PRACTICE EXAM 16: LIFE SCIENCE: BIOLOGY SIMULATION (50 QUESTIONS)

Instructions: Practice Exam 16 emphasizes biochemistry, enzyme kinetics, photosynthesis and respiration mechanisms, cell division, advanced genetics with calculations, population genetics, evolution, environmental disturbances, and human body systems. Multiple questions are accompanied by figures requiring data interpretation. Select the one best answer for each item.

1. A student wants to test a food sample for the presence of protein. Which laboratory test should the student use?

A. Benedict's test, which turns orange-red in the presence of simple sugars such as glucose
B. Lugol's iodine, which turns blue-black in the presence of starch in a tested food sample
C. Sudan III stain, which turns red in the presence of fats and lipids dissolved in solution
D. Biuret reagent, which turns violet in the presence of peptide bonds found in protein molecules

2. Lipids in living organisms function primarily as:

A. Long-term energy storage molecules and as major structural components of cellular membranes
B. The primary source of immediate energy for daily cellular metabolic activities in animal tissues
C. Genetic information storage molecules that direct cellular protein synthesis activities continuously
D. The structural components of bones, tendons, and other connective tissues of an animal's body

3. Glucose and other carbohydrates serve which primary role in the cells of most organisms?

A. To form the structural framework of the outer cell membrane in nearly every eukaryotic cell
B. To store genetic information that directs the production of proteins throughout the entire body
C. To provide a readily available source of chemical energy through cellular respiration pathways
D. To carry oxygen molecules from the lungs to the body's various tissues through the bloodstream

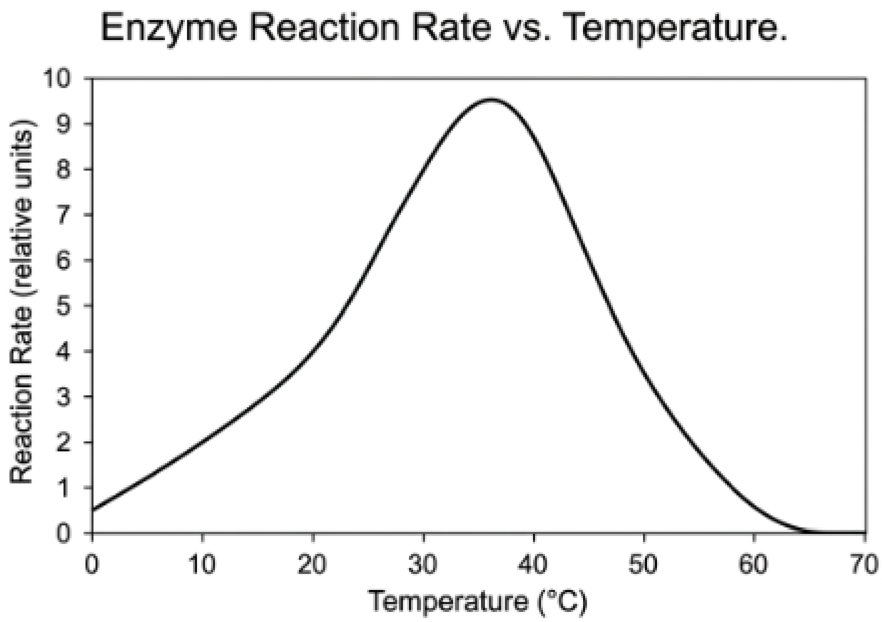
4. Proteins perform an exceptionally wide variety of functions in living cells. Which of the following statements best illustrates this functional diversity?

A. Proteins serve only a structural role in the body and have no role in any other cellular activities
B. Proteins serve as enzymes, structural components, transporters, antibodies, and hormone messengers
C. Proteins serve only as energy storage molecules and provide the cell with most of its ATP energy
D. Proteins serve only as genetic information carriers and direct cellular protein synthesis activities

5. A nucleotide, the basic structural unit of both DNA and RNA, consists of:

A. Two amino acids joined by a peptide bond and a single phosphate group attached to the chain
B. Three fatty acid molecules attached to a single glycerol backbone through ester bond linkages
C. A nitrogen-containing base, a five-carbon sugar, and one or more phosphate groups bonded together
D. A single sugar molecule linked to several long fatty acid chains through ester bond linkages

6. The graph below shows the rate of an enzyme-catalyzed reaction at different temperatures.



Based on the graph, the optimal temperature for this enzyme is approximately:

A. 10°C, where the curve first rises sharply above the zero baseline of the graph on the left side
B. 20°C, where the reaction rate first reaches a moderate value on the y-axis of the graph
C. 30°C, where the reaction rate has not yet reached its highest plotted value on the curve
D. 37°C, where the curve reaches its highest peak value across the entire range of temperatures

7. As substrate concentration increases in an enzyme-catalyzed reaction, the reaction rate eventually levels off and stops increasing. The most likely explanation is that:

A. All available enzyme active sites are occupied by substrate, so adding more substrate cannot speed it up
B. The enzyme has begun to denature gradually because of the higher substrate concentration in the solution
C. The substrate molecules have started reacting with each other rather than with the enzyme molecules
D. The product of the reaction has begun to convert back into the original substrate at the same rate

8. Pepsin in the stomach functions optimally at a pH of about 2, while trypsin in the small intestine functions optimally at a pH of about 8. Which conclusion is best supported by this information?

A. All digestive enzymes in the human body share the same optimal pH for their biochemical activity
B. Different enzymes have different optimal pH values that are matched to their location of activity
C. Both pepsin and trypsin would denature at any pH below 1 anywhere within the human digestive system
D. The pH of the surrounding solution has essentially no effect on the activity of any digestive enzyme

