establish a new population. The allele frequencies of the island birds differ noticeably from those of the mainland birds. This is best described as:

- A. The bottleneck effect, in which a sharp reduction in population size changes the allele frequencies
- B. Natural selection, in which heritable traits that improve survival increase in frequency over generations
- C. Gene flow, in which alleles move between two existing populations through the ongoing migration of individuals
- D. The founder effect, in which a small subset of individuals establishes a new population in a new area

12. When individuals migrate between two populations and breed with members of their new population, the resulting change in allele frequencies is best described as:

- A. Genetic drift, in which allele frequencies change randomly from one generation to the next by chance
- B. Natural selection, in which advantageous heritable traits become more common over many generations
- C. Gene flow, in which alleles move from one population to another through the migration of individuals
- D. Reproductive isolation, in which two populations are prevented from interbreeding with each other

13. Hardy-Weinberg equilibrium describes a population in which allele frequencies remain constant from one generation to the next. Maintaining this equilibrium requires:

- A. A small, isolated population with very limited resources and frequent random environmental disturbances
- B. No mutations, no natural selection, no migration, random mating, and a very large population size
- C. Strong natural selection acting against any disadvantageous alleles in every single generation continuously
- D. Frequent migration between populations and a steady supply of new mutations entering the gene pool

14. Two populations of an animal can no longer interbreed and produce fertile offspring. These two populations are best classified as:

A. Separate biological species, since the inability to interbreed and produce fertile offspring defines distinct species

B. Two subspecies of one parent species, still capable of exchanging genes if reunited under favorable conditions

C. A single species displaying internal genetic variation across different parts of its overall geographic range

D. Closely related genera that no longer share recent common ancestry within the past one million years

15. When a newly formed mountain range physically separates a single ancestral population into two groups that gradually evolve into separate species, the process is best classified as:

A. Sympatric speciation, in which new species arise within the same geographic area without physical separation

B. Convergent evolution, in which unrelated species independently develop similar physical traits over time

C. Coevolution, in which two interacting species evolve in response to each other over many generations

D. Allopatric speciation, in which physical separation of populations leads to the formation of new species

16. A plant species diverges into two new species in the same area through a chromosome doubling event that prevents interbreeding, without any geographic barrier. This process is best classified as:

A. Allopatric speciation, in which a physical geographic barrier separates populations and allows divergence

B. Convergent evolution, in which unrelated species independently develop similar physical traits over time

C. Sympatric speciation, in which new species arise within the same geographic area without physical separation

D. Gene flow, in which alleles move between populations through the migration of individual organisms

17. Many flowering plants and their insect pollinators have evolved together so that each is closely adapted to the other. This pattern of reciprocal evolutionary change between interacting species is best described as:

A. Coevolution, in which two interacting species act as agents of natural selection on each other over time

B. Convergent evolution, in which unrelated species independently develop similar physical traits over time

C. Divergent evolution, in which two related species develop different traits from a single common ancestor

D. Adaptive radiation, in which one ancestral species diversifies into many species filling different niches

18. A mass extinction event is best described as:

A. The natural background extinction rate that affects only a small number of species in any given century

B. A relatively short period during which a very large number of species go extinct across multiple habitats

C. The extinction of a single species due to a localized environmental change in one small geographic region

D. The gradual loss of one species followed by the gradual appearance of a closely related new species nearby

19. A region containing an exceptionally large number of species (many of which are not found anywhere else) but also facing severe threat from human activities is best classified as:

A. A monoculture, in which one single species dominates a large area such as in industrial farming today

B. A climax community, in which an ecosystem has reached a long-term stable balance among its species

C. An invasive species range, in which introduced species are spreading rapidly outside of their native habitat

D. A biodiversity hotspot, a region of exceptionally high species richness that faces significant habitat threats

20. When two species in an ecosystem rely on the same limited resource in the same way, one species typically outcompetes the other and the loser disappears from that area. This principle is best described as:

A. Mutualism, in which both species in a close ecological relationship benefit from their interaction together

B. Predation, in which one species directly hunts and consumes another species within their shared habitat

C. Competitive exclusion, in which two species cannot coexist long-term if they occupy the exact same niche

D. Symbiotic dependence, in which one species cannot survive at all without the presence of the other species

21. Lichens consist of a fungus and a photosynthetic alga or cyanobacterium living closely together, with both partners benefiting from the relationship. This type of interaction is best classified as:

A. Mutualism, a relationship in which both species involved in the interaction benefit from each other

B. Commensalism, a relationship in which one species benefits and the other is neither helped nor harmed

C. Parasitism, a relationship in which one species benefits at the direct expense of the other species

D. Competition, a relationship in which two species struggle for the same limited resource at one time

22. A barnacle attached to the skin of a whale is carried through nutrient-rich waters, while the whale is essentially unaffected by the barnacle's presence. This relationship is best classified as:

A. Mutualism, a relationship in which both of the species involved benefit from the close interaction

B. Commensalism, a relationship in which one species benefits and the other is essentially unaffected

C. Parasitism, a relationship in which one species benefits while directly harming the other species

D. Predation, a relationship in which one species hunts and consumes the other species for food

23. A tapeworm living in the intestine of a mammal absorbs nutrients from the host and gradually weakens the host over time. This relationship is best classified as:

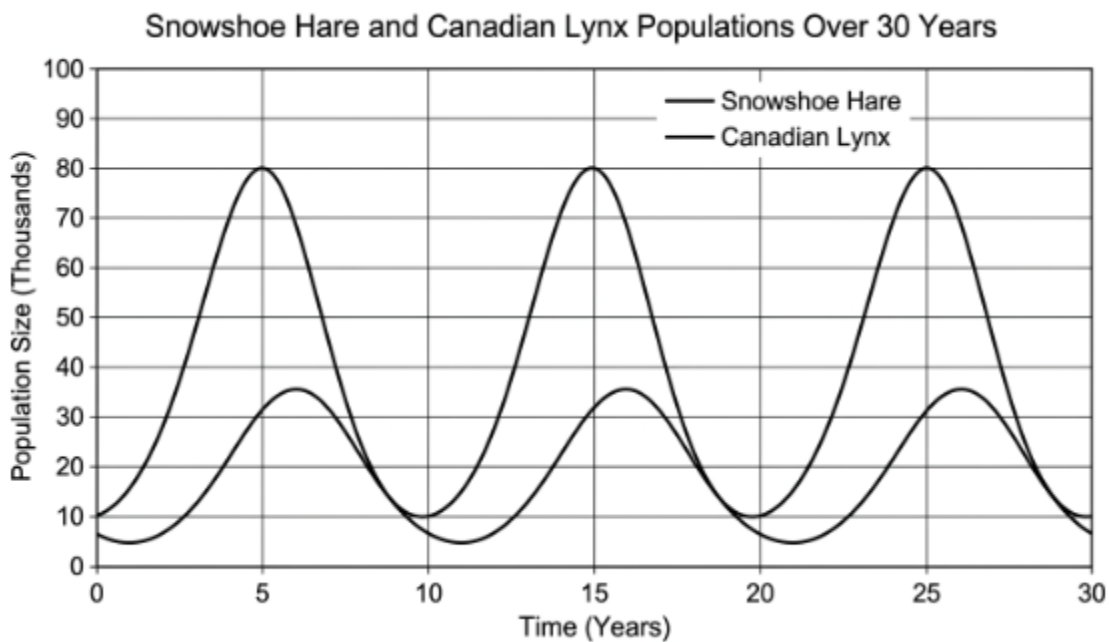
A. Mutualism, a relationship in which both of the species involved benefit from their close interaction

B. Commensalism, a relationship in which one species benefits and the other is neither helped nor harmed

C. Parasitism, a relationship in which one species benefits at the direct expense of the host organism

D. Predation, in which one organism rapidly kills and consumes another organism as a single complete meal

24. A graph of snowshoe hare and Canadian lynx populations in a Canadian forest shows that lynx populations rise and fall about one year after hare populations rise and fall. This pattern is best illustrated as:



A. The competitive exclusion principle, in which one species drives the other entirely to extinction completely

B. Mutualistic coexistence, in which both species depend on each other for mutual survival across all time

C. Random independent fluctuations, in which the two populations rise and fall by completely random chance

D. A predator-prey cycle, in which the predator population responds to changes in the prey population over time

25. A species whose presence or activity has a disproportionately large effect on the structure of an ecosystem — far greater than would be expected from its abundance alone — is best described as:

A. An invasive species, a non-native species that spreads rapidly and disrupts the existing ecological balance

B. A keystone species, whose removal would cause major changes throughout the structure of the ecosystem

C. A pioneer species, the first species to colonize a barren area such as bare rock after a glacier retreats

D. An apex predator, a top-level consumer that has no natural predators of its own within the food chain

26. An invasive species introduced to a new ecosystem often outcompetes native species largely because the invasive species:

A. Frequently lacks the natural predators, parasites, and competitors that controlled it within its native range

B. Always reproduces by asexual reproduction in the new environment and so produces identical offspring rapidly

C. Brings new diseases with it that affect only the invasive species itself and not the native species at all

D. Is genetically identical to one of the native species but happens to be physically larger in average body size

27. Habitat fragmentation refers to:

A. The complete and rapid loss of an entire habitat type from across the surface of one whole continent at once

B. The natural seasonal cycling of populations within a single habitat over the course of several growing seasons

C. The breaking apart of a once-continuous habitat into smaller, isolated patches separated by other land uses

D. The introduction of new species into an existing habitat with the goal of enriching the local biodiversity

28. Conservation biologists work primarily to:

A. Eliminate as many species as possible from ecosystems in order to simplify the structure of the food webs

B. Increase the introduction of non-native species to ecosystems to add new genetic diversity quickly each year

C. Convert as much remaining wilderness as possible into farmland to support continued human population growth

D. Preserve biodiversity by protecting habitats, restoring damaged ecosystems, and managing threatened species

29. The polymerase chain reaction (PCR) is a laboratory technique used to:

A. Make many copies of a small section of DNA from a tiny starting sample within a short period of time

B. Cut DNA molecules into smaller fragments at specific recognition sites using restriction enzymes accurately

C. Separate DNA fragments of different sizes by moving them through a porous gel under an electric voltage

D. Convert messenger RNA back into a complementary strand of DNA for use in molecular research analysis

30. Gel electrophoresis is a laboratory technique most often used to:

A. Make many identical copies of a small section of DNA by repeated cycles of heating and cooling reactions

B. Separate DNA fragments by size by moving them through a gel matrix under the influence of electric voltage

C. Synthesize entirely new DNA sequences from individual nucleotides under controlled laboratory conditions

D. Convert DNA into protein directly without the intermediate steps of transcription and translation in cells

31. DNA fingerprinting is most commonly used in:

A. Plant fertilization, in which the pollen of one species is used to fertilize the ovules of a different species

B. The synthesis of artificial sweeteners through the addition of new chemical functional groups to sugar molecules

C. Forensic investigations and paternity testing, where unique DNA patterns are used to identify specific individuals

D. The transport of dissolved gases such as oxygen and carbon dioxide through the bloodstream of mammal species

32. Recombinant DNA technology involves:

A. Combining DNA from two different sources, often using restriction enzymes and a vector such as a plasmid

B. Replicating the complete genome of an organism inside a single cell within only a few hours of cell growth

C. Permanently destroying all of an organism's DNA and replacing it with entirely new artificial genetic material

D. Sequencing the entire genome of an organism by reading nucleotides directly under a high-power light microscope

33. A genetically modified organism (GMO) is best defined as an organism that:

A. Has been bred through traditional selective breeding methods practiced over the course of many generations

B. Has been exposed to ultraviolet radiation during its development inside a specialized laboratory chamber

C. Has been raised under organic farming conditions without the use of any synthetic chemical pesticides at all

D. Has had its genome deliberately altered using modern biotechnology techniques such as targeted gene insertion

34. Reproductive cloning of an animal involves:

A. Combining the genetic material from two different parents in a laboratory dish to produce one unique organism

B. Producing a genetically identical copy of a donor organism by transferring a nucleus into an enucleated egg cell

C. Inserting human genes into a bacterium so that the bacterium can produce a specific useful human protein

D. Sequencing the entire genome of an organism in order to identify every nucleotide of its genetic code precisely

35. Embryonic stem cells are particularly valuable in medical research because they:

A. Have a very limited lifespan in culture and divide only a few times before dying off naturally each time

B. Are derived only from adult skin tissue and can produce only skin cells when grown in a laboratory dish

