

# PRACTICE EXAM 24: LIFE SCIENCE: BIOLOGY SIMULATION (50 QUESTIONS — INTEGRATED SYSTEMS & ADAPTATIONS FOCUS)

---

**Instructions:** Practice Exam 24 emphasizes plant adaptations and tropisms, ecosystem dynamics, sensory systems, embryonic development, DNA organization, and integrated body-system reasoning within the New York Living Environment scope. Each question is independent. Select the one best answer.

1. A cactus has thick, fleshy stems, reduced leaves modified into spines, and a thick waxy cuticle on its outer surface. These features most directly help the cactus to:

- A. Capture more sunlight in shaded forest environments where many other plants compete for sunlight throughout the day
- B. Avoid being eaten by herbivorous mammals living in moist rainforest understory environments worldwide year-round
- C. Maximize their water loss to soften the harsh sandy soils typical of the world's various desert environments daily
- D. Conserve water and survive in hot, dry environments where water is scarce throughout much of the growing season

2. A young bean plant grown in a closet with light entering only through a narrow crack near the floor will bend toward the light source. This directional growth response is best classified as:

- A. Phototropism, the directional growth of a plant in response to a light source coming from one particular direction
- B. Hydrotropism, the directional growth of a plant in response to a moisture gradient within the surrounding soil environment
- C. Gravitropism, the directional growth of a plant in response to the downward pull of Earth's gravity on growing roots
- D. Thigmotropism, the directional growth of a plant in response to physical touch or contact with another solid object

- 3.** A scientist treats young bean seedlings with auxin (a plant growth hormone) on only one side of the stem. After several days, the treated stems bend toward the untreated side. The most likely reason for this bending is that:
- A. Auxin caused the cells on the treated side to die, leaving only the untreated side able to continue growing normally
  - B. Auxin caused the cells on the treated side to elongate more than the untreated cells, lengthening the treated side
  - C. Auxin caused the cells on the untreated side to elongate more than the treated cells, lengthening the untreated side
  - D. Auxin had no measurable effect on plant cells when applied to only one side of a young bean seedling stem in the lab
- 4.** Tropical rainforest ecosystems support enormous biodiversity compared with most other terrestrial biomes on Earth. The most direct biological reason for this remarkable diversity is that tropical rainforests have:
- A. Very cold average temperatures and limited rainfall, which together create a wide variety of microclimates throughout the year
  - B. A complete absence of decomposers in the soil, allowing producer biomass to accumulate steadily over many decades of growth
  - C. Year-round warmth, abundant rainfall, and stable conditions, which together provide favorable conditions for many species to thrive
  - D. No sunlight reaching the forest floor at all, which allows fungi to dominate and outcompete all other organism types completely
- 5.** A scientist studying a coastal sand dune ecosystem observes pioneer plant species (such as beach grass) colonizing the bare sand, followed gradually over decades by shrubs and eventually by trees. This sequence of community change over time is best described as:
- A. Ecological succession, in which one community is gradually replaced by another community over time at a single site
  - B. Speciation, in which one ancestral species gradually diverges into two or more separate biological species over time
  - C. Migration, in which large numbers of organisms move seasonally between different geographic locations year after year
  - D. Symbiosis, in which two species develop a close ecological relationship with mutual benefits over many generations
- 6.** Which of the following is NOT a typical characteristic of a mature climax community?
- A. The community has a relatively stable composition of species that has reached a mature state of development over time
  - B. The community contains a diverse mix of species, including producers, consumers, and decomposers in ecological balance
  - C. The community shows a slow rate of change in species composition over time compared with earlier

successional stages

D. The community is composed primarily of the same pioneer species that first colonized the area many years before maturity

**7.** A herd of zebras grazing on a savanna in Africa eats grass, then obtains energy from the grass through cellular respiration. The grass plants themselves originally obtained their energy from:

A. The microorganisms living in the soil that produce sugars for direct use by the grass roots underground each day

B. The carbon dioxide that the zebras exhale into the atmosphere as a waste product of their own cellular respiration daily

C. Sunlight, which the grass captured through photosynthesis to produce glucose used as a stored chemical energy source

D. The minerals dissolved in groundwater, which the grass converted directly into glucose without using any light energy

**8.** The rate of decomposition by bacteria and fungi tends to be much slower in cold tundra environments than in warm tropical environments. The most likely biological explanation is that:

A. Tundra environments contain very few species of bacteria and fungi compared to tropical environments around the world

B. Cold temperatures slow the rates of enzyme-catalyzed reactions, reducing the metabolic activity of the decomposer organisms

C. Tropical decomposers contain mitochondria while tundra decomposers lack mitochondria entirely and so respire very slowly

D. Tundra producers do not photosynthesize at all, leaving no organic material for the decomposers to break down each year

**9.** In a temperate forest in autumn, deciduous trees drop their leaves, which gradually decompose on the forest floor through the winter and spring. The carbon contained in the decomposed leaves is most likely to:

A. Return to the atmosphere as carbon dioxide through the cellular respiration of decomposer bacteria and fungi over time

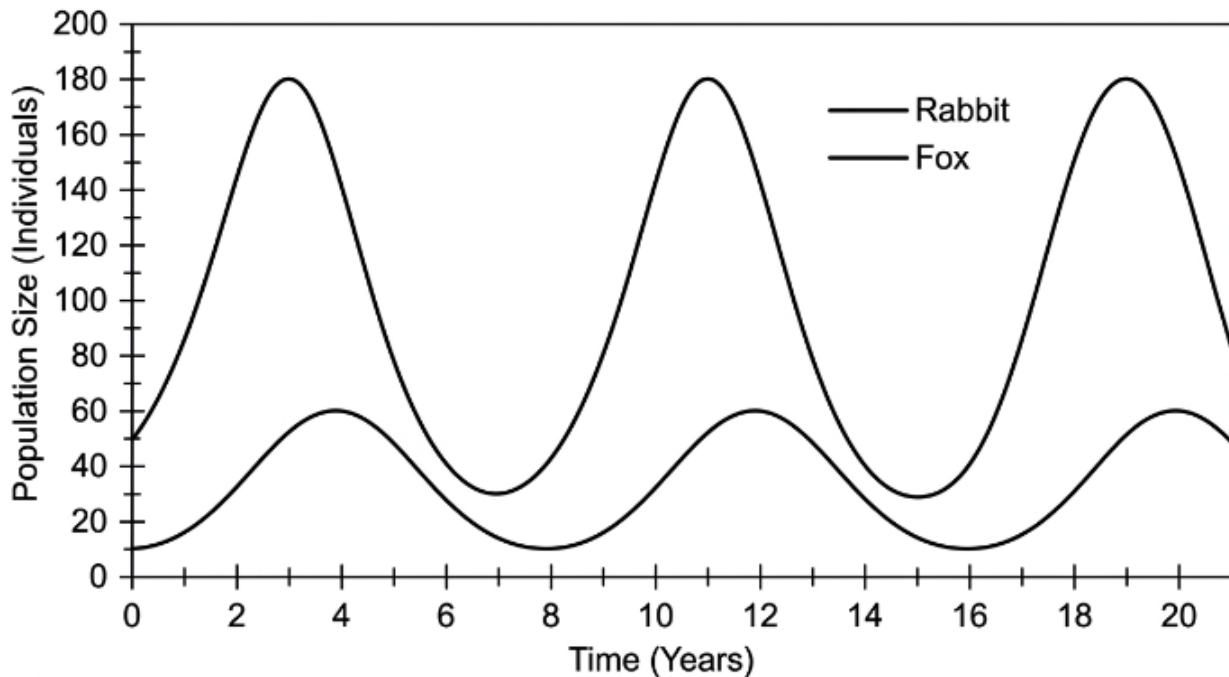
B. Permanently remain in the soil as a solid mineral compound that no other living organism can access ever again afterward

C. Be converted into oxygen gas, which then accumulates in the atmosphere as a major byproduct of the decomposition process

D. Be converted directly into starch granules that can be used immediately as a food source by overwintering forest animals

**10.** The graph below shows the population sizes of a predator (foxes) and its prey (rabbits) in a forest over a 20-year period.

### Predator and Prey Population Cycles in a Forest.



Which conclusion is best supported by the graph?

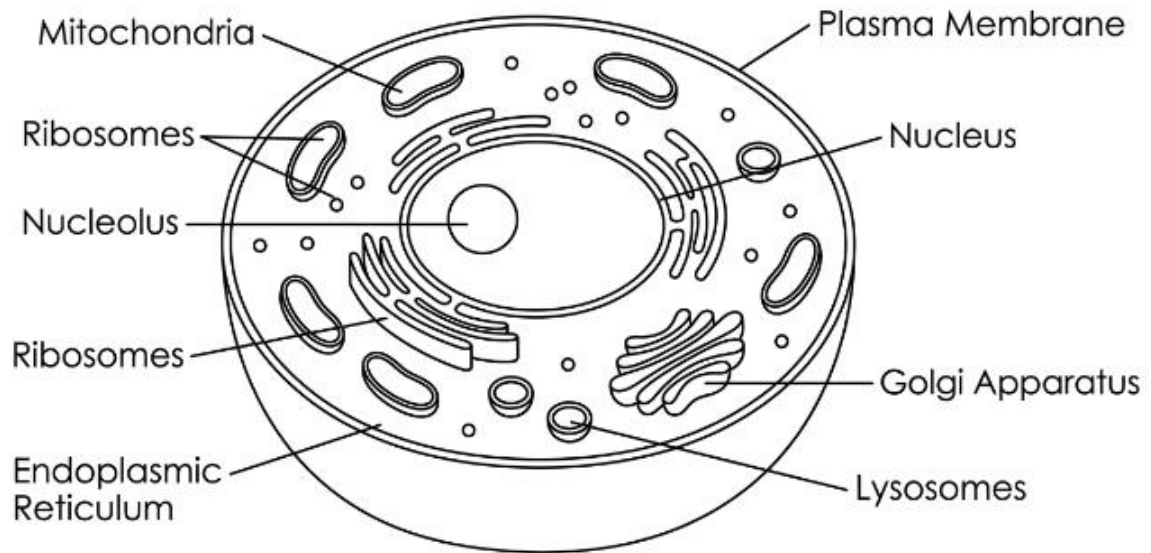
- A. The fox and rabbit populations rise and fall independently of one another with no biological relationship between them at all
- B. The rabbit population is causing both populations to slowly decline over time toward complete and final extinction of both
- C. The fox population always peaks at exactly the same time as the rabbit population peaks in each cycle of population change
- D. The fox population peaks shortly after the rabbit population peaks, consistent with a typical predator-prey cycle in nature

**11.** A meadow contains many populations of different species interacting with each other and with their physical environment of soil, water, and air. This entire system is best described as:

- A. A population, which is a group of organisms of the same species living together in the same geographic area at one time
- B. A biome, which is a large geographic region characterized by a particular climate and a typical community of living things
- C. An ecosystem, which includes all of the populations in an area together with their abiotic physical environment surroundings
- D. A niche, which describes the specific functional role that one particular species plays within its surrounding community

**12.** The diagram below shows the structure of a typical animal cell.

# Generalized Animal Cell



Which structure shown in the diagram is the primary site of cellular respiration?

- A. The nucleus, which contains the cell's genetic material and controls the cell's many daily metabolic activities throughout life
- B. The mitochondria, where glucose is broken down to produce ATP through the process of aerobic cellular respiration in the cell
- C. The Golgi apparatus, which packages proteins and other molecules for transport throughout the cell and to its outside surface
- D. The endoplasmic reticulum, where proteins and lipids are synthesized and transported within the cell to other organelles inside

**13.** A red blood cell is unique among human cells in that it lacks a nucleus and most other organelles after maturation. This unusual cellular structure most directly contributes to:

- A. The cell's primary function of carrying oxygen, since the lack of organelles leaves more room inside for hemoglobin molecules
- B. The cell's ability to divide rapidly throughout the lifetime of the person to maintain a constant blood volume each day at rest
- C. The cell's ability to produce its own proteins from amino acids found floating freely in the surrounding bloodstream around it
- D. The cell's resistance to attack by pathogenic viruses and other infectious agents that target the nucleus inside the cell body

**14.** A neuron has long extensions called axons that can be over a meter long in some cases in the human body. The unusually long shape of these cells is most directly related to their primary biological function of:

- A. Storing large amounts of glucose for use by other body cells during periods of intense physical activity throughout the day
- B. Filtering waste products from the blood and producing urine that is later excreted from the body by the kidneys each day
- C. Producing all of the body's hormones, which are then released into the bloodstream for distribution to organs throughout
- D. Transmitting electrical signals over long distances within the body to coordinate body activities very rapidly and precisely