9. A competitive inhibitor reduces the rate of an enzyme-catalyzed reaction by:

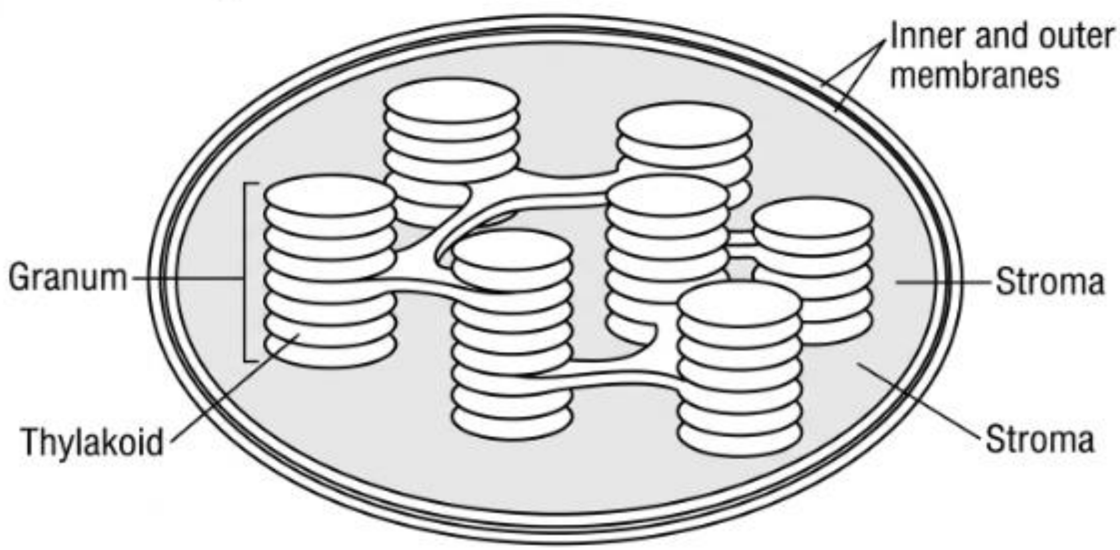
A. Permanently destroying the active site of the enzyme so that no substrate can ever bind it again
B. Increasing the optimal temperature at which the enzyme functions most efficiently inside of the cell
C. Causing the enzyme to break apart into smaller fragments that cannot perform their normal function
D. Binding to the enzyme's active site and blocking the normal substrate from binding to the enzyme

10. A noncompetitive inhibitor differs from a competitive inhibitor in that the noncompetitive inhibitor:

A. Binds directly to the enzyme's active site and prevents the normal substrate from binding there
B. Has the same chemical shape as the natural substrate of the enzyme and competes with it directly
C. Binds to a site other than the active site and changes the enzyme's shape so substrate cannot bind well
D. Permanently destroys the enzyme, so that the reaction cannot occur even if more substrate is added

11. The diagram below shows a simplified chloroplast.

Figure PQ-2: Chloroplast Cross-Section



The light-dependent reactions of photosynthesis take place in which part of the chloroplast?

A. The thylakoid membranes within the grana, where the chlorophyll molecules absorb the light energy
B. The stroma, the fluid surrounding the grana where carbon dioxide is fixed into sugar molecules
C. The outer membrane of the chloroplast, which encloses the entire organelle and isolates its contents

D. The space between the inner and outer membranes, which has no role at all in the photosynthesis process

12. C4 plants such as corn and sugarcane are more efficient at photosynthesis in hot, dry conditions than C3 plants because C4 plants:

A. Open their stomata wider than C3 plants do to capture more atmospheric carbon dioxide each day
B. Use a specialized pathway to concentrate carbon dioxide near the enzyme that fixes carbon in the leaf
C. Carry out photosynthesis entirely in the dark, allowing them to keep their stomata closed all day long
D. Do not require any carbon dioxide at all, because they obtain their carbon directly from soil nitrogen

13. In the light-dependent reactions of photosynthesis, water molecules are split in a process called photolysis. This process:

A. Produces glucose molecules and releases them directly into the chloroplast's surrounding stroma fluid
B. Combines water with carbon dioxide to make sugar through the action of the enzyme RuBisCO directly
C. Uses energy from glucose to break apart oxygen and produce additional water inside of the chloroplast
D. Releases oxygen, hydrogen ions, and electrons, with oxygen released to the atmosphere as a waste gas

14. NADPH produced by the light reactions of photosynthesis is best described as:

A. A waste product of the light-dependent reactions that the plant must remove from the chloroplasts
B. The pigment that captures light energy at the very first step of the light-dependent reactions of photosynthesis
C. An electron carrier that provides energy and reducing power to drive the Calvin cycle reactions
D. A storage form of glucose that the plant can use during nighttime cellular respiration in its cells

15. Which statement best describes the relationship between photosynthesis and cellular respiration?

A. Photosynthesis produces glucose and oxygen, which cellular respiration uses to release stored energy
B. Photosynthesis and cellular respiration are unrelated processes that share no common molecules at all
C. Cellular respiration produces glucose, which photosynthesis then breaks down to release stored energy
D. Both processes occur only in plant cells, while animals must obtain all their energy from sunlight directly

16. The diagram below shows the three main stages of aerobic cellular respiration.

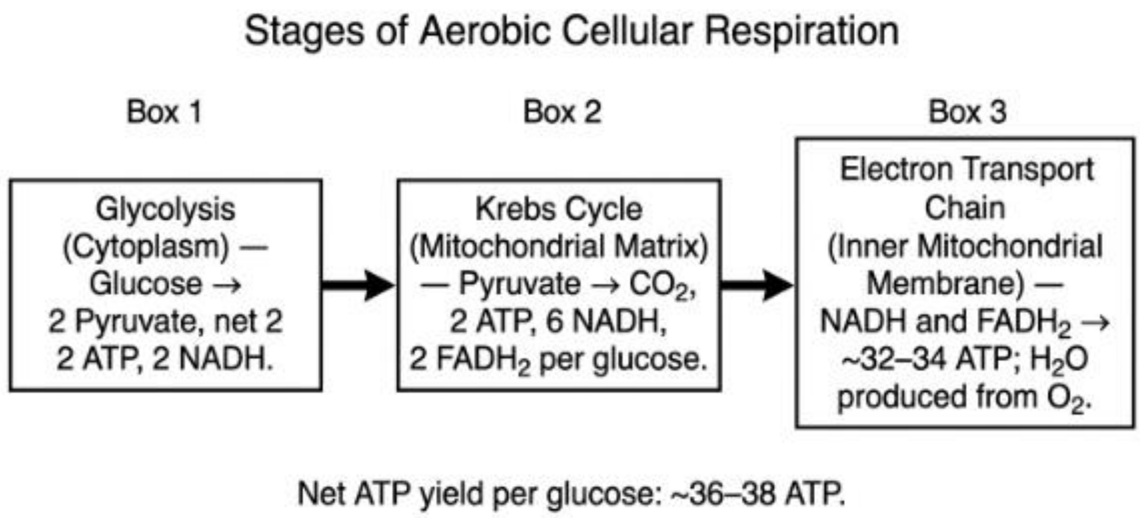


Figure PQ-3

Based on the diagram, which stage of aerobic cellular respiration produces the largest amount of ATP per glucose molecule?

