PRACTICE EXAM 30: 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 is sequenced to be substantially more challenging than Practice Exam 1. Questions are organized into stimulus-based clusters. Read each stimulus completely before answering any questions in the set. Watch for EXCEPT, NOT, and LEAST items, which ask you to identify the answer choice that does NOT fit. 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 transport across kidney tubule cells, which normally absorb glucose from the filtrate back into the bloodstream against a steep concentration gradient. The researchers tested how glucose transport was affected by three conditions: normal conditions with oxygen and ATP available; the presence of ouabain, a chemical that inhibits the sodium-potassium pump; and the absence of sodium ions in the surrounding fluid. In all three conditions, glucose was present in the filtrate at the same concentration. The kidney cells use a cotransporter protein that binds both sodium and glucose simultaneously and moves them together across the cell membrane. The table below shows their results.

Condition	Glucose Transport Rate (relative to normal)	Sodium-Potassium Pump Activity
Normal (O_2 and ATP available)	100%	Active
Ouabain added	8%	Blocked
Sodium removed from surroundings	12%	Active (no Na^+ available to pump)

1. What is the most likely role of the sodium-potassium pump in glucose transport across these kidney cells?

A. It directly binds glucose molecules and pumps them across the membrane B. It maintains a sodium gradient that powers glucose entry by cotransport C. It blocks glucose from entering the cell through facilitated diffusion D. It produces the ATP needed for glucose-binding receptors to function

2. Which conclusion is best supported by the data in the table?

A. The kidney cells transport glucose by simple diffusion alone B. Sodium ions slow glucose transport when present in the surroundings C. Glucose transport in these cells depends indirectly on the sodium-potassium pump D. The sodium-potassium pump and glucose transport function independently

3. All of the following are forms of active transport EXCEPT:

A. Osmosis of water through aquaporin channels in cell membranes B. Operation of the sodium-potassium pump against ion gradients C. Endocytosis of large particles into vesicles using ATP energy D. Movement of solutes against a concentration gradient using ATP

4. Which of the following would most likely happen if ATP production were suddenly blocked in these kidney cells?

A. The sodium-potassium pump would accelerate to compensate for the energy loss B. The glucose-binding receptors would change shape to bind glucose more strongly C. Sodium and potassium concentrations across the membrane would remain stable D. The sodium gradient would dissipate, and glucose transport would decline sharply

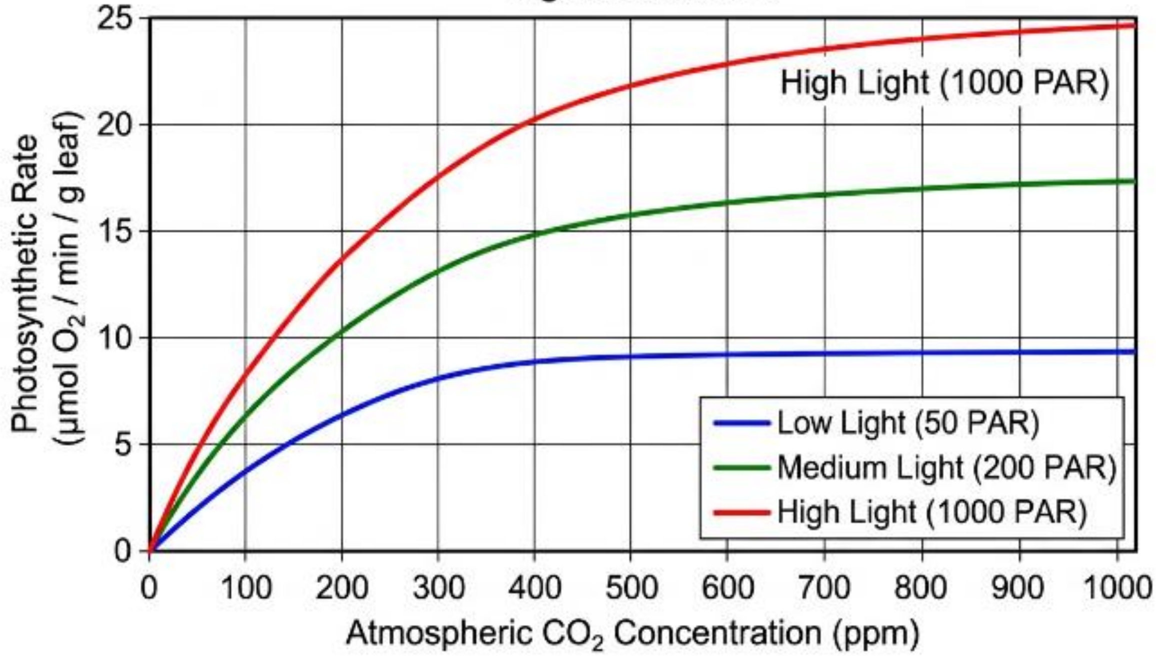
5. A second drug is found that does not affect the sodium-potassium pump but specifically blocks the glucose-sodium cotransporter on the membrane. The most likely effect on the cells would be that:

A. The sodium gradient across the membrane would collapse within seconds B. ATP production by the mitochondria would increase to compensate for losses C. Sodium would still be pumped out, but glucose would not enter the cell D. The cell would still absorb glucose at nearly normal rates by diffusion

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

A research team grew genetically identical wheat plants under controlled greenhouse conditions and measured photosynthetic rate (in micromoles O_2 produced per minute per gram of leaf tissue) at varying atmospheric CO_2 concentrations and three different light intensities. The results are shown in the graph below.