**15.** A protein found embedded in the cell membrane functions to actively pump ions across the membrane against their concentration gradient. This protein is best classified as:

- A. A structural protein, which gives the cell its shape and connects neighboring cells together within a tissue throughout the body
- B. A transport protein, which moves specific molecules or ions across the cell membrane during cellular activity each second
- C. An enzyme protein, which catalyzes a specific chemical reaction within the cytoplasm of the cell each second of cellular life
- D. A hormone protein, which is released by glandular cells and travels through the bloodstream to other organs and tissues

**16.** The fluid mosaic model of the cell membrane describes the cell membrane as:

- A. A solid sheet of carbohydrate molecules that gives the cell its overall shape and provides absolute structural rigidity at all times
- B. A continuous uniform layer of identical phospholipids with no embedded proteins anywhere along its outer surface throughout
- C. A flexible bilayer of phospholipids in which protein and other molecules are embedded and can move laterally within the bilayer
- D. A network of metal ions held together by hydrogen bonds that completely blocks all transport into the cell at any moment of time

**17.** A solution surrounding a plant cell contains less solute than the cell's cytoplasm contains. As a result of this difference:

- A. Water will move into the plant cell, increasing turgor pressure against the rigid cell wall and keeping the plant cell firm and rigid
- B. Water will move out of the plant cell, causing the cell to shrink dramatically away from its rigid cell wall over a short period
- C. Solute will move out of the cell down its concentration gradient until equilibrium is reached on both sides of the cell membrane

D. Solute will move into the cell against its concentration gradient using ATP for energy throughout this active transport process

**18.** A starfish in a tide pool can withstand brief periods of immersion in either fresh water or salt water because of its ability to regulate the salt content of its body fluids. This ability is best classified as an example of:

- A. Mutualism, in which two species depend on each other for survival within a shared aquatic ecosystem environmental community
- B. Photosynthesis, in which the starfish captures light energy and converts it into stored chemical energy throughout the day
- C. Predation, in which one organism hunts and consumes another organism within a typical food chain in the marine environment
- D. Homeostasis, the maintenance of a stable internal environment despite changing external environmental conditions over time

**19.** When a person becomes dehydrated, the hormone ADH (antidiuretic hormone) is released, causing the kidneys to reabsorb more water from the urine back into the bloodstream. This regulatory response is best classified as:

- A. A positive feedback loop, which amplifies the original change and causes the body to move further from its normal set point
- B. A direct learned behavior in which the person has consciously trained their body to reabsorb water during periods of dehydration
- C. A negative feedback loop, which reverses the original change (low body water) and restores the body to its normal water balance
- D. A random process that has no clear physiological purpose for the body during periods of normal daily life and routine activity

**20.** During strenuous exercise, a person's breathing rate and depth increase dramatically. The most direct cause of this increased breathing rate is the:

- A. Increased glucose level in the bloodstream that signals the lungs to expand more fully during each individual breath at rest
- B. Increased carbon dioxide level in the bloodstream, which is detected by sensors and signals the brain to increase breathing
- C. Decreased body temperature that signals the lungs to inhale more cool air to maintain the body's normal core temperature
- D. Increased adrenaline produced in the muscles that is sent directly to the lungs to expand the lungs during exercise periods

**21.** Insulin and glucagon are two hormones that work together to regulate blood glucose levels in the human body. Insulin and glucagon are best described as:

- A. Antagonistic hormones, with insulin lowering blood glucose levels and glucagon raising blood glucose levels in the bloodstream

- B. Synergistic hormones that work together to raise blood glucose levels in the body after a meal containing carbohydrates each time
- C. Identical hormones that have exactly the same effect on blood glucose levels in the body throughout the day every day of life
- D. Unrelated hormones that do not affect blood glucose levels at all in any human body during the course of a normal day routine

**22.** The endocrine system regulates many body functions slowly and over relatively long periods of time. The nervous system, in contrast, regulates body functions:

- A. Very slowly, taking hours or days to respond to a change in the body's external or internal environmental conditions over time
- B. Only during sleep, when the rest of the body's organ systems are in a state of low metabolic activity and reduced organ function
- C. Only in the muscles of the limbs, having no effect on any of the body's internal organ systems at any point during the day at all
- D. Very rapidly, transmitting electrical signals along nerves to coordinate near-instantaneous responses to stimuli around the body

**23.** A reflex arc allows the body to respond rapidly to a potentially harmful stimulus, such as touching a hot object on a stove. In a typical reflex arc, the sensory signal travels:

- A. From the receptor directly to the brain, where it is consciously processed before any motor response is initiated by the body
- B. From the receptor directly to the muscle that will respond, completely bypassing the central nervous system entirely each time
- C. From the receptor through a sensory neuron to the spinal cord, then through a motor neuron to the muscle that responds quickly
- D. From the muscle to the brain, which then sends a signal back to the receptor to confirm the original sensory stimulus each time

**24.** The retina at the back of the human eye contains specialized photoreceptor cells called rods and cones. Cones are most responsible for:

- A. Sensing the precise odors of various foods and other substances that come into contact with the surface of the eye each day
- B. Color vision and detailed central vision in bright light, since cones detect different wavelengths of visible light in the eye
- C. Producing tears that lubricate the surface of the eye and protect it from foreign particles in the surrounding air around the body
- D. Producing the hormone melatonin that helps regulate the sleep-wake cycle of humans during each twenty-four-hour day cycle

**25.** The human ear is divided into the outer, middle, and inner ear. The three small bones of the middle ear (the malleus, incus, and stapes) function to:

- A. Amplify sound vibrations from the eardrum and transmit them to the fluid-filled cochlea of the inner ear for further processing
- B. Detect changes in body position and direction of motion to help the body maintain its sense of balance during physical movement
- C. Produce earwax that protects the ear canal from foreign particles, bacteria, and excessive moisture entering the ear canal daily
- D. Filter sound waves coming from outside the body to block out background noise during normal daily conversations at all times

**26.** A monarch butterfly migrates each year from Mexico northward to the northeastern United States and Canada, then returns south to Mexico over several generations. This complex migratory behavior is best classified as:

- A. A learned behavior, in which each individual butterfly learns the migration route by following older experienced butterflies along
- B. A conditioned response, in which the butterflies have been trained over their adult lifetime to respond to specific environmental cues
- C. A direct social behavior, in which the butterflies communicate verbally with each other about the route in real time during their travel
- D. An innate behavior, a genetically programmed behavior that does not require learning from previous individuals or prior experience

