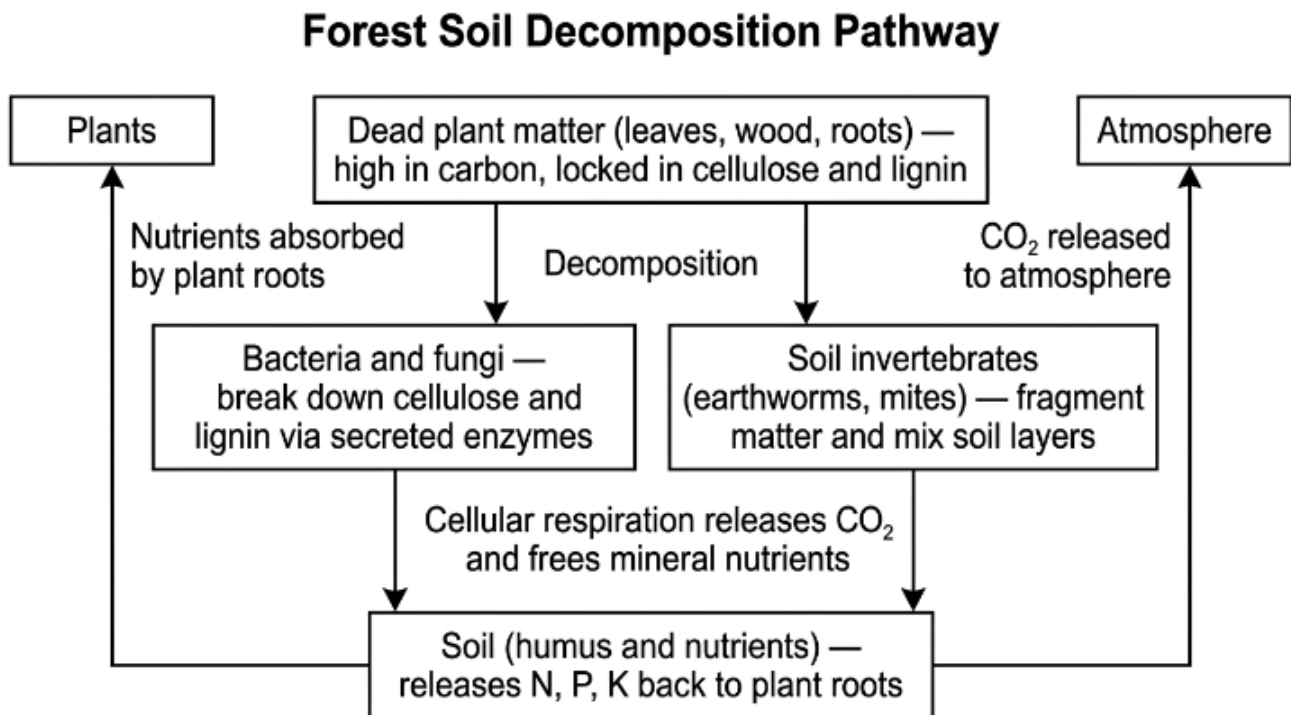


# PRACTICE EXAM 33: LIFE SCIENCE: BIOLOGY SIMULATION (50 QUESTIONS)

**Instructions:** This synthesis-level simulation exam mirrors the format of the New York State Regents Examination in Life Science: Biology and emphasizes cross-domain integration, process-ordering, multi-step quantitative reasoning, and inference from experimental data. Several items require synthesizing concepts across two or more biology domains within a single question. Read each stimulus carefully before answering. Select the one best answer for each question.

*Base your answers to questions 1 through 5 on the information below and on your knowledge of biology.*

A team of biologists is studying how dead plant matter is broken down in a forest soil ecosystem. They identify three groups of organisms working together: bacteria, fungi, and small soil invertebrates (such as earthworms and mites). Each group plays a distinct role in decomposing fallen leaves and returning nutrients to the soil. The diagram below shows the flow of carbon and nitrogen during decomposition.



1. The breakdown of cellulose and lignin by bacteria and fungi is best classified as which type of biological process?

- A. Photosynthesis, because it converts solar energy into chemical energy in the soil
- B. Active transport, because it moves nutrients against a concentration gradient in cells
- C. Translation, because it produces proteins from genetic instructions in the soil organisms
- D. Cellular respiration, because it releases CO<sub>2</sub> while extracting energy from organic compounds

2. The release of CO<sub>2</sub> by soil decomposers and the absorption of CO<sub>2</sub> by plants illustrates how two biological processes are linked. Which sequence best traces the carbon path?

- A. Decomposer respiration → atmospheric CO<sub>2</sub> → plant photosynthesis → plant biomass
- B. Plant photosynthesis → decomposer respiration → atmospheric CO<sub>2</sub> → plant biomass
- C. Atmospheric CO<sub>2</sub> → decomposer respiration → plant biomass → plant photosynthesis
- D. Plant biomass → atmospheric CO<sub>2</sub> → plant photosynthesis → decomposer respiration

3. If soil invertebrates were removed from this ecosystem, what would be the most likely consequence for decomposition?

- A. Decomposition would stop completely because invertebrates do the entire breakdown alone
- B. Decomposition would accelerate because bacteria and fungi would have more food available
- C. Decomposition would slow because invertebrates fragment matter, exposing it to microbes
- D. Decomposition rates would not change because invertebrates have no role in this process

4. The nitrogen released by decomposers and absorbed by plant roots is most likely incorporated into which type of plant molecule?

- A. Carbohydrates such as glucose and cellulose that store and support the plant
- B. Proteins and nucleic acids that require nitrogen atoms in their molecular structures
- C. Lipids and waxes that form waterproof coverings on leaves and stems of plants
- D. Water molecules that are used in photosynthesis as the source of electrons

5. A logging operation removes all dead wood from a forest floor. What cause-and-effect chain best predicts the long-term consequences?

- A. Less dead wood → more decomposers → more CO<sub>2</sub> release → ecosystem accelerates rapidly
- B. Less dead wood → more soil oxygen → faster photosynthesis → more plant growth occurs
- C. Less dead wood → fewer decomposers → less nutrient release → poorer plant growth
- D. Less dead wood → cooler soil temperatures → more decomposers active → faster cycling

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

Protein synthesis in eukaryotic cells involves a precisely ordered sequence of events that translates the information in a gene into a functional protein. The numbered list below shows six steps of this process, but they are listed in random order:

1. mRNA exits the nucleus through nuclear pores into the cytoplasm
2. Ribosomes assemble around the mRNA and begin translation
3. DNA double helix unwinds at the gene location to expose the template strand
4. tRNA molecules deliver amino acids to the ribosome in the order specified by codons
5. Amino acids are joined by peptide bonds into a growing polypeptide chain
6. RNA polymerase synthesizes mRNA using the DNA template strand

**6.** What is the correct chronological order of these six steps?

- A. 3, 6, 1, 2, 4, 5
- B. 6, 3, 1, 5, 2, 4
- C. 1, 2, 3, 4, 5, 6
- D. 3, 1, 6, 4, 2, 5

**7.** Steps 3 and 6 together describe which overall biological process?

- A. Translation, the second main step of protein production from mRNA input molecules
- B. Transcription, in which DNA serves as a template to produce mRNA molecules
- C. DNA replication, in which DNA is copied to produce daughter DNA strands
- D. Cellular respiration, in which energy is extracted from glucose molecules in cells

**8.** In step 4, the order in which tRNA molecules deliver amino acids is determined by:

- A. The sequence of codons on the mRNA, read three nucleotides at a time
- B. The order in which DNA bases originally appeared in the gene during replication
- C. The relative concentrations of each amino acid available in the cytoplasm overall
- D. The arrangement of ribosomal subunits during the assembly of the ribosome itself

**9.** If step 3 (DNA unwinding for this gene) failed, which of the subsequent steps for producing THIS specific protein would still be possible?

- A. Step 6 alone, because RNA polymerase can synthesize mRNA without unwinding DNA
- B. Steps 4 and 5, because translation can proceed using a previously made mRNA copy
- C. None of the steps would proceed, because all subsequent steps depend on step 3
- D. Steps 1, 2, 4, and 5, because they take place outside the nucleus completely

**10.** A mutation in the gene changes one DNA nucleotide in the template strand. At which step is this mutation FIRST translated into a change in the resulting protein?

- A. Step 1 — mRNA exits the nucleus carrying a different sequence from before
- B. Step 2 — ribosomes assemble around a slightly different mRNA molecule overall
- C. Step 4 — tRNA delivers a different amino acid at the affected codon position
- D. Step 5 — peptide bonds form between the same amino acids in the growing chain

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

In a particular plant population, flower color is determined by a single gene with two alleles. The allele for red (R) shows complete dominance over the allele for white (r). A botanist examines 1,000 plants from a wild population and records the following phenotypes: 840 red-flowered plants and 160 white-flowered plants. The botanist wants to estimate allele frequencies and genotype distributions in this population. Assume the population is in Hardy-Weinberg equilibrium.

**11.** What is the frequency of the recessive (r) allele in the population?

- A. 0.4 — the square root of 0.16, the frequency of homozygous recessive plants
- B. 0.16 — the same as the proportion of white-flowered plants in the population
- C. 0.84 — the same as the proportion of red-flowered plants in the population
- D. 0.6 — calculated from the proportion of red-flowered plants directly observed

**12.** What is the frequency of the dominant (R) allele in the population?

- A. 0.6 — calculated as 1 minus the frequency of the recessive allele
- B. 0.4 — calculated directly from the frequency of red-flowered plants
- C. 0.84 — calculated directly from the proportion of red-flowered plants observed
- D. 0.16 — calculated from the frequency of homozygous white-flowered plants observed

**13.** How many of the 1,000 plants are estimated to be heterozygous (Rr)?

- A. 360 plants — calculated as  $p^2 \times 1,000$  (homozygous dominant plants only)
- B. 160 plants — calculated as  $q^2 \times 1,000$  (homozygous recessive plants only)
- C. 600 plants — calculated as  $2pq + p^2 \times 1,000$  (heterozygous plus dominant)
- D. 480 plants — calculated as  $2pq \times 1,000$  with  $p = 0.6$  and  $q = 0.4$

**14.** How many of the 840 red-flowered plants are expected to be homozygous (RR)?

- A. 360 plants — calculated as  $p^2 \times 1,000$  with  $p = 0.6$  (so  $p^2 = 0.36$ )
- B. 480 plants — equal to the estimated number of heterozygous plants in population
- C. 840 plants — all red-flowered plants are homozygous dominant in this population
- D. 160 plants — equal to the number of homozygous recessive white-flowered plants

**15.** A wildfire destroys all white-flowered plants before they can reproduce. In the next generation, the new allele frequencies will most likely:

- A. Remain exactly the same because Hardy-Weinberg equilibrium is automatic and stable
- B. Both alleles will drop to zero because population size has decreased substantially overall

- C. Shift toward higher R frequency because rr plants no longer contribute alleles
- D. Shift toward higher r frequency because rare alleles are favored after disturbance

Base your answers to questions 16 through 20 on the information below and on your knowledge of biology.

Researchers test whether two compounds, X and Y, inhibit the enzyme amylase, which breaks down starch into sugar. The reaction rate is measured as  $\mu\text{mol}$  starch broken down per minute. The experiment includes a control (no inhibitor), tests with each inhibitor at varying substrate (starch) concentrations, and a tube where both inhibitors are added together.

Starch Concentration (mM)	Control Rate	+ Inhibitor X	+ Inhibitor Y	+ Both X and Y
1	8	4	7	3
5	25	12	24	11
10	38	19	36	18
20	50	25	48	24
50	60	30	58	29

16. Across all substrate concentrations, Inhibitor X reduces the reaction rate by approximately:

- A. 25% — quartering the reaction rate at every substrate concentration tested
- B. 50% — halving the reaction rate at every substrate concentration tested
- C. 75% — reducing the reaction rate to a quarter of the control value
- D. 100% — completely stopping the reaction at all conditions tested

17. Inhibitor Y has a much smaller effect than Inhibitor X. The most parsimonious explanation is:

- A. Inhibitor Y is identical in structure to Inhibitor X but in much more concentrated form
- B. Inhibitor Y is the same compound as the substrate starch and is consumed during reaction
- C. Inhibitor Y blocks the enzyme's active site completely at all concentrations tested
- D. Inhibitor Y binds amylase weakly and reduces the reaction rate only slightly

18. The data for "Both X and Y" show rates approximately equal to those with X alone. The best inference is:

- A. Y's effect cancels out X's effect when the two compounds are mixed together
- B. The two inhibitors must compete for the same binding site on amylase enzyme
- C. The total inhibitory effect equals the sum of each inhibitor's individual effect
- D. Inhibitor X's strong effect dominates and Y's weak effect adds very little

19. A student claims Inhibitor X must be a competitive inhibitor of amylase. Which observation from the data BEST contradicts this claim?

- A. The reaction rate increased with substrate concentration in all four tubes overall
- B. The reaction rate was higher in the control tube than in any tube with inhibitor
- C. The inhibition stayed at ~50% even at very high (50 mM) substrate concentrations
- D. The reaction rate doubled when substrate concentration was increased five-fold

**20.** The researchers want to determine whether Inhibitor X kills cells or just inhibits the enzyme. Which additional test would best answer this question?

- A. Add more substrate to the inhibitor X tube and measure reaction rate increases over time
- B. Add more enzyme to the inhibitor X tube and measure the rate of reaction
- C. Add inhibitor X to a different enzyme reaction and measure inhibition there as well
- D. Remove inhibitor X from cells exposed to it and test whether the enzyme recovers function

*Base your answers to questions 21 through 25 on the information below and on your knowledge of biology.*

Mitosis and meiosis are two different types of cell division. Mitosis produces two genetically identical daughter cells; meiosis produces four genetically distinct gametes with half the chromosome number. The list below shows seven events that occur during cell division. Each event applies to mitosis, meiosis, or both:

1. DNA replication during interphase
2. Homologous chromosomes pair and undergo crossing over
3. Sister chromatids separate at the centromere
4. Spindle fibers attach to centromeres
5. Two divisions occur in succession (Meiosis I and Meiosis II)
6. Chromosomes condense and become visible
7. Cell membrane pinches to form two daughter cells (cytokinesis)

**21.** Which events from the list occur in BOTH mitosis and meiosis?

- A. Only events 2 and 5, which both involve genetic recombination during meiosis
- B. Events 1, 3, 4, 6, and 7, which involve general division mechanisms
- C. Only event 1, which is required for any type of cell division process
- D. All seven events, since mitosis and meiosis are nearly identical processes

**22.** Which event uniquely identifies a process as meiosis?

- A. Event 1 — DNA replication during interphase before division begins
- B. Event 2 — Homologous chromosomes pair and undergo crossing over
- C. Event 3 — Sister chromatids separate at the centromere during anaphase
- D. Event 6 — Chromosomes condense and become visible during prophase

23. In what order do events 1, 2, 5, and 7 occur during meiosis?

- A. 5, 1, 2, 7 — divisions occur first, followed by replication and pairing
- B. 1, 5, 2, 7 — replication, both divisions complete, then pairing and cytokinesis
- C. 7, 2, 1, 5 — cytokinesis happens before any chromosome action occurs
- D. 1, 2, 5, 7 — replication, then pairing, then two divisions, then cytokinesis

24. If event 3 (sister chromatid separation) failed during Meiosis II, what would be the most likely outcome?

- A. The cell would produce four normal gametes with the correct chromosome number
- B. The cell would produce gametes with abnormal chromosome numbers (nondisjunction)
- C. The cell would produce eight gametes instead of the expected four gametes
- D. The cell would skip Meiosis II entirely and proceed directly to cytokinesis

25. A diploid cell with  $2n = 8$  chromosomes enters meiosis. How many chromosomes will each of the four resulting gametes contain?

- A. 4 chromosomes — half of the diploid number, since meiosis halves the chromosome count
- B. 8 chromosomes — the same as the original diploid number maintained throughout meiosis
- C. 16 chromosomes — twice the original number, since DNA was replicated once before
- D. 2 chromosomes — one quarter of the diploid number due to two rounds of division

*Base your answers to questions 26 through 30 on the information below and on your knowledge of biology.*

An ancestral population of small lizards once lived on a single large island. Over millions of years, the island fractured into four smaller islands separated by deep water channels. Each of the four small islands developed distinct environmental conditions. Today, researchers identify four distinct lizard species, one on each island, with the characteristics shown below.

Species	Island	Body Color	Limb Length	Primary Food
Lizard 1	Forest	Dark brown	Medium	Insects on tree bark
Lizard 2	Grassland	Tan with stripes	Long	Grasshoppers in open ground
Lizard 3	Cliffs	Mottled gray	Short with strong toes	Insects in rock crevices
Lizard 4	Wetlands	Dark with sheen	Long with webbed feet	Insects in shallow water

26. The four species evolved from one ancestral population. This is an example of:

- A. Adaptive radiation, in which one ancestral lineage diversifies into multiple specialized species
- B. Convergent evolution, in which unrelated species evolve to look the same over time
- C. Coevolution, in which two species evolve in response to each other across generations
- D. Artificial selection, in which humans deliberately choose which traits will be passed on

**27.** Why has each species developed traits specific to its island?

- A. The ancestral population already possessed these distinct trait combinations naturally
- B. Natural selection on each island favored the traits matching the local environment
- C. The four populations migrate between islands and exchange traits over time across them
- D. Random genetic drift on each island produced these trait differences independently somehow

**28.** Lizard 4's webbed feet and Lizard 3's strong gripping toes evolved separately on different islands but both serve to help the lizards move through their environments. This is an example of:

- A. Parallel adaptation — different traits arose to solve different problems in different environments
- B. Convergent evolution — unrelated species evolved identical traits independently of each other
- C. Vestigial structures — traits that have lost their original function over generations of evolution
- D. Sexual selection — traits that arose because they attract mates rather than aid survival

**29.** Two lizards from different islands are brought together. They attempt to mate but produce no offspring. Which conclusion is best supported?

- A. The two populations are still members of the same biological species overall
- B. The two populations have diverged in body color but not in any other traits
- C. Reproductive isolation has occurred, marking the formation of distinct species
- D. The two populations would interbreed successfully if they shared a common island

**30.** If Islands 1 and 2 became reconnected by a land bridge, the future of the two lizard species would most likely involve:

- A. Immediate fusion of the two species into a single ancestral lizard population
- B. Continued separation if reproductive isolation is already complete between them
- C. Rapid evolution of both species into completely new forms unrelated to either ancestor
- D. The disappearance of the lizards because reconnection always causes extinction

*Base your answers to questions 31 through 35 on the information below and on your knowledge of biology.*

A grassland ecosystem is studied for its energy flow. Producers (grasses) capture 10,000 kJ of solar energy per square meter per year through photosynthesis. The energy transfer efficiency between trophic levels is approximately 10%. The ecosystem contains: producers (grasses), primary consumers (grasshoppers and small mammals), secondary consumers (snakes and small birds of prey), and tertiary consumers (hawks and large owls).

**31.** What is the approximate energy available at the primary consumer level?

- A. 10 kJ/m<sup>2</sup>/year — calculated as 0.1% of the energy fixed by the producers
- B. 100 kJ/m<sup>2</sup>/year — calculated as 1% of the energy fixed by the producers
- C. 1,000 kJ/m<sup>2</sup>/year — calculated as 10% of the energy fixed by the producers
- D. 10,000 kJ/m<sup>2</sup>/year — equal to the energy fixed by the producers initially captured

**32.** What is the approximate energy available at the tertiary consumer level?

- A. 100 kJ/m<sup>2</sup>/year — equal to one percent of the producer energy initially captured
- B. 1,000 kJ/m<sup>2</sup>/year — equal to ten percent of the producer energy fixed initially
- C. 10 kJ/m<sup>2</sup>/year — calculated as 10% of 10% of 10% of producer energy
- D. 1 kJ/m<sup>2</sup>/year — calculated as 0.01% of the original producer energy captured

**33.** A new top predator (a mountain cat) appears in this ecosystem and feeds exclusively on tertiary consumers. How much energy per square meter per year would be available to support this new predator?

- A. 1 kJ/m<sup>2</sup>/year — calculated as 10% of the energy available to tertiary consumers
- B. 10 kJ/m<sup>2</sup>/year — equal to the energy available at the tertiary consumer level
- C. 100 kJ/m<sup>2</sup>/year — calculated as 100% of the tertiary consumer energy directly available
- D. 1,000 kJ/m<sup>2</sup>/year — equal to the energy available at the primary consumer level

**34.** The 1 kJ/m<sup>2</sup>/year energy budget for the mountain cat suggests:

- A. The mountain cat population can grow to large sizes in this ecosystem easily
- B. The mountain cat will outcompete and replace the hawks as the dominant predator
- C. The mountain cat population will increase faster than any other predator population
- D. The mountain cat population must be very small or absent due to limited energy

**35.** Why are there typically fewer trophic levels in any ecosystem than there are organisms at each level?

- A. Energy is gained at each step, so higher levels accumulate more energy over time
- B. ~90% of energy is lost at each transfer, leaving too little to support higher levels
- C. Higher trophic level organisms reproduce too slowly to maintain large populations
- D. Predators at higher levels live longer than prey, reducing reproductive output

*Base your answers to questions 36 through 40 on the information below and on your knowledge of biology.*

Researchers conduct a long-term study of a deciduous forest in the northeastern United States from 1985 to 2025. They record three variables annually: the date of leaf emergence in spring (in days from January 1), the average summer temperature in °C, and the timing of caterpillar emergence in spring (in days from January 1). Caterpillars are an important food source for migratory songbirds that arrive each spring on a relatively fixed calendar schedule.

Year	Leaf Emergence (day)	Summer Temp (°C)	Caterpillar Emergence (day)
1985	116	21.0	124
1995	112	21.4	119
2005	108	21.9	114
2015	104	22.3	110
2025	101	22.8	106

- 36.** Between 1985 and 2025, both leaf emergence and caterpillar emergence shifted by approximately:
- Earlier by about 5 days, a relatively minor change overall in seasonal timing
  - Earlier by about 15 to 18 days, a substantial change in seasonal timing
  - Later by about 5 to 10 days, a small but measurable change in seasonal timing
  - Later by about 15 to 18 days, a substantial change in seasonal timing overall
- 37.** The most likely cause of the shift in leaf and caterpillar emergence dates is:
- Birds arriving earlier each year and triggering plant and insect responses to their presence
  - Increasing precipitation each year as more rainfall stimulates plants and insects equally
  - Rising average temperatures as warmer springs trigger earlier emergence in both organisms
  - Changes in soil chemistry that affect both plant and insect emergence at the same rate
- 38.** Migratory songbirds time their spring arrival to take advantage of peak caterpillar abundance to feed their chicks. As caterpillars emerge earlier, what is the most likely consequence for the birds?
- The birds will quickly adapt their migration timing to the new caterpillar schedule
  - The birds will switch to other food sources and not be affected by these changes
  - The birds may experience reduced reproductive success if their arrival now mismatches peak
  - The birds will increase migration speed to arrive at the same calendar date as before
- 39.** Which observation from the data would BEST support the conclusion that temperature is driving the timing shifts?
- Leaf and caterpillar emergence dates closely track each other across the 40 years
  - Leaf emergence dates change but caterpillar emergence dates remain constant over time
  - Leaf and caterpillar emergence dates change in opposite directions during the study
  - Leaf and caterpillar emergence dates vary randomly with no clear pattern over time
- 40.** Which inference does the data most strongly support?
- The forest ecosystem is fundamentally unchanged from its condition in 1985 generally
  - Birds will quickly adapt to new conditions without any reproductive consequences ever
  - Climate change is reshaping species interactions with cascading effects on the food web
  - The data show no relationship between summer temperatures and biological events at all

Base your answers to questions 41 through 45 on the information below and on your knowledge of biology.

Two regions are being compared for their impact on the nitrogen cycle. Region A is an intensive agricultural area where farmers apply 200 kg of nitrogen fertilizer per hectare per year. Region B is a protected forest preserve with no fertilizer application. Both regions receive equal rainfall and natural nitrogen deposition from the atmosphere. Researchers measure nitrate levels in water leaving each watershed: Region A water shows 15 mg/L nitrate; Region B water shows 0.4 mg/L nitrate. The EPA limit for safe drinking water is 10 mg/L nitrate.

- 41.** The substantially higher nitrate level in Region A water is most directly caused by:
- A. Forest in Region B actively destroying nitrate molecules through unique biological processes
  - B. Heavy precipitation in Region A converting atmospheric nitrogen into nitrate compounds
  - C. Region B has more livestock and they consume more nitrogen than the soil produces
  - D. Fertilizer application adding far more nitrogen than crops can absorb, causing runoff
- 42.** Region A's water exceeds the EPA limit of 10 mg/L. Which sequence best describes the downstream consequences?
- A. Excess nitrate → cleaner drinking water → improved aquatic ecosystems → healthier communities
  - B. Excess nitrate → reduced plant growth → less photosynthesis → lower CO<sub>2</sub> absorption rates
  - C. Excess nitrate → smaller plant root systems → soil erosion → soil quality declines further
  - D. Excess nitrate → algae bloom downstream → oxygen depletion → fish kills and dead zones
- 43.** Which intervention would most effectively reduce nitrate runoff while preserving agricultural productivity in Region A?
- A. Increase the amount of nitrogen fertilizer applied to maximize crop yields per hectare
  - B. Apply fertilizer only at times and amounts matching crop nitrogen uptake (precision farming)
  - C. Remove all vegetation from the area to prevent any further nitrogen cycling activity
  - D. Replace agricultural crops with non-native species that require no nitrogen at all
- 44.** If Region A were converted to a forest similar to Region B, what would happen to nitrogen cycling?
- A. Nitrate runoff would remain at 15 mg/L because the change would have no effect at all
  - B. Nitrate runoff would increase dramatically because forests release more nitrogen than crops
  - C. Nitrate runoff would decrease because forests retain and recycle nitrogen far more efficiently
  - D. Nitrate runoff would oscillate randomly with no predictable pattern over the years to come
- 45.** The comparison between Regions A and B best illustrates which principle of ecology?
- A. Predator-prey cycles drive the dynamics of all ecosystems regardless of conditions
  - B. Photosynthesis is the only biological process that affects nitrogen cycling locally everywhere

- C. Producer biomass is identical in all ecosystems across the globe regardless of how managed
- D. Human activities can profoundly alter biogeochemical cycles compared to natural systems

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

A city is planning to convert a 50-acre abandoned industrial site into a public greenspace. Three design teams have proposed different approaches. Team 1: Traditional park with mowed lawn, planted ornamental trees, and concrete pathways. Team 2: Restored native ecosystem with native plants only, no mowing, walking trails of natural mulch. Team 3: Mixed-use design — half traditional park (gathering spaces, sports fields) and half native ecosystem restoration. The city wants the greenspace to deliver multiple benefits: public recreation, biodiversity habitat, stormwater management, and educational value.

**46.** Which combination of design criteria did the city specify?

- A. Cost reduction, biodiversity habitat, and quick completion within the first year only
- B. Public recreation only, with biodiversity and stormwater serving as secondary considerations
- C. Stormwater management and biodiversity, with recreation excluded from the design criteria
- D. Recreation, biodiversity habitat, stormwater management, and educational value all together

**47.** Which design would most likely BEST satisfy ALL four criteria simultaneously?

- A. Team 1's traditional park, because well-mowed lawns provide the most flexible recreation
- B. Team 3's mixed-use design, because it includes elements that address each criterion in part
- C. Team 2's restored ecosystem, because native plants are the most economical option overall
- D. Any of the three would equally satisfy all four criteria with no important differences

**48.** Compared to Team 1's design, Team 2's native ecosystem would likely provide BETTER:

- A. Open spaces for organized sports activities and other team-based recreation events
- B. Aesthetic uniformity that visitors are accustomed to seeing in traditional parks
- C. Hard-surface pathways suitable for jogging, biking, and wheelchair access generally
- D. Stormwater absorption due to deep native plant roots holding the soil structure

**49.** One concern with Team 2's design is that some neighbors may prefer the appearance of a traditional manicured park. Which approach would BEST address this concern?

- A. Signage explaining the ecological value of native plants and what visitors are seeing
- B. Replacing all native plants with mowed lawn to match traditional neighborhood expectations
- C. Building a fence around the native ecosystem to hide it from view of the neighbors
- D. Removing the native ecosystem and converting it entirely to paved parking instead

**50.** The city wants to measure whether the new greenspace successfully delivers its intended benefits. Which combination of measurements would BEST evaluate success?

- A. Visitor counts, species inventories, stormwater retention data, and educational program attendance
- B. Cost per acre to maintain the greenspace, calculated annually after the project is complete
- C. Number of complaint letters received from neighbors during the first year of operation
- D. Distance from the greenspace to other parks in the city across the metropolitan area

## Practice Exam 33: Full Answer Key with Explanations

**1. D** — Decomposer bacteria and fungi secrete digestive enzymes that break down cellulose and lignin and then absorb the resulting sugars, oxidizing them through cellular respiration to extract energy. The byproducts are CO<sub>2</sub> released to the atmosphere and energy captured as ATP. This is the same fundamental process by which all heterotrophs obtain energy.

**2. A** — Decomposers respire dead organic matter, releasing CO<sub>2</sub> to the atmosphere. Plants then capture that atmospheric CO<sub>2</sub> during photosynthesis and incorporate the carbon into their biomass as sugars, cellulose, and other organic compounds. This cycling between respiration and photosynthesis is the backbone of the terrestrial carbon cycle.

**3. C** — Soil invertebrates do not break down cellulose themselves, but they fragment large pieces of dead matter into smaller pieces and mix them through the soil profile. This dramatically increases the surface area accessible to bacteria and fungi and the contact between substrate and microbes. Without invertebrates, microbial decomposition slows substantially.

**4. B** — Nitrogen is a key element of amino acids (proteins) and nucleotide bases (DNA and RNA). When plants absorb nitrate ions from soil, the nitrogen is incorporated into newly synthesized proteins and nucleic acids essential for growth and reproduction. Carbohydrates and lipids contain mostly carbon, hydrogen, and oxygen but no nitrogen.

**5. C** — Dead wood is a primary food source for the decomposer community. Removing it starves the bacteria and fungi that recycle nutrients from organic matter back into the soil. With slower decomposition comes slower nutrient release, which in turn reduces the supply of nitrogen, phosphorus, and potassium available to plants.

**6. A** — Protein synthesis begins inside the nucleus with DNA unwinding (step 3), followed by RNA polymerase synthesizing mRNA from the template strand (step 6). The mRNA then exits the nucleus through nuclear pores (step 1), ribosomes assemble around it in the cytoplasm (step 2), tRNAs deliver amino acids (step 4), and peptide bonds join those amino acids into a polypeptide chain (step 5).

**7. B** — Transcription is the process in which DNA serves as a template to produce mRNA. Step 3 (DNA unwinding to expose the template strand) and step 6 (RNA polymerase synthesizing mRNA from that template) together constitute the full transcription step of protein synthesis. Translation comes afterward when the mRNA is decoded into protein.

**8. A** — During translation, ribosomes move along the mRNA reading three nucleotides (one codon) at a time. Each codon specifies which tRNA, carrying which amino acid, can bind to the ribosome at that step. The codon sequence on the mRNA therefore directly determines the amino acid order in the resulting protein.

**9. C** — Step 3 (DNA unwinding) is the first event in the transcription-translation pipeline for any particular gene. Without unwinding, RNA polymerase cannot access the template strand to produce mRNA, so steps 6, 1, 2, 4, and 5 for that gene all fail in turn. The pipeline is sequential and dependent at each step.

**10. C** — A DNA template-strand change passes through transcription as an altered mRNA codon and then through translation, where it first manifests in protein sequence when tRNA delivers a different amino acid at the affected codon position (step 4). Steps 1 and 2 simply transport the altered mRNA without changing the protein; step 5 is just the bonding of whichever amino acid arrived. The protein sequence first differs at step 4.

**11. A** — Under Hardy-Weinberg, the frequency of homozygous recessive ( $rr$ ) plants equals  $q^2$ , where  $q$  is the recessive allele frequency. Here  $q^2 = 160/1,000 = 0.16$ , so  $q = \sqrt{0.16} = 0.4$ . The square root step is essential — taking  $q = 0.16$  directly is a common but incorrect shortcut.

**12. A** — Under Hardy-Weinberg, the two allele frequencies sum to 1 ( $p + q = 1$ ). Since  $q = 0.4$ , we calculate  $p = 1 - 0.4 = 0.6$ . The phenotype frequencies (0.84 red and 0.16 white) cannot be used directly as allele frequencies because the dominant phenotype includes both homozygous and heterozygous genotypes.

**13. D** — The frequency of heterozygotes under Hardy-Weinberg is  $2pq$ . Plugging in  $p = 0.6$  and  $q = 0.4$ :  $2(0.6)(0.4) = 0.48$ , so  $0.48 \times 1,000 = 480$  heterozygous plants. Heterozygotes are typically the largest single genotype class in populations with intermediate allele frequencies.

**14. A** — Homozygous dominant ( $RR$ ) plants make up  $p^2$  of the population. With  $p = 0.6$ :  $p^2 = 0.36$ , so  $0.36 \times 1,000 = 360$   $RR$  plants. Verify:  $360$   $RR$  +  $480$   $Rr$  +  $160$   $rr = 1,000$  total, and red plants =  $RR$  +  $Rr = 360 + 480 = 840$  — matching the observed phenotype count.