Figure PQ-1 Photosynthetic Rate vs. CO_2 Concentration at Three Light Intensities



6. At very low CO_2 concentrations (below 100 ppm), the three curves nearly overlap. The best explanation for this observation is:

A. CO_2 is the limiting factor at low concentrations, regardless of light intensity B. Light intensity has no effect on photosynthesis at any CO_2 concentration C. The wheat plants stop photosynthesizing entirely below 100 ppm CO_2 D. The plants switch to cellular respiration whenever CO_2 becomes scarce

7. As CO_2 concentration increases above 600 ppm, the high-light curve continues to rise slightly while the low-light curve has fully leveled off. This pattern indicates that:

A. The low-light condition produces more glucose than the high-light condition does B. CO_2 becomes toxic to wheat plants when light intensity is also low C. The low-light condition allows wheat to grow faster than the high-light condition D. At low light, factors other than CO_2 have become limiting for the low-light plants

8. Which statement about the oxygen produced in this experiment is best supported by the chemistry of photosynthesis?

A. The oxygen comes from the carbon atoms in atmospheric CO_2 B. The oxygen comes from water molecules split during the light reactions C. The oxygen is produced as a waste of the Calvin cycle in the stroma D. The oxygen is captured from the surrounding atmosphere during respiration

9. All of the following could explain the leveling off of photosynthetic rate at high CO_2 concentrations EXCEPT:

A. The enzymes of carbon fixation have become saturated with substrate B. The Calvin cycle has begun running in reverse, consuming sugar instead C. The water available for the light reactions has become limiting D. The rate at which CO_2 diffuses into leaves has reached its maximum

10. An additional experiment shows that net photosynthetic rate becomes negative in complete darkness at all CO_2 concentrations. The best explanation is that:

A. Cellular respiration continues in darkness, consuming oxygen and releasing CO_2 B. The leaves stop performing both photosynthesis and respiration in darkness C. The Calvin cycle begins running in reverse without light energy input D. Photolysis of water continues, but oxygen is consumed by stomata closure

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

Cystic fibrosis (CF) is a genetic disease caused by mutations in the CFTR gene, which codes for a chloride ion channel protein in the cell membrane. The most common CF-causing mutation is a three-nucleotide deletion in the DNA sequence that removes the codon for phenylalanine at position 508 in the CFTR protein. Patients with this mutation produce a CFTR protein that misfolds and is degraded before reaching the cell membrane, leading to thick mucus accumulation in the lungs and other organs. Researchers are investigating gene therapy approaches that would introduce a functional copy of the CFTR gene into airway cells using a modified virus as the delivery vehicle.

11. The three-nucleotide deletion in the CFTR gene is best classified as which type of mutation?

A. A point mutation involving a single base substitution B. A frameshift mutation that scrambles the entire downstream sequence C. A small in-frame deletion that removes one amino acid from the protein D. A whole-chromosome duplication affecting many genes simultaneously

12. Why does the deletion of a single codon from the CFTR gene produce a non-functional protein, even though most of the protein's amino acids remain unchanged?

A. The deletion stops translation at the position where phenylalanine should appear B. The remaining amino acids cannot form peptide bonds without phenylalanine C. The missing amino acid disrupts the protein's folding and three-dimensional shape D. The deletion adds a premature stop codon that truncates the protein chain

13. Which sequence of cellular events best describes how the CFTR gene normally produces a functional protein?

A. DNA → mRNA via transcription → polypeptide via translation at the ribosome B. DNA → polypeptide via direct translation → mRNA via reverse transcription C. mRNA → DNA via replication

→ polypeptide via Calvin cycle synthesis D. DNA → mRNA via translation → polypeptide via transcription in the nucleus

14. A proposed gene therapy delivers a functional CFTR gene into airway cells using a modified virus as the delivery vehicle. For the therapy to succeed, the introduced gene must:

A. Replace every existing copy of the mutant gene throughout the entire body B. Be expressed by the cell's transcription and translation machinery to produce functional protein C. Permanently integrate into the patient's germ-line DNA for inheritance by offspring D. Replicate independently in the cytoplasm without using any host-cell machinery

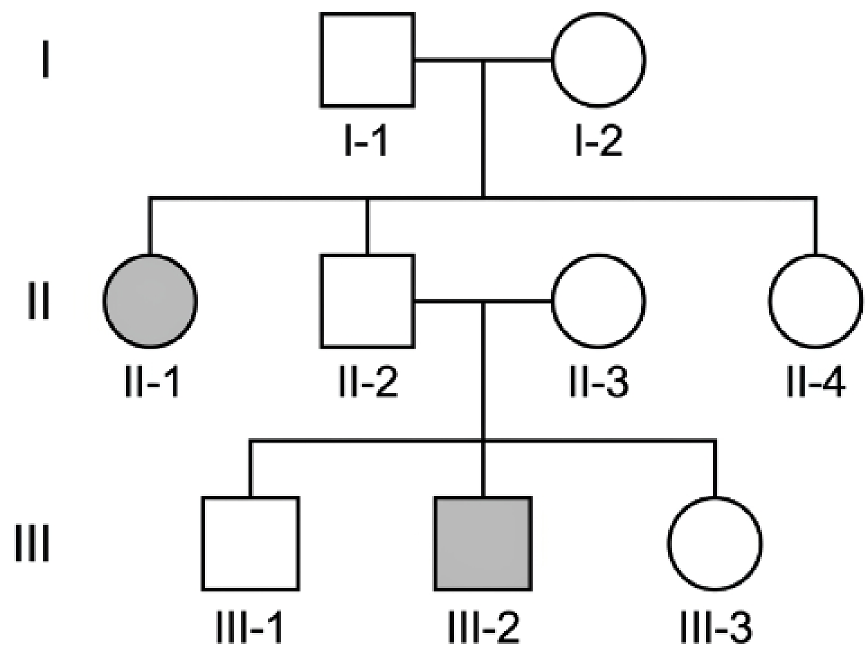
15. Which of the following is the LEAST likely concern for gene therapy approaches to cystic fibrosis?

A. The patient's immune system may react against the viral delivery vehicle B. The introduced gene may insert into a site that disrupts another important gene C. The therapeutic effect may diminish as treated cells die and are replaced over time D. The introduced gene may produce too much functional CFTR protein, causing toxicity

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

A pedigree showing the inheritance of a particular trait across three generations of a single family is provided below. Affected individuals are shown in shaded symbols; unaffected individuals are shown in unshaded symbols. Squares represent males; circles represent females. The trait appears in some individuals and not in others, and the pedigree should be analyzed to determine the most likely inheritance pattern.