A. Glycolysis, which directly produces the largest amount of ATP through the initial breakdown of glucose
B. The electron transport chain, which produces the majority of the ATP in aerobic cellular respiration
C. The Krebs cycle, which produces a very large amount of ATP from each molecule of pyruvate in cells
D. Lactic acid fermentation, which produces more ATP than any of the three stages shown in the diagram

17. Anaerobic respiration (fermentation) produces far less ATP per glucose molecule than aerobic respiration. The approximate net ATP yields are:

A. 36–38 ATP from anaerobic respiration and only 2 ATP from aerobic cellular respiration in each case
B. 100 ATP from aerobic respiration and 50 ATP from anaerobic respiration under the same conditions
C. 36–38 ATP from aerobic respiration and only 2 ATP from anaerobic fermentation per glucose molecule
D. Equal amounts of ATP from aerobic and anaerobic respiration in nearly all conditions in nature

18. In the electron transport chain of mitochondria, the energy released as electrons pass between carriers is used directly to:

A. Synthesize new molecules of glucose from carbon dioxide and water inside the mitochondrial matrix
B. Build new ribosomal subunits inside the mitochondria for future translation of mitochondrial proteins
C. Split water molecules into hydrogen and oxygen for use in the Krebs cycle and the glycolysis pathways

D. Pump hydrogen ions across the inner mitochondrial membrane, creating a gradient that powers ATP synthesis

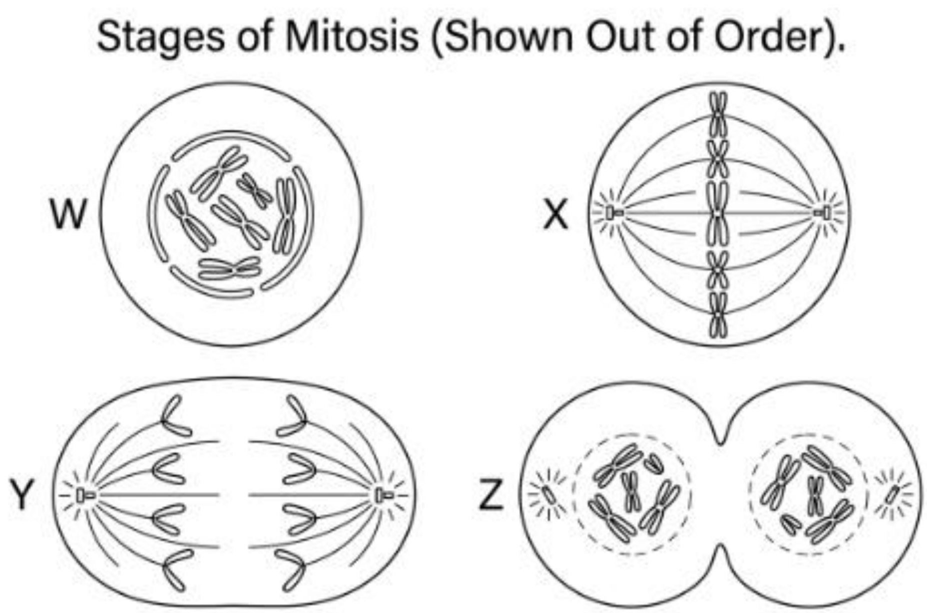
19. In the absence of oxygen, human muscle cells and baker's yeast cells both produce ATP through fermentation. The end products differ in that:

A. Human muscle cells produce lactic acid, while yeast cells produce ethanol and carbon dioxide gas
B. Human muscle cells produce ethanol, while yeast cells produce lactic acid and carbon dioxide gas
C. Both cell types produce only carbon dioxide and water as the final end products of their fermentation
D. Both cell types produce only ATP and oxygen gas as the final end products of fermentation each time

20. The inner membrane of the mitochondrion is highly folded into structures called cristae. The primary functional advantage of this folding is that it:

A. Allows the mitochondrion to divide quickly in cells with very high energy demands every single day
B. Prevents oxygen from leaking out of the mitochondrion into the surrounding cytoplasm of the cell
C. Greatly increases the surface area available for the proteins of the electron transport chain to operate
D. Allows the mitochondrion to absorb sunlight directly and produce sugar through photosynthesis pathways

21. The diagram below shows four different stages of mitosis in an animal cell, labeled W, X, Y, and Z. The stages are not arranged in chronological order.



Which cell shown in the diagram represents metaphase?

A. Cell W, the stage in which the chromosomes are first beginning to condense and become visible
B. Cell X, the stage in which the chromosomes are aligned along the equator of the dividing cell

C. Cell Y, the stage in which the sister chromatids are being pulled toward opposite poles of the cell
D. Cell Z, the stage in which two new nuclei are forming and the cytoplasm is dividing in two parts

22. During cell division, cytokinesis occurs differently in plant cells than in animal cells because plant cells:

A. Do not undergo cytokinesis at all, since they divide only by binary fission like prokaryotes do
B. Form a cleavage furrow that pinches the parent cell in half just like in animal cells of the same type
C. Combine cytokinesis and mitosis into a single step that occurs simultaneously inside the dividing cell
D. Have a rigid cell wall, requiring them to build a new cell plate between the dividing daughter cells

23. Proteins called cyclins help regulate the cell cycle by:

A. Combining with kinases to form complexes that signal the cell to move from one phase of the cell cycle to the next
B. Permanently damaging the DNA of cells that have grown too large to function properly in adult tissues
C. Carrying genetic information from the cytoplasm into the cell's nucleus for transcription each time
D. Providing the structural framework for the spindle fibers that form during cell division throughout the cell

24. A table comparing mitosis and meiosis in animal cells is shown below.

Comparison of Mitosis and Meiosis

Feature	Mitosis	Meiosis
Number of divisions	1	2
Number of daughter cells produced	2	4
Chromosome number of daughter cells	Same as parent (diploid)	Half of parent (haploid)
Genetic identity of daughter cells	Identical to parent	Genetically unique
Crossing over occurs	No	Yes
Type of cells produced	Somatic body cells	Gametes (sperm and egg)

Based on the table, which statement about meiosis is correct?