C. Have the potential to differentiate into many different cell types found within the body's various tissues

D. Are unable to divide in culture and therefore produce no usable population of cells for any kind of research

36. CRISPR-Cas9 is a biotechnology tool that allows researchers to:

A. Edit specific DNA sequences in a genome with high precision by targeting and cutting chosen DNA sites

B. Sequence the complete genome of an organism by directly reading the nucleotides through a light microscope

C. Transport oxygen molecules efficiently from the lungs to the body's tissues through the circulatory system

D. Convert messenger RNA molecules directly into functional finished proteins within a test tube reaction

37. A vaccine works to protect a person against future infection primarily by:

A. Killing all of the pathogens currently present in the bloodstream at the precise moment the vaccine is given

B. Providing antibiotics that destroy any bacterial pathogens that might infect the body later in adult life

C. Permanently changing the DNA of every cell in the body to make those cells resistant to any future infection

D. Stimulating the immune system to produce memory cells that are specific to the pathogen's surface antigens

38. Antibodies and antigens interact according to which biological principle?

A. Each antibody binds many different antigens nonspecifically, regardless of the three-dimensional shape of the antigen

B. Each antibody has a specific shape that binds a specific antigen, similar to a lock-and-key fit at the molecular level

C. Antibodies destroy pathogens by directly absorbing their genetic material into the antibody's own internal structure

D. Antigens directly attack the body's red blood cells and prevent the transport of oxygen to the body's various tissues

39. A person who receives an injection of preformed antibodies immediately after exposure to a snake's venom has received:

A. Active immunity from a vaccine, which would produce memory cells over a period of several weeks after injection

B. Active immunity from natural exposure, similar to recovering from an infectious disease in early childhood years

C. Passive immunity, in which preformed antibodies provide immediate but relatively short-term protection from harm

D. Innate immunity, the nonspecific physical and chemical barriers that are present from birth in all human beings

40. An allergic reaction occurs when the immune system:

A. Overreacts to a harmless substance such as pollen, dust, or a specific food, treating it as a dangerous threat

B. Fails to produce any antibodies during exposure to a serious bacterial or viral pathogen during an infection

C. Recognizes its own healthy cells as foreign and destroys them, as occurs in autoimmune disorders specifically

D. Is severely weakened by a virus that destroys the body's helper T cells, as occurs in HIV infection over time

41. The endocrine system regulates body function primarily by:

A. Delivering electrical signals from the brain to the body's muscles through long, fast-conducting motor neurons

B. Releasing chemical messengers called hormones into the bloodstream, where they act on distant target cells

C. Pumping blood through a network of arteries, veins, and capillaries to all of the body's various tissues and organs

D. Exchanging gases such as oxygen and carbon dioxide between the body's bloodstream and the outside atmosphere

42. A person with type 1 diabetes produces little or no insulin. Without insulin, blood glucose levels:

A. Drop sharply because the body's cells take up glucose so rapidly that the bloodstream becomes depleted of sugar

B. Remain within the normal healthy range because other hormones in the body can fully compensate for the missing insulin

C. Decrease gradually as the body converts the excess blood glucose directly into stored body protein within the muscles

D. Remain too high because the body's cells cannot effectively take up glucose from the bloodstream without insulin

43. The hormone thyroxine, produced by the thyroid gland, primarily regulates:

A. The amount of calcium present in the bloodstream by stimulating bone tissue to release stored calcium ions

B. The body's blood sugar level by stimulating liver cells to release stored glucose into the bloodstream rapidly

C. The body's overall metabolic rate, including the rate at which energy is used in cells throughout the body

D. The body's water balance by controlling water reabsorption within the kidney tubules during urine formation

44. The hormone adrenaline (epinephrine) is released during a fight-or-flight response and acts to:

A. Increase the heart rate, dilate the airways, and redirect blood flow toward the skeletal muscles for action

B. Decrease the heart rate, narrow the airways, and reduce blood flow toward the skeletal muscles during stress

C. Stimulate the digestive system to digest food more rapidly during a stressful emergency situation for survival

D. Reduce blood glucose levels by causing the body's cells to take up sugar from the bloodstream very quickly

45. When body temperature falls below the normal set point, the hypothalamus triggers shivering and constriction of skin blood vessels to generate and conserve heat. This response is best classified as:

A. A positive feedback loop, which amplifies the original change and moves the body further from the set point

B. A negative feedback loop, which reverses the original change and restores the body to its normal set point

C. A direct hormonal mechanism that permanently lowers the body's set point to a new and lower temperature value

D. A reflex arc that bypasses the brain entirely and produces a rapid involuntary muscle contraction in response

46. During early embryonic development, a fertilized egg divides repeatedly to form a hollow ball of cells called the:

A. Zygote, which is the single cell formed by the fusion of a sperm cell and an egg cell at the moment of fertilization

B. Gastrula, the developmental stage at which three distinct germ layers have already formed from the embryo's cells

C. Fetus, the later developmental stage at which most of the major organ systems have already begun functioning

D. Blastula, an early embryonic stage consisting of a hollow ball of cells that surrounds an internal fluid-filled cavity

47. Cell differentiation during embryonic development is the process by which:

A. Genetically identical cells turn on different sets of genes and become specialized for different functions in the body

B. Each cell in the developing embryo permanently loses portions of its DNA to become a specialized adult cell type

C. New genetic information is added to the cells during development by random mutations from environmental factors

D. Cells in the developing embryo all become identical in their structure and biological function as they continue to divide

48. Many birth defects are caused by environmental factors that interfere with the development of an embryo. These factors are best classified as:

A. Carcinogens, environmental factors that increase the risk of cancer developing in the tissues of adults during life

B. Pathogens, infectious agents that cause illness in already fully developed adult individuals after sustained exposure

C. Teratogens, agents such as certain drugs, viral infections, or chemicals that disrupt normal embryonic development

D. Hormones, chemical messengers released by glands to regulate metabolic and growth processes throughout the body

49. Identical (monozygotic) twins are produced when:

A. Two separate eggs are released and each is fertilized by a different sperm cell at approximately the same time

B. A single fertilized egg divides early in development to form two separate but genetically identical embryos

C. Two unrelated embryos implant in the same uterus at the same time and then develop simultaneously together

D. A single fertilized egg is deliberately split in the laboratory using modern assisted reproductive technology

50. In humans, the testes produce sperm cells and the ovaries produce egg cells. These reproductive organs are best classified as:

A. Endocrine glands only, since they release hormones and have no role in producing reproductive cells at all

B. Components of the digestive system, since they help to process certain nutrients during the process of digestion

C. Components of the excretory system, since they help filter waste products from the bloodstream of the body

D. Gonads, the primary reproductive organs that produce gametes and also release sex hormones into the bloodstream

Practice Exam 15: Life Science: Biology Simulation – Answer Key with Explanations

- 1. B** — As humidity increases, transpiration rate decreases steadily across the entire range. Water vapor diffuses from the leaf interior to the surrounding air down its concentration gradient, so when the surrounding air is already saturated with water vapor, the gradient is shallower and transpiration slows. This is why plants lose far more water on hot, dry days than on humid ones.
- 2. D** — Allow gas exchange and release of water vapor between the leaf interior and the surrounding atmosphere. Stomata are pores bordered by guard cells that open to admit CO₂ for photosynthesis and release O₂ and water vapor. Their opening and closing balances photosynthetic needs against water loss, which is critical for plant survival in variable environments.
- 3. A** — Phototropism, the directional growth of a plant in response to a light source coming from one side. The plant hormone auxin accumulates on the shaded side of the stem, stimulating more cell elongation there and causing the stem to bend toward the light. This adaptive growth response maximizes light capture for photosynthesis.
- 4. C** — Transporting water and dissolved minerals upward from the roots to the leaves of the plant body. Xylem is composed of dead, hollow cells that form continuous tubes from root to shoot, with water pulled upward by transpiration. Phloem, by contrast, carries sugars produced in photosynthesis to the rest of the plant.
- 5. B** — The ovary, the female reproductive structure that contains the ovules and develops into the fruit. After fertilization, the ovary wall thickens and matures into the fruit, while the ovules become seeds inside the fruit. This is why a tomato or peach contains seeds — each is a mature plant ovary surrounding fertilized ovules.
- 6. A** — Innate behavior, a genetically programmed behavior that does not require prior learning from experience. Innate behaviors appear in the correct form the first time they are needed and are coded by an organism's genes rather than acquired through experience. The sea turtle's ocean-finding behavior is a classic example, since the hatchling has had no opportunity to learn it from any other turtle.
- 7. D** — A young animal forms a strong attachment to the first moving object it sees during a critical early period. Konrad Lorenz famously showed that newly hatched geese will follow whatever they see moving during a narrow window after hatching — normally the mother, but possibly a human or even an object. Once this critical period closes, the attachment cannot easily be changed.
- 8. B** — Increases survival by allowing the birds to escape cold conditions and reach areas of more abundant food. Migration is a heritable behavior shaped by natural selection because birds that move to favorable winter habitats survive at higher rates and leave more offspring. The result is a complex annual cycle that has been refined over many generations.
- 9. C** — Genetic drift, in which allele frequencies change randomly from one generation to the next by chance. Drift is purely a sampling phenomenon and is strongest in small populations, where chance events

