PRACTICE EXAM 35: 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 diagnostic reasoning, evidence evaluation, counterfactual reasoning, error identification in experimental designs, and application of biological principles to novel contexts. Read each case study or scenario carefully before answering the questions in that 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.

ABO blood type is determined by a single gene with three alleles: I^A, I^B, and i. The I^A and I^B alleles are codominant (both are expressed when present together); both are completely dominant over i. The four possible blood types are: A (I^A I^A or I^A i), B (I^B I^B or I^B i), AB (I^A I^B), and O (ii). A mother with type A blood and a father with type B blood have four children. Their children's blood types are: Child 1 — type A, Child 2 — type B, Child 3 — type AB, Child 4 — type O. A hospital error is suspected for one of the children.

1. A genetic counselor analyzes whether the parents (type A × type B) could produce children of all four blood types. What is the genetic requirement?

A. Both parents must be homozygous for their respective alleles — I^A I^A × I^B I^B
B. The mother must be homozygous I^A I^A and the father must be heterozygous I^B i
C. The father must be homozygous I^B I^B and the mother must be heterozygous I^A i
D. Both parents must be heterozygous — mother I^A i and father I^B i, respectively

2. If both parents are heterozygous (I^A i × I^B i), what is the predicted ratio of blood types among offspring?

A. All offspring will be type AB because they receive one I^A and one I^B allele
B. 1 type A : 1 type B : 1 type AB : 1 type O — equal 25% probabilities expected
C. 3 type A : 1 type O — typical dominance ratio with no other types possible
D. 9 type AB : 3 type A : 3 type B : 1 type O — typical dihybrid ratio observed

3. Which child's blood type would be IMPOSSIBLE if Child 4 (type O) were a biological child of these parents?

A. Child 1 (type A) — could be I^A i with i from mother and I^A from father
B. Child 2 (type B) — could be I^B i with i from father and I^B from mother
C. None of the children's types would be impossible — all four can occur
D. Child 3 (type AB) — would require both parents to lack i alleles entirely

4. A laboratory error is suspected for one child. Based on the blood types alone, which child's blood type would NOT match the expected genetic possibilities if the suspected parents were both HOMOZYGOUS instead of heterozygous?

A. Child 4 (type O), because homozygous parents (I^A I^A × I^B I^B) could only produce AB offspring
B. Child 1 (type A), because homozygous parents could not produce a type A child overall
C. Child 2 (type B), because homozygous parents could not produce a type B child overall
D. Child 3 (type AB), because homozygous parents could only produce non-AB offspring

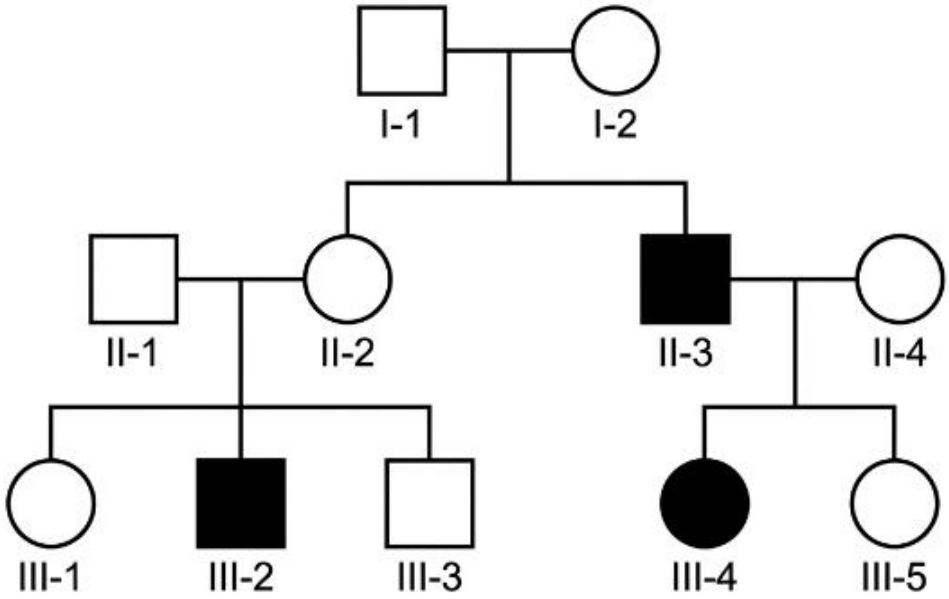
5. A friend claims "If a child has type O blood, neither parent can have type AB blood." This claim is:

A. False — type AB parents can produce all four blood types in their offspring possibly
B. False — type AB parents have multiple i alleles available to pass to their offspring
C. True — type AB individuals are I^A I^B and have no i allele to transmit to offspring
D. True — type AB individuals always produce only type AB offspring exclusively each time

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

A genetic counselor analyzes a family pedigree for a rare inherited condition. Filled symbols represent affected individuals; squares are males and circles are females.

Pedigree of an Inherited Condition — Three Generations



6. What pattern of inheritance is most consistent with this pedigree?

A. X-linked dominant — affected individuals occur in every generation and males are unaffected
B. Y-linked — only males are affected and condition passes from father to son directly
C. Autosomal recessive — affected individuals appear from unaffected parents in two generations
D. Autosomal dominant — every affected child has at least one affected parent in this case

7. If the condition is autosomal recessive, the most likely genotype of II-2 (unaffected mother of affected III-2) is:

A. Homozygous dominant (DD) — she has no affected alleles to transmit ever
B. Homozygous recessive (dd) — she would express the condition herself though
C. Carrier with two normal alleles — phenotypically and genotypically normal entirely
D. Heterozygous carrier (Dd) — she carries one recessive allele transmitted to III-2

8. II-1 (unaffected, married into family) is the father of affected III-2. What is the best diagnostic conclusion about II-1's genotype?

A. He must be a heterozygous carrier (Dd) for III-2 to inherit two recessive alleles
B. He must be homozygous recessive (dd) and showing no symptoms despite his genotype
C. He must be homozygous dominant (DD) and III-2's condition came from mother only
D. His genotype cannot be determined from the information shown in the pedigree directly

9. If II-3 (affected) and II-4 (unaffected carrier, Dd) have a third child, what is the probability that child is affected?

