

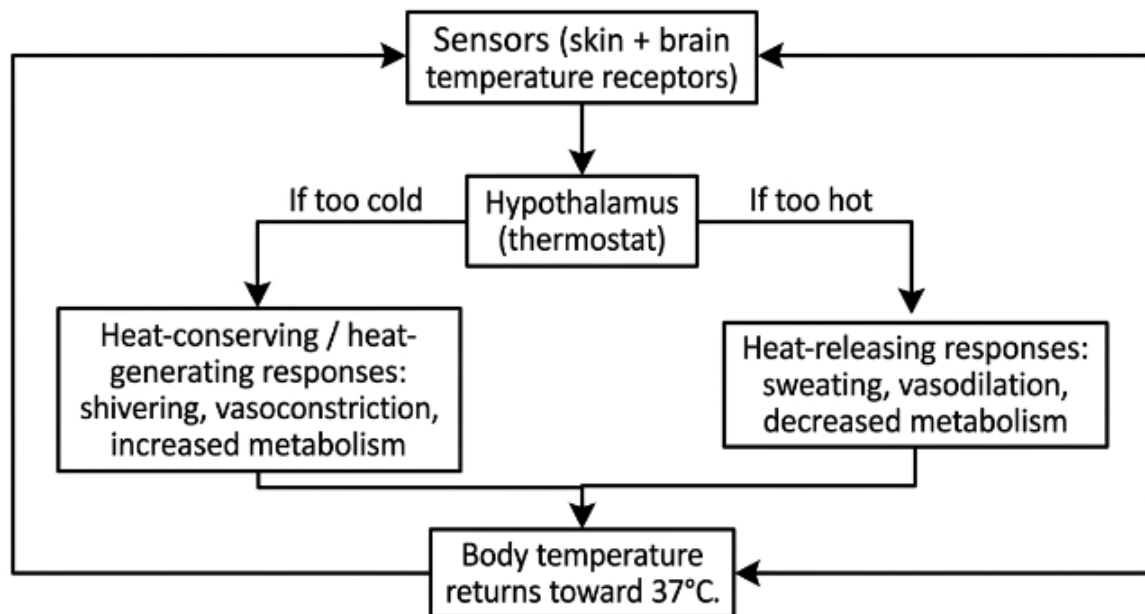
PRACTICE EXAM 34: LIFE SCIENCE: BIOLOGY SIMULATION (50 QUESTIONS)

Instructions: This simulation exam mirrors the format of the New York State Regents Examination in Life Science: Biology and emphasizes mechanism-focused perturbation reasoning, diagram interpretation, categorization, extrapolation, and trade-off analysis. The exam is figure-heavy — read each diagram and graph carefully before answering the cluster questions. 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.

The human body maintains a core temperature near 37°C through a homeostatic feedback loop. Temperature receptors in the skin and brain send signals to the hypothalamus, which acts as the body's thermostat. The hypothalamus then triggers responses through the nervous and endocrine systems to either generate or release heat. The diagram below shows the major components of the temperature regulation pathway.

Human Body Temperature Homeostasis (Negative Feedback Loop)



1. A person walks into a cold room. Predict the sequence of responses that returns body temperature to normal.
 - A. Skin sensors detect cold → blood vessels dilate → body cools further → temperature drops more
 - B. Brain sensors detect cold → sweating begins → evaporation cools skin → temperature drops further
 - C. Skin sensors detect cold → hypothalamus signals → shivering begins + blood vessels constrict → heat retained
 - D. Hypothalamus warms first → skin sensors detect warmth → body adjusts → temperature stabilizes overall
2. If the hypothalamus were damaged and could no longer respond to temperature signals, the most likely consequence would be:
 - A. Body temperature would rise rapidly and reach dangerous levels within minutes of damage
 - B. Body temperature would drift with the environment rather than staying near 37°C
 - C. Body temperature would drop steadily until cellular processes failed completely overall
 - D. Body temperature would oscillate rapidly between very hot and very cold extremes daily
3. Sweating cools the body primarily because:
 - A. Sweat carries heat directly out of the skin through chemical reactions in the glands
 - B. Sweat is colder than the body and reduces the body's temperature on contact directly
 - C. Sweat blocks heat from reaching the body's surface through the skin layer mostly
 - D. Evaporation of sweat requires energy, which is absorbed from the skin as heat

4. If a drug blocked sweating entirely while a person exercised in hot conditions, what cascade of consequences would most likely follow?