[Figure PQ-2] Pedigree — Inheritance of Trait X



16. Based on the pedigree, the trait is most likely inherited as:

A. Autosomal dominant, because affected individuals appear in multiple generations B. X-linked dominant, because both males and females are affected in the family C. Autosomal recessive, because affected children have two unaffected parents D. Y-linked inheritance, because the trait passes from fathers to sons in this family

17. What is the most likely genotype of individual II-2 (the unaffected son of I-1 and I-2)?

A. AA, because both parents are carriers and most unaffected offspring are homozygous dominant B. aa, because the trait is recessive and unaffected individuals must be homozygous recessive C. AA or Aa with equal probability, because we cannot determine which without testing D. Aa, because he must be a carrier to have an affected child with a carrier partner

18. Individuals III-1 and III-3 are unaffected. Given their parents' genotypes (both heterozygous carriers), what is the probability that any one of them is a carrier?

A. 1/4, since one of four possible offspring genotypes is heterozygous in this cross B. 2/3, since two of the three possible unaffected genotypes are heterozygous carriers C. 1/2, since half of all offspring from a heterozygous cross are also heterozygous D. 1/3, since the trait shows in only one of three unaffected children in this pedigree

19. If individual III-2 (the affected child) grows up and has children with an individual from the general population who is not a carrier, what is the probability that any one of his children will be affected?

A. 0%, because the unaffected partner contributes only dominant alleles to every offspring B. 25%, because the affected parent could pass either allele to offspring randomly C. 50%, since the affected parent will pass the recessive allele to half of his offspring D. 100%, because affected individuals always produce affected offspring regardless of partner

20. Which conclusion about this trait is LEAST supported by the pedigree?

A. The trait shows an autosomal recessive inheritance pattern in this family B. Both parents in Generation I are heterozygous carriers of the recessive allele C. The trait skips generations because environmental factors trigger its expression D. Unaffected individuals in the family may still be carriers of the recessive allele

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

Researchers added equal amounts of yeast to four sealed flasks containing identical sugar solutions but different gases filling the headspace above the liquid. They measured the rate of CO_2 production from the yeast over a one-hour period at 30°C. The results are shown below.

Flask	Headspace Gas	Rate of CO_2 Production (mL/hr)
1	Air (21% O_2)	45
2	Pure nitrogen (0% O_2)	38
3	Pure oxygen (100% O_2)	47
4	Carbon dioxide (0% O_2)	36

21. Which conclusion is best supported by the data in the table?

A. Yeast produces more CO_2 when no oxygen is available than when oxygen is present B. Yeast can produce CO_2 both with and without oxygen, but the rates differ C. Yeast cells stop producing CO_2 entirely when surrounded by carbon dioxide gas D. The presence of nitrogen completely halts fermentation activity in yeast cells

22. The CO_2 produced in Flask 2 (pure nitrogen, no oxygen) is most likely a product of:

A. Aerobic cellular respiration, which produces CO_2 as a final waste product B. The Calvin cycle, which fixes CO_2 from the surrounding gas mixture C. Alcoholic fermentation, which produces CO_2 and ethanol from pyruvate D. Active transport, which uses ATP to pump CO_2 across the cell membrane

23. A key difference between aerobic respiration and fermentation in yeast is that:

A. Aerobic respiration yields far more ATP per glucose molecule than fermentation does B. Fermentation requires oxygen as the final electron acceptor in the electron transport chain C. Aerobic respiration produces ethanol while fermentation produces only carbon dioxide D. Fermentation occurs in the mitochondrial matrix while aerobic respiration occurs in the cytoplasm

24. If the researchers measured ethanol concentration in each flask after one hour, they would most likely find:

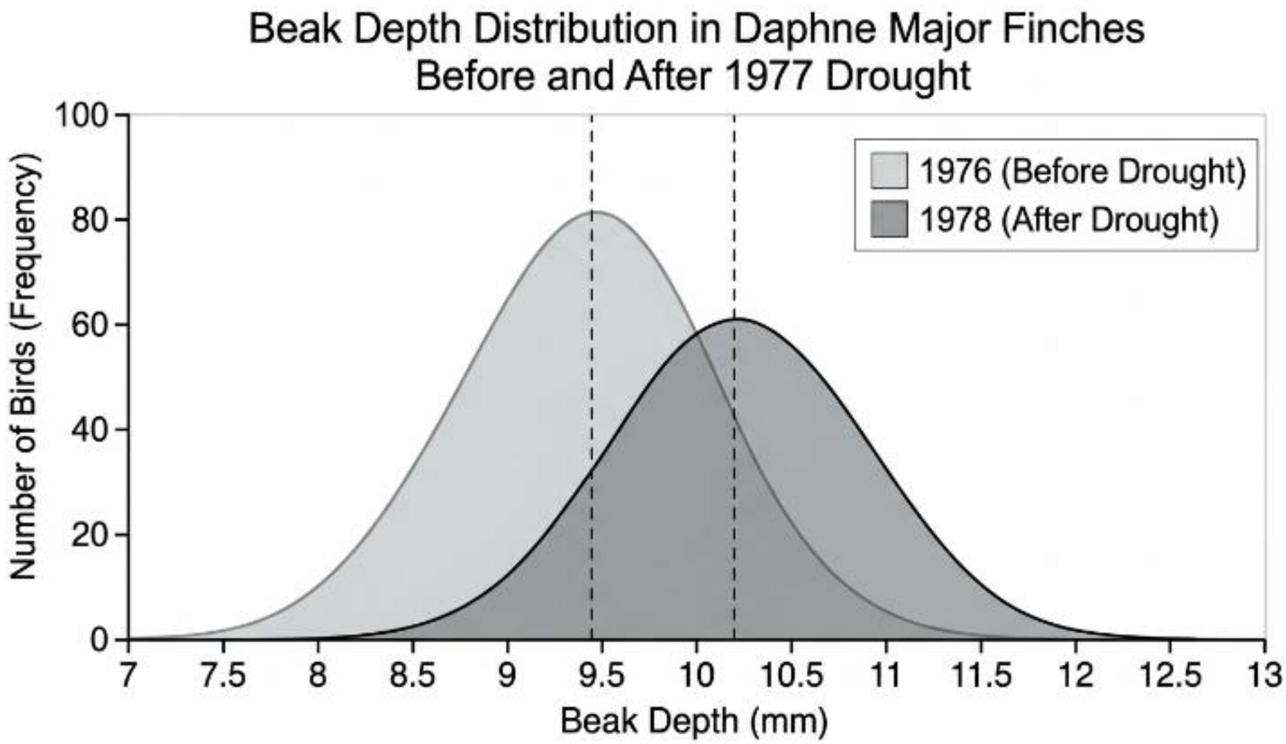
A. The highest ethanol levels in Flasks 2 and 4, where oxygen was absent B. The highest ethanol levels in Flasks 1 and 3, where oxygen was present C. No ethanol in any flask because yeast cannot produce ethanol from sugar D. Equal ethanol levels in all four flasks regardless of oxygen presence