**27.** A dog can be trained to sit when its owner says the word "sit" through repeated practice with treats as a reward. This is best classified as:

- A. An innate behavior, in which the dog's response to verbal commands is genetically programmed at birth in every dog ever born
- B. A learned behavior, specifically operant conditioning, in which the dog learns to associate the behavior with a desirable reward
- C. An automatic reflex arc, which is processed entirely by the spinal cord without involving the dog's brain at all during the act of sitting
- D. Imprinting, in which the dog forms an attachment to the first moving object it sees during a critical early life period after birth

**28.** A baby goose follows the first moving object it sees after hatching, even if that object happens to be a human researcher rather than its biological mother. This behavior was famously studied by Konrad Lorenz and is best classified as:

- A. A conditioned reflex that the gosling has learned through repeated reward over its first few days of life in its natural environment
- B. A directly learned behavior in which the gosling carefully observes other adult geese and then mimics their behavior closely over time
- C. Imprinting, in which a young animal forms a rapid, strong attachment to an object during a critical early period of life after birth
- D. An act of mutualism, in which both the gosling and the moving object benefit equally from their close interaction with one another

**29.** Sickle cell anemia results from a single base substitution in the gene that codes for the beta chain of hemoglobin. This mutation changes the codon GAG to GUG, replacing the amino acid glutamic acid with valine at position 6 of the protein. This type of mutation is best classified as:

- A. A point mutation, since only a single nucleotide has changed in the original DNA sequence of the affected gene in the cell
- B. A frameshift mutation, since the reading frame of every codon downstream has been altered by this single small change to one base
- C. A chromosomal mutation, since the entire affected chromosome has been duplicated by the change in just one nucleotide base
- D. A silent mutation, since the small change has no measurable effect on the protein product encoded by the affected gene at all

**30.** Sickle cell anemia is most common in regions where malaria is also common. People who are heterozygous for the sickle cell allele are more resistant to malaria than people who carry two normal alleles. This pattern is best explained by:

- A. Genetic drift, in which random changes in allele frequencies have caused the sickle cell allele to become more common in these regions
- B. Convergent evolution, in which unrelated species in malaria-prone regions have independently evolved the same sickle cell allele
- C. Inheritance of acquired traits, in which people who survive malaria pass on their acquired immunity to their offspring directly each time
- D. Heterozygote advantage, in which heterozygotes have a survival advantage over both types of homozygotes in this particular environment

**31.** A genetic counselor is working with a couple who are both carriers of the recessive cystic fibrosis allele but who do not have the disorder themselves. The probability that any single child of this couple will be born with cystic fibrosis is:

- A. 0 percent, since two carrier parents cannot produce an affected child under the standard rules of Mendelian inheritance in genetics
- B. 25 percent, since the cross of two heterozygous carriers ( $Cc \times Cc$ ) produces one homozygous recessive ( $cc$ ) child out of four offspring
- C. 50 percent, since each parent contributes either a dominant or a recessive allele with equal probability to every child of the couple
- D. 75 percent, since the cross of two heterozygous carriers produces three of every four affected children on average in each pregnancy

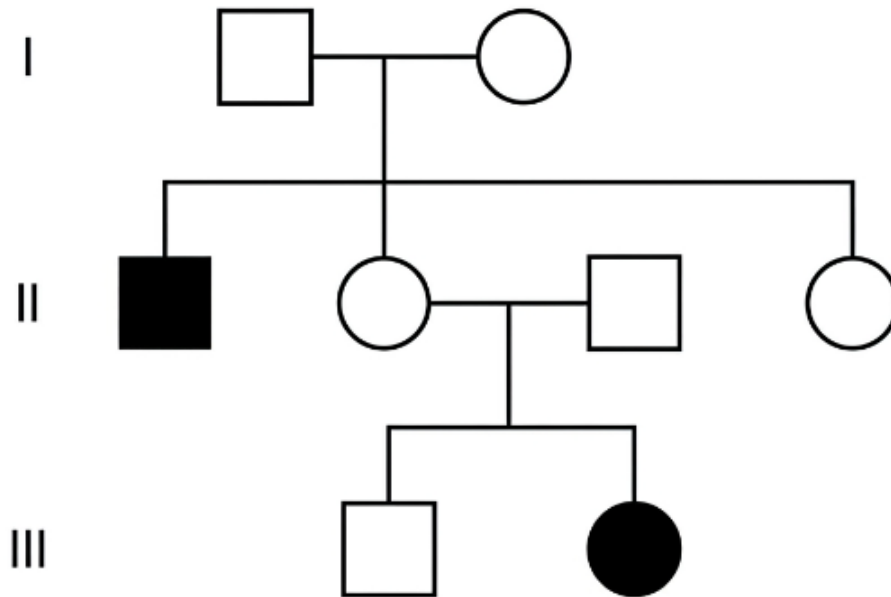
**32.** A young child is diagnosed with Duchenne muscular dystrophy, a sex-linked recessive disorder carried on the X chromosome. The child's mother is a carrier of the allele but does not have the disorder, and the child's father does not carry the allele. The child with Duchenne muscular dystrophy is most likely:

- A. A daughter who inherited the recessive allele from both her mother and her father at the moment of fertilization in early development

- B. A daughter who inherited the recessive allele only from her father but not from her carrier mother at the moment of fertilization
- C. A son who inherited the recessive allele from his mother on the single X chromosome he received during fertilization of the egg
- D. A son who inherited the recessive allele from his father, who normally passes only his Y chromosome to a son during fertilization

33. The pedigree below shows three generations of a family with a particular inherited disorder.

### Pedigree of an Inherited Disorder



The pattern of inheritance shown in the pedigree is most consistent with:

- A. Sex-linked dominant inheritance, since the trait appears in both males and females throughout the entire pedigree presented above
- B. Mitochondrial inheritance, since the trait passes only from affected mothers to all of their children regardless of the offspring's sex
- C. Autosomal dominant inheritance, since the trait appears in every generation and one dominant allele is sufficient to express the trait
- D. Autosomal recessive inheritance, since the trait skips a generation and appears in the offspring of two unaffected parents in the family

34. A new gene is inserted into the genome of a bacterium so that the bacterium produces a human protein such as insulin. The product of this laboratory process is best classified as:

- A. A genetically modified organism, since the bacterium's genome has been deliberately altered using modern biotechnology techniques