**15. C** — Killing all  $rr$  plants removes the only individuals that produce  $r$ -only gametes. The remaining population (mostly  $RR$  and  $Rr$ ) still produces some  $r$  alleles but at a reduced overall frequency. In the next generation,  $q$  will be smaller and  $p$  larger, with the population evolving away from the recessive allele.

**16. B** — Comparing column-by-column:  $4/8 = 0.50$ ,  $12/25 \approx 0.48$ ,  $19/38 = 0.50$ ,  $25/50 = 0.50$ ,  $30/60 = 0.50$ . The reaction rate with Inhibitor X is consistently about half of the control rate at every substrate concentration. This pattern of constant fractional inhibition is characteristic of non-competitive inhibition.

**17. D** — Comparing Y-treated to control:  $7/8$ ,  $24/25$ ,  $36/38$ ,  $48/50$ ,  $58/60$  — all roughly 95–97% of control values. Inhibitor Y reduces the reaction rate only slightly, consistent with weak binding to the enzyme that allows most catalytic activity to continue. The contrast with X's 50% inhibition demonstrates very different binding strengths.

**18. D** — The "Both" column values (3, 11, 18, 24, 29) are very close to the X-alone column values (4, 12, 19, 25, 30), only slightly lower. Adding Y to X produces only a marginal additional decrease in rate because Y's effect is small to begin with. Inhibitor X's strong effect therefore dominates, with Y making only a small added contribution.

**19. C** — A competitive inhibitor competes with substrate for the active site, so increasing substrate concentration can overcome the inhibition (the rate approaches the uninhibited rate at high substrate). Here the inhibition stays at ~50% even at 50 mM substrate — substrate cannot outcompete the inhibitor — which is the signature of non-competitive inhibition, not competitive inhibition.

**20. D** — A reversible enzyme inhibitor only blocks the enzyme while present. Removing the inhibitor and observing recovery of enzyme activity confirms reversible inhibition rather than cell death, which would be permanent and would not recover upon inhibitor removal. This wash-out test is a standard way to distinguish inhibition from toxicity.

**21. B** — Mitosis and meiosis share the basic machinery: both require DNA replication (1), both attach spindle fibers to chromosomes (4), both condense chromosomes (6), both separate sister chromatids in one of their divisions (3), and both end with cytokinesis (7). The unique features of meiosis are homologous pairing with crossing over (2) and the second division (5).

**22. B** — Homologous chromosomes pair (form bivalents) and undergo crossing over only during prophase I of meiosis. This event does not occur in mitosis at all, so observing it identifies the process as meiosis. DNA replication, chromatid separation, spindle assembly, and chromosome condensation all occur in both types of division.

**23. D** — During meiosis the sequence runs: DNA replication during interphase (1), homologous pairing and crossing over during prophase I (2), the two successive divisions of Meiosis I and II (5), and cytokinesis after each division (7). The two divisions follow replication and pairing because they separate the chromosomes that were prepared during earlier stages.

**24. B** — Sister chromatid separation in Meiosis II is the equivalent of anaphase in mitosis. If chromatids fail to separate properly (nondisjunction), the resulting gametes end up with one or three copies of the affected chromosome instead of the usual one. This nondisjunction is the cause of trisomies such as Down syndrome (trisomy 21).

**25. A** — Meiosis halves the chromosome number: a  $2n = 8$  diploid cell produces  $n = 4$  haploid gametes. The first division separates homologous pairs (reducing from  $2n$  to  $n$ ), and the second division separates sister chromatids without changing the chromosome count. Each of the four gametes therefore contains 4 chromosomes.

**26. A** — Adaptive radiation occurs when a single ancestral lineage diversifies rapidly into multiple species occupying different ecological niches. The four lizard species occupying four distinct island habitats and feeding on different prey types fits this pattern exactly. Darwin's Galápagos finches are the classic textbook example.

**27. B** — Each island presented different selective pressures: forest cover favored dark camouflage and tree-climbing limbs; grasslands favored striped tan color and long running limbs; cliffs favored mottled gray color and gripping toes; wetlands favored sheen and webbed feet. Natural selection on heritable variation produced these locally adaptive traits over generations.

**28. A** — Lizards 3 and 4 evolved different limb traits (gripping toes vs. webbed feet) in response to different problems (climbing rocks vs. moving through water) on different islands. This is parallel adaptation — divergent traits solving divergent problems. Convergent evolution would be the reverse pattern: similar traits evolving in unrelated lineages facing the same problem.

**29. C** — When two populations can no longer interbreed and produce fertile offspring, they have crossed the threshold of reproductive isolation, the defining criterion of the biological species concept. The fact that mating attempts produce no offspring is the diagnostic evidence that speciation has occurred. The four island lizards are therefore considered distinct species.

**30. B** — Reproductive isolation, once complete, is generally irreversible — the populations have accumulated enough genetic differences that interbreeding no longer produces viable, fertile offspring even when the populations are physically reunited. Land bridges that reconnect formerly separated populations do not necessarily reverse speciation. The two species will continue to evolve independently.

**31. C** — Energy transfer between trophic levels is about 10% efficient. Producers capture 10,000 kJ/m<sup>2</sup>/year, so primary consumers receive about  $10,000 \times 0.10 = 1,000$  kJ/m<sup>2</sup>/year. The remaining 90% is lost as metabolic heat or used by the producers themselves.

**32. C** — Each transfer between levels is about 10% efficient, so by the third transfer the cumulative efficiency is  $0.10 \times 0.10 \times 0.10 = 0.001$ . From the original 10,000 kJ/m<sup>2</sup>/year of producer energy, tertiary consumers receive  $10,000 \times 0.001 = 10$  kJ/m<sup>2</sup>/year. This drastic reduction across just three steps illustrates why high trophic levels can support so few organisms.