25. If the researchers wanted to use the same yeast to produce alcoholic beverages most efficiently, they should:

A. Provide maximum oxygen, since CO_2 production was highest with oxygen present B. Provide a moderate amount of oxygen to balance both pathways simultaneously C. Heat the flasks above 50°C to speed up all metabolic reactions involved D. Eliminate oxygen, since ethanol is produced primarily by anaerobic fermentation

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

For decades, researchers studied a population of medium ground finches on Daphne Major, a small Galápagos island. The finches eat seeds of varying sizes, and individual birds differ in beak depth, with deeper beaks better suited to cracking large, hard seeds. In 1977, a severe drought struck the island. Small soft seeds, normally abundant, became scarce. Larger, harder seeds remained available throughout the drought. The graph below shows the distribution of beak depths in the population before the drought (1976) and after the drought (1978).



26. Which of the following best describes the change in beak depth between 1976 and 1978?

A. Beak depth became substantially more variable in the population after the drought B. The average beak depth in the population increased noticeably after the drought C. Beak depth was unchanged because the drought lasted less than a generation D. All birds with shallow beaks survived the drought as well as deep-beaked birds

27. What is the most likely cause of the change shown in the graph?

A. The drought caused random mutations that produced deeper beaks in surviving birds B. The surviving finches gradually grew larger beaks during the drought to access tough seeds C. Natural selection favored birds with deeper beaks because they could crack the remaining seeds D. Finch parents passed their drought experiences to offspring through learned behaviors and habits

28. Which of the following conditions must be true for this change to be considered evolution by natural selection?

A. Beak depth must be heritable, with parents passing the trait to offspring through genes B. The drought must have caused every finch in the population to develop a deeper beak C. All surviving finches must have produced exactly the same number of offspring afterward D. The population must have remained genetically identical from before to after the drought

29. Decades later, several years of unusually wet weather make small soft seeds extremely abundant. Which prediction about the finch population is most consistent with natural selection?

A. Average beak depth may decrease over generations as smaller-beaked birds gain an advantage B. Average beak depth will continue increasing because evolution moves in only one direction C. The population will become extinct because all current finches have beaks adapted to hard seeds D. Beak depth will randomly fluctuate with no relationship to seed availability or food access

30. A student claims that the change in beak depth shows that finches "evolved to be better adapted to drought conditions." Which of the following best evaluates this claim?

A. The claim is fully correct because individual finches changed their beaks during their lifetimes B. The claim is broadly correct but should clarify that populations evolve, not individual finches C. The claim is incorrect because finches cannot evolve in response to short-term climate events D. The claim is incorrect because drought conditions do not affect biological adaptation patterns

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

A hospital laboratory studied a bacterial strain that has become resistant to a commonly used antibiotic. Genetic analysis revealed that the resistant bacteria carry a plasmid — a small circular DNA molecule separate from the main chromosome — that codes for an enzyme called beta-lactamase. This enzyme breaks down the antibiotic before it can damage the bacterial cell. Researchers found that resistant bacteria can transfer the plasmid to other bacteria through a process called conjugation, in which one cell donates a copy of the plasmid to another through direct contact. The lab is investigating how quickly resistance spreads through bacterial populations and whether new antibiotics can target the beta-lactamase enzyme itself.

31. The beta-lactamase enzyme reduces antibiotic effectiveness primarily by:

A. Strengthening the bacterial cell wall to resist antibiotic attack completely B. Pumping the antibiotic out of the bacterial cell faster than it can enter C. Preventing the antibiotic from binding to bacterial ribosomes during translation D. Chemically breaking down the antibiotic into inactive products before it can act

32. The transfer of plasmids between bacteria through conjugation differs from typical inheritance because:

A. It allows resistance to spread between unrelated bacteria, not just from parents to offspring B. It produces offspring that always carry exactly the same alleles as both of the parent bacteria C. It occurs only during binary fission, when bacteria divide into two identical daughter cells D. It requires meiosis to occur, which is a normal feature of bacterial reproductive division

33. Which of the following is LEAST likely to slow the spread of antibiotic resistance in hospital settings?

A. Limiting antibiotic use only to infections where bacterial cause is confirmed B. Isolating patients infected with resistant bacteria from other patients C. Requiring strict hand hygiene by all healthcare workers between patients D. Increasing the dose of the existing antibiotic substantially when treatment begins to fail

34. A new drug is developed that specifically inhibits beta-lactamase without harming any other bacterial enzymes. The drug would most likely be used:

A. As a replacement for the original antibiotic, used by itself for treating infections B. Together with the original antibiotic, allowing the antibiotic to remain effective C. Only on patients who do not yet have a bacterial infection of any kind D. To prevent the original antibiotic from causing harmful side effects in patients

35. A researcher claims that the use of antibiotics in livestock feed contributes to the rise of resistance in human pathogens. Which of the following best evaluates this claim?

A. The claim is plausible, since antibiotic use anywhere creates selective pressure that can spread to other settings B. The claim is incorrect, because resistance in livestock bacteria cannot transfer to bacteria that infect humans C. The claim is incorrect, because antibiotics used in livestock are entirely different from those used in human medicine D. The claim is plausible only if all livestock bacteria are genetically identical to human pathogenic bacteria

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

Researchers measured the total biomass (in kilograms per hectare) at each trophic level in three nearby freshwater aquatic ecosystems with similar climates but different histories of human use. The data are shown in the table below.

Ecosystem	Producers	Primary Consumers	Secondary Consumers	Tertiary Consumers
Lake A	10,000	1,000	100	10
Lake B	12,000	1,200	100	5
Lake C	8,000	600	30	0

36. Which conclusion about energy flow is best supported by the data across all three lakes?

A. Energy increases substantially as it moves up through the trophic levels of each lake B. The amount of energy at each level is roughly the same across all three lakes C. Each trophic level contains substantially less biomass than the level below it D. Tertiary consumers carry the largest pool of available energy in each studied lake

37. The decline in biomass from each trophic level to the next is most directly explained by:

A. Energy is lost as heat through cellular respiration by organisms at each level B. Carbon dioxide accumulating in organisms as they progress up the food chain C. Predators consuming larger amounts of food than they need to survive each day D. Organisms at higher trophic levels reproduce faster than those at lower levels

38. Lake C lacks tertiary consumers entirely. Which factor most likely explains their absence?

A. The lake is too cold to support large predators of any kind B. The biomass of secondary consumers is insufficient to support a tertiary level C. Tertiary consumers were specifically removed from Lake C by researchers D. The producers in Lake C are nutritionally unsuitable for higher consumers

39. An invasive species is introduced into Lake A that preys heavily on the primary consumers. Which of the following is the most likely short-term consequence?

A. Producer biomass will increase as herbivory by primary consumers declines B. Secondary consumer populations will grow because primary consumers reproduce faster C. Tertiary consumer biomass will increase due to direct feeding on the invasive species D. The biomass at each trophic level will remain essentially unchanged in the short term

40. A new species is introduced into Lake A that feeds at multiple trophic levels — eating producers, primary consumers, and secondary consumers. This species is best classified as a(n):

A. Decomposer, because it breaks down dead material from multiple trophic levels B. Producer, because it gains energy from organisms at lower trophic positions C. Omnivore, because it consumes both plant matter and other consumer organisms D. Tertiary consumer, because it sits at the very top of the food web

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

A forest in the northeastern United States was clear-cut in 1950 for agricultural use. The land was abandoned by 1960 and left to recover naturally. Researchers monitored species composition and biomass on the recovering site every five years for the next seven decades. They also measured atmospheric inputs and outputs of carbon, nitrogen, and phosphorus across the site over time. After 70 years, the recovering forest is approaching the species composition of a mature deciduous forest typical of the region.

41. The recovery of the forest after clear-cutting and agricultural abandonment is best classified as:

A. Primary succession, because the original community was completely destroyed by clear-cutting B. Secondary succession, because soil and some living organisms remained at the start of recovery C. Convergent evolution, because related plant species developed similar adaptations independently D. Coevolution, because plant and animal species evolved together during the recovery period

42. During the first ten years of recovery, the site was dominated by fast-growing grasses and herbaceous plants. These plants are best classified as:

A. Climax species, which dominate the final stable stage of forest succession B. Keystone species, which have a disproportionate effect on community structure C. Invasive species, which were intentionally introduced from outside the region D. Pioneer species, which colonize disturbed areas and tolerate harsh conditions

43. As the forest matured over 70 years, the total carbon stored in living plant biomass on the site:

A. Decreased steadily as decomposers broke down organic matter into atmospheric carbon B. Remained constant because new growth was balanced by equal decomposition losses C. Fluctuated randomly with no consistent trend across the seven decades of recovery D. Increased substantially as trees grew larger and stored carbon in wood and leaves

44. Most of the nitrogen entering the recovering forest from outside the site came from:

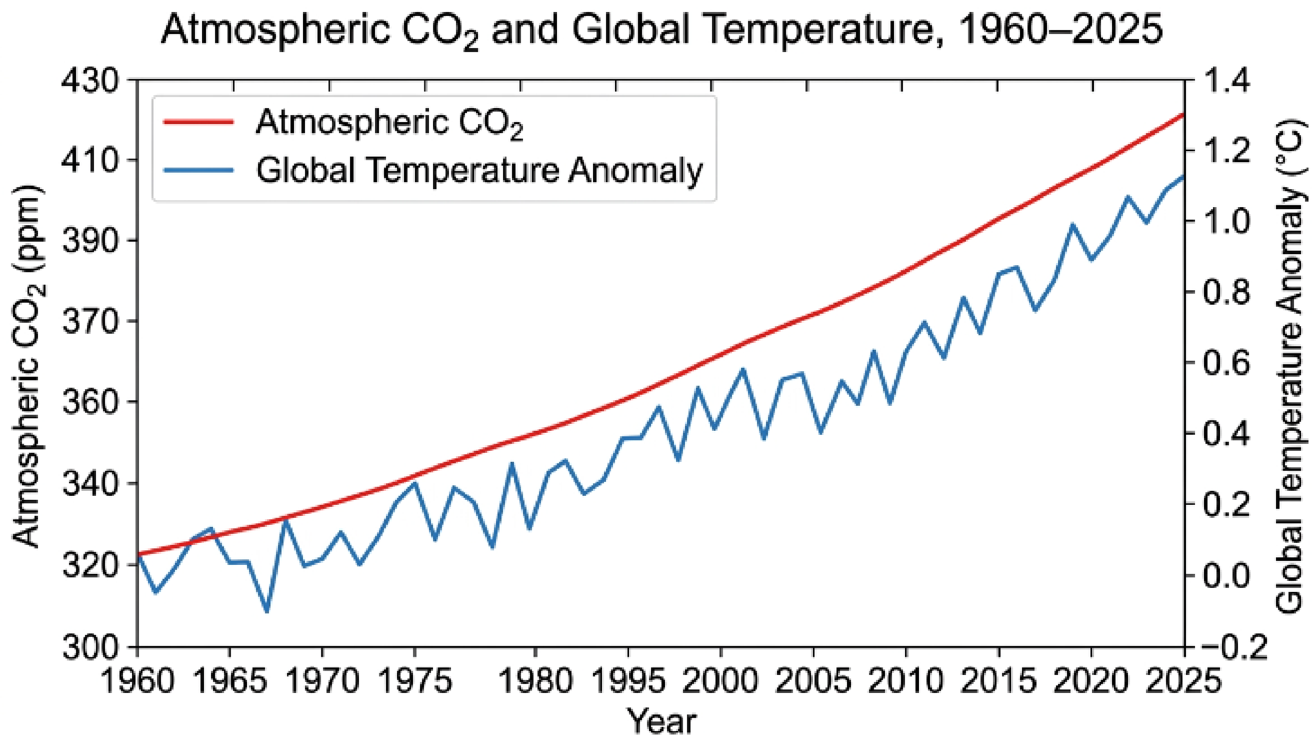
A. Direct uptake of nitrogen gas (N_2) from the atmosphere by tree roots and leaves B. Sedimentary rocks slowly releasing nitrogen as they weathered over time C. Atmospheric nitrogen fixed by specialized soil bacteria and deposited through precipitation D. The combustion of fossil fuels in surrounding cities that fell directly onto the soil