- B. A natural mutation, since random DNA changes occur frequently in bacteria and produce new traits without any human intervention
- C. A hybrid organism, since the bacterium is now composed equally of bacterial cells and human cells working together in a hybrid form
- D. A clone of the original bacterium, since the bacterium reproduces and produces genetically identical offspring after the gene insertion

**35.** Genetically modified crops have been developed to be resistant to certain insect pests through the insertion of an insecticidal gene. A potential long-term ecological concern with the widespread use of such crops is:

- A. The modified crops will produce far less oxygen than ordinary crops, sharply reducing the amount of atmospheric oxygen present
- B. The modified crops will spontaneously revert to their original wild form within a single growing season after the first planting in the field
- C. Insects may evolve resistance to the pest-control trait over time, eventually reducing the long-term effectiveness of the engineered trait
- D. The modified crops cannot reproduce at all, requiring farmers to manually pollinate every single plant in the field by hand each year manually

**36.** Stem cells offer significant potential in regenerative medicine. Adult stem cells differ from embryonic stem cells in that adult stem cells are typically:

- A. Pluripotent, meaning that they can differentiate into virtually any cell type found in the body during the course of normal development
- B. Multipotent, meaning that they can differentiate into only a limited number of related cell types within the surrounding tissue type
- C. Totipotent, meaning that they can give rise to an entire complete organism including all of the supporting placental tissues each time
- D. Unable to differentiate at all, meaning that they have no medical or therapeutic value to researchers under any conditions whatsoever

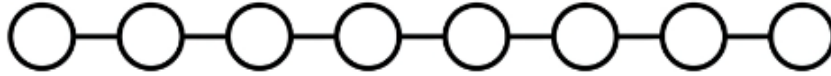
**37.** The technique known as polymerase chain reaction (PCR) allows researchers to:

- A. Cut DNA into small fragments using restriction enzymes that recognize specific nucleotide sequences within the DNA each time
- B. Separate fragments of different sizes by passing them through a porous gel in the presence of an electrical voltage from a power source
- C. Permanently alter the genome of a living organism by inserting a new gene at a specific location in the organism's chromosome
- D. Make many copies of a small region of DNA from a tiny starting sample through repeated cycles of heating and cooling reactions

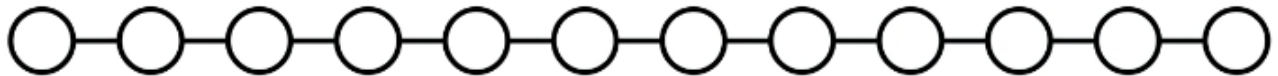
**38.** The diagram below shows three different polypeptide chains synthesized at ribosomes from three different mRNAs.

## Three Polypeptides Produced by Translation.

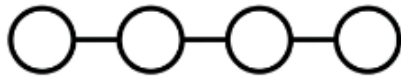
Polypeptide A — 8 amino acids



Polypeptide B — 12 amino acids



Polypeptide C — 4 amino acids



Based on the diagram, which mRNA most likely contained the longest sequence of codons coding for amino acids?

- A. The mRNA that produced polypeptide B, since polypeptide B contains the largest number of amino acids of the three chains in the diagram
- B. The mRNA that produced polypeptide A, since polypeptide A is drawn at the top of the diagram and labeled first overall in the figure
- C. The mRNA that produced polypeptide C, since polypeptide C is drawn at the bottom of the diagram and labeled last of the three chains
- D. All three mRNAs were the same length, since they were all translated by the same ribosome at exactly the same time and rate each second

**39.** During DNA replication, each strand of the original double helix serves as a template for the synthesis of a new complementary strand. After replication, each new DNA double helix contains:

- A. Two strands that are both newly synthesized during the process of replication, with no original strands present at all in either new helix
- B. Two original strands from the parent double helix and no newly synthesized strands at all, since the parent DNA is fully conserved as is
- C. One original strand from the parent double helix and one newly synthesized strand, giving the process its descriptive name semiconservative
- D. Strands made of RNA paired with strands made of DNA, since DNA replication uses RNA nucleotides throughout the entire copying process

**40.** The chromosomes of a single human body cell contain a total of about 6 billion base pairs of DNA distributed across 46 chromosomes. Within each chromosome, the DNA is tightly packaged with the help of:

- A. Lipid molecules called phospholipids that form a thin protective layer around the DNA inside the nucleus of the cell at all times
- B. Proteins called histones that the DNA wraps around to form compact structures called nucleosomes inside the cell's nucleus during division
- C. Carbohydrate molecules that form a rigid scaffolding around which the DNA is wrapped during the early stages of normal cell division
- D. Inorganic mineral salts that crystallize around the DNA molecule and provide additional structural support during cell division each time

**41.** Meiosis produces gametes with half the chromosome number of the parent cell. In humans, meiosis in one primary spermatocyte produces:

- A. Four haploid sperm cells, each containing 23 chromosomes, produced through two sequential meiotic divisions of the original cell
- B. Two diploid sperm cells, each containing 46 chromosomes, produced through one division of the original primary spermatocyte cell
- C. One haploid sperm cell, containing 23 chromosomes, produced through one division of the original primary spermatocyte each time
- D. Eight haploid sperm cells, each containing 12 chromosomes, produced through three sequential divisions of the original parent cell

**42.** During meiosis I, homologous chromosomes pair up and may exchange portions of their genetic material in a process called:

- A. Mitosis, the process by which a single cell divides to form two genetically identical daughter cells in the body's somatic tissues
- B. Replication, the process by which DNA molecules are copied to produce two identical strands prior to any cell division each time
- C. Translation, the process by which messenger RNA is decoded by ribosomes to produce specific polypeptide chains for cellular use
- D. Crossing over, the exchange of corresponding segments of DNA between homologous chromosomes during the prophase of meiosis I

**43.** The total amount of genetic variation introduced into gametes by sexual reproduction is increased by all of the following EXCEPT:

- A. Crossing over between homologous chromosomes during the early phases of meiosis I in the primary sex cells of the body each time
- B. Independent assortment of homologous chromosome pairs during meiosis I, producing many possible combinations in the resulting gametes
- C. Mitotic cell division of somatic body cells, which produces genetically identical daughter cells used in growth and routine tissue repair

D. Random fertilization in which any one of millions of sperm can fertilize any one of multiple egg cells produced during sexual reproduction

**44.** The cells of a developing human embryo all contain identical genetic material, yet over time they develop into many different types of cells with different structures and functions. This process is best described as:

A. Mutation, in which the genetic material of each cell is permanently altered to encode different proteins in different cell types over time

B. Cell differentiation, in which different sets of genes are expressed in different cells, producing specialized cell types and tissues over time

C. Cell division, in which a single cell divides repeatedly to produce many genetically identical and structurally identical daughter cells

D. Cell death, in which large numbers of cells in the embryo die so that only a few specialized cell types remain in the adult body permanently

**45.** A fertilized human egg cell undergoes many rounds of cell division early in development. The form of cell division that produces the trillions of body cells from a single zygote is:

A. Meiosis, the form of cell division that reduces the chromosome number from diploid to haploid for the production of gametes for reproduction

B. Binary fission, the form of cell division used by prokaryotic organisms such as bacteria to reproduce themselves asexually in their habitats

C. Fertilization, the form of cell division that combines genetic material from two parent cells to form a single zygote at the very beginning of life

D. Mitosis, the form of cell division that produces two genetically identical diploid daughter cells used for the body's growth and tissue repair

**46.** The first stages of human embryonic development take place inside the female reproductive tract. The fertilized egg eventually implants in the:

A. Wall of the uterus, where the embryo continues to develop with the support of the placenta over the course of nine months in human pregnancy

B. Wall of the urinary bladder, where the embryo develops surrounded by urine being stored just before the bladder empties out into the urethra

C. Inner wall of the large intestine, where the embryo develops surrounded by undigested food material moving through the digestive system

D. Wall of the small intestine, where the embryo develops surrounded by nutrient-rich digestive contents during pregnancy in the human body

**47.** The placenta plays a critical role in supporting a developing fetus throughout pregnancy. The placenta functions primarily to:

A. Produce the genetic material of the developing fetus during the first few weeks following implantation in the uterine wall of the mother

B. Filter waste products out of the maternal bloodstream directly into the urinary bladder of the mother

throughout the duration of pregnancy

C. Allow the exchange of nutrients, oxygen, and waste products between the mother's bloodstream and the developing fetus's bloodstream

D. Produce the hormone insulin needed by the fetus during the development of the entire human nervous system in utero during pregnancy

**48.** During pregnancy, certain drugs, infections, and chemicals are known to cross the placenta and harm the developing fetus. These harmful substances are best classified as:

A. Carcinogens, which are environmental agents that increase the risk of cancer developing in already mature adult tissue cells of the body

B. Teratogens, which are environmental agents that disrupt the normal development of an embryo or a fetus during the pregnancy period

C. Pathogens, infectious agents that cause illness in fully developed individuals and have no effect at all on developing embryos in the womb

D. Hormones, chemical messengers released by glands in the body that regulate growth and many other physiological processes throughout

**49.** A scientist studies a small isolated population of birds on a remote island for several decades. Over time, the population shows changes in beak shape that appear to match changes in the available seed types caused by climate variation. This observation provides direct evidence of:

A. Coevolution, in which the birds and their parasites evolve together over many generations to maintain a stable equilibrium relationship

B. Mutualism, in which the birds and the seed-producing plants depend on each other for mutual survival within the island ecosystem

C. Convergent evolution, in which two unrelated bird species independently evolve similar beak shapes in two distinct environments

D. Natural selection, in which heritable variations that improve survival and reproduction become more common in the bird population

**50.** All of the following observations are considered evidence supporting the theory of biological evolution EXCEPT:

A. Modern humans speak many different languages around the world, reflecting cultural and historical differences among populations

B. The fossil record showing changes in species over time, including transitional forms between major groups of organisms across history

C. Similar embryonic development patterns shared among vertebrates, including fish, reptiles, birds, and mammals, during their early stages

D. Comparative molecular biology showing strong DNA sequence similarities among closely related species across the tree of life worldwide

## Practice Exam 24: Life Science: Biology Simulation – Answer Key with Explanations

- 1. D** — Conserve water and survive in hot, dry environments where water is scarce throughout much of the growing season. Thick fleshy stems store water, reduced leaves minimize surface area for transpiration, and the waxy cuticle prevents evaporation through the plant's epidermis. These three adaptations work together as a classic suite of features for life in arid environments.
- 2. A** — Phototropism, the directional growth of a plant in response to a light source coming from one particular direction. The plant hormone auxin accumulates on the shaded side of the stem, stimulating greater cell elongation there and bending the stem toward the light. This adaptive response maximizes light capture for photosynthesis.
- 3. B** — Auxin caused the cells on the treated side to elongate more than the untreated cells, lengthening the treated side. When one side of the stem elongates more than the other, the stem bends away from the longer side, which here is the auxin-treated side. This is precisely the mechanism by which auxin redistribution underlies natural phototropism in young seedlings.
- 4. C** — Year-round warmth, abundant rainfall, and stable conditions, which together provide favorable conditions for many species to thrive. Consistent high productivity and a stable, long-term climate allow more species to specialize and coexist than in seasonally variable biomes. These conditions are why tropical rainforests, despite covering a small fraction of Earth's land area, contain most of the planet's biodiversity.
- 5. A** — Ecological succession, in which one community is gradually replaced by another community over time at a single site. Pioneer species first colonize and modify a barren area, allowing later species to establish, until the community gradually develops into a more mature climax community. This pattern is observed predictably in newly exposed environments, from sand dunes to lava flows.
- 6. D** — The community is composed primarily of the same pioneer species that first colonized the area many years before maturity. Climax communities contain different species than the pioneers, since later-stage species replace early colonizers as the environment changes. Stability, biodiversity, and slow turnover are all genuine features of climax communities, but pioneer composition is not.
- 7. C** — Sunlight, which the grass captured through photosynthesis to produce glucose used as a stored chemical energy source. Plants and other producers convert solar energy into chemical bonds in glucose, which is then passed up the food chain. The sun is therefore the ultimate energy source for nearly every ecosystem on Earth.
- 8. B** — Cold temperatures slow the rates of enzyme-catalyzed reactions, reducing the metabolic activity of the decomposer organisms. Enzymes work best within an optimal temperature range, and low temperatures sharply reduce molecular motion and reaction rates. Slow decomposition is why tundra soils accumulate large amounts of undecomposed organic matter (peat) over thousands of years.

**9. A** — Return to the atmosphere as carbon dioxide through the cellular respiration of decomposer bacteria and fungi over time. Decomposers break down organic molecules in leaves and respire, releasing CO<sub>2</sub> back to the atmosphere. This recycling is a key step in the carbon cycle and balances the carbon fixed by plants during photosynthesis.

**10. D** — The fox population peaks shortly after the rabbit population peaks, consistent with a typical predator-prey cycle in nature. The roughly one-year lag between prey and predator peaks reflects the time required for predators to reproduce in response to abundant food. This pattern of coupled oscillations is one of the most thoroughly documented patterns in population ecology.

**11. C** — An ecosystem, which includes all of the populations in an area together with their abiotic physical environment surroundings. Ecosystems integrate the biotic (living) community with the abiotic (nonliving) environment, including soil, water, light, and air. This larger-scale level of organization encompasses populations and communities but is broader than either.

**12. B** — The mitochondria, where glucose is broken down to produce ATP through the process of aerobic cellular respiration in the cell. The Krebs cycle and electron transport chain occur in the mitochondrial matrix and inner membrane, producing the majority of cellular ATP. Cells with high energy demands, such as cardiac muscle, contain especially large numbers of mitochondria.

**13. A** — The cell's primary function of carrying oxygen, since the lack of organelles leaves more room inside for hemoglobin molecules. Mature red blood cells lose their nucleus and most organelles during development, maximizing internal space for hemoglobin and improving flexibility through capillaries. This specialization gives them a roughly 120-day lifespan because they cannot make new proteins to repair damage.

**14. D** — Transmitting electrical signals over long distances within the body to coordinate body activities very rapidly and precisely. The long axon allows a single neuron to span from the spinal cord to a distant muscle or sensory organ. This extreme cellular geometry is what enables the nervous system to coordinate the body with near-instantaneous speed.

**15. B** — A transport protein, which moves specific molecules or ions across the cell membrane during cellular activity each second. Active-transport pumps, such as the sodium-potassium pump, use ATP to move ions against their gradients across the membrane. These transport proteins are essential for maintaining concentration gradients that underlie nerve impulses, muscle contraction, and many other processes.

**16. C** — A flexible bilayer of phospholipids in which protein and other molecules are embedded and can move laterally within the bilayer. The fluid mosaic model captures both the fluidity of the membrane and the "mosaic" of embedded proteins, glycoproteins, and cholesterol. This dynamic structure is essential for membrane functions ranging from cell signaling to selective transport.

**17. A** — Water will move into the plant cell, increasing turgor pressure against the rigid cell wall and keeping the plant cell firm and rigid. A hypotonic surrounding solution draws water into the cell by osmosis, and the rigid cell wall prevents the cell from bursting. Adequate turgor pressure is what keeps plant tissues firm and is the reason wilting occurs when water is scarce.

**18. D** — Homeostasis, the maintenance of a stable internal environment despite changing external environmental conditions over time. The starfish actively regulates its internal salt content even when the external salinity changes dramatically with the tide. This is a textbook example of how homeostatic mechanisms allow organisms to survive in variable environments.

**19. C** — A negative feedback loop, which reverses the original change (low body water) and restores the body to its normal water balance. ADH causes the kidneys to reabsorb water, which raises blood water levels back toward the set point, reducing further ADH release. Most physiological control systems — including blood glucose, blood pressure, and temperature — operate through similar negative feedback loops.

**20. B** — Increased carbon dioxide level in the bloodstream, which is detected by sensors and signals the brain to increase breathing. Chemoreceptors in the carotid bodies and brainstem detect rising CO<sub>2</sub> (and falling pH) and signal the respiratory center to increase ventilation. CO<sub>2</sub> is actually a stronger stimulus for breathing than low oxygen under most conditions.

**21. A** — Antagonistic hormones, with insulin lowering blood glucose levels and glucagon raising blood glucose levels in the bloodstream. Antagonistic hormone pairs allow precise regulation by pushing a variable in opposite directions as needed. Disruption of this insulin-glucagon balance underlies diabetes and other disorders of glucose metabolism.

**22. D** — Very rapidly, transmitting electrical signals along nerves to coordinate near-instantaneous responses to stimuli around the body. Nerve impulses travel at speeds of up to about 100 meters per second, which is why nervous responses occur in milliseconds. The endocrine system, by contrast, uses chemical messengers traveling in the blood and produces slower but longer-lasting effects.

**23. C** — From the receptor through a sensory neuron to the spinal cord, then through a motor neuron to the muscle that responds quickly. The reflex arc bypasses the brain, allowing the response to begin before conscious processing occurs. This is why the hand moves before the pain is consciously felt when touching a hot object.

**24. B** — Color vision and detailed central vision in bright light, since cones detect different wavelengths of visible light in the eye. Cones contain three different pigments tuned to red, green, and blue wavelengths and are concentrated in the fovea for sharp central vision. Rods, in contrast, provide sensitivity to dim light but no color discrimination.

**25. A** — Amplify sound vibrations from the eardrum and transmit them to the fluid-filled cochlea of the inner ear for further processing. The malleus, incus, and stapes form a lever system that boosts the pressure of sound vibrations enough to set the fluid in the cochlea in motion. This mechanical amplification is essential because fluid is much harder to vibrate than air.

**26. D** — An innate behavior, a genetically programmed behavior that does not require learning from previous individuals or prior experience. Because the migration spans multiple generations of monarchs, no individual butterfly can have learned the route from another butterfly. The behavior must be inherited and triggered by environmental cues such as day length and temperature.