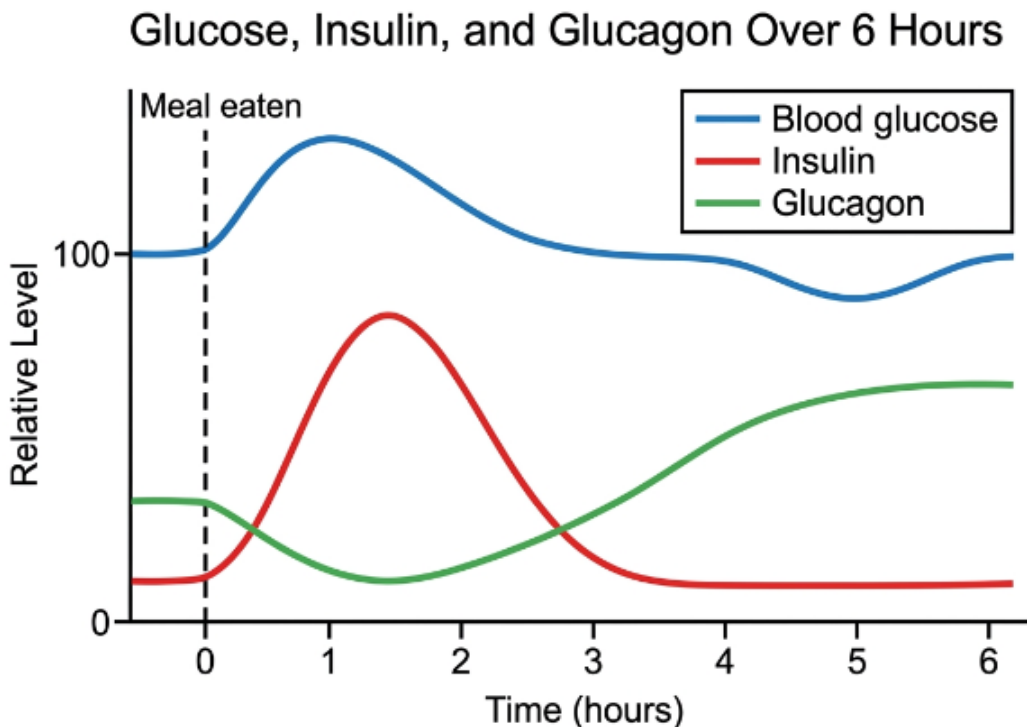
- A. Body temperature rises → enzymes denature → cellular function fails → heat stroke results
- B. Body temperature falls → metabolism slows → cellular function decreases → hypothermia results
- C. Body temperature stays the same → no compensation occurs → no measurable consequences result
- D. Heart rate slows → blood pressure falls → oxygen delivery decreases → fainting occurs

5. The temperature regulation system shown is a negative feedback loop. Which property makes it "negative"?

- A. The system produces negative emotions when temperature changes occur in the body
- B. The system responds to disturbances in a way that opposes the original change
- C. The system's responses cause increasingly larger temperature changes over time
- D. The system can only detect decreases in temperature, not any increases above normal

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

Blood glucose concentration is tightly regulated through two opposing hormones: insulin (released when glucose is high) and glucagon (released when glucose is low). Both are produced by the pancreas. The graph below shows how blood glucose and the two hormones change over a 6-hour period during which a person eats a large meal at time 0, then fasts.