**33. A** — Adding a fourth consumer level means another 10% transfer:  $10 \text{ kJ} \times 0.10 = 1$  kJ/m<sup>2</sup>/year available for the mountain cat. Each successive transfer multiplies by 0.10, so each level above producers shrinks the energy budget by an order of magnitude. The mountain cat represents the fourth trophic transfer in this calculation.

**34. D** — With only 1 kJ/m<sup>2</sup>/year of energy available, an apex predator cannot maintain a large or even moderate population. Ecosystems rarely support more than four trophic levels because the energy budget at the top is too thin to support a sustainable population of high-energy-demanding predators. The mountain cat would likely be sparse, transient, or absent.

**35. B** — Each trophic transfer loses about 90% of available energy as metabolic heat or as energy used by the organisms themselves for life processes. After three or four transfers, the remaining energy is simply too small to sustain another level of predators. This thermodynamic constraint limits ecosystems to typically 4–5 trophic levels.

**36. B** — Leaf emergence shifted from day 116 to day 101 (15 days earlier), and caterpillar emergence shifted from day 124 to day 106 (18 days earlier). Both shifts are substantial, especially considering that

the climate has only warmed by about 1.8°C over the same period. Such shifts of more than two weeks fundamentally alter spring biological timing.

**37. C** — Summer temperatures rose from 21.0°C in 1985 to 22.8°C in 2025 — a 1.8°C increase. Warmer spring temperatures advance the breaking of plant dormancy (earlier leaf emergence) and accelerate insect development (earlier caterpillar emergence). The temperature trend tracks the timing shifts closely, supporting temperature as the proximate driver.

**38. C** — Songbirds time their breeding to coincide with peak caterpillar abundance because caterpillars are the high-protein food they feed to nestlings. If caterpillars peak weeks earlier but birds arrive on their usual calendar schedule, they miss the food peak — a phenomenon called phenological mismatch. The result is reduced food for nestlings, lower chick survival, and reduced reproductive success.

**39. A** — If both species emerge earlier in parallel and both shifts coincide with the temperature trend, the simplest explanation is that temperature is a shared driver acting on both species. Independent or divergent timing shifts would not support a single environmental driver. The close tracking across all five data points is strong evidence that temperature controls both.

**40. C** — The data show that warming temperatures shift the timing of plant and insect events in parallel, while the birds that depend on these timings cannot adjust as quickly. This is a clear case of climate change altering species interactions and creating cascading effects through the food web. The data demonstrate that climate change is not merely a physical phenomenon but a biological one.

**41. D** — Crops cannot absorb nitrogen as fast as farmers apply it at 200 kg per hectare per year. The excess nitrate dissolves in water and runs off into nearby streams and groundwater, raising nitrate concentrations far above natural background levels. Region B has no such fertilizer input, which explains its much lower nitrate levels in its outflow water.

**42. D** — High nitrate concentrations in surface water cause excessive growth of algae (algal bloom). When these algae die, decomposer bacteria consume the dissolved oxygen as they break down the dead biomass. The resulting oxygen depletion suffocates fish and other aquatic life, creating "dead zones" — a well-documented consequence of agricultural nitrogen pollution.

**43. B** — Precision farming matches the timing and quantity of fertilizer application to crop nitrogen uptake needs, minimizing the excess that runs off into water systems. Both productivity and water quality benefit because crops still get adequate nitrogen while environmental losses are reduced. The other options either increase pollution or eliminate productivity.

**44. C** — Forest ecosystems retain and recycle nitrogen far more efficiently than annual cropland because deep tree roots intercept nitrate before it leaches, mycorrhizal fungi facilitate nutrient capture, and the leaf litter cycle keeps nitrogen circulating within the system. Without fertilizer additions and with efficient internal cycling, nitrate runoff drops dramatically — as evidenced by Region B's 0.4 mg/L level.

**45. D** — Region A (intensive agriculture) shows nitrate levels 37 times higher than Region B (protected forest) under the same rainfall and natural deposition conditions. The only difference is human

management. This demonstrates that human activities can profoundly alter biogeochemical cycles like the nitrogen cycle compared to natural systems — a principle central to modern environmental science.

**46. D** — The city specified four distinct goals: public recreation, biodiversity habitat, stormwater management, and educational value. All four are listed as design criteria the greenspace must satisfy. The other answer options omit one or more of the stated criteria or invent criteria the city did not specify.

**47. B** — Team 3's mixed-use design dedicates half the site to traditional park amenities (recreation and gathering) and half to native ecosystem restoration (biodiversity, stormwater absorption, and educational opportunity). This balanced approach addresses all four criteria simultaneously. Pure-recreation (Team 1) shortchanges biodiversity; pure-ecosystem (Team 2) shortchanges flexible recreation.

**48. D** — Native plant communities feature deep, complex root systems that hold soil, absorb large volumes of water, and slow runoff. Traditional mowed turfgrass has shallow roots and provides minimal stormwater retention. The difference can be significant: native plantings often absorb several times more rainfall per acre than turfgrass landscapes.

**49. A** — Educational signage explaining the ecological value of native plants helps visitors understand and appreciate what they are seeing, transforming an unfamiliar landscape into a meaningful environmental experience. This addresses the aesthetic concern without sacrificing the ecological design. The other options abandon the conservation goals entirely.

**50. A** — Each of the four criteria has a direct measurement: visitor counts measure recreation, species inventories measure biodiversity, stormwater retention data measure water management, and educational program attendance measures educational impact. This combination directly tests whether the project achieved its stated goals. Single-metric evaluations would miss most of the project's value.