- 27. B** — A learned behavior, specifically operant conditioning, in which the dog learns to associate the behavior with a desirable reward. Reinforcement through treats increases the probability that the dog will perform the requested behavior in the future. This is the central principle of B.F. Skinner's operant conditioning, widely used in animal training.
- 28. C** — Imprinting, in which a young animal forms a rapid, strong attachment to an object during a critical early period of life after birth. Lorenz's classic geese experiments showed that imprinting occurs only within a brief sensitive period and is essentially irreversible afterward. Imprinting is a special category of learning that depends on a precise developmental window.
- 29. A** — A point mutation, since only a single nucleotide has changed in the original DNA sequence of the affected gene in the cell. Substituting one base for another in a single codon is the defining feature of a point mutation (specifically a missense mutation in this case). The change does alter one amino acid but does not shift the reading frame or duplicate any chromosome.
- 30. D** — Heterozygote advantage, in which heterozygotes have a survival advantage over both types of homozygotes in this particular environment. Heterozygotes are largely protected from malaria yet do not suffer the severe consequences of full sickle cell anemia. This balanced polymorphism keeps the sickle cell allele common in malaria-endemic regions, a classic textbook example of balancing selection.
- 31. B** — 25 percent, since the cross of two heterozygous carriers ( $Cc \times Cc$ ) produces one homozygous recessive ( $cc$ ) child out of four offspring. The Punnett square for  $Cc \times Cc$  yields a 1:2:1 ratio of  $CC:Cc:cc$ , so 1/4 of offspring are predicted to be affected. Each pregnancy is independent and carries the same 25% risk.
- 32. C** — A son who inherited the recessive allele from his mother on the single X chromosome he received during fertilization of the egg. The carrier mother ( $X^H X^h$ ) can pass either allele to her sons, while the father passes Y. Sons who inherit the  $X^h$  have no second X to compensate and are therefore affected, which is why X-linked recessive disorders predominantly affect males.
- 33. D** — Autosomal recessive inheritance, since the trait skips a generation and appears in the offspring of two unaffected parents in the family. Two unaffected Generation I parents produced an affected Generation II son, and unaffected Generation II parents produced an affected Generation III daughter. Both sexes are equally affected, ruling out sex-linked patterns, and the skipping of generations rules out dominant inheritance.
- 34. A** — A genetically modified organism, since the bacterium's genome has been deliberately altered using modern biotechnology techniques. Inserting a foreign gene to give the host a new trait is the defining feature of genetic modification. Production of human insulin in genetically modified *E. coli* was one of the first major commercial applications of biotechnology.
- 35. C** — Insects may evolve resistance to the pest-control trait over time, eventually reducing the long-term effectiveness of the engineered trait. Any strong selective pressure can drive the evolution of resistance, just as antibiotic use selects for resistant bacteria. Refuge strategies and crop rotation are commonly used to slow this evolution in pest populations.

**36. B** — Multipotent, meaning that they can differentiate into only a limited number of related cell types within the surrounding tissue type. Adult stem cells (for example, bone marrow stem cells) can produce several related cell types but not the full range of cells in the body. Embryonic stem cells, by contrast, are pluripotent and can give rise to nearly any cell type.

**37. D** — Make many copies of a small region of DNA from a tiny starting sample through repeated cycles of heating and cooling reactions. PCR uses a heat-stable polymerase, primers, and free nucleotides to exponentially amplify a target DNA region. This amplification is foundational to modern molecular biology, forensics, and disease diagnostics.

**38. A** — The mRNA that produced polypeptide B, since polypeptide B contains the largest number of amino acids of the three chains in the diagram. The codon-to-amino-acid relationship is 3:1, so the mRNA with the longest coding sequence produces the longest polypeptide. Polypeptide B, with 12 amino acids, would have required the longest stretch of codons (36 nucleotides) to translate.

**39. C** — One original strand from the parent double helix and one newly synthesized strand, giving the process its descriptive name semiconservative. The Meselson–Stahl experiment confirmed semiconservative replication using nitrogen isotope labeling in DNA. This mechanism preserves the original genetic information while producing an accurate copy each generation.

**40. B** — Proteins called histones that the DNA wraps around to form compact structures called nucleosomes inside the cell's nucleus during division. Histone proteins organize roughly 147 base pairs of DNA into each nucleosome, allowing more than two meters of DNA to fit into each cell's tiny nucleus. Modifications of histones also play a major role in regulating gene expression.

**41. A** — Four haploid sperm cells, each containing 23 chromosomes, produced through two sequential meiotic divisions of the original cell. One primary spermatocyte undergoes meiosis I to form two secondary spermatocytes, each of which undergoes meiosis II to form two spermatids, giving four haploid sperm per original cell. Each sperm carries half the parental chromosome number, ready to combine with an egg at fertilization.

**42. D** — Crossing over, the exchange of corresponding segments of DNA between homologous chromosomes during the prophase of meiosis I. Crossing over occurs at chiasmata and recombines maternal and paternal alleles, generating new combinations not present in either parent. This recombination is one of the major sources of genetic variation in sexually reproducing populations.

**43. C** — Mitotic cell division of somatic body cells, which produces genetically identical daughter cells used in growth and routine tissue repair. Mitosis does not introduce genetic variation because the daughter cells are clones of the parent cell. Crossing over, independent assortment, and random fertilization, by contrast, all contribute to the genetic variation in offspring.

**44. B** — Cell differentiation, in which different sets of genes are expressed in different cells, producing specialized cell types and tissues over time. All somatic cells share the same DNA, but selective gene expression — controlled by transcription factors and epigenetic marks — gives rise to the diversity of cell types in the body. This selective expression is what allows one fertilized egg to develop into a complex multicellular organism.

**45. D** — Mitosis, the form of cell division that produces two genetically identical diploid daughter cells used for the body's growth and tissue repair. The zygote and its descendants divide mitotically to produce the body's trillions of somatic cells, each carrying the same genome. Meiosis, in contrast, is reserved for producing gametes with halved chromosome number.

**46. A** — Wall of the uterus, where the embryo continues to develop with the support of the placenta over the course of nine months in human pregnancy. The blastocyst burrows into the endometrium of the uterine wall, establishing the maternal-fetal interface that becomes the placenta. Implantation in any other location is termed an ectopic pregnancy and is a medical emergency.

**47. C** — Allow the exchange of nutrients, oxygen, and waste products between the mother's bloodstream and the developing fetus's bloodstream. The placenta provides an extensive interface where diffusion and selective transport occur between the two circulations without their blood actually mixing. Damage to placental function can compromise fetal growth and development.

**48. B** — Teratogens, which are environmental agents that disrupt the normal development of an embryo or a fetus during the pregnancy period. Classic examples include alcohol (fetal alcohol syndrome), rubella virus (congenital rubella syndrome), and thalidomide (limb defects). The first trimester, when organ systems are forming, is the period of greatest vulnerability to teratogens.

**49. D** — Natural selection, in which heritable variations that improve survival and reproduction become more common in the bird population. When environmental conditions favor a particular beak shape, birds with that shape leave more offspring and pass on the relevant alleles. This is precisely the mechanism documented by the Grants in their long-term study of Galapagos finches.

**50. A** — Modern humans speak many different languages around the world, reflecting cultural and historical differences among populations. Language diversity is a cultural and historical phenomenon, not biological evidence of evolution. The fossil record, embryological similarities, and molecular comparisons, by contrast, are all major lines of biological evidence supporting evolution.