45. Compared to the carbon and nitrogen cycles, the phosphorus cycle differs because:

A. Phosphorus has the largest atmospheric reservoir of any biogeochemical cycling element B. Phosphorus moves much faster through ecosystems than carbon or nitrogen does C. Phosphorus is not required by living organisms in any measurable quantities D. Phosphorus lacks an atmospheric component and moves primarily through rocks and water

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

Researchers have measured atmospheric CO_2 concentration and global average surface temperature for over six decades. The graph below shows the trends from 1960 to 2025. Engineers are developing several proposed responses to address rising CO_2 levels, including direct air capture systems (devices that pull CO_2 out of the atmosphere), large-scale reforestation projects, and switching electricity generation from fossil fuels to renewable sources such as wind and solar.



46. Which conclusion is best supported by the data shown in the graph?

A. Atmospheric CO_2 levels have remained essentially constant over the past six decades B. Global temperatures have decreased steadily as CO_2 concentrations have increased C. CO_2 concentration and global temperature show no measurable relationship to each other D. Atmospheric CO_2 and global temperature have both risen substantially since 1960

47. The greenhouse effect contributes to global warming primarily by:

A. Reflecting incoming solar radiation back into space before it warms the surface B. Trapping infrared radiation emitted from Earth's surface within the lower atmosphere C. Increasing the speed at which solar radiation reaches the surface of the planet D. Cooling the stratosphere by accelerating reactions between ozone and atmospheric gases

48. A team evaluating three engineering approaches — direct air capture, reforestation, and renewable electricity — must weigh trade-offs among them. Which factor is LEAST useful for comparing these approaches?

A. The total amount of CO_2 each approach could remove or avoid each year at scale B. The energy required to operate each approach and where that energy would come from C. The land area each approach would require if deployed at meaningful global scale D. The aesthetic appearance of the technology when viewed from a distant vantage point

49. Reforestation reduces atmospheric CO_2 primarily because trees:

A. Reflect sunlight back into space before it reaches the surrounding ground B. Release oxygen that chemically combines with atmospheric CO_2 to form water C. Absorb atmospheric CO_2 during photosynthesis and store carbon in their woody tissues D. Convert atmospheric CO_2 directly into nitrogen-rich compounds within their leaves

50. Which combination of strategies is most likely to be effective in addressing rising atmospheric CO_2?

A. Reforestation by itself, deployed across all available agricultural land worldwide B. Direct air capture by itself, deployed at industrial scale in coastal regions C. Multiple strategies acting together, including emission reductions and CO_2 removal D. A single proven technology applied universally to all global energy production needs

PRACTICE EXAM 30: ANSWER KEYS

1. B — The sodium-potassium pump uses ATP to push Na^+ out of the cell, creating a steep sodium gradient between the cell interior and the surrounding fluid. Glucose then enters the cell against its concentration gradient by riding on a cotransporter that uses the inward flow of Na^+ as the energy source. The pump powers glucose absorption indirectly through this gradient.

2. C — When the Na/K pump is blocked (ouabain) or sodium is absent, glucose transport drops dramatically — to 8% and 12% of normal respectively. Both conditions disrupt the sodium gradient that powers cotransport, even though the cotransporter itself is intact. The data therefore indicate that glucose transport is indirectly dependent on the Na/K pump.

3. A — Active transport requires energy (usually ATP) to move substances against a concentration gradient. Osmosis of water through aquaporins is passive — water simply flows down its own concentration gradient without ATP. The Na/K pump, endocytosis, and ATP-driven solute movement are all active processes.

4. D — The Na/K pump requires ATP to maintain the sodium gradient. Without ATP, the pump stops, sodium leaks back into the cell down its gradient, and the gradient dissipates. With no sodium gradient, the cotransporter cannot pull glucose into the cell, so glucose transport declines sharply — the same effect seen when ouabain blocks the pump.

5. C — Blocking only the cotransporter leaves the Na/K pump fully functional, so sodium continues to be pumped out and the sodium gradient is maintained. However, without the cotransporter, glucose has no way to enter the cell because it cannot diffuse against its own gradient. Glucose transport stops while ion homeostasis continues.

6. A — Photosynthesis requires CO_2 as a substrate; without enough of it, no amount of light can speed the reaction. At very low CO_2 concentrations, CO_2 is the limiting factor, so all three light levels produce the same low rate — the curves converge. This is Liebig's Law of the Minimum applied to photosynthesis.

7. D — The high-light curve continues rising while the low-light curve plateaus, meaning the low-light plants have reached their maximum photosynthetic rate despite more available CO_2. The limiting factor for the low-light condition has switched from CO_2 to light intensity itself. The pattern shows how the limiting factor changes with conditions.

8. B — During the light reactions, water molecules are split (photolysis) to provide electrons for the electron transport chain. The oxygen produced as a byproduct comes from these split water molecules, not from the CO_2 used in the Calvin cycle. Isotope-labeling experiments with H_2O^{18} confirmed this in the 1940s.

9. B — The Calvin cycle does not run in reverse to consume sugar — that would be cellular respiration, which is a separate pathway. Enzyme saturation, limiting water, and maximum CO_2 diffusion are all legitimate explanations for the plateau. The Calvin cycle running backward is biologically incorrect.

10. A — In darkness, photosynthesis stops because there is no light to drive the light reactions. Cellular respiration continues constantly in plants, consuming oxygen and releasing CO_2. The result is a net consumption of O_2 and net production of CO_2 — exactly the negative net photosynthetic rate observed.

11. C — A deletion of exactly three nucleotides removes one full codon without shifting the reading frame, since the remaining nucleotides still group into intact codons of three. This is a small in-frame deletion. The protein loses one amino acid (phenylalanine 508) but retains the rest of its sequence.

12. C — The missing phenylalanine sits at a position critical for the CFTR protein to fold correctly into its functional three-dimensional shape. Without proper folding, the cell's quality-control system degrades the protein before it reaches the cell membrane. Even when most of the protein sequence is correct, misfolding eliminates function.

13. A — The central dogma of molecular biology is DNA → mRNA → polypeptide. DNA is transcribed into mRNA (transcription), and then mRNA is translated into a polypeptide chain at the ribosome (translation). This unidirectional flow is the foundation of how genes are expressed as proteins.

14. B — The introduced gene is just DNA — it cannot produce protein on its own. It must be transcribed and translated by the cell's existing machinery (RNA polymerases, ribosomes, tRNAs) to produce functional CFTR protein. Gene therapy succeeds when the host cell expresses the delivered gene like any other gene.

15. D — CFTR is a chloride channel that is naturally regulated by the cell, and overexpression is unlikely to cause toxicity at the levels gene therapy would produce. Immune reactions to viral vectors, insertional mutagenesis, and treatment durability are all well-documented concerns in real CFTR gene therapy trials. Protein overexpression is not the primary safety concern.

16. C — In an autosomal recessive trait, both parents may be unaffected carriers and still produce affected children. The pedigree shows exactly this: unaffected parents (I-1 and I-2) producing an affected daughter (II-1), and unaffected parents (II-2 and II-3) producing an affected son (III-2). Affected individuals appear among both sexes, ruling out X-linked or Y-linked inheritance.

17. D — II-2 is unaffected, so he is not aa. He produced an affected son III-2 (aa), so he must have transmitted a recessive allele a. This means II-2 must be heterozygous Aa — a carrier of the recessive allele. He could not be homozygous AA, since AA parents cannot produce aa offspring.

18. B — Among offspring of Aa × Aa, the genotypic ratio is 1 AA : 2 Aa : 1 aa. Excluding the affected (aa) genotype, the unaffected offspring consist of 1 AA and 2 Aa — so 2 out of 3 unaffected individuals are heterozygous carriers. The probability that any unaffected child is a carrier is 2/3.

19. A — III-2 is affected (aa) and contributes only a to his offspring. A partner who is not a carrier is genotype AA and contributes only A. Every child of this cross is therefore Aa — an unaffected carrier. The probability of an affected (aa) child is 0%.

20. C — The pedigree clearly shows the trait following an autosomal recessive pattern with both Gen I parents as carriers and unaffected individuals potentially being carriers — all of which are supported. Claim C invokes environmental factors as the cause of generation-skipping, but the pattern is fully explained by genetic carrier status without invoking environmental triggers. C is the only statement not supported by the pedigree data.

21. B — Yeast produced CO_2 in all four flasks, but at different rates: about 45 mL/hr in air, 47 mL/hr in pure O_2, 38 mL/hr in pure N_2, and 36 mL/hr in pure CO_2. The yeast can therefore produce CO_2 with or without oxygen — but the production rate differs depending on conditions. The data refute claims that yeast stops entirely without oxygen.

22. C — Flask 2 has pure nitrogen with no oxygen, ruling out aerobic respiration. Yeast cells under anaerobic conditions perform alcoholic fermentation, converting pyruvate to ethanol and CO_2 to regenerate NAD^+. The 38 mL/hr CO_2 production observed comes from this fermentation pathway.

23. A — Aerobic respiration completely oxidizes glucose to CO_2 and water, extracting about 32 ATP per glucose. Fermentation only completes glycolysis and yields just 2 ATP per glucose, leaving most of the energy still locked in the partially-oxidized end product. The 16-fold ATP yield difference is the central distinction.

24. A — Ethanol is produced specifically during alcoholic fermentation, which yeast switches to when oxygen is absent. Flasks 2 (pure N_2) and 4 (pure CO_2) both lack O_2, so yeast cells in these flasks would perform fermentation and produce ethanol. Flasks 1 and 3 (with oxygen) would primarily perform aerobic respiration, which does not produce ethanol.

25. D — Alcoholic beverages depend on the ethanol produced by anaerobic fermentation. Eliminating oxygen forces yeast into fermentation, maximizing ethanol production. Adding oxygen would push the yeast toward aerobic respiration, which produces CO_2 but no ethanol. This is why beer and wine fermentation traditionally occur in sealed containers.

26. B — The 1976 distribution is centered around 9.5 mm, while the 1978 distribution is centered around 10.5 mm — a clear rightward shift of about 1 mm. The post-drought distribution is also narrower. The average beak depth in the population increased after the drought.

27. C — During the drought, only large hard seeds remained, and birds with deeper beaks were better able to crack them and survive. Shallow-beaked birds, lacking access to suitable food, died at higher rates and contributed fewer offspring to the next generation. This is the classic mechanism of natural selection, documented by Peter and Rosemary Grant.

28. A — Natural selection acting on the population over generations requires that the trait under selection (beak depth) is heritable — transmitted from parents to offspring through genes. If beak depth were determined only by environment with no genetic component, selection on this trait could not produce evolutionary change. Heritability is the essential precondition.

29. A — Selection responds to whichever traits favor survival and reproduction in the current environment. With abundant soft seeds, smaller-beaked finches (which can handle softer seeds without disadvantage and may be more efficient eaters of them) would gain a slight advantage. Over many generations, average beak depth could shift back downward.

30. B — The student's claim has the right general idea but is imprecise on one important point: individual finches did not "evolve" deeper beaks during their own lifetimes — populations evolved as the frequency of alleles for deep beaks rose through differential survival. Evolution is a population-level phenomenon, not an individual-level one. The clarification preserves the broad correctness while sharpening the language.

31. D — Beta-lactam antibiotics (such as penicillin) contain a chemical ring structure that must remain intact for the drug to work. Beta-lactamase enzymes cleave this ring through hydrolysis, breaking the antibiotic down into inactive products before it can reach its target on the bacterial cell wall. The drug becomes chemically harmless to the bacteria.

32. A — Conjugation transfers a plasmid horizontally — directly from one bacterium to another through cell contact — and the recipient need not be a daughter or descendant of the donor. This means resistance genes can spread between unrelated species and lineages of bacteria, not just from parent to offspring within a single line. Horizontal gene transfer is a major reason resistance can spread rapidly.

33. D — Increasing antibiotic dose imposes even stronger selective pressure on the bacterial population, favoring bacteria with the strongest resistance and accelerating rather than slowing the evolution of resistance. Limiting use, isolating patients, and improving hygiene all reduce selection pressure or transmission. Higher dosing is the least likely to slow resistance.

34. B — Beta-lactamase inhibitors do not kill bacteria themselves; they protect the original antibiotic from being broken down. Used together with the original antibiotic, the inhibitor preserves antibiotic effectiveness against resistant bacteria. This is exactly how combinations like amoxicillin/clavulanate (Augmentin) and piperacillin/tazobactam work in clinical practice.

35. A — Resistance evolves whenever any bacterial population is exposed to antibiotics — including bacteria in livestock. Plasmids carrying resistance genes can transfer between bacterial species, including from livestock-associated bacteria to human pathogens. The selective pressure from livestock antibiotic use therefore plausibly contributes to resistance in human pathogens.

36. C — Across all three lakes, producer biomass is by far the largest at the base, and each successive trophic level above contains only a fraction of the biomass of the level below. This consistent pattern — biomass declining sharply up the food chain — is the universal signature of energy loss between trophic levels. No lake shows the opposite pattern.

37. A — About 90% of the energy at each trophic level is lost as metabolic heat or used by the organisms themselves for life processes (movement, maintenance, reproduction). Only about 10% is converted into new biomass available to the next level. This thermodynamic loss explains why biomass at each level must be much smaller than the level below it.

38. B — Lake C has only 30 kg/ha of secondary consumer biomass — far less than Lakes A and B (100 kg/ha). At the 10% transfer rate typical of food webs, this would support only about 3 kg/ha of tertiary consumers — too little to maintain a viable population. The trophic level effectively cannot be sustained.

39. A — A predator that targets primary consumers reduces their population, so the producers (which the primary consumers eat) face less herbivory and tend to increase in biomass. This cascading effect — predator → reduced herbivore → increased plants — is called a trophic cascade and is well documented in real ecosystems like Yellowstone after wolf reintroduction.

40. C — An omnivore eats at multiple trophic levels — both producers (plants) and consumers (animals). A species feeding at three trophic levels (producers, primary consumers, and secondary consumers) fits this definition exactly. Humans, bears, and raccoons are common examples of omnivores.

41. B — Secondary succession occurs when a disturbed area still retains soil and some living organisms (seeds, roots, soil microbes) from the previous community. Clear-cutting and agriculture left the soil and its biological community intact, even though the trees were gone. This contrasts with primary succession (e.g., bare lava rock), which starts from no soil at all.

42. D — Pioneer species are the first colonizers of disturbed habitats. They typically tolerate harsh conditions (full sun, poor soil, temperature extremes) and grow rapidly to produce many seeds. Grasses and herbaceous plants fit this role in old-field succession, eventually being replaced by shrubs and then trees as the habitat changes.

43. D — As the recovering forest matures from grasses through shrubs to trees over 70 years, the standing biomass increases dramatically. Trees can accumulate decades or centuries of carbon in their woody tissues, storing far more carbon per acre than grasslands. Forest succession is a major mechanism for terrestrial carbon storage.

44. C — Plants cannot directly use atmospheric N_2 gas. Soil bacteria (free-living and in legume root nodules) fix atmospheric nitrogen into ammonium and nitrate, which plants can absorb. Some additional fixed nitrogen reaches the forest through precipitation, which dissolves atmospheric ammonia and nitrogen oxides. Both pathways are biological in origin.

45. D — Phosphorus has no significant atmospheric reservoir — it does not form a stable gaseous compound under normal Earth conditions. Instead, phosphorus cycles primarily through weathering of phosphate-bearing rocks, uptake by organisms, decomposition, and movement through soils and waters. The carbon and nitrogen cycles, in contrast, have major atmospheric components.

46. D — Both lines on the graph trend upward over 1960–2025: atmospheric CO_2 from about 315 ppm to about 420 ppm, and global temperature anomaly from near 0°C to about +1.1°C. The parallel rises are visually unmistakable on the dual-axis chart. The data clearly show substantial increases in both variables.

47. B — Earth's surface absorbs incoming solar radiation and re-emits it as infrared radiation. Greenhouse gases (CO_2, methane, water vapor) absorb this outgoing infrared radiation and re-emit some of it back toward the surface, trapping heat in the lower atmosphere. This trapping mechanism is the physical basis of the greenhouse effect.

48. D — Engineering evaluation compares technologies on measurable, function-relevant criteria: how much CO_2 each removes, energy costs, and physical resources required. Aesthetic appearance from a distance has essentially no relevance to a technology's effectiveness in addressing atmospheric CO_2. Visual appeal is not a useful basis for engineering choice in this context.

49. C — Trees capture atmospheric CO_2 through photosynthesis and convert the carbon into glucose, cellulose, lignin, and other organic compounds that build trunk, branches, and roots. The carbon remains stored in this woody biomass for the lifetime of the tree — often decades or centuries. Reforestation therefore acts as a long-term carbon sink.

50. C — The scale of CO_2 emissions globally is too large for any single approach to solve. Effective strategies combine emission reductions (renewable energy, efficiency) with active CO_2 removal (reforestation, direct air capture) and other complementary actions. No single technology applied universally would be sufficient on its own.