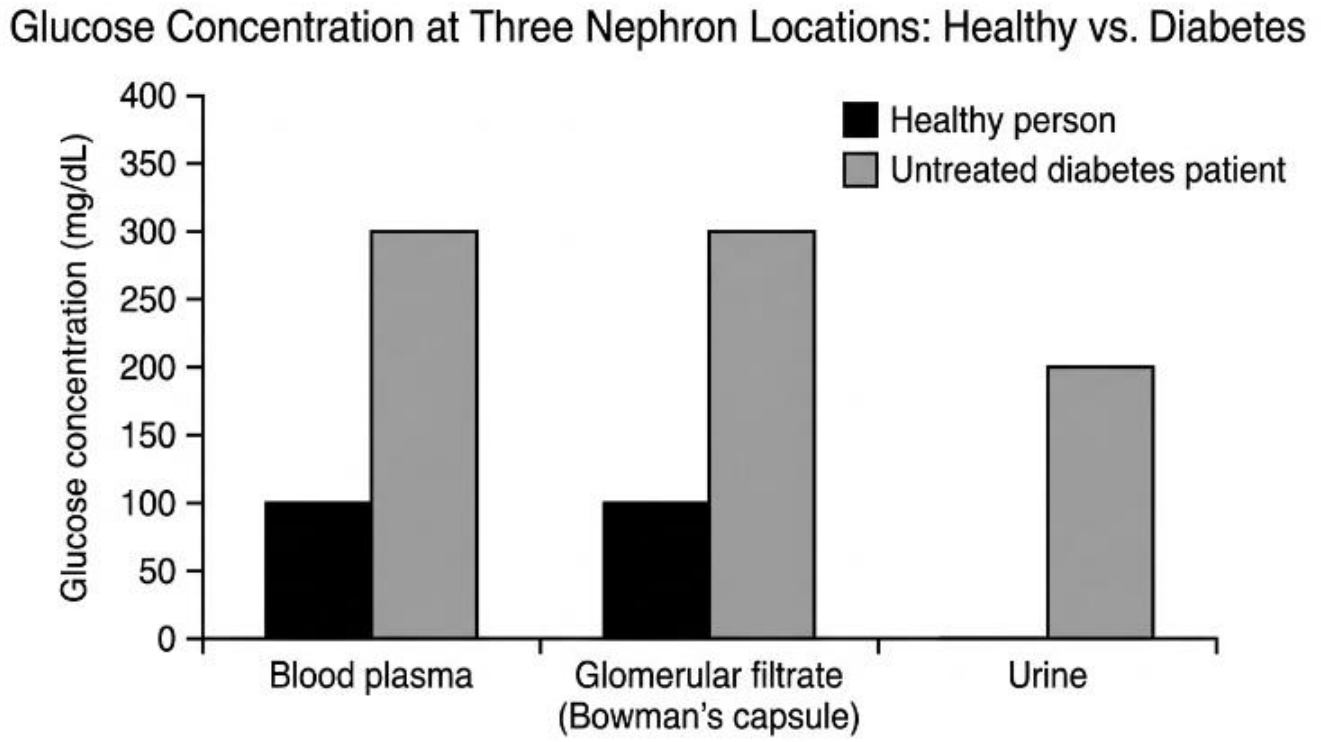
A. 0% — the condition has skipped a generation already and will not appear again
B. 25% — only one quarter of children of carriers inherit the affected genotype here
C. 50% — half their children will be dd and affected by the condition genetically
D. 100% — both parents will contribute the recessive allele to every child possible

10. III-5 (unaffected daughter of II-3 affected × II-4 carrier) has what probability of being a heterozygous carrier (Dd)?

A. 0% — she shows no symptoms so cannot carry the recessive allele in her genotype overall
B. 100% — every unaffected child of this couple must be a heterozygous carrier genotype
C. 25% — only one in four children of carriers ends up as a heterozygous carrier
D. 50% — half the children of any carrier-affected pair are heterozygous carriers

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

The human kidney maintains homeostasis by filtering blood and producing urine. The nephron is the functional unit of the kidney. Blood enters through the glomerulus, where small molecules (water, salts, glucose, urea) filter into Bowman's capsule. As the filtrate moves through the tubule, useful molecules (glucose, most water, ions) are reabsorbed back into the blood, while waste (urea) remains in the urine. The graph below shows glucose concentration in three locations in a healthy person and in a patient with untreated diabetes.



11. In a healthy person, urine glucose is 0 mg/dL even though glomerular filtrate glucose is 100 mg/dL. The most likely reason is:

A. Glucose is destroyed by enzymes in the kidney tubule before reaching the urine itself
B. Glucose never enters the glomerulus from the blood plasma during filtration normally
C. Glucose is fully reabsorbed from the filtrate back into the blood by the tubule
D. Glucose precipitates as a solid in the kidney and remains there as crystals always

12. In the diabetes patient, urine glucose is 200 mg/dL — much higher than 0. The best diagnostic explanation is:

A. Blood glucose is so high that reabsorption is overwhelmed and excess spills into urine
B. The kidney has lost the ability to filter glucose from the blood plasma entirely now
C. The patient has been drinking sugar-containing fluids that go directly into urine
D. The glucose in the urine comes from bacterial fermentation in the bladder tissues

13. The diabetes patient's blood glucose of 300 mg/dL would also cause excessive urination. Trace the cause:

A. High blood glucose damages the bladder → frequent urination follows directly from injury
B. Excess glucose in urine draws water with it by osmosis → more urine volume produced
C. The kidney tries to compensate by producing more urine to dilute the glucose entering
D. Glucose in urine stimulates bladder muscles to contract rapidly → urgency to urinate

14. If a patient has 150 mg/dL blood glucose but normal urine glucose (0 mg/dL), the most likely explanation is:

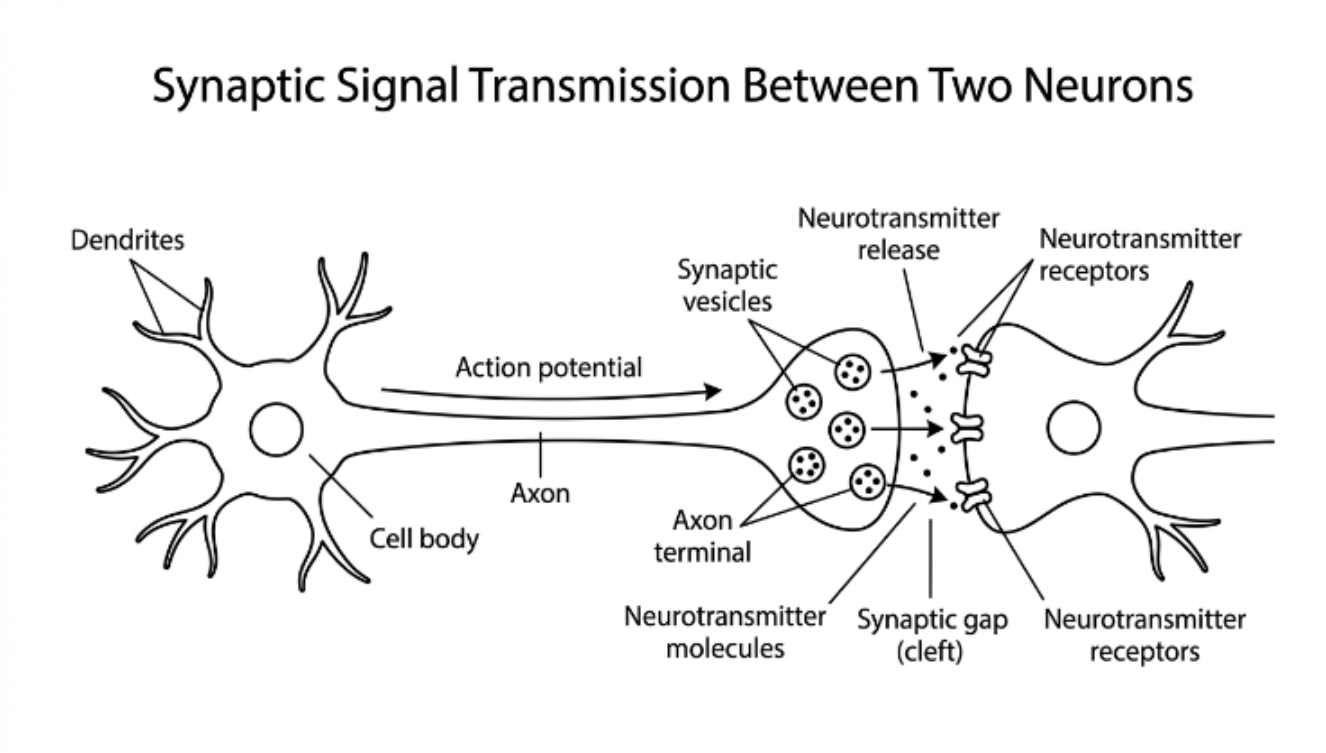
A. The patient is severely dehydrated and the urine is not flowing at all today consistently
B. Patient's blood glucose is below the kidney's reabsorption threshold (~180 mg/dL)
C. The kidney has been damaged and is no longer filtering glucose into the urine
D. The patient is taking insulin which is preventing glucose from entering the urine

15. The kidney's reabsorption system can be modeled as having transport proteins with limited capacity. If a researcher wanted to test whether glucose reabsorption follows enzyme-kinetics-like behavior, the best prediction would be:

A. Reabsorption rate would increase linearly with blood glucose concentration indefinitely upward
B. Reabsorption rate would decrease as blood glucose increases above any threshold value
C. Reabsorption rate would oscillate randomly with no relationship to blood glucose levels
D. Reabsorption rate would plateau at high blood glucose, similar to enzyme saturation patterns

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

Neurons are specialized cells that transmit electrical signals along their length. Each neuron has a cell body, dendrites that receive signals, and a long axon that carries signals away. At the end of the axon, the signal must cross a small gap (the synapse) to the next neuron. The diagram below shows two neurons connected by a synapse.



16. When an action potential reaches the axon terminal, what happens next in the signal transmission sequence?

A. Synaptic vesicles release neurotransmitter molecules into the synaptic gap
B. The action potential jumps across the gap directly to the next neuron's axon
C. Neurotransmitter receptors fire their own action potential to alert the next neuron
D. Dendrites of the receiving neuron extend across the gap to make contact directly always

17. A drug blocks neurotransmitter receptors on the post-synaptic membrane. Predict the consequence for signal transmission:

A. Signal transmission is enhanced because more neurotransmitter is available in the gap
B. Signal transmission stops because the post-synaptic neuron cannot detect the signal
C. The pre-synaptic neuron compensates by releasing more neurotransmitter into the gap
D. The post-synaptic neuron fires action potentials randomly without receptor input ever

18. A patient is given a drug that blocks acetylcholine receptors at neuromuscular junctions. What is the most likely effect?

A. Muscles become hyperactive due to overstimulation from the blocked receptors there
B. Muscles experience stronger contractions because acetylcholine builds up in the gap
C. The nervous system compensates by producing more acetylcholine over time daily
D. Muscles become paralyzed because the signal from nerve to muscle is not received

19. The diagram shows neurotransmitter receptors on the post-synaptic membrane but not on the pre-synaptic membrane. This arrangement explains why:

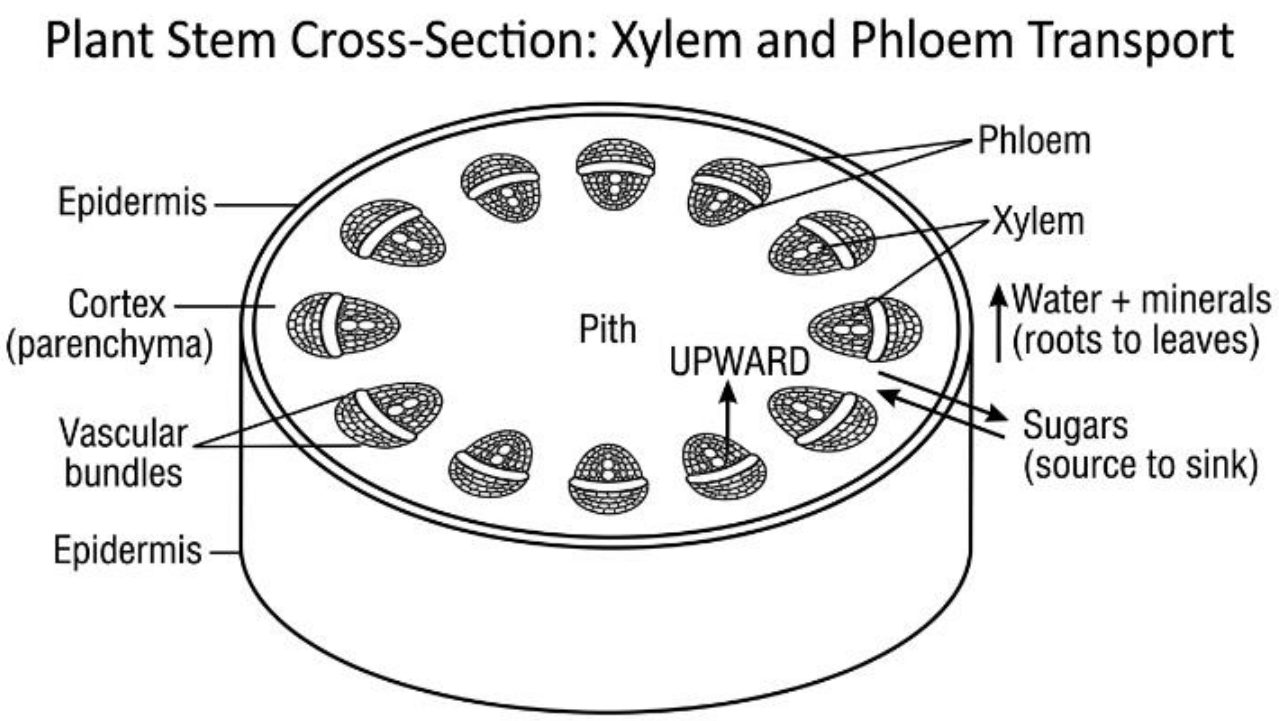
A. Signals travel in one direction across the synapse (pre-synaptic to post-synaptic)
B. Both neurons can communicate equally in either direction across the synaptic gap
C. Neurotransmitters do not affect the pre-synaptic neuron after they are released initially
D. The synaptic gap can only be crossed by very small molecules and ions present there

20. A new drug is being tested that increases neurotransmitter release at synapses. The most likely intended therapeutic effect is to:

A. Slow neural communication for patients with conditions involving excess neural firing
B. Enhance neural communication for patients with conditions involving deficient signaling
C. Block all neural communication for patients undergoing major surgical procedures safely
D. Eliminate the synaptic gap entirely so neurons can directly connect physically together

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

Plants transport materials through two vascular tissues: xylem and phloem. Xylem carries water and dissolved minerals from roots up to leaves through the transpiration stream. Phloem carries dissolved sugars (mostly sucrose) from "source" tissues (mature leaves) to "sink" tissues (roots, fruits, young leaves) through a process called translocation. The diagram below shows a cross-section of a plant stem with both vascular tissues identified.



21. Which observation would best support the conclusion that xylem transport is driven primarily by transpiration (water evaporation from leaves)?

A. Xylem transport speeds up at night when stomata are closed and humidity is high
B. Xylem transport is constant regardless of the light or humidity around the plant overall
C. Xylem transport occurs equally well in plants with no leaves and plants with leaves
D. Xylem transport slows when humidity is high and accelerates when humidity is low

22. A plant biologist tested whether a chemical blocked phloem transport. They labeled sugars with a radioactive tracer in source leaves and measured movement to roots. In treated plants, no radioactivity appeared in the roots. The best conclusion is:

A. The chemical blocked xylem transport from leaves to roots in the experiment overall
B. The radioactive tracer was destroyed by exposure to the chemical compound directly
C. The chemical blocked phloem transport from source leaves to root sinks effectively
D. The roots stopped growing in response to the chemical applied directly to the bark

23. Trace the path of water from soil to a leaf in a typical plant:

A. Soil → root hairs → root cortex → xylem in roots → xylem in stem → xylem in leaf → mesophyll → stomata
B. Soil → leaf surface directly → mesophyll cells → xylem → roots → cortex → soil again
C. Soil → root hairs → phloem in roots → phloem in stem → phloem in leaf → mesophyll cells
D. Soil → atmosphere → leaf stomata directly → mesophyll → roots → soil again continuously

24. A girdling experiment removes a complete ring of bark (including the phloem) from around a tree trunk, leaving the xylem intact. Predict the consequence after several months:

A. The roots receive less water → tree dies of dehydration from the top down quickly
B. The leaves receive less water → tree dies of dehydration from the bottom up overall
C. The roots receive no sugar → roots die first → eventually the whole tree dies
D. The tree compensates by growing new bark and is unharmed by this treatment

25. A counterfactual: if a plant species evolved without phloem, what would be the most likely consequence for its biology?

A. The plant would grow faster because it would not need to spend energy on phloem
B. The plant would have a more efficient water transport system without phloem competition
C. Plant could not transport sugars to non-photosynthetic tissues like roots or fruits effectively
D. The plant would survive without changes because phloem is not really essential for life

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

Charles Darwin observed that the Galápagos Islands contain multiple finch species, each with a distinct beak shape adapted to its food source. The finches share a common ancestor (a single mainland finch species that arrived long ago). Modern researchers continue to study how natural selection has shaped these beak differences.

26. A researcher proposes the hypothesis: "Galápagos finch beak shapes were shaped by natural selection based on local food sources." Which evidence would best SUPPORT this hypothesis?

A. The finches all live in the same general environment with very similar climate conditions
B. Finches on islands with hard seeds have deep, strong beaks; on islands with insects, slender beaks
C. The number of finch species has stayed exactly constant for thousands of years now
D. All Galápagos finch species can be brought together to produce fertile hybrid offspring

27. Which evidence would best ARGUE AGAINST the hypothesis above?

A. Each island has a slightly different climate that influences plant growth on that island
B. Galápagos finches are similar in size despite their beak differences across the islands
C. Some Galápagos finch species occasionally migrate between nearby islands to forage
D. Finch beak shapes are identical regardless of the food sources available on each island

28. A researcher tracked beak depth in one finch species through a major drought year. During the drought, only large hard seeds remained, and 90% of the finch population died. Among the survivors, average beak depth was 11 mm; before the drought, it was 9 mm. This observation BEST supports:

A. Natural selection — birds with deeper beaks crack hard seeds and survive at higher rates
B. Lamarckian inheritance — birds grew deeper beaks during the drought to adapt directly
C. Genetic drift — beak changes were caused by random sampling rather than selection
D. Convergent evolution — multiple species independently evolved similar beaks during stress

29. When normal rains returned the following year, the next generation of finches had average beak depth of 10.5 mm — slightly less than the drought survivors but more than pre-drought. The BEST conclusion from this observation:

A. The trait (deeper beak) is heritable and partially passed to the next generation
B. The drought damaged the birds' genes and they recovered their original phenotype
C. The next generation evolved different beaks unrelated to the parents' beaks completely
D. Beak depth has no genetic basis at all because the trait shrank back somewhat

30. A skeptic claims, "The beak depth change during drought is not real evolution — it just shows which birds happened to survive." Which response BEST addresses this critique?

A. The skeptic is correct; selection without genetic change is not considered to be evolution
B. The skeptic is correct; evolution requires changes in many generations of organisms together
C. The change in average beak depth among survivors IS evolution if the trait is heritable
D. The skeptic is correct because beak depth cannot be transmitted genetically by birds

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

Imagine a hypothetical Earth where the laws of biology operate slightly differently. For each scenario below, predict the consequences for life on this alternate Earth.

31. If mutations could NEVER occur, what would happen to life on this Earth over millions of years?

A. Life would evolve faster because no harmful mutations would slow down adaptation
B. Life would evolve at the same rate because adaptation depends on selection alone
C. Life would not evolve at all because new variation could not arise in populations easily
D. Life would diversify into more species because organisms would become more stable

32. If all individuals in a species could reproduce ASEXUALLY only, predict the consequence:

A. The species would diversify much more rapidly than sexually reproducing species do
B. The species would have less genetic variation, since shuffling alleles is eliminated
C. The species would no longer be subject to natural selection at all in any condition
D. The species would become immortal because asexual reproduction prevents aging entirely

33. If acquired characteristics (changes during an individual's lifetime) WERE passed to offspring, predict the consequence:

A. Evolution would proceed much more slowly because acquired changes are rare in nature
B. Natural selection would no longer be a useful concept for explaining adaptation in species
C. Evolution would proceed at the same rate but through different molecular mechanisms now
D. Adaptation could occur within a single generation, much faster than current evolution

34. If every individual produced exactly the same number of offspring (no variation in reproductive success), predict the consequence:

A. Genetic variation would increase rapidly across the entire population's gene pool
B. Beneficial alleles would still increase in frequency through random chance alone
C. The population would go extinct because no individuals would compete with each other
D. Natural selection could not operate because differential reproduction is its mechanism here

35. If DNA copying were perfectly accurate (zero replication errors), predict the long-term consequence:

A. Evolution would speed up because every offspring would be perfectly adapted to parents
B. New genetic variation would arise only from rare sources, slowing evolutionary change
C. Mutations would still occur from environmental damage at the same rate as before
D. Evolution would stop entirely because all variation comes from copy errors only

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

For each experiment described below, identify the most serious design flaw that would prevent the researchers from drawing valid conclusions.

36. A researcher tests whether a new fertilizer increases tomato yield. She applies the fertilizer to plants in her greenhouse and grows comparison plants without fertilizer in her outdoor garden. After 3 months, the greenhouse plants produce 2× the tomatoes. She concludes the fertilizer works. The most serious flaw:

A. The two groups differ in growing conditions (greenhouse vs. outdoor), confounding the fertilizer effect
B. The sample size of one plant per condition is too small to draw conclusions from these data
C. Experiment ran for too short a time to detect any meaningful difference between the groups
D. The researcher used tomatoes — fertilizers should be tested only on grain crops in fields always

37. A researcher claims that students who eat breakfast score higher on tests. He compares the test scores of 50 students who chose to eat breakfast that morning to 50 students who chose to skip breakfast. The breakfast eaters scored 8 points higher on average. The most serious flaw:

A. Sample size of 100 students total is not large enough to draw any conclusions about behavior
B. Test scores can be measured to one decimal place, making the comparison meaningless overall
C. Students who eat breakfast and students who skip cannot be compared scientifically at all
D. Self-selection — students who choose breakfast may differ in other ways (sleep, study habits)

38. A researcher gives all 200 patients in her study the experimental drug and finds that 75% improve. She concludes the drug works. The most serious flaw:

A. The study uses too few patients to reach a statistical significance threshold for reliability
B. The 75% improvement rate is too low to count as evidence of a working drug overall
C. Patients are too similar in age and background to represent the wider population overall
D. The study lacks a control group — patients might have improved without drug treatment

39. A researcher tests four pesticides on aphids and finds Pesticide A kills 100% of aphids in test 1, 50% in test 2, and 80% in test 3. He concludes Pesticide A is unreliable. The most serious flaw:

A. The researcher tested too few pesticides — a true comparison needs five or more options
B. The researcher did not control for variables across the three tests, making variation hard to interpret
C. The researcher should have used Pesticide B as the comparison rather than aphid mortality alone
D. The researcher should have tested only one trial because more trials introduce extra variability

40. A researcher surveys 50 readers of a fitness magazine and finds that 90% exercise regularly. He concludes that 90% of the general population exercises regularly. The most serious flaw:

A. The sample size is too small to make any conclusion about population behavior at all
B. The sample is biased — fitness magazine readers are not representative of the general population
C. The survey questions about exercise are too vague to interpret meaningfully across all readers
D. The researcher should have used in-person interviews rather than survey responses for accuracy

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

Read each scenario and apply your biology knowledge to a new context.

41. A medical researcher studies how a single chemical can cause cancer in mice but be harmless in humans. To which biological principle is this BEST applied?

A. Natural selection works the same way in mice and humans across all generations evenly
B. All chemicals affect all organisms identically because biochemistry is conserved completely
C. Genetic drift produces all the differences between mice and humans over time evenly
D. Different species can have different responses to chemicals because of evolved differences

42. A farmer notices that after spraying the same pesticide for 10 years, fewer insects are killed each year. The BEST explanation, applying evolutionary principles:

A. Natural selection has favored insects with resistance genes, increasing resistance over generations
B. The pesticide molecule has chemically degraded over the 10-year period of repeated use
C. Insects have learned to avoid the sprayed crops through behavioral conditioning over time
D. Climate change has made insects more resistant to chemicals in general now overall

43. A new species of parasite begins infecting a host species that has never encountered it before. Applying what you know about ecology and evolution, predict the most likely outcome over many generations:

A. Both species evolve together — parasite less virulent over time, host more resistant
B. The host species goes extinct because the parasite has perfect adaptation already
C. The parasite goes extinct because it cannot infect the resistant host species ever
D. The two species reach exactly the same equilibrium population sizes by chance alone

44. A team is engineering a fast-growing crop to feed a growing population. They focus on a single high-yield variety. Applying ecological principles, what risk does this strategy create?

A. The crop will grow too quickly and be impossible for farmers to harvest in time
B. The crop will require more fertilizer than older varieties because of rapid growth rates
C. A single disease or pest could destroy the entire crop because of low genetic diversity
D. The crop will lose its high-yield trait over generations because of natural selection

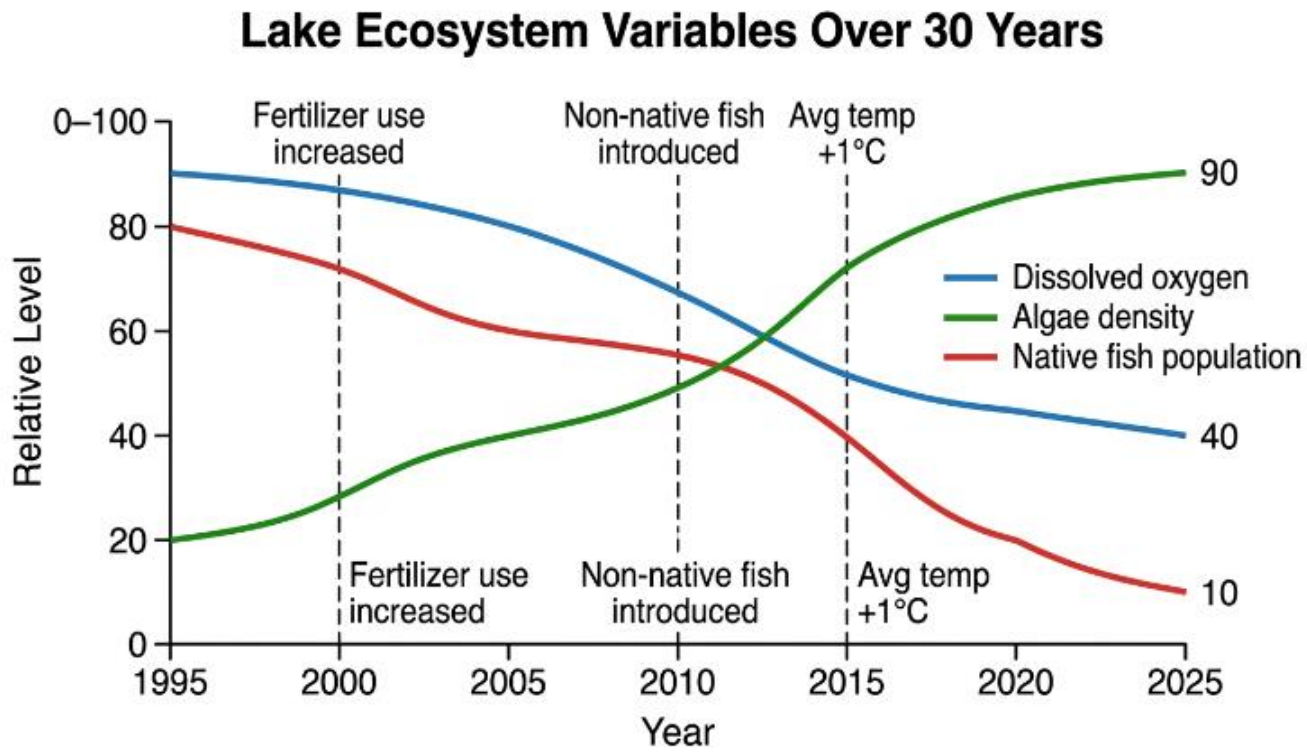
45. A doctor sees a patient with a bacterial infection. The patient's friend recommends they share antibiotics from their own previous prescription. Applying evolutionary principles, the doctor should explain that:

A. Sharing antibiotics is fine because all bacteria respond identically to all antibiotics overall
B. Incomplete or shared antibiotic use can select for resistant bacteria, making treatment harder later
C. The friend's antibiotics will be slightly more effective because they were used recently
D. Sharing antibiotics is fine if the patients have the same type of bacterial infection

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

A small lake in upstate New York is studied for 30 years. Over that period, surrounding farms increased fertilizer use, the air temperature rose by 1.5°C, and a non-native fish species was introduced. The graph

below shows changes in three lake variables: dissolved oxygen, algae density, and native fish population.



46. The decline in dissolved oxygen between 2005 and 2025 is best explained by:

A. Warmer water holds more oxygen, so the dissolved oxygen reading is artificially low overall
B. The fertilizer added oxygen to the lake initially but ran out over time eventually completely
C. Algae blooms led to massive decomposition, which consumed dissolved oxygen rapidly over years
D. Native fish breathing consumed all the available oxygen in the lake completely over years

47. The native fish decline accelerates after 2010. Apply what you know about ecology to identify the BEST explanation:

A. The non-native fish introduced in 2010 outcompetes or preys on the native fish population
B. The native fish naturally migrate out of lakes after 15 years regardless of any conditions
C. The native fish are sensitive to dissolved oxygen levels alone and unaffected by other factors
D. The native fish population always declines on a 30-year cycle in this region of New York

48. Which intervention would BEST address the ROOT cause of the lake's degradation?

A. Reducing fertilizer runoff from surrounding farms through better agricultural practices
B. Adding aerators to the lake to maintain dissolved oxygen levels throughout the year
C. Restocking native fish into the lake to maintain native fish populations going forward
D. Removing the non-native fish species through trapping and physical removal alone here

49. If a researcher concluded "Climate change is the sole cause of the lake's decline," the BEST critique would be:

A. The researcher is correct because temperature rise is shown in the data set clearly
B. The researcher is incorrect because climate change has nothing to do with lakes at all
C. The conclusion oversimplifies — fertilizer, climate, and invasive species all interact here
D. The researcher cannot conclude anything without measuring atmospheric CO_2 levels too

50. Predicting forward from the 2025 data point, if no intervention occurs, the most likely future state of the lake is:

A. Recovery to 1995 conditions because lakes naturally heal themselves over decades alone
B. Stable maintenance of current conditions for the foreseeable future without intervention
C. Improvement as native fish adapt to non-native fish through rapid evolutionary change overall
D. Continued deterioration — further algae growth, lower oxygen, and continued fish decline

Practice Exam 35: Full Answer Key with Explanations

1. D — All four blood types (A, B, AB, O) can only appear in the offspring if both parents carry an i allele. With mother I^A i × father I^B i, the cross produces all four genotypes: I^A I^B (AB), I^A i (A), I^B i (B), and ii (O). Homozygous parents would lack the i allele needed to produce type O offspring.

2. B — A Punnett square for I^A i × I^B i yields four equally probable offspring genotypes: I^A I^B, I^A i, I^B i, and ii. These correspond to phenotypes AB, A, B, and O respectively, each at 25%. The 1:1:1:1 ratio is the signature outcome of a doubly heterozygous cross with codominance plus a recessive third allele.

3. C — With both parents heterozygous (I^A i × I^B i), all four blood types are genetically possible offspring outcomes. There is no impossible blood type among Children 1–4 — the observed pattern fits exactly what the genetics predicts. The hospital error suspicion, if any, would need to be based on something other than blood type alone.

4. A — If the parents were homozygous (I^A I^A × I^B I^B), every offspring would receive one I^A and one I^B allele, producing only type AB children. Child 4 (type O) requires both parents to carry an i allele, which is impossible if both parents are homozygous. The other three children's blood types could be explained by a hospital error, but the type O child specifically rules out homozygous parents.

5. C — Type AB individuals have the genotype I^A I^B and carry no i allele. They can only pass I^A or I^B to their offspring, never i. Since type O (ii) requires two i alleles, no child of an AB parent can be type O — this is a definitive exclusion used in paternity testing.

6. C — The condition appears in offspring of unaffected parents in two separate generations (I-1 × I-2 → II-3, and II-1 × II-2 → III-2), which is the diagnostic signature of a recessive pattern. Both sexes are affected (III-4 is an affected female), ruling out X-linked recessive in this strict pattern. Autosomal recessive is the simplest inheritance pattern that fits all observations.

7. D — II-2 produced an affected (dd) child, III-2, meaning she must carry at least one d allele to transmit. She is phenotypically unaffected, so she cannot be homozygous dd. The only remaining genotype consistent with both facts is Dd — heterozygous carrier.

8. A — III-2 is dd and inherited one d allele from each parent. II-2 (the mother) is a carrier (Dd). For III-2 to be dd, II-1 (the father) must have contributed a d allele as well. Since II-1 is phenotypically unaffected, his genotype must be Dd — heterozygous carrier.

9. C — II-3 is affected (dd) and transmits d to every child. II-4 is a carrier (Dd) and transmits D or d with equal probability. The cross dd × Dd yields 50% Dd (carrier, unaffected) and 50% dd (affected), giving each child a 50% probability of being affected.

10. B — II-3 is dd, so every child of II-3 inherits a d allele from the father with certainty. Since III-5 is phenotypically unaffected (so not dd), her other allele (from carrier mother II-4) must be the dominant D. This means III-5 is necessarily Dd — every unaffected child of an affected × carrier mating is a heterozygous carrier.

11. C — In a healthy kidney, glucose passes freely through the glomerulus into the filtrate (100 mg/dL in both blood plasma and glomerular filtrate), but specialized transport proteins in the proximal tubule reabsorb all the glucose back into the blood. The result is that no glucose appears in the urine. Glucose appearing in urine is therefore a sign of disrupted kidney homeostasis.

12. A — Glucose reabsorption depends on a limited number of transport proteins that become saturated when blood glucose exceeds about 180 mg/dL (the renal threshold). At 300 mg/dL, blood glucose far exceeds this threshold, so the unreabsorbed excess spills into the urine. Glucose in the urine (glucosuria) is a classic diagnostic sign of poorly controlled diabetes.

13. B — Glucose in the renal tubule and bladder is osmotically active — it draws water from surrounding tissue into the urine by osmosis. This means more water remains in the urine, producing greater urine volume (polyuria). Excessive urination and the resulting thirst (polydipsia) are two of the classic signs of untreated diabetes that often lead to diagnosis.

14. B — Normal renal glucose reabsorption removes essentially all glucose from the filtrate as long as blood glucose stays below the threshold of about 180 mg/dL. At 150 mg/dL, the reabsorption system is not saturated, so all glucose is reabsorbed and urine remains glucose-free. This explains why mild hyperglycemia may not be detectable through urine testing alone.

15. D — Transport proteins, like enzymes, work by binding their substrate at a finite number of sites. When all sites are occupied, increasing substrate concentration cannot increase the rate of transport — the rate plateaus. This is the same Michaelis-Menten saturation pattern seen in enzymes, and it explains why kidneys cannot keep up with very high blood glucose levels.

16. A — When an action potential reaches the axon terminal, voltage-gated calcium channels open and trigger synaptic vesicles to fuse with the pre-synaptic membrane, releasing neurotransmitter into the synaptic gap. The neurotransmitter then diffuses across the gap to bind post-synaptic receptors. This chemical-then-electrical sequence is the fundamental mechanism of neural communication.

17. B — Neurotransmitters can only affect the post-synaptic neuron by binding to its receptors. If the receptors are blocked, the post-synaptic neuron cannot detect the signal regardless of how much neurotransmitter is released. This pharmacological strategy is the basis for many drugs that block specific receptor types — including some treatments for high blood pressure, anxiety, and pain.

18. D — Acetylcholine is the neurotransmitter that activates skeletal muscle contraction at the neuromuscular junction. Blocking its receptors prevents the muscle from receiving the nerve signal, leaving it paralyzed. This is how curare and similar paralytic agents work, and is also exploited clinically by anesthesia drugs used during surgery.

19. A — Neurotransmitter release occurs only from pre-synaptic terminals, and detection occurs only at post-synaptic receptors. This asymmetric arrangement enforces one-way signaling: signals can travel from pre-synaptic to post-synaptic but never in reverse. This unidirectional flow is essential for organized nervous system function.

20. B — Increasing neurotransmitter release amplifies the signal between neurons, making the post-synaptic neuron more likely to fire. Therapeutically, this helps patients whose neural communication is deficient — for example, drugs that increase serotonin levels (SSRIs) are used to treat depression by enhancing serotonergic signaling. The approach assumes the underlying problem is too little signaling.

21. D — Transpiration is the evaporation of water from leaves through stomata. When humidity is low, water evaporates faster, creating a stronger negative pressure that pulls more water up through the xylem from the roots. Conversely, high humidity slows evaporation and reduces the pulling force, slowing xylem transport. This pattern directly links environmental conditions to transport rate.

22. C — The radioactive tracer was applied to source leaves (where sugars are produced) and measured for arrival in root sinks (where sugars are consumed). The lack of tracer in roots after chemical treatment means the sugar transport pathway — phloem — was blocked. This experimental design is the standard way to study phloem function.

23. A — Water enters plant roots through root hairs (extensions of the epidermis), passes through the root cortex, enters xylem in the root, ascends xylem through the stem, branches into leaf xylem, exits xylem into mesophyll cells, and finally evaporates through stomata. This pathway is the classic transpiration stream that powers most plant water transport. Each step is necessary and ordered.

24. C — Phloem is the only tissue that transports sugars from leaves down to roots. When girdling severs the phloem, sugars produced by photosynthesis cannot reach root cells. The roots, which depend on this sugar supply to function, gradually starve and die — and with dead roots, the rest of the tree soon dies too. Girdling is a practical example of how blocking one transport tissue can kill a whole plant.

25. C — Phloem's specific function is moving sugars from source tissues (mature leaves) to sink tissues (roots, fruits, growing tips). Without phloem, the leaves would still photosynthesize but could not deliver the sugars to the rest of the plant, leaving roots and fruits without an energy source. This is why phloem is essential for any multicellular plant with non-photosynthetic tissues.

26. B — The strongest evidence for natural selection shaping beak shape would be a correlation between beak shape and the food the birds eat — exactly what option B describes. This correlation is what biologists have observed across Galápagos finch species, and it is the foundational evidence Darwin and later researchers have used to support adaptive radiation by natural selection.

27. D — If natural selection truly shaped beak differences based on local food sources, then differences in food should produce differences in beak shape. Identical beaks regardless of food source would mean natural selection had no effect on beak shape — directly contradicting the hypothesis. This is a textbook example of evidence that would falsify a hypothesis.

28. A — The dramatic shift in average beak depth (from 9 to 11 mm) among drought survivors is exactly what natural selection predicts: birds with deeper beaks survived because they could crack the remaining hard seeds, while birds with shallower beaks died. The 90% mortality during the drought provided strong selective pressure on this single trait. The Grants' work on Galápagos finches is a famous real-world demonstration of natural selection in action.

29. A — A heritable trait would be partially passed to offspring, so the next generation should be somewhat (but not perfectly) like their parents. The observed beak depth of 10.5 mm — between pre-drought (9 mm) and survivor (11 mm) — fits this pattern of partial heritability with regression toward the mean. If beak depth were entirely heritable, the offspring would average 11 mm; if entirely non-heritable, they would average 9 mm.

30. C — Differential survival of individuals with heritable variations IS the operational definition of natural selection. If beak depth is heritable (transmitted through alleles), then the changed allele frequencies in the survivor pool ARE evolution. The skeptic's argument confuses the mechanism (which is selection) with the outcome (which is changed gene frequencies — that is, evolution).

31. C — Mutations are the ultimate source of all new genetic variation in populations. Without mutation, no new alleles would arise, and the existing variation could only be shuffled by sexual recombination without ever introducing anything novel. Eventually, with no new variation entering the system, evolution would grind to a halt.

32. B — Asexual reproduction produces offspring that are genetic clones of the parent, with no recombination of alleles from two different individuals. This eliminates one of the major sources of genetic variation in populations. Asexual lineages do still mutate, but they lose the diversity-generating power of sexual reproduction and tend to evolve more slowly.

33. D — If acquired traits passed to offspring (Lamarckian inheritance), changes that an organism experienced during its lifetime would immediately appear in its descendants. This would allow populations to adapt within a single generation rather than waiting for the slow process of selection on heritable variation. Lamarckian inheritance does not occur in nature, but in this counterfactual it would speed adaptation dramatically.

34. D — Natural selection operates because some individuals leave more offspring than others, allowing favored alleles to spread through the population. If every individual produced exactly the same number of offspring regardless of any trait, allele frequencies could not change in response to selection — there

would be no mechanism for advantageous traits to spread. Differential reproductive success is the engine of natural selection.

35. B — Mutations arise from two main sources: errors in DNA replication and damage from environmental factors (UV light, chemicals, radiation). Eliminating replication errors would remove one major source of new variation, slowing the rate at which new alleles arise. However, environmental damage would continue to produce mutations, so evolution would slow but not stop entirely.

36. A — The fertilizer plants grew in a greenhouse while the no-fertilizer plants grew outdoors. The 2× yield difference could be caused by the fertilizer, the greenhouse conditions (controlled temperature, humidity, light), or both — but the design cannot distinguish between these. To isolate the fertilizer's effect, all other conditions must be identical, with only the presence or absence of fertilizer varying.

37. D — Students who choose to eat breakfast may differ from those who skip in many other ways: they may sleep better, have more organized homes, have more parental support, or have better study habits. Any of these uncontrolled differences could explain the test score gap rather than the breakfast itself. Self-selection bias is one of the most common sources of error in observational studies.

38. D — Without a control group of patients who did not receive the drug, the 75% improvement could be due to natural recovery, the placebo effect, regression to the mean, or other unmeasured factors. A control group provides the baseline needed to attribute improvement specifically to the drug. This is why randomized controlled trials with placebo groups are the gold standard in clinical research.

39. B — Variation in the kill rate across three tests (100%, 50%, 80%) might mean the pesticide is unreliable — or it might mean test conditions (aphid age, temperature, dose, application method) varied between tests. Without controlling these variables, the data cannot distinguish "unreliable pesticide" from "uncontrolled experimental conditions." Proper experimental design requires holding all variables constant except the one being tested.

40. B — Surveying readers of a fitness magazine systematically over-samples people who are interested in fitness. The 90% exercise rate reflects this biased sample, not the general population. Conclusions from a non-representative sample cannot be generalized to the broader population. Random sampling from the target population is essential for inferences about the population at large.

41. D — Different species have different biochemical pathways, enzymes, and detoxification systems, all shaped by their evolutionary history. A chemical that interacts dangerously with one species' biology may be harmless to another whose pathways differ. This is why drug and pesticide testing must always consider species-specific responses.

42. A — When a pesticide is applied repeatedly, individuals with genetic variants that confer resistance survive at higher rates than susceptible individuals. Over generations, the frequency of resistance alleles rises in the population, making the pesticide progressively less effective. This is natural selection in action and is a major reason agricultural pesticides lose effectiveness over time.

43. A — When a parasite encounters a new host, both species enter an evolutionary arms race. Hosts that survive infection (because of genetic variation in resistance) pass on resistance alleles, while parasites that

don't kill their hosts too quickly have more opportunity to spread to new hosts. The result is typically declining virulence in the parasite and increasing resistance in the host — classic coevolution.

44. C — A genetically uniform crop has no variation to defend against a new pest or pathogen — if one plant is susceptible, they all are. A single outbreak could devastate the entire crop, as happened in the Irish potato famine. Genetic diversity in agricultural crops is essential for resilience against disease, climate variation, and emerging threats.

45. B — Each bacterial infection contains many bacterial cells with slight genetic variation; antibiotics kill the susceptible ones first. Incomplete courses leave some surviving bacteria — those with the most resistance — to multiply, increasing the prevalence of resistance in the bacterial population. This is one of the major causes of antibiotic resistance globally, making once-treatable infections harder to cure.

46. C — Excess nutrients (from fertilizer runoff) cause algae populations to grow explosively (algal bloom). When the algae die, decomposer bacteria consume them and use up the dissolved oxygen in the process. The result is hypoxic (low-oxygen) water that suffocates fish — the classic sequence of eutrophication.

47. A — Introducing a non-native predator or competitor often devastates native species that have not evolved defenses against the new threat. The 2010 timing of the non-native fish introduction matches exactly the year native fish decline accelerated, supporting cause-and-effect. Invasive species are one of the leading drivers of biodiversity loss worldwide.

48. A — The lake's degradation chain begins with fertilizer runoff causing eutrophication, which drives all subsequent problems (algal bloom, dissolved oxygen loss, fish die-off). Addressing fertilizer runoff at its source is the only intervention that targets the root cause rather than treating downstream symptoms. The other options would help temporarily but would not solve the underlying problem.

49. C — Real ecological declines almost always have multiple interacting causes. The lake's data show three plausible drivers operating simultaneously (fertilizer, non-native species, climate). Attributing the decline to any single cause oversimplifies the actual ecology. Effective management requires understanding and addressing all major drivers.

50. D — The downward trends in dissolved oxygen and native fish, and the upward trend in algae, will continue as long as the underlying drivers (fertilizer runoff, non-native fish presence, warming temperatures) persist. Without intervention, the lake will likely cross a tipping point into a stable degraded state — a common outcome for eutrophied lake ecosystems. Conservation requires action before such tipping points are reached.