A. Meiosis produces two identical daughter cells with the same chromosome number as the parent cell
B. Meiosis produces somatic body cells that the organism uses for tissue growth and tissue repair daily
C. Meiosis produces four genetically unique haploid daughter cells used for sexual reproduction in

animals
D. Meiosis produces gametes through a single round of cell division that includes crossing over of DNA

25. During meiosis I, homologous chromosomes pair up and exchange segments of DNA in a process called crossing over. This process:

A. Reduces the genetic variation among the offspring produced by sexual reproduction in animals overall
B. Increases the genetic variation among the gametes produced and therefore among the offspring later
C. Has essentially no effect on the genetic variation of the gametes produced during meiosis at any time
D. Permanently damages the homologous chromosomes and prevents them from functioning correctly later

26. A pea plant with purple flowers may be either homozygous dominant (PP) or heterozygous (Pp). To determine the genotype of this purple-flowered plant, a researcher should cross it with a:

A. Homozygous recessive (pp) white-flowered plant and observe the phenotypes of all the resulting offspring
B. Homozygous dominant (PP) purple-flowered plant and observe the phenotypes of all of the offspring
C. Heterozygous (Pp) purple-flowered plant and observe the phenotypes of all the next-generation offspring
D. Plant with red flowers, which represents a third allele of the same flower color gene found in pea plants

27. In pea plants, the allele for yellow seeds (Y) is dominant over green seeds (y), and the allele for round seeds (R) is dominant over wrinkled seeds (r). A dihybrid cross between two heterozygous plants (YyRr × YyRr) produces 320 offspring. The Punnett square for this cross is shown below.

Figure PQ-6: Clean black-line technical Punnett square on white background

Dihybrid Cross: YyRr × YyRr

Feature	Mitosis			Meiosis	
Number of divisions		YR	Yr	yR	yr
Number of daughter cells produced	YR	YYRR	YYRr	YyRR	YyRr
Chromosome number of daughter cells	Yr	YYRr	YYrr	YyRr	Yyrr
Genetic identity of daughter cells	yR	YyRR	YyRr	yyRR	yyRr
Crossing over occurs	yr	YyRr	Yyrr	yyRr	yyrr
9 yellow round : 3 yellow wrinkled : 3 green round : 1 green wrinkled					

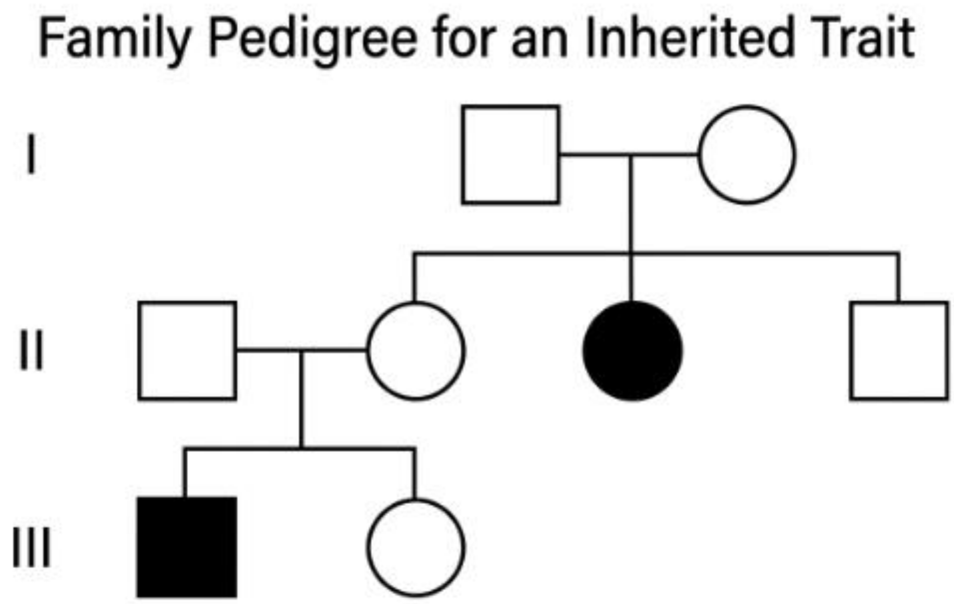
Approximately how many of the 320 offspring would be expected to have yellow, round seeds?

A. 20 offspring, since the predicted ratio of yellow round seeds is 1/16 of the offspring produced by this cross
B. 60 offspring, since the predicted ratio of yellow round seeds is 3/16 of the offspring produced by this cross
C. 80 offspring, since the predicted ratio of yellow round seeds is 4/16 of the offspring produced by this cross
D. 180 offspring, since the predicted ratio of yellow round seeds is 9/16 of the offspring produced by this cross

28. Color blindness is a sex-linked recessive trait carried on the X chromosome in humans. A man with normal color vision marries a woman who is a carrier of the color blindness allele. What is the probability that any one of their sons will be color blind?

A. 0 percent, since the father has normal color vision and no other genetic factors are involved at all
B. 25 percent, equivalent to one out of every four sons born to this particular pair of parents on average
C. 50 percent, equivalent to one out of every two sons born to this particular pair of parents on average
D. 100 percent, equivalent to every one of the sons born to this particular pair of parents being affected

29. A partial pedigree of a family showing an inherited trait is shown below.



Based on the pedigree, the inheritance pattern of this trait is most likely:

A. Autosomal dominant, since the trait appears in every generation of this particular family pedigree shown
B. Autosomal recessive, since the trait can skip generations and appears in offspring of unaffected parents

C. Sex-linked dominant, since the trait affects more males than females in this particular pedigree shown
D. Mitochondrial inheritance, since the trait is passed only from affected mothers to all of their children

30. In a cross between two heterozygous parents (Aa × Aa), what is the probability that any single offspring will be heterozygous (Aa)?

A. 50 percent, since two of the four equally likely offspring genotypes are heterozygous (Aa) in this cross
B. 25 percent, since one of the four equally likely offspring genotypes is heterozygous (Aa) in this cross
C. 75 percent, since three of the four equally likely offspring genotypes are heterozygous (Aa) in this cross
D. 100 percent, since all of the four equally likely offspring genotypes are heterozygous (Aa) in this cross

31. In a population of 1,000 plants, 160 have white flowers (a recessive trait), and the remaining 840 have purple flowers. Assuming the population is in Hardy-Weinberg equilibrium, the frequency of the recessive allele (q) in this population is approximately:

A. 0.16, calculated directly from the proportion of white-flowered plants in this particular plant population
B. 0.84, calculated directly from the proportion of purple-flowered plants in this particular plant population
C. 0.20, calculated as the square of the proportion of white-flowered plants in this particular population
D. 0.40, calculated as the square root of the proportion of white-flowered plants in this particular population

32. Continuing the scenario from the previous question, what is the approximate frequency of the dominant allele (p) in the same population of plants?