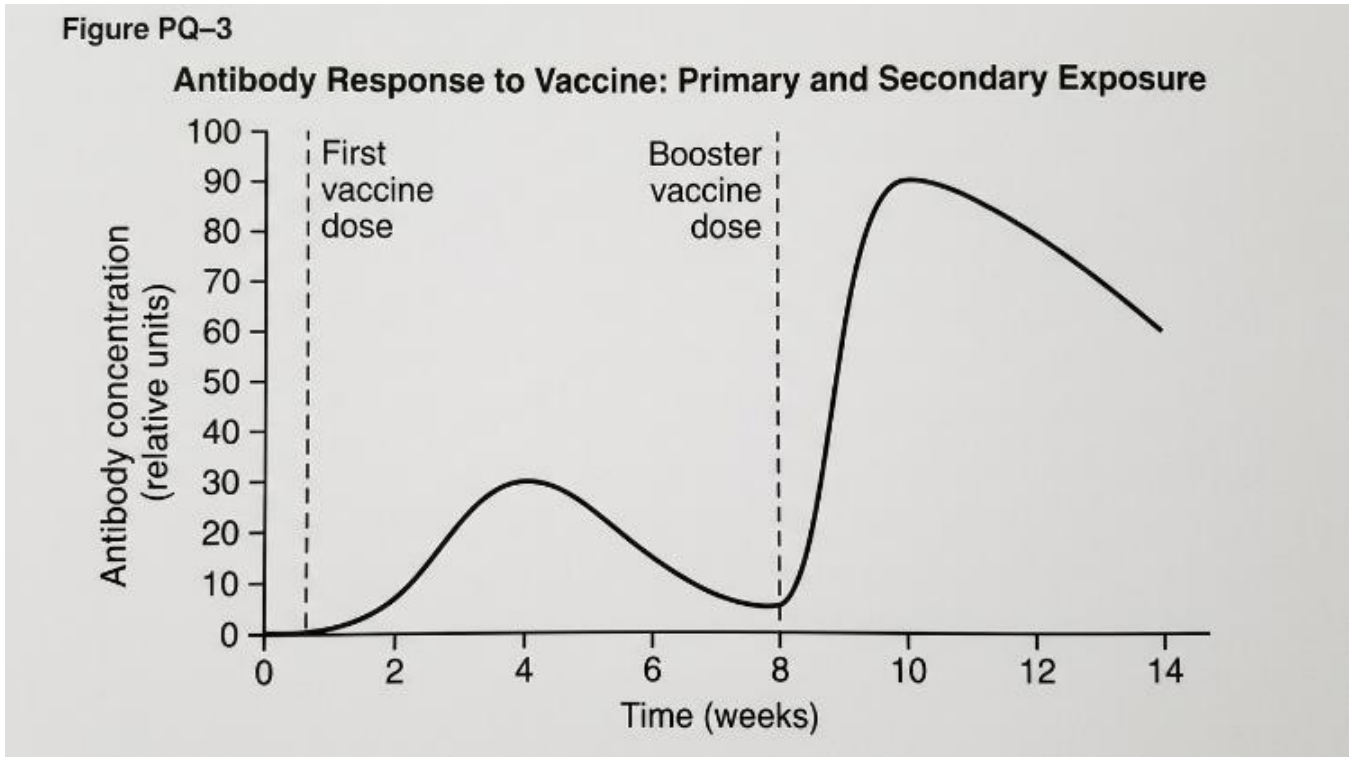


6. Reading the graph, what is the peak blood glucose value reached, and when does it occur?
- A. About 100, occurring at the time of the meal at time zero overall
 - B. About 160, occurring approximately 1 hour after eating the meal
 - C. About 80, occurring approximately 1.5 hours after eating the meal
 - D. About 85, occurring approximately 5 hours after the meal was eaten
7. Insulin levels peak at about 1.5 hours, slightly after the blood glucose peak. The most likely explanation is:
- A. Rising glucose triggers insulin release with a short delay as pancreatic cells respond
 - B. Insulin levels rise BEFORE meals to anticipate incoming glucose ahead of time daily
 - C. Insulin levels are unrelated to glucose levels and rise on a fixed daily schedule
 - D. Insulin peaks coincide with glucagon peaks at exactly the same time of day
8. What happens to blood glucose at about 5 hours, and which hormone is responsible for correcting it?
- A. Glucose rises to about 130 — corrected by an additional surge of insulin from the pancreas
 - B. Glucose remains exactly at 100 — no hormonal correction needed at this time point
 - C. Glucose drops to about 85 — corrected by rising glucagon mobilizing stored glycogen
 - D. Glucose drops to about 50 — corrected by adrenaline released from adrenal glands quickly
9. If a person had no functional insulin (as in untreated Type 1 diabetes), predict the consequences after eating a large meal:
- A. Blood glucose would remain at baseline because food would not be absorbed at all
 - B. Blood glucose would drop because glucagon would compensate for insulin loss completely
 - C. Blood glucose would rise briefly and then fall as expected without intervention needed
 - D. Blood glucose would rise high and stay elevated because cells cannot take it up
10. The relationship between insulin and glucagon is best described as:
- A. Synergistic — both hormones work together to raise blood glucose levels significantly
 - B. Sequential — insulin acts first, glucagon acts second, both with the same effect on glucose
 - C. Antagonistic — insulin lowers blood glucose while glucagon raises it back up
 - D. Reinforcing — insulin amplifies glucagon's effect on blood glucose levels strongly

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

The human immune system distinguishes "self" from "non-self" through specialized white blood cells. When a foreign pathogen (such as a virus) enters the body, B cells produce antibodies that recognize and bind specific antigens (molecules) on the pathogen. Some of these B cells become memory cells that persist for years. Vaccines work by exposing the immune system to harmless versions of a pathogen,

training the body to recognize the real pathogen if it ever appears. The graph below shows antibody levels after a first vaccine dose and a second (booster) dose.



11. Comparing the first response to the booster response, the most striking differences are that the booster response is:

- A. Faster and stronger, reaching higher antibody levels in less time overall
- B. Slower and weaker, taking longer to reach lower antibody levels than before
- C. Identical in both speed and strength to the first response wave seen
- D. Limited only to certain people, not occurring in all vaccinated individuals overall

12. The faster and stronger booster response is best explained by:

- A. The booster contains a more concentrated dose of the antigen than the original dose
- B. Memory B cells from the first exposure recognize the antigen and respond rapidly
- C. The immune system has forgotten the first dose and starts fresh with the booster
- D. The booster contains entirely different antigens that activate new B cells exclusively

13. If a person were given the booster dose, but their immune system had no memory cells, predict the most likely outcome:

- A. The response to the booster would be much faster and stronger than the first response
- B. The response would be identical to the booster response in a normal immune system overall
- C. The booster response would be much stronger because no memory cells slow it down
- D. The booster response would look similar to the first (slower and weaker) response

14. A virus mutates so that its surface antigen changes shape. Predict the consequence for previously vaccinated people:

- A. The original antibodies may no longer recognize the mutated virus, reducing protection
- B. The original antibodies will recognize the mