PRACTICE EXAM 31: LIFE SCIENCE: BIOLOGY SIMULATION (50 QUESTIONS)

Instructions: This simulation exam mirrors the format of the New York State Regents Examination in Life Science: Biology and emphasizes experimental design evaluation, quantitative reasoning, and the assessment of competing hypotheses. Several items use Roman-numeral combinations (I, II, III) where you must judge which statements are supported. Read each stimulus completely before answering any questions in the set. 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.

Researchers studied osmoregulation in a saltwater bass species. Each fish was placed individually in a tank with controlled water salinity. The researchers measured urine production rate (mL per hour) and the activity of sodium ion pumps in the gill cells (a measure of active ion transport). Five separate experimental tanks were used, each with a different salinity concentration. The same fish was used across all five tanks, with one rest day between salinity exposures. Temperature, lighting, dissolved oxygen, and feeding schedule were held constant across all conditions.

Salinity (% NaCl)	Urine Production (mL/hr)	Gill Ion Pump Activity (units)
0% (freshwater)	14	9 (pumping Na^+ INTO body)
1%	8	5 (pumping Na^+ INTO body)
2%	3	2 (near equilibrium)
3.5% (seawater)	2	7 (pumping Na^+ OUT of body)
5% (hypersaline)	1	14 (pumping Na^+ OUT of body)

1. At 3.5% NaCl (typical seawater), the gill ion pumps move sodium OUT of the fish's body. Which biological process most directly necessitates this active pumping?

A. Sodium ions diffuse OUT of the body into the surrounding water at this salinity
B. The water surrounding the fish contains less sodium than the fish's body fluids do
C. Sodium ions diffuse INTO the body from the higher-sodium surrounding water
D. The fish needs to absorb more sodium to maintain ion concentrations inside cells

2. The experimental design lacks which key control element?

A. A baseline group of fish kept at unchanging salinity for no-treatment comparison
B. Identical tank dimensions across the five salinity treatments to standardize space
C. Daily verification that dissolved oxygen levels remained constant across the tanks
D. Adjustments to feeding schedule to compensate for salinity-driven appetite changes

3. A researcher hypothesizes that the gill ion pumps reverse direction (from pumping IN to pumping OUT) at the salinity where internal and external sodium concentrations become equal. Which observation from the table best supports this hypothesis?

A. The ion pump activity is highest at the lowest and highest salinity values tested
B. At 2% NaCl, pump activity is at its minimum near a near-equilibrium condition
C. Urine production decreases as salinity increases across all five conditions tested
D. The fish produces concentrated urine only when placed in salty environments overall

4. The decreasing urine production as salinity increases is best explained by the need to:

A. Excrete more sodium that is being pumped out of the gill cells
B. Filter ammonia and other nitrogen waste more efficiently from blood
C. Eliminate water that the fish drinks while in saltwater environments
D. Conserve body water that is lost by osmosis to the saltier surroundings

5. If a second experiment used a freshwater fish placed in saltwater (3.5%), which combination of observations would you most likely make?

I. The fish's body would gain water by osmosis
II. The fish's gill cells would need to pump sodium OUT
III. Urine production would increase compared to freshwater conditions

A. II only
B. I and III only
C. I, II, and III
D. III only

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

A class measured the rate of the enzyme lactase breaking down lactose at varying substrate concentrations and at two different enzyme concentrations. The reaction rate is reported as µmol of lactose broken down per minute. All trials were conducted at pH 7 and 37°C. The data are shown in the table below.

Substrate (Lactose) Concentration (mM)	Rate at 1× Enzyme (µmol/min)	Rate at 2× Enzyme (µmol/min)
0.5	6	12

1.0	10	20
2.0	16	32
4.0	22	44
8.0	25	50
16.0	25	50

6. At which substrate concentration does the 1× enzyme reach saturation?

A. 0.5 mM, where the rate is already at its lowest measurable value
B. 2.0 mM, where the rate first exceeds half of the eventual maximum
C. 8.0 mM, where the rate first reaches the maximum value of 25 μmol/min
D. 16.0 mM, where the rate has been doubled by the additional substrate

7. Doubling the enzyme concentration approximately doubled the reaction rate at every substrate concentration tested. The best explanation is that:

A. More enzyme molecules means more active sites available to act on substrate per unit time
B. Doubling enzyme concentration speeds the breakdown of each individual enzyme molecule
C. The added enzyme molecules increase the rate of substrate diffusion in the solution
D. Each enzyme molecule catalyzes more reactions per second when more enzyme is present

8. Which prediction best fits the saturation pattern shown for the 2× enzyme?

A. The 2× enzyme will reach saturation at approximately 4.0 mM substrate, half the 1× saturation point
B. The 2× enzyme will fail to reach saturation at any concentration tested in this experiment
C. The 2× enzyme will saturate at exactly the same substrate concentration as the 1× enzyme
D. The 2× enzyme will reach saturation at approximately 8.0 mM substrate, similar to the 1× enzyme

9. Suppose the experiment were repeated at pH 4 instead of pH 7. Which result is most consistent with what we know about lactase?

A. Reaction rate would increase substantially because acidic conditions accelerate enzymes
B. Reaction rate would remain identical because pH does not affect lactase activity
C. Reaction rate would decrease because pH 4 is below lactase's optimum range
D. Reaction rate would oscillate randomly because pH disrupts the reaction pathway

10. The researchers want to demonstrate that lactase is functioning as a catalyst rather than as a reactant. Which additional measurement would best support that conclusion?

A. Measure the temperature change of the solution during the reaction process
B. Measure the concentration of glucose and galactose at the end of the reaction
C. Measure the lactase concentration before and after the reaction is complete
D. Measure the rate of reaction at progressively higher substrate concentrations

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

Researchers grew aquatic plants in closed glass containers and measured the net change in dissolved oxygen and dissolved CO_2 over a 24-hour period. The containers were divided into three treatment groups: continuous light, continuous darkness, and alternating 12 hours light and 12 hours dark. The data below show the net change in each gas. Positive values indicate net production by the plants; negative values indicate net consumption.

Treatment	Net ΔO_2 (mg/L)	Net ΔCO_2 (mg/L)
Continuous light	+35	−30
Continuous darkness	−18	+18
12 hr light / 12 hr dark	+12	−10

11. The negative net change in O_2 during continuous darkness is best explained by:

A. Plants stop performing photosynthesis but produce O_2 through cellular respiration
B. Plants release stored O_2 back into the water gradually over the 24-hour period
C. Light-independent reactions of photosynthesis continue in darkness, consuming O_2
D. Cellular respiration consumes O_2 while photosynthesis is no longer producing it

12. In the 12 hr light / 12 hr dark treatment, the plants showed a net production of O_2. The most direct conclusion is that:

A. Photosynthesis stops during the dark period and respiration stops during the light period
B. Photosynthesis during the light period produced more O_2 than respiration consumed in darkness
C. Cellular respiration occurs only during the light period in these aquatic plant species
D. Net oxygen change in plants is always positive regardless of available light conditions

13. What does the relationship between ΔO_2 and ΔCO_2 across the three treatments suggest?

A. Oxygen production and carbon dioxide consumption occur together during photosynthesis
B. Photosynthesis produces oxygen but not carbon dioxide as a measurable byproduct
C. Carbon dioxide is consumed faster than oxygen is produced under all tested conditions
D. The two gases vary independently and are unrelated in plant metabolic processes

14. If the researchers wanted to confirm that the gas changes are caused by the plants and not by some other process in the water, the best additional experimental control would be:

A. Measuring the temperature of the water continuously across all three treatment groups
B. Adding a buffer to keep pH constant in each container during the 24-hour period
C. Setting up identical containers with no plants and measuring gas changes in those
D. Repeating the experiment at different times of year to control for seasonal variation

15. The data suggest that during the dark period, the plants:

A. Stop all metabolic processes entirely until light becomes available again
B. Perform photosynthesis using stored chemical energy from earlier light reactions
C. Continue to release oxygen produced earlier and stored in their tissues
D. Carry out cellular respiration, consuming oxygen and releasing carbon dioxide

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

In a particular plant species, flower color is controlled by a single gene with two alleles. The allele R produces red flowers, and the allele r produces white flowers when homozygous. Heterozygous plants (Rr) produce pink flowers — an example of incomplete dominance. A breeder crosses a pink-flowered plant with another pink-flowered plant and obtains 320 offspring.

16. What approximate phenotypic ratio is expected among the 320 offspring?

A. All offspring will be pink because both parents are heterozygous pink plants
B. Three red to one white, because red is dominant over white in this plant species
C. Two pink to one red to one white, because pink is the dominant heterozygous form
D. One red to two pink to one white, the expected ratio for incomplete dominance

17. Based on the 1:2:1 ratio, how many of the 320 offspring would be expected to have red flowers?

A. 40 plants, since red is the rarest of the three flower colors in this cross
B. 60 plants, since each parent contributes a red allele to about one-fifth of offspring
C. 80 plants, since one quarter of the 320 offspring should be homozygous red
D. 160 plants, since half of all offspring inherit a red allele in this cross

18. A pink-flowered offspring is crossed with a white-flowered plant. What ratio of phenotypes is expected in their offspring?

A. All offspring will be pink-flowered because pink is dominant over white in this plant
B. Three pink to one white, because pink contains one dominant allele in heterozygous form
C. One pink to one white, because the cross Rr × rr produces half each in this case
D. Two pink to one red to one white, because all three colors must appear in offspring

19. If pink flower color in this plant species followed COMPLETE dominance rather than incomplete dominance, which observation from the original cross would be different?

A. The total number of offspring produced by the pink × pink cross would change
B. The ratio of dominant to recessive genotypes among the offspring would change
C. The cross would produce all white offspring instead of a mix of three colors
D. Heterozygous plants would appear red rather than pink in this offspring set

20. The breeder observes that some flowers are blue rather than red, pink, or white. Among 320 offspring, 20 are blue. Which hypothesis best explains this observation?

A. Blue is an extreme version of red caused by aging of the red flowers over time
B. The Punnett square predictions for this cross were incorrectly calculated by the researchers
C. White and red parental alleles combined to make blue through random mutation
D. A second gene is influencing flower color in addition to the R/r gene observed

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

A particular protein produced by the human body is exactly 300 amino acids long. The gene that codes for this protein is being studied by researchers investigating a new genetic disorder. In affected patients, the same protein is only 95 amino acids long. Sequencing of the affected patients' DNA reveals a single base change in the coding region of the gene at codon 96. The protein in affected patients lacks function entirely.

21. Approximately how many DNA nucleotides code for the normal 300-amino-acid protein (not counting the start and stop codons)?

A. About 900 nucleotides, since each amino acid is coded by a three-nucleotide codon
B. About 600 nucleotides, since each amino acid is coded by a two-nucleotide pair
C. About 300 nucleotides, since each amino acid is coded by a single nucleotide base
D. About 1,500 nucleotides, since each amino acid is coded by five nucleotides on average

22. A single base change at codon 96 that produces a truncated 95-amino-acid protein is best classified as which type of mutation?

A. A silent mutation that produces no change in the protein's amino acid sequence
B. A nonsense mutation that creates a premature stop codon in the coding sequence
C. A frameshift mutation caused by insertion or deletion of a single base
D. A whole-chromosome duplication affecting the gene's regulatory region

23. Which scenario would most likely produce a protein of unchanged length but disrupted function?

A. A nonsense mutation that produces a premature stop codon early in the sequence
B. A frameshift mutation caused by deletion of one base near the start of the gene
C. A whole-gene deletion that completely removes the entire coding sequence at once
D. A missense mutation that changes one amino acid at a critical functional position

24. The researchers compare two competing hypotheses about why the truncated protein lacks function. Hypothesis 1: The protein is too short to perform its normal structural role. Hypothesis 2: The truncation

deletes the active site of the protein. Which observation would best distinguish between these two hypotheses?

A. Measure the total amount of truncated protein produced in affected patients' cells
B. Determine whether other proteins in patients' cells also show length differences
C. Test whether the 95-amino-acid fragment retains any partial enzyme activity in vitro
D. Compare the gene sequence of affected patients to other unrelated genetic disorders

25. A drug company hopes to treat this disorder by introducing a functional copy of the gene into affected patients. The introduced gene would need to:

A. Replace every mutant copy of the gene in every body cell across the patient
B. Be expressed by the patient's transcription and translation machinery to produce full-length protein
C. Permanently integrate into the patient's germ-line so offspring inherit the corrected version
D. Function independently of the patient's ribosomes and produce protein directly in the cytoplasm

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

Researchers monitored a population of moths in an industrial region of England between 1850 and 1950. The frequency of dark-colored and light-colored moths shifted dramatically over this period, as shown in the table below. Air pollution from coal-burning industry darkened the bark of trees throughout the region during this time.

Decade	% Light-colored moths	% Dark-colored moths
1850s	96	4
1880s	80	20
1910s	35	65
1940s	8	92

26. Three hypotheses are proposed to explain the shift. Hypothesis 1: Pollution chemically darkened the wings of individual moths during their lifetimes. Hypothesis 2: Dark moths were better camouflaged on sooty bark and survived bird predation at higher rates. Hypothesis 3: Moths chose to become darker through deliberate behavioral changes. Which hypothesis is most consistent with the principles of natural selection?

A. Hypothesis 1, because environmental change directly modifies organisms during their lives
B. Hypothesis 2, because differential survival of preexisting variation drives evolutionary change
C. Hypothesis 3, because organisms purposefully change their phenotype to fit the environment
D. None of the hypotheses can be evaluated using the data shown in the table

27. A researcher hypothesizes that if pollution were reduced and bark lightened again, the population would shift back toward the light-colored form. The best evidence supporting this prediction would come from:

A. Genetic analysis showing that all current dark moths are identical genetic clones
B. Records showing that the same shift occurred in moth populations on every continent
C. Observations of light moths reappearing in areas where air quality improved over time
D. Climate data showing that temperature change influenced moth color independently

28. If a researcher experimentally measured the survival rate of light and dark moths on different bark types, which results would most strongly support natural selection as the mechanism?

I. Light moths survive better on light bark than dark moths do
II. Dark moths survive better on dark bark than light moths do
III. Both moth colors survive equally well on both bark types

A. Both I and II together support natural selection occurring here
B. I and II support selection while III contradicts the mechanism
C. III alone is what supports natural selection occurring
D. None of the three results above would support natural selection

29. A critic claims that the shift in moth colors must be due to mutations occurring in response to the polluted environment, not natural selection acting on existing variation. Which observation would best refute this critic's claim?

A. Light and dark moths both existed at low frequencies long before industrialization began
B. Dark moths appear only in regions where industrial pollution is currently the heaviest
C. The frequency of light moths decreased more rapidly than the dark moths increased
D. Moths in unpolluted regions of the world have never been found in dark-colored forms

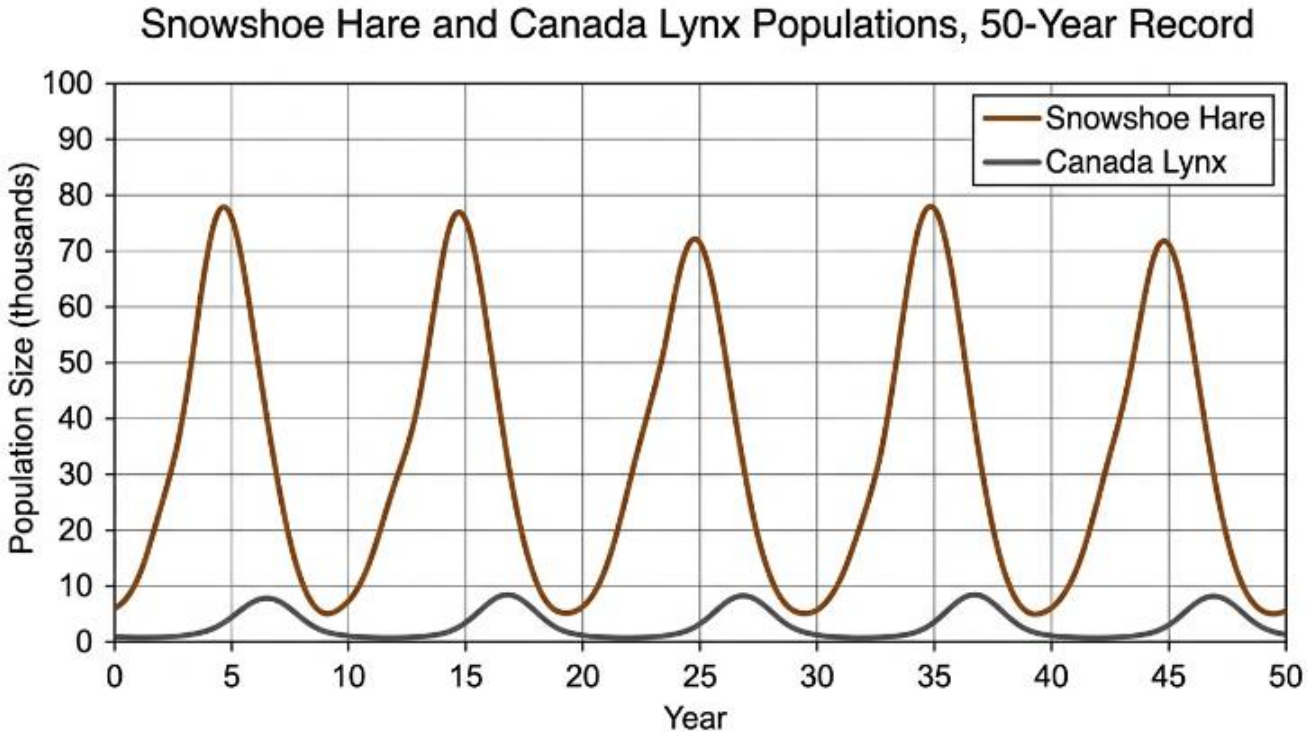
30. During the 1940s, dark moths reached 92% of the population. If pollution were eliminated immediately and tree bark gradually returned to its lighter color, which prediction is most consistent with natural selection?

A. Light moths would gradually become more common as selection now favors them
B. Dark moths would remain at 92% because they have permanently replaced light moths
C. All moths would die out because they cannot survive in unpolluted environments
D. The two forms would reach exactly equal proportions and remain stable indefinitely

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

For 50 years, researchers tracked the populations of snowshoe hares and Canada lynx in a remote northern forest ecosystem. Lynx are predators that depend heavily on hares as their primary prey. The

graph below shows the two populations oscillating in linked cycles, with hare population peaks consistently preceding lynx population peaks by approximately one to two years. The typical cycle lasts about ten years from one peak to the next.



31. Which observation from the graph best supports the conclusion that lynx population is limited primarily by hare availability?

A. Lynx peaks always occur in the same calendar years as hare population peaks
B. Hare population fluctuations are much smaller than lynx population fluctuations annually
C. Lynx peaks consistently follow hare peaks by approximately one to two years
D. Hare and lynx populations move in opposite directions across the entire cycle

32. The decline in hare population that begins at each peak is most likely caused by:

A. Lynx populations are still too small to have any meaningful effect on hare numbers
B. Hares spontaneously stop reproducing once their population reaches a maximum value
C. Increased lynx predation combined with depletion of plant food limits hare population
D. Climate variations completely independent of the lynx population drive hare numbers down

33. If lynx were completely removed from the ecosystem, the most likely short-term effect on the hare population would be:

A. Hare numbers would rise above their normal peak before plant food becomes limiting
B. Hare numbers would crash immediately because lynx are essential for hare survival

C. Hare populations would oscillate at exactly the same amplitude and cycle length always
D. Hare populations would migrate out of the ecosystem in search of new food sources

34. A new study finds that hare populations also oscillate in 10-year cycles even in regions where no lynx are present. Which conclusion is best supported by this finding?

A. Factors other than lynx predation also contribute substantially to hare population cycles
B. Lynx are not a predator of hares in any region of North America
C. Lynx populations in the original study area must have been incorrectly identified
D. Hare cycles are entirely random and unrelated to any environmental factors

35. A researcher hypothesizes that food shortage caused by overgrazing contributes to the hare decline at each peak. Which experimental approach would best test this hypothesis?

A. Track lynx population sizes in areas where hares have been completely removed
B. Measure the air temperature at the time of each peak across multiple cycle years
C. Provide supplemental food to one experimental hare population and compare to a control
D. Compare hare and lynx populations in two different geographic ecosystems simultaneously

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

A team of researchers measured the rate of carbon dioxide release from soil in a forest ecosystem at varying temperatures. The release of CO_2 from soil comes primarily from the cellular respiration of soil bacteria, fungi, and small invertebrates that decompose dead organic matter. The team collected samples from the same forest site and measured CO_2 release in a controlled chamber at five temperatures. The results are below.

Soil Temperature (°C)	CO_2 Release Rate (µmol/m²/sec)
5	1.2
15	3.4
25	7.8
35	11.5
45	6.0

36. The increase in CO_2 release between 5°C and 35°C is most directly explained by:

A. Photosynthetic activity in the soil increasing rapidly with warmer temperatures
B. CO_2 becoming more soluble in soil water at progressively higher temperatures
C. Plants in the soil increasing their cellular respiration in response to warmth
D. Decomposer organisms increasing their metabolic activity at warmer temperatures

37. The decline in CO_2 release between 35°C and 45°C is best explained by:

A. CO_2 becomes less soluble in soil water at high temperatures and escapes quickly
B. Enzymes in the decomposer organisms begin to denature at 45°C, slowing metabolism
C. The decomposer organisms reproduce more rapidly above 35°C, doubling their numbers
D. Carbon dioxide is reabsorbed by the soil minerals when temperatures rise above 35°C

38. A critic suggests that the CO_2 release might come from plant roots present in the soil rather than from decomposers. Which experimental approach would best address this concern?

A. Repeat the experiment at temperatures both above and below the original range tested
B. Use root-free soil samples that contain only decomposer organisms at the same temperatures
C. Add additional decomposer organisms to the soil and measure how CO_2 release changes
D. Measure plant root respiration in a separate experiment using no soil at all

39. The CO_2 released by soil decomposers is part of which larger biological cycle?

A. The water cycle, which moves H_2O between atmosphere, surface waters, and living organisms
B. The phosphorus cycle, which moves phosphate between soils, water, and living organisms
C. The nitrogen cycle, which moves nitrogen between atmosphere, soil, and living organisms
D. The carbon cycle, which moves carbon between atmosphere, organisms, soil, and oceans

40. If global temperatures rose by several degrees, the data from this experiment would predict that:

A. Soil CO_2 release would increase significantly across forest ecosystems globally over time
B. Soil CO_2 release would decrease as decomposers struggle in the warmer climate
C. The carbon cycle would slow because plants would absorb more CO_2 overall
D. Photosynthesis would replace decomposition as the dominant source of soil CO_2

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

A coastal community is monitoring local environmental changes attributed to global climate change. Over the past 30 years, average annual temperatures have increased by 1.2°C, sea level has risen 15 cm, and the population of a regionally important fish species (Atlantic cod) has declined by 60 percent. Researchers want to determine whether the cod decline is caused by climate change or by other factors.

41. Three potential causes of the cod decline are proposed. I: Warming ocean temperatures shift cod food sources northward. II: Sea level rise floods coastal cod nursery habitats. III: Overfishing by commercial fleets removes adult cod from the population. If all three factors are operating simultaneously, the most accurate conclusion would be that:

A. Climate change is the sole cause and overfishing is not contributing to the decline
B. Multiple interacting factors are contributing, making it hard to isolate any one cause

C. Overfishing must be the dominant factor because it removes individuals directly
D. None of the three factors actually contribute to the cod population decline directly

42. To determine specifically how much warming temperatures alone have affected the cod population, researchers should:

A. Compare cod populations across multiple decades and look for any pattern at all
B. Compare cod populations in regions with similar fishing pressure but different temperature changes
C. Stop all fishing in the region for one year and observe what happens to cod numbers
D. Add cod from other regions into the local population and measure their survival rates

43. Which observation would most directly support the hypothesis that climate change is contributing to the cod decline?

A. Cod populations are also declining in unfished regions where temperatures have risen
B. Cod populations remain stable in heavily fished regions with unchanged temperatures
C. The decline of cod began before any measurable temperature increase occurred
D. Sea level rise has affected coastlines worldwide regardless of cod population changes

44. Sea level rise affects coastal cod nursery habitats primarily through:

A. Saltwater intrusion changing the salinity of estuaries where young cod develop
B. Direct contact with cod eggs causes them to fail before they hatch into larvae
C. Mechanical pressure from deeper water crushes cod eggs against the seafloor below
D. Cod parents migrate to deeper water and abandon their nursery sites entirely

45. Which combination of strategies would most effectively help the cod population recover?

A. Reducing fishing alone, since climate change is too large to address at any local scale
B. Addressing climate change globally alone, since fishing pressure has little local effect
C. Doing nothing and allowing natural selection to produce climate-adapted cod populations
D. Combining reduced fishing pressure with global emissions reductions over a long period

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

A conservation team is designing a wildlife corridor to connect two fragmented forest areas where a population of red foxes lives. The two forest patches are separated by a four-lane highway. The team is evaluating three corridor designs. Design A: A wide overpass with native vegetation planted on top (cost: $10 million, completion: 3 years). Design B: An underpass tunnel beneath the highway, lit with infrared light (cost: $4 million, completion: 18 months). Design C: A series of three small underpasses spaced along a one-mile stretch (cost: $2 million, completion: 12 months).

46. Which factor is LEAST relevant for evaluating these three engineering designs?

A. The total construction cost and the speed of completion for each design option
B. The expected effectiveness of each design in actually moving foxes between forests
C. The environmental impact of each design's construction on the surrounding ecosystem
D. The artistic appearance of each structure when viewed from the highway by passing drivers

47. Design C uses three smaller underpasses rather than one larger structure. This approach reflects which engineering principle?

A. Maximizing total cost to ensure the highest possible quality of the final design
B. Selecting the slowest design to allow more thorough environmental review processes
C. Distributing risk so that disruption of one passage does not block all wildlife crossings
D. Minimizing the number of passages so that foxes can concentrate their migration efforts

48. A critical part of the engineering process is identifying CRITERIA that any successful corridor must meet. Which is most clearly a criterion (rather than a constraint)?

A. The corridor must allow at least 80% of fox movement attempts to succeed
B. The total budget cannot exceed the $10 million approved by the funding agency
C. Construction must be completed within five years to qualify for federal grant money
D. The corridor cannot disrupt highway traffic for more than two weeks during installation

49. After construction, the team plans to monitor whether foxes actually use the corridor. Which monitoring approach would most directly measure success?

A. Counting the total fox population on both sides of the highway annually after construction
B. Installing motion-triggered cameras at the corridor entrances and exits to record fox crossings
C. Measuring the air quality near the corridor to detect any change after foxes begin using it
D. Conducting public opinion surveys about whether nearby residents support the corridor design

50. The team is also considering whether the corridor might benefit other species besides foxes. Which combination of considerations is most consistent with good engineering design?

I. The corridor might also help raccoons, opossums, and small mammals cross safely
II. Some predators of foxes could use the corridor to attack the fox population
III. Aquatic species cannot benefit from a corridor designed for terrestrial animals

A. I only — designs should focus on benefits to the target species without other considerations
B. I, II, and III — engineering design should consider all potential effects, both positive and negative
C. III only — the design should explicitly exclude any species other than foxes from using it
D. None of these considerations — the team should make decisions based only on cost factors

Practice Exam 31: Full Answer Key with Explanations

1. C — Seawater contains higher sodium than the fish's body fluids, so sodium passively diffuses INTO the body down its concentration gradient. To maintain stable internal ion concentrations, the gill cells must actively pump Na^+ OUT against this gradient. This active transport requires energy and is the defining osmoregulatory challenge of marine bony fish.

2. A — The design uses the same fish across all five treatments with no untreated baseline group, leaving handling stress, fatigue, and carryover effects uncontrolled. A separate fish held at one unchanging salinity throughout would isolate the salinity effect from these confounding variables. Without this comparison, observed changes cannot be cleanly attributed to salinity alone.

3. B — If the pumps truly reverse direction at the salinity where internal and external sodium are balanced, the data should show a minimum pump activity at that crossover point. At 2% NaCl, pump activity drops to 2 units (the lowest in the data set) and is labeled "near equilibrium." This minimum is precisely the pattern the hypothesis predicts.

4. D — As external salinity rises above the fish's body fluid concentration, water leaves the body by osmosis to the saltier surroundings. To conserve body water under this osmotic stress, the kidneys reduce urine output and produce more concentrated urine. The decreasing urine production with rising salinity matches this water-conservation strategy directly.

5. A — In saltwater (3.5%), a freshwater fish's body fluids are less concentrated than the surrounding water, so it would LOSE water by osmosis (I is false), and urine production would DECREASE to conserve that water (III is false). Sodium would diffuse INTO the body from the higher-sodium environment, forcing the gill cells to pump Na^+ OUT (II is true). Only statement II is supported.

6. C — Enzyme saturation is the point where all active sites are occupied and increasing substrate no longer raises the reaction rate. At 8.0 mM the 1× enzyme reaches 25 μmol/min, and at 16.0 mM the rate stays at 25 — confirming the plateau began at 8.0 mM. This is the classic signature of Vmax being reached.

7. A — Each enzyme molecule has one active site, so the total reaction rate depends on how many active sites are working simultaneously. Doubling the enzyme concentration doubles the available active sites, directly doubling the reaction rate at any given substrate concentration. The catalytic speed of each individual enzyme does not change — only the number of molecules working at once.

8. D — Examination of the table shows the 2× enzyme rate hits 50 μmol/min at 8.0 mM and stays at 50 at 16.0 mM — the same saturation point as the 1× condition. Saturation occurs when all active sites are occupied, which depends on substrate concentration relative to enzyme-substrate binding affinity (Km), not on the total enzyme amount. Both curves therefore plateau at the same substrate concentration.

9. C — Lactase functions optimally at near-neutral pH (around 6–7) in the small intestine. Lowering the pH to 4 disrupts the hydrogen bonds and ionic interactions that maintain the enzyme's active-site shape, reducing or eliminating substrate binding. The result is a decreased reaction rate as the enzyme partially denatures.

10. C — A defining property of a catalyst is that it speeds a reaction without being consumed in it. Measuring lactase concentration before and after the reaction tests this directly: if the lactase concentration is unchanged, it is acting as a catalyst rather than as a reactant. The other measurements describe products or reaction kinetics, not the fate of the enzyme itself.

11. D — Without light, photosynthesis cannot occur and no O_2 is produced, but cellular respiration continues using oxygen to break down stored sugars for energy. The result is a net loss of O_2 from the closed container, matching the −18 mg/L value observed in continuous darkness. Both photosynthesis and respiration normally operate in plants, but only respiration runs in the dark.

12. B — A net production of +12 mg/L O_2 across the alternating cycle means the light-period O_2 output exceeded the dark-period O_2 consumption. This confirms photosynthesis runs only in light while respiration runs continuously, with photosynthesis being the dominant of the two when light is available. Plants are net O_2 producers over 24 hours under typical day/night conditions.

13. A — Across all three treatments, ΔO_2 and ΔCO_2 are nearly equal in magnitude but opposite in sign — when O_2 rises, CO_2 falls, and vice versa. This tight coupling reflects photosynthesis ($CO_2 + H_2O \rightarrow$ glucose $+ O_2$) and respiration (glucose $+ O_2 \rightarrow CO_2 + H_2O$) using these two gases in linked stoichiometric ratios. The two gases are not independent variables in plant metabolism.

14. C — A no-plant control with identical water and container conditions would reveal any gas changes caused by bacteria, chemical processes, or atmospheric exchange independent of the plants. If the control shows minimal or zero ΔO_2 and ΔCO_2, the changes in the experimental containers can be confidently attributed to plant metabolism. This is the standard negative-control approach used to isolate a biological effect from background processes.

15. D — During continuous darkness the plants show −18 mg/L O_2 and +18 mg/L CO_2 — the exact gas signature of cellular respiration consuming oxygen and releasing carbon dioxide. Plants respire constantly, day and night, to power their cellular activities using stored glucose. At night photosynthesis ceases, so respiration alone determines the gas balance.

16. D — A Rr × Rr cross produces a 1:2:1 genotypic ratio of RR : Rr : rr, which under incomplete dominance also shows as a 1:2:1 phenotypic ratio (red : pink : white). Each parent contributes either R or r with equal probability, generating one homozygous red, two heterozygous pink, and one homozygous white per four offspring on average. This ratio is the hallmark of incomplete dominance.

17. C — Under the 1:2:1 phenotypic ratio expected from Rr × Rr, red-flowered plants represent one of every four offspring. Calculating: 320 ÷ 4 = 80 red-flowered plants. The other 240 offspring should split as 160 pink and 80 white under the same ratio.

18. C — A Rr × rr cross gives each offspring an r allele from the white parent and either R or r from the pink parent with equal probability. This produces a 1:1 ratio of Rr (pink) to rr (white) phenotypes. This pattern — a 1:1 ratio in a test cross with a homozygous recessive parent — is a standard tool for revealing the heterozygous genotype.

19. D — Under complete dominance, the heterozygous Rr genotype produces the dominant phenotype (red) rather than an intermediate pink. The same 1:2:1 genotypic ratio would still occur, but the phenotypic ratio would collapse to 3 red : 1 white because all three R-containing genotypes look red. The disappearance of the pink intermediate is the most visible signature of complete versus incomplete dominance.

20. D — Blue is not a predicted phenotype from the R/r gene alone, which only produces red, pink, or white. The most parsimonious explanation is that a second gene at a different locus also influences flower color, with certain allele combinations producing blue. This pattern — multiple genes interacting to determine a single trait — is called polygenic inheritance or epistasis.

21. A — The genetic code uses three-nucleotide codons, with each codon specifying one amino acid in the protein. For a 300-amino-acid protein, the coding region needs $300 \times 3 = 900$ nucleotides (not counting start and stop codons). This 3:1 relationship between nucleotides and amino acids is foundational to molecular biology.

22. B — A nonsense mutation occurs when a single base change converts a codon into one of the three stop codons (UAA, UAG, UGA), terminating translation prematurely. In this case the change at codon 96 stops translation after 95 amino acids — exactly the truncated length observed in patients. The resulting protein is incomplete and almost always nonfunctional.

23. D — A missense mutation changes a single nucleotide that alters which amino acid is encoded at one position, but the protein length is preserved because no stop codon is introduced. If the substituted amino acid sits at a functionally critical position (such as the active site or a folding hinge), the full-length protein can still be inactive. Sickle-cell hemoglobin is a classic example of a missense mutation disrupting function without changing length.

24. C — The two hypotheses make different predictions about residual activity: if the truncation only removes structural length while preserving the active site (H1), the fragment may retain partial activity in vitro; if the truncation eliminates the active site itself (H2), the fragment will show zero activity. Measuring partial activity therefore directly discriminates between the two explanations. The other options test peripheral facts that do not differentiate the hypotheses.

25. B — Gene therapy works by introducing a functional gene copy that the patient's own ribosomes, RNA polymerases, and other cellular machinery can read and translate into protein. The introduced gene does not need to replace mutant copies in every cell, nor does it need to enter the germline — it only needs to be expressed in enough cells to restore protein function. This approach is the basis of modern gene therapies for genetic disorders.

26. B — Natural selection requires preexisting variation in a population combined with differential survival or reproduction based on heritable traits. Hypothesis 2 invokes both — variation in moth color already existed, and dark moths survived predator attacks at higher rates on sooty bark. Hypothesis 1 (Lamarckian acquired traits) and Hypothesis 3 (purposeful change) are not mechanisms of natural selection.

27. C — The hypothesis predicts a reverse shift toward light moths after pollution decreases, and the strongest direct evidence would be observing exactly that reversal in real populations. This reversal has been documented in regions of Britain where air quality improvements followed the Clean Air Acts of the mid-20th century. Empirical observation of the predicted outcome is the gold-standard evidence for any selection hypothesis.

28. B — Statements I and II both describe differential survival based on the match between moth color and bark color — exactly the mechanism by which natural selection operates. Statement III (equal survival on both bark types) would mean there is no selective pressure favoring either color, which directly contradicts the natural selection explanation. So I and II support the mechanism while III would refute it.

29. A — The critic's claim depends on dark moths arising as a new mutation in response to pollution. Documented existence of dark moths at low frequencies before industrialization began directly refutes this claim, showing that the variation already existed in the population. Natural selection then changed the FREQUENCIES of pre-existing variants — it did not create new ones in response to need.

30. A — Once bark lightens, the camouflage advantage flips: light moths become harder for predators to spot, and dark moths face higher predation. This differential survival favors light moths each generation, gradually shifting the population back toward higher frequencies of the light form. The change is gradual because selection acts across generations rather than within individual lifetimes.

31. C — In a predator-prey relationship where the predator depends on the prey, the predator population responds to changes in prey availability with a time lag — predators need time to convert abundant prey into reproductive success. The observed 1–2 year lag of lynx peaks behind hare peaks is precisely this delayed response. Simultaneous peaks (option A) would suggest no causal dependency.

32. C — At the hare population peak, two factors combine to reverse the trend: lynx numbers are also high (intensifying predation pressure), and the dense hare population has overgrazed available plant food. Together these top-down and bottom-up pressures cause the hare population to crash. This dual-pressure mechanism explains why hare cycles are so dramatic.

33. A — Removing the lynx eliminates the top-down predation pressure, allowing hare numbers to rise beyond their normal peak. However, bottom-up regulation from plant food availability would still kick in eventually, causing decline once vegetation is depleted. The hare population would reach a higher ceiling than under lynx presence, but it cannot grow indefinitely.

34. A — Observing 10-year hare cycles in lynx-free regions proves that something besides lynx predation is driving the cycle. Plausible alternative drivers include food availability, disease, weather patterns, or stress effects from high density. Lynx predation amplifies the cycle where lynx are present, but it is not the only mechanism.

35. C — A controlled experiment that supplements food in one hare population while leaving another unfed (the control) directly tests whether food shortage drives the decline. If the supplemented population avoids the expected crash while the control population still declines, the food-shortage hypothesis is strongly supported. This manipulative design — varying the proposed cause while controlling everything else — is the gold standard for identifying mechanisms.

36. D — Soil CO_2 release in this system comes primarily from decomposer respiration. As temperature rises from 5°C to 35°C, enzyme-catalyzed metabolic reactions in the decomposers speed up, increasing their cellular respiration and CO_2 output. This temperature-driven acceleration of metabolism is universal across nearly all organisms up to an optimum temperature.

37. B — As temperature climbs above an organism's enzymatic optimum, the hydrogen bonds maintaining enzyme tertiary structure are disrupted, causing denaturation and loss of catalytic activity. At 45°C the decomposer enzymes denature faster than they can be replaced, slowing cellular respiration and reducing CO_2 release. This pattern of activity rising with temperature then falling sharply above the optimum is the classic enzyme-temperature curve.

38. B — To distinguish decomposer respiration from plant root respiration, the cleanest experimental approach is to remove the roots while keeping the decomposer community intact, then measure CO_2 release. If root-free soil produces the same temperature-CO_2 pattern as the original, decomposers must be the source. Sterilization (which would kill BOTH decomposers and roots) cannot isolate the variable.

39. D — Soil decomposers break down dead organic matter and release the carbon stored in it as CO_2 via cellular respiration. This CO_2 returns to the atmosphere, completing one branch of the global carbon cycle that moves carbon among the atmosphere, living organisms, soils, oceans, and rocks. Decomposers are a major (and often underappreciated) contributor to atmospheric CO_2 flux.

40. A — Across the rising portion of the curve (5°C–35°C), soil CO_2 release increases sharply with temperature. Most forest soils currently sit well below the 35°C optimum, so global warming would push them toward higher CO_2 release. This represents a positive feedback in the climate system: warming increases soil respiration, which adds CO_2 to the atmosphere, accelerating further warming.

41. B — When three plausible causes are operating at once, the scientifically accurate conclusion is that multiple factors are likely contributing, and isolating any single dominant cause requires further controlled comparison. Real-world ecological declines almost always have multiple interacting drivers — claiming a single cause is rarely justified without targeted experiments. This kind of careful causal reasoning is central to ecological science.

42. B — To isolate the effect of temperature, the researchers need to hold other variables (especially fishing pressure) constant while varying temperature. Comparing regions with similar fishing pressure but different temperature trajectories reveals the temperature signal. This is the comparative natural-experiment approach used widely in ecology when controlled experiments at ecosystem scale are impossible.

43. A — A decline in unfished regions where temperatures have risen rules out fishing as the cause for that population, leaving climate change as the strongest remaining candidate. This is the logic of negative controls applied to natural systems: by eliminating one alternative explanation, the data more directly support the remaining hypothesis. Multiple independent regional declines tied to warming would build a strong case.

44. A — Cod nursery habitats are typically in coastal estuaries with carefully balanced salinity from mixing fresh and salt water. Sea level rise pushes saltwater further inland, raising salinity in zones that

were previously brackish or freshwater. The altered salinity stresses developing young cod, whose physiology is adapted to specific salinity ranges. This indirect, salinity-mediated effect is the dominant mechanism.

45. D — Because the decline has multiple causes (warming, sea level rise, overfishing), addressing only one source provides incomplete relief. Combining local action on fishing pressure with global emissions reductions tackles both the immediate population stress and the longer-term climate driver. This integrated approach reflects how modern conservation increasingly addresses interacting threats simultaneously.

46. D — Engineering design for a wildlife corridor weighs function (does it move foxes?), cost, completion time, and environmental impact — all directly relevant to whether the project achieves its goal. Aesthetic appearance to highway drivers is essentially irrelevant to the corridor's function and is the weakest evaluation criterion among the four options. Function and effectiveness drive engineering decisions, not visual appeal to outside observers.

47. C — Using three smaller passages rather than one large one creates redundancy: if any single passage is blocked by debris, flooding, or predator activity, foxes can still cross through the others. This redundancy is a core engineering principle for systems where any single-point failure is unacceptable. Aerospace and infrastructure engineering use similar redundancy strategies.

48. A — In engineering design, criteria specify the positive performance goals the design must achieve (what success looks like), while constraints specify the limits the design must not exceed (cost ceilings, time deadlines, regulatory limits). An 80% movement success rate is a positive performance target — a criterion. The budget cap, completion deadline, and traffic-disruption limit are all constraints, not criteria.

49. B — Motion-triggered cameras at the corridor entrances and exits directly count fox crossings, providing exactly the success metric the team needs to evaluate corridor use. Total population counts are indirect and influenced by many other factors; air-quality and public-opinion measurements are unrelated to whether foxes actually cross. Cameras are widely used in wildlife monitoring for this precise reason.

50. B — Comprehensive engineering design weighs positive side effects (helping other terrestrial species), negative side effects (enabling predator access), and limitations of scope (aquatic species cannot benefit from a terrestrial corridor). All three statements describe real considerations that responsible designers should evaluate before construction. Good design anticipates a full range of intended and unintended consequences.