A. 0.16, calculated as the same value used for the frequency of the recessive allele in this population
B. 0.84, calculated directly from the proportion of purple-flowered plants in this same plant population
C. 0.60, calculated by subtracting the frequency of the recessive allele from 1 in this same population
D. 0.40, calculated using the same value used for the frequency of the recessive allele in this same group

33. The pelvic bones of modern whales are small, embedded in muscle, and do not connect to the spine or to any external legs. These bones are best classified as:

A. Analogous structures, which evolved independently in unrelated species to perform similar functions today
B. Vestigial structures, the remnants of structures that were functional in the species' evolutionary ancestors
C. Convergent traits, which evolved independently in unrelated organisms because of similar environments
D. Adaptive traits, which currently provide a major selective advantage to whales in their ocean environments

34. Early embryos of fish, reptiles, birds, and mammals all show similar features such as gill pouches and tails, even though these features differ greatly in the adult forms of each group. This embryonic similarity is most often interpreted as:

A. Evidence that fish, reptiles, birds, and mammals are completely unrelated and evolved entirely independently
B. Evidence that environmental conditions during embryonic development always produce identical embryos in animals
C. Evidence that all multicellular animals develop from the same single ancestral fertilized egg cell in the past
D. Evidence that these groups share a common ancestor and inherited similar developmental programs from it

35. Dolphins and sharks have very similar streamlined body shapes and fins for life in water, but they evolved from very different ancestors — dolphins from mammals and sharks from fish. This similarity of form is best explained by:

A. Convergent evolution, in which unrelated species independently evolve similar traits due to similar selective pressures
B. Divergent evolution, in which closely related species evolve different traits to fit different environments over time
C. Coevolution, in which two interacting species evolve in response to each other over many generations of time
D. Genetic drift, in which random changes in allele frequencies happen by pure chance in small populations of organisms

36. Human activity has significantly increased atmospheric carbon dioxide levels in recent centuries. The single largest source of this added CO_2 is:

A. The respiration of land animals that consume plant material as part of their normal daily metabolism
B. The release of CO_2 from active and dormant volcanoes located throughout various parts of the world
C. The burning of fossil fuels such as coal, oil, and natural gas for energy production and transportation
D. The decomposition of dead organic matter in temperate and tropical forests during the warmer seasons

37. Agricultural runoff that carries excess nitrogen and phosphorus into freshwater lakes often causes a dramatic decline in fish populations. The most direct cause of this fish decline is:

A. Fish die because their gills are damaged by direct contact with the dissolved nitrogen and phosphorus chemicals
B. Algal blooms triggered by the nutrients eventually decompose, depleting dissolved oxygen in the water column
C. The added nutrients accelerate the freezing of the lake, killing fish by extreme cold even during the summer
D. The nutrients combine to form a thick solid layer that physically prevents fish from breathing through their gills

38. The greenhouse effect refers to the natural process by which:

A. Certain gases in the atmosphere trap heat near Earth's surface by absorbing outgoing infrared radiation
B. Ozone in the upper atmosphere absorbs ultraviolet radiation before it can reach the surface of the Earth
C. Cloud cover at high altitudes reflects sunlight back into space and cools the planet during summer months
D. Plants on land absorb visible light from the sun and convert it directly into mechanical kinetic energy

39. Rising global temperatures driven by climate change are most likely to affect biological communities in which of the following ways?

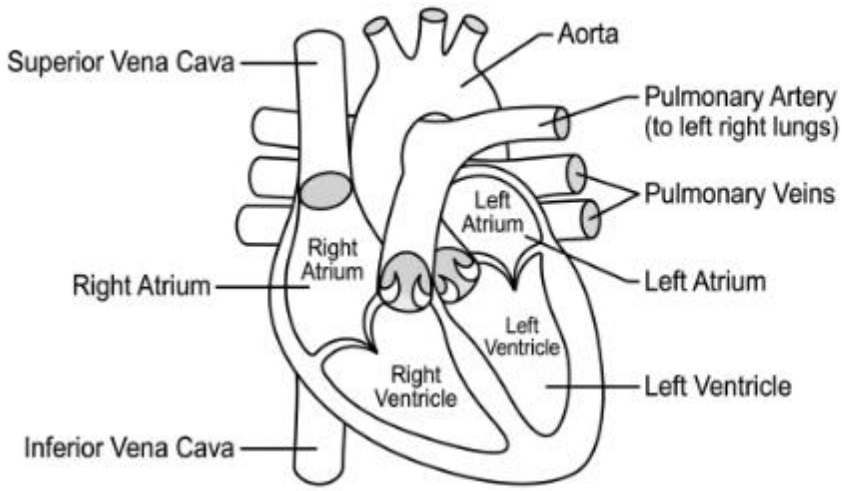
A. By directly destroying the DNA of all plant and animal species within a single human generation rapidly
B. By creating identical environments worldwide, allowing all species to thrive equally well together everywhere
C. By having no measurable effect on living organisms, since species can quickly adapt to any environmental conditions
D. By shifting species ranges, disrupting seasonal timing, and increasing the risk of local extinctions globally

40. Which of the following human practices is most clearly considered a sustainable practice in terms of long-term environmental impact?

A. Cutting down all of the trees in a forest to create permanent farmland for short-term food production
B. Releasing untreated factory waste directly into nearby rivers in order to reduce the cost of waste management
C. Using solar and wind energy to replace fossil fuels in electrical power generation throughout entire regions
D. Hunting wild populations down to extremely low numbers to obtain meat and other animal products quickly

41. The diagram below shows a simplified human heart.

Human Heart — Frontal View



Which chamber of the heart pumps oxygen-rich blood to the rest of the body through the aorta?