can substantially shift allele frequencies in a single generation. Unlike natural selection, drift acts without regard to whether the affected alleles are favorable, harmful, or neutral.

10. A — The bottleneck effect, a sharp reduction in population size that alters the surviving allele frequencies. When a catastrophe leaves only a small surviving population, the genetic makeup of those few survivors may differ markedly from the original — purely by chance. Cheetahs and northern elephant seals show reduced genetic variation today as a result of past bottlenecks.

11. D — The founder effect, in which a small subset of individuals establishes a new population in a new area. The few colonizing individuals carry only a sample of the original population's alleles, so the new population's gene pool can differ noticeably from the source. This effect is well documented in island populations and in human groups that descended from small founding populations.

12. C — Gene flow, in which alleles move from one population to another through the migration of individuals. When migrants interbreed with members of their new population, they add their alleles to that population's gene pool. Gene flow tends to homogenize populations and counteracts the divergence caused by selection and drift.

13. B — No mutations, no natural selection, no migration, random mating, and a very large population size. These five conditions ensure that no evolutionary mechanism is acting to change allele frequencies between generations. Real populations almost never meet all five, so Hardy-Weinberg equilibrium serves as a null model against which real evolutionary change is measured.

14. A — Separate biological species, since the inability to interbreed and produce fertile offspring defines distinct species. Under the biological species concept, reproductive isolation is the defining criterion that separates one species from another. This is why horses and donkeys are separate species despite their close relationship — their hybrid offspring (mules) are infertile.

15. D — Allopatric speciation, in which physical separation of populations leads to the formation of new species. The Greek "allo-" means different and "patric" refers to country, indicating different geographic areas. The Grand Canyon's role in separating squirrel populations on the North and South rims is a textbook example of allopatric speciation in action.

16. C — Sympatric speciation, in which new species arise within the same geographic area without physical separation. Polyploidy (chromosome doubling) is a well-documented mechanism of sympatric speciation, especially in plants, because polyploid offspring are immediately reproductively isolated from their diploid parents. Many crop species, including modern wheat, arose through this process.

17. A — Coevolution, in which two interacting species act as agents of natural selection on each other over time. As flowers evolve traits that attract specific pollinators, those pollinators evolve traits that exploit those flowers more effectively, and the cycle continues. Long-tongued moths and deep-throated orchids are a striking example of this reciprocal evolutionary partnership.

18. B — A relatively short period during which a very large number of species go extinct across multiple habitats. Mass extinctions, such as the end-Permian and end-Cretaceous events, sharply elevate extinction rates above background levels across many taxonomic groups simultaneously. Many biologists argue that

human activity is driving a current mass extinction event known as the Holocene or Anthropocene extinction.

19. D — A biodiversity hotspot, a region of exceptionally high species richness that faces significant habitat threats. The term, coined by Norman Myers, requires both high endemism and substantial habitat loss to qualify, which prioritizes regions for conservation funding. Examples include the tropical Andes, Madagascar, and the California Floristic Province.

20. C — Competitive exclusion, in which two species cannot coexist long-term if they occupy the exact same niche. Also known as Gause's principle, this concept holds that when two species require identical resources used in identical ways, the better competitor will eventually displace the other from that area. Real species often avoid exclusion through resource partitioning — using slightly different parts of the niche.

21. A — Mutualism, a relationship in which both species involved in the interaction benefit from each other. The alga or cyanobacterium gains protection and access to moisture from the fungus, while the fungus gains sugars from its photosynthetic partner. This ++ relationship is the defining feature of mutualism.

22. B — Commensalism, a relationship in which one species benefits and the other is essentially unaffected. The barnacle gains transport and access to food-rich waters, while the whale neither benefits nor suffers in any measurable way. The +/- outcome is the defining feature of commensalism.

23. C — Parasitism, a relationship in which one species benefits at the direct expense of the host organism. The tapeworm gains nutrients and habitat while the host loses nutrients and may develop anemia, malnutrition, or other ill effects. Parasitism differs from predation in that the parasite typically does not kill its host quickly — instead, it usually lives in or on the host for an extended period.

24. D — A predator-prey cycle, in which the predator population responds to changes in the prey population over time. The lynx and hare data, collected from Hudson's Bay Company fur records, show classic coupled oscillations where prey population peaks are followed by predator peaks, then prey crashes, then predator crashes. This time-lagged pattern is a hallmark of predator-prey dynamics in nature.

25. B — A keystone species, whose removal would cause major changes throughout the structure of the ecosystem. The classic example is the sea star *Pisaster*, whose removal allowed mussels to dominate intertidal communities and pushed out many other species. Keystone species exert disproportionate ecological influence relative to their abundance.

26. A — Frequently lacks the natural predators, parasites, and competitors that controlled it within its native range. This "enemy release" allows invasive populations to grow explosively when introduced to a new region, often outcompeting native species. Examples include cane toads in Australia and zebra mussels in North American freshwaters.

27. C — The breaking apart of a once-continuous habitat into smaller, isolated patches separated by other land uses. Roads, farms, and developments commonly carve up natural habitats, creating fragments that

may be too small to support viable populations of certain species. Fragmentation also limits dispersal, increases edge effects, and reduces overall biodiversity.

28. D — Preserve biodiversity by protecting habitats, restoring damaged ecosystems, and managing threatened species. Conservation biology is an applied science that combines ecology, genetics, and policy to slow biodiversity loss. Methods range from protected areas and captive breeding to invasive species control and habitat restoration projects.

29. A — Make many copies of a small section of DNA from a tiny starting sample within a short period of time. PCR uses a heat-stable DNA polymerase and repeated cycles of heating and cooling to exponentially amplify a target DNA region. This amplification allows tiny samples — from a single hair, a forensic swab, or a fossil — to be analyzed.

30. B — Separate DNA fragments by size by moving them through a gel matrix under the influence of electric voltage. DNA, which is negatively charged, migrates toward the positive electrode; smaller fragments travel farther through the gel than larger ones. This size-based separation is a foundational technique in molecular biology, forensics, and DNA fingerprinting.

31. C — Forensic investigations and paternity testing, where unique DNA patterns are used to identify specific individuals. DNA fingerprinting compares variable regions of the genome to produce a profile that, except for identical twins, is essentially unique to each person. This makes it a powerful tool for matching biological samples to specific people.

32. A — Combining DNA from two different sources, often using restriction enzymes and a vector such as a plasmid. Restriction enzymes cut DNA at specific sequences, allowing fragments from one organism to be inserted into a vector that is then introduced into a host such as a bacterium. This is the basis of producing human insulin in bacteria and many other biotechnology applications.

33. D — Has had its genome deliberately altered using modern biotechnology techniques such as targeted gene insertion. GMOs are created by directly modifying DNA — for example, inserting a bacterial gene into a plant — rather than by traditional crossbreeding alone. Common examples include Bt corn, Roundup-Ready soybeans, and golden rice.

34. B — Producing a genetically identical copy of a donor organism by transferring a nucleus into an enucleated egg cell. Somatic cell nuclear transfer was the technique used to produce Dolly the sheep in 1996, the first cloned mammal. The resulting organism carries the nuclear DNA of the donor and is therefore essentially a genetic copy.

35. C — Have the potential to differentiate into many different cell types found within the body's various tissues. Embryonic stem cells are pluripotent, meaning they can develop into nearly any cell type given the appropriate signals. This makes them highly valuable for regenerative medicine research, although their use raises ethical considerations.

36. A — Edit specific DNA sequences in a genome with high precision by targeting and cutting chosen DNA sites. CRISPR uses a guide RNA to direct the Cas9 enzyme to a specific genomic location, where

Cas9 cuts the DNA so that the cell's repair machinery can introduce edits. The precision and ease of CRISPR have revolutionized genetic engineering across biology and medicine.

37. D — Stimulating the immune system to produce memory cells that are specific to the pathogen's surface antigens. Vaccines expose the immune system to antigens from a weakened, killed, or molecular form of the pathogen, prompting production of antibodies and long-lived memory cells. On later real exposure, those memory cells respond rapidly and prevent illness.

38. B — Each antibody has a specific shape that binds a specific antigen, similar to a lock-and-key fit at the molecular level. The variable region of every antibody is shaped to recognize one particular antigen, which gives the immune system its remarkable specificity. This precise match is what allows antibodies to flag the right pathogens for destruction.

39. C — Passive immunity, in which preformed antibodies provide immediate but relatively short-term protection from harm. Because the recipient's own immune system did not make the antibodies, no memory cells form, and protection wanes as the injected antibodies are degraded. Antivenom and the antibodies a newborn receives through breast milk are familiar examples of passive immunity.

40. A — Overreacts to a harmless substance such as pollen, dust, or a specific food, treating it as a dangerous threat. The body produces IgE antibodies and releases histamine, causing sneezing, itching, swelling, or in severe cases anaphylaxis. The substance triggering this misdirected response is called an allergen.

41. B — Releasing chemical messengers called hormones into the bloodstream, where they act on distant target cells. Endocrine signaling is slower than nervous signaling but typically longer lasting, and it coordinates processes such as growth, reproduction, metabolism, and stress response. Only cells bearing the appropriate receptors respond to each particular hormone.

42. D — Remain too high because the body's cells cannot effectively take up glucose from the bloodstream without insulin. Insulin normally signals liver, muscle, and fat cells to absorb glucose and store it, so without it, glucose accumulates in the blood and is excreted in the urine. Untreated, this hyperglycemia leads to dehydration, ketoacidosis, and long-term damage to many organ systems.

43. C — The body's overall metabolic rate, including the rate at which energy is used in cells throughout the body. Thyroxine (T4) and its more active form T3 increase oxygen consumption, heat production, and the rate of many metabolic reactions. Hypothyroidism causes fatigue, weight gain, and cold intolerance, while hyperthyroidism produces the opposite effects.

44. A — Increase the heart rate, dilate the airways, and redirect blood flow toward the skeletal muscles for action. Adrenaline mobilizes the body's resources for short-term physical effort by stimulating cardiovascular and respiratory output while reducing nonessential functions such as digestion. This coordinated response is the classic physiology of the fight-or-flight reaction.

45. B — A negative feedback loop, which reverses the original change and restores the body to its normal set point. Shivering generates heat and vasoconstriction conserves it, both of which work against the

original drop in body temperature. Most physiological control systems — thermoregulation, blood glucose, blood pressure — rely on this kind of negative feedback to maintain homeostasis.

46. D — Blastula, an early embryonic stage consisting of a hollow ball of cells that surrounds an internal fluid-filled cavity. After several rounds of cleavage divide the zygote without much growth, the embryo becomes a hollow sphere known as the blastula (in mammals, the equivalent stage is called the blastocyst). The gastrula follows, when the embryo folds in to form the primary germ layers.

47. A — Genetically identical cells turn on different sets of genes and become specialized for different functions in the body. All somatic cells in a body share the same DNA, but each cell type expresses a unique subset of genes that gives it its distinctive structure and function. This selective gene expression is what turns one fertilized egg into the hundreds of specialized cell types found in a mature organism.

48. C — Teratogens, agents such as certain drugs, viral infections, or chemicals that disrupt normal embryonic development. Examples include alcohol (causing fetal alcohol syndrome), thalidomide (causing limb defects), and rubella infection (causing congenital rubella syndrome). The developing embryo is especially vulnerable to teratogens during the first trimester, when major organ systems are forming.

49. B — A single fertilized egg divides early in development to form two separate but genetically identical embryos. Because both embryos arise from the same zygote, they share the same DNA and are therefore monozygotic. Fraternal (dizygotic) twins, in contrast, develop from two separately fertilized eggs and are no more genetically similar than ordinary siblings.

50. D — Gonads, the primary reproductive organs that produce gametes and also release sex hormones into the bloodstream. The testes produce sperm and testosterone, while the ovaries produce eggs and estrogens, so the gonads serve both a reproductive and an endocrine function. This dual role coordinates the development and maintenance of secondary sex characteristics with the production of gametes.