A. The left ventricle, the thickest-walled chamber, which pumps oxygenated blood to the entire body
B. The right ventricle, which pumps oxygen-poor blood through the pulmonary artery to the lungs for oxygenation
C. The left atrium, which receives oxygen-rich blood from the lungs through the pulmonary veins each beat
D. The right atrium, which receives oxygen-poor blood from the body through the superior and inferior vena cava

42. After blood leaves the right ventricle of the heart, its next destination in the circulatory system is the:

A. Aorta, which carries oxygen-rich blood directly to all of the body's various tissues and organ systems
B. Pulmonary artery, which carries oxygen-poor blood from the heart to the lungs for gas exchange
C. Left atrium, which receives oxygen-rich blood arriving from the lungs through the pulmonary veins
D. Vena cava, which carries oxygen-poor blood from the body back to the right atrium of the heart

43. The lymphatic system in humans serves which combination of functions in the body?

A. Pumping oxygen-rich blood to all of the body's various tissues throughout each part of the day
B. Producing red blood cells in the bone marrow that carry oxygen from the lungs to the body's tissues
C. Returning excess tissue fluid to the bloodstream and producing immune cells that defend against pathogens
D. Filtering waste from the bloodstream and producing urine for excretion through the urinary system tubes

44. The functional unit of the kidney that filters blood and produces urine is the:

A. Alveolus, the tiny air sac in the lung where gas exchange occurs across thin capillary walls each breath
B. Glomerulus only, which is the tiny tuft of capillaries that filters fluid from the blood into the kidney capsule
C. Hepatocyte, the main functional cell of the liver, which performs many metabolic functions in the body
D. Nephron, which includes the glomerulus, the surrounding capsule, and the long associated kidney tubule

45. During the formation of urine, useful substances such as glucose, amino acids, and water are returned to the bloodstream from the kidney tubule in a process called:

A. Reabsorption, in which useful substances move from the kidney tubule back into the surrounding bloodstream
B. Filtration, in which fluid and small molecules are pushed out of the blood into the Bowman's capsule of the kidney
C. Secretion, in which additional waste molecules are actively added from the bloodstream into the kidney tubule
D. Excretion, in which the final formed urine is expelled from the body through the urethra during the act of urination

46. The human skeletal system performs all of the following functions EXCEPT:

A. Providing structural support for the body and giving the body its overall shape and physical form
B. Producing antibodies that recognize specific foreign pathogens and mark them for immune destruction
C. Protecting internal organs such as the brain, heart, and lungs from direct physical injury and damage
D. Producing blood cells in the red bone marrow of certain bones such as the sternum and the femur

47. Which of the following is the type of muscle found in the walls of internal organs such as the stomach, intestines, and blood vessels?

A. Skeletal muscle, which is striated, multinucleate, and under voluntary conscious control from the brain
B. Cardiac muscle, which is striated, branched, and found only in the wall of the heart and not elsewhere
C. Smooth muscle, which is non-striated, mononucleate, and under involuntary autonomic nervous control
D. Tendinous tissue, dense connective tissue that connects muscles to bones throughout the human body

48. When a neuron is stimulated above its threshold, an action potential travels along the neuron's axon. This action potential is best described as:

A. A continuous chemical change that slowly spreads down the length of the axon over several minutes
B. A small mechanical wave that pushes neurotransmitter molecules down the axon at a constant slow rate
C. A flow of electricity through the axon, similar to electrical current flowing through a copper wire

conductor
D. A rapid change in electrical charge across the membrane, propagated by the movement of ions across the axon

49. When an action potential reaches the end of one neuron at a synapse, the signal is passed to the next neuron primarily by:

A. A direct flow of electrical current from one neuron to the next neuron, exactly like current in a metal wire
B. The release of neurotransmitter chemicals that diffuse across the synaptic cleft and bind to receptors on the next neuron
C. Direct physical contact in which the membrane of one neuron fuses permanently to the membrane of the next neuron
D. The migration of the first neuron's nucleus into the cell body of the next neuron at the location of the synapse

50. When a person touches a very hot stove, the hand is pulled away before the brain has consciously registered the pain. This rapid response is best described as a:

A. Reflex arc, in which a sensory signal triggers a motor response through the spinal cord without first reaching the brain
B. Voluntary motor action, in which the conscious brain has already initiated movement of the muscles in the arm before pulling
C. Hormonal response, in which the endocrine system releases hormones that cause immediate muscle contraction in the arm
D. Cognitive response, in which the higher cortex of the brain processes the pain information before the arm muscles contract

Practice Exam 16: Life Science: Biology Simulation — Answer Key with Explanations

1. D — Biuret reagent, which turns violet in the presence of peptide bonds found in protein molecules. Biuret reagent reacts specifically with the peptide bonds that link amino acids together in a protein, producing a violet color. The four classic food tests are Benedict's (sugars), iodine (starch), Sudan (lipids), and biuret (protein), each targeting a different macromolecule.

2. A — Long-term energy storage molecules and as major structural components of cellular membranes. Triglycerides store more than twice the energy per gram of carbohydrates, while phospholipids form the bilayer of every cell membrane. Lipids also serve as hormones (steroids) and insulation, making them one of the most functionally versatile biomolecules.

3. C — To provide a readily available source of chemical energy through cellular respiration pathways. Carbohydrates, especially glucose, are the cell's preferred fuel for ATP production through glycolysis, the

Krebs cycle, and the electron transport chain. Excess glucose is stored as glycogen in animals and as starch in plants for later use.

4. B — Proteins serve as enzymes, structural components, transporters, antibodies, and hormone messengers. This diversity arises from the nearly unlimited combinations of the 20 amino acids that fold into specific three-dimensional shapes. The shape-function relationship is what allows proteins to perform almost every type of cellular work.

5. C — A nitrogen-containing base, a five-carbon sugar, and one or more phosphate groups bonded together. The base may be A, T, G, C (DNA) or A, U, G, C (RNA), and the sugar is deoxyribose or ribose respectively. These three components are universal across all nucleotides and form the building blocks of all nucleic acids.

6. D — 37°C, where the curve reaches its highest peak value across the entire range of temperatures. The optimal temperature is defined as the temperature at which the reaction rate is highest, which corresponds to the peak of the bell-shaped curve. Most human enzymes have optimal temperatures near 37°C, matching normal body temperature.

7. A — All available enzyme active sites are occupied by substrate, so adding more substrate cannot speed it up. This condition is called enzyme saturation and produces a plateau on a rate-vs-concentration graph. Adding more enzyme would be required to further increase the reaction rate at this point.

8. B — Different enzymes have different optimal pH values that are matched to their location of activity. Pepsin functions in the acidic stomach (pH ~2), while trypsin works in the alkaline environment of the small intestine (pH ~8) where pancreatic bicarbonate has neutralized acid. This pH-specific design ensures each digestive enzyme is most active where it is needed.

9. D — Binding to the enzyme's active site and blocking the normal substrate from binding to the enzyme. A competitive inhibitor resembles the substrate closely enough to occupy the active site, preventing substrate binding while it remains there. Increasing substrate concentration can often overcome competitive inhibition.

10. C — Binds to a site other than the active site and changes the enzyme's shape so substrate cannot bind well. Noncompetitive inhibitors bind at an allosteric site, distorting the enzyme's three-dimensional structure and disabling the active site indirectly. Increasing substrate concentration cannot overcome this type of inhibition, because the problem is not access to the active site.

11. A — The thylakoid membranes within the grana, where the chlorophyll molecules absorb the light energy. Chlorophyll, photosystems, and the electron transport chain of photosynthesis are all embedded in the thylakoid membranes. The Calvin cycle (light-independent reactions), in contrast, occurs in the stroma.

12. B — Use a specialized pathway to concentrate carbon dioxide near the enzyme that fixes carbon in the leaf. C4 plants initially fix CO_2 into a four-carbon compound in mesophyll cells and then shuttle it to bundle-sheath cells, where it is released at high concentration around RuBisCO. This minimizes wasteful photorespiration in hot, dry conditions where stomata are partly closed.

13. D — Releases oxygen, hydrogen ions, and electrons, with oxygen released to the atmosphere as a waste gas. Photolysis (the splitting of water) replenishes electrons in Photosystem II and is the source of nearly all of Earth's atmospheric O_2. The hydrogen ions contribute to the proton gradient that drives ATP synthesis in the chloroplast.

14. C — An electron carrier that provides energy and reducing power to drive the Calvin cycle reactions. NADPH, produced in the light reactions, donates its high-energy electrons in the Calvin cycle, where they help reduce CO_2 to sugar. Without NADPH and ATP from the light reactions, the Calvin cycle cannot continue producing sugar.

15. A — Photosynthesis produces glucose and oxygen, which cellular respiration uses to release stored energy. The two processes are essentially the reverse of each other and form a continuous cycle in living systems. Both plants and animals perform cellular respiration, but only plants and algae carry out photosynthesis.

16. B — The electron transport chain, which produces the majority of the ATP in aerobic cellular respiration. The ETC generates roughly 32–34 ATP of the total 36–38 ATP yield per glucose, compared to only 2 each from glycolysis and the Krebs cycle. This is why aerobic organisms are so much more energy-efficient than anaerobic ones.

17. C — 36–38 ATP from aerobic respiration and only 2 ATP from anaerobic fermentation per glucose molecule. The dramatic difference comes from the electron transport chain, which depends on oxygen as the final electron acceptor and is bypassed entirely during fermentation. This is why aerobic exercise can be sustained much longer than anaerobic exertion.

18. D — Pump hydrogen ions across the inner mitochondrial membrane, creating a gradient that powers ATP synthesis. The protein complexes of the chain use the energy from electron flow to push H^+ ions into the intermembrane space, building a proton gradient. ATP synthase then uses the flow of these ions back across the membrane to attach phosphate groups to ADP.

19. A — Human muscle cells produce lactic acid, while yeast cells produce ethanol and carbon dioxide gas. Both pathways regenerate NAD^+ so that glycolysis can continue producing ATP without oxygen, but the end products differ. The fermentation of yeast underlies the production of bread, beer, and wine, while lactic acid buildup contributes to muscle fatigue in humans.

20. C — Greatly increases the surface area available for the proteins of the electron transport chain to operate. The folds dramatically expand the surface area of the inner membrane, allowing more ETC complexes and ATP synthase enzymes to be embedded in it. Mitochondria of metabolically active cells, such as cardiac muscle, often have especially numerous and densely packed cristae.

21. B — Cell X, the stage in which the chromosomes are aligned along the equator of the dividing cell. Alignment of chromosomes at the metaphase plate is the defining feature of metaphase. This alignment ensures that each daughter cell will receive exactly one copy of every chromosome during the upcoming anaphase.

22. D — Have a rigid cell wall, requiring them to build a new cell plate between the dividing daughter cells. Vesicles from the Golgi gather at the midline and fuse to form a cell plate that develops into a new cell wall. Animal cells, lacking a cell wall, divide instead by contracting a ring of actin and myosin to form a cleavage furrow.

23. A — Combining with kinases to form complexes that signal the cell to move from one phase of the cell cycle to the next. Cyclin-dependent kinase (CDK) complexes phosphorylate target proteins, triggering the events of the cell cycle in the correct order. Misregulation of cyclins and CDKs is a hallmark of many cancers.

24. C — Meiosis produces four genetically unique haploid daughter cells used for sexual reproduction in animals. The two divisions of meiosis halve the chromosome number and, combined with crossing over and independent assortment, generate extensive genetic variation among gametes. This variation is the raw material for evolutionary change and the basis of family resemblance without identity.

25. B — Increases the genetic variation among the gametes produced and therefore among the offspring later. Crossing over recombines maternal and paternal alleles on the same chromosome, creating combinations that did not exist in either parent. Along with independent assortment and random fertilization, this is one of the major sources of genetic diversity in sexually reproducing populations.

26. A — Homozygous recessive (pp) white-flowered plant and observe the phenotypes of all the resulting offspring. A test cross with a homozygous recessive partner reveals the unknown genotype by phenotype: if any offspring show the recessive trait, the unknown parent must be heterozygous. If all offspring show the dominant trait, the unknown parent is homozygous dominant.

27. D — 180 offspring, since the predicted ratio of yellow round seeds is 9/16 of the offspring produced by this cross. The dihybrid cross YyRr × YyRr produces a 9:3:3:1 phenotypic ratio, and $9/16 \times 320 = 180$. This is the classic outcome of two independently assorting genes with complete dominance, first described by Mendel.

28. C — 50 percent, equivalent to one out of every two sons born to this particular pair of parents on average. The carrier mother (X^AX^a) passes X^A or X^a to each son with equal probability, and the father always passes Y to a son. Half of all sons therefore inherit the recessive allele on their single X and are color blind.

29. B — Autosomal recessive, since the trait can skip generations and appears in offspring of unaffected parents. The affected daughter in Generation II and the affected grandson in Generation III both have unaffected parents, indicating that both parents must be heterozygous carriers. Equal occurrence in males and females rules out sex-linked patterns, while skipping a generation rules out dominant inheritance.

30. A — 50 percent, since two of the four equally likely offspring genotypes are heterozygous (Aa) in this cross. The Punnett square for Aa × Aa yields 1 AA, 2 Aa, and 1 aa, so heterozygotes represent 2/4 = 50% of offspring. This is the same ratio whether one tracks genotype Aa specifically or phenotype in incomplete dominance.

31. D — 0.40, calculated as the square root of the proportion of white-flowered plants in this particular population. Under Hardy-Weinberg, q^2 equals the frequency of the homozygous recessive phenotype, so $q^2 = 160/1000 = 0.16$ and $q = \sqrt{0.16} = 0.40$. This formula lets researchers estimate allele frequencies from phenotypic data without needing to genotype every individual.

32. C — 0.60, calculated by subtracting the frequency of the recessive allele from 1 in this same population. Because the two alleles must add to 1 in a two-allele system, $p = 1 - q = 1 - 0.40 = 0.60$. This relationship is a foundational rule of Hardy-Weinberg analysis.

33. B — Vestigial structures, the remnants of structures that were functional in the species' evolutionary ancestors. The reduced pelvic bones reflect descent from four-legged land mammals that have since evolved into fully aquatic forms. Vestigial structures are common evolutionary evidence, including human appendices, wisdom teeth, and tailbone.

34. D — Evidence that these groups share a common ancestor and inherited similar developmental programs from it. Shared early embryonic features reflect the conserved genetic toolkit (such as Hox genes) inherited from a vertebrate common ancestor. These developmental similarities are a key line of evidence in comparative embryology.

35. A — Convergent evolution, in which unrelated species independently evolve similar traits due to similar selective pressures. The water environment imposes the same hydrodynamic constraints regardless of ancestry, so streamlined bodies and fins evolved independently in fish, marine reptiles, and marine mammals. Internal anatomy reveals the different ancestries despite the similar external form.

36. C — The burning of fossil fuels such as coal, oil, and natural gas for energy production and transportation. Fossil fuel combustion releases carbon that has been locked underground for millions of years back into the atmosphere as CO_2 in just a few centuries. This rapid release is the dominant driver of the modern rise in atmospheric carbon dioxide.

37. B — Algal blooms triggered by the nutrients eventually decompose, depleting dissolved oxygen in the water column. The process, called eutrophication, ends in hypoxic (low-oxygen) "dead zones" in which fish and other aerobic organisms cannot survive. Notable examples include the Gulf of Mexico dead zone fed by Mississippi River agricultural runoff.

38. A — Certain gases in the atmosphere trap heat near Earth's surface by absorbing outgoing infrared radiation. Carbon dioxide, methane, water vapor, and nitrous oxide allow visible sunlight to reach the surface but absorb the infrared heat that radiates back. Without this natural greenhouse effect, Earth's surface would be too cold to support most known life.

39. D — By shifting species ranges, disrupting seasonal timing, and increasing the risk of local extinctions globally. Documented effects include earlier flowering, mismatched timing between predators and prey, poleward range shifts, and population declines in species that cannot adapt fast enough. These changes are already disrupting ecological communities worldwide.

40. C — Using solar and wind energy to replace fossil fuels in electrical power generation throughout entire regions. Sustainable practices meet present needs without compromising the ability of future generations to meet theirs, which renewable energy directly supports. The other options accelerate resource depletion, pollution, or species loss.

41. A — The left ventricle, the thickest-walled chamber, which pumps oxygenated blood to the entire body. Its thick muscular wall generates the high pressure needed to push blood through the systemic circulation. The right ventricle, by contrast, only needs to pump blood to the nearby lungs and has a much thinner wall.

42. B — Pulmonary artery, which carries oxygen-poor blood from the heart to the lungs for gas exchange. The pulmonary artery is the one artery in the body that carries deoxygenated blood, because it is defined by direction of flow rather than oxygen content. Oxygen-rich blood returns to the heart from the lungs via the pulmonary veins.

43. C — Returning excess tissue fluid to the bloodstream and producing immune cells that defend against pathogens. Lymphatic vessels collect interstitial fluid that has leaked from capillaries and return it to the venous system through the thoracic duct. Lymph nodes house concentrations of lymphocytes that filter the lymph and mount immune responses to foreign antigens.

44. D — Nephron, which includes the glomerulus, the surrounding capsule, and the long associated kidney tubule. Each kidney contains roughly a million nephrons that filter blood, reabsorb useful substances, secrete additional wastes, and concentrate urine. Disease processes that damage nephrons reduce the kidney's filtering capacity and underlie chronic kidney disease.

45. A — Reabsorption, in which useful substances move from the kidney tubule back into the surrounding bloodstream. After filtration in the glomerulus, the renal tubule reclaims most of the water, glucose, and amino acids that would otherwise be lost in urine. Glucose appearing in the urine in diabetes results from filtered glucose exceeding the tubule's reabsorption capacity.

46. B — Producing antibodies that recognize specific foreign pathogens and mark them for immune destruction. Antibodies are produced by plasma cells of the immune system, not by the skeleton itself. The skeletal system does support, protect, allow movement, and produce blood cells in the marrow, but antibody production is an immune function.

47. C — Smooth muscle, which is non-striated, mononucleate, and under involuntary autonomic nervous control. Smooth muscle lines hollow internal organs and the walls of blood vessels, contracting slowly and steadily to move materials such as food through the gut or to regulate vessel diameter. Its contractions are not consciously controlled.

48. D — A rapid change in electrical charge across the membrane, propagated by the movement of ions across the axon. Voltage-gated sodium channels open and let Na^+ rush in, briefly reversing the membrane's polarity; potassium channels then open to restore the resting potential. This wave of ion movement, not electrical current in the wire sense, is what travels along the axon.

49. B — The release of neurotransmitter chemicals that diffuse across the synaptic cleft and bind to receptors on the next neuron. Action potentials trigger voltage-gated calcium channels at the axon terminal, prompting vesicles to fuse with the membrane and release neurotransmitter into the cleft. This chemical step is what gives synapses their flexibility, including the ability to be modified by drugs and learning.

50. A — Reflex arc, in which a sensory signal triggers a motor response through the spinal cord without first reaching the brain. The signal travels from sensory neuron → interneuron in the spinal cord → motor neuron → muscle, with the brain being informed only after the response has already begun. This shortcut allows protective responses to occur quickly enough to limit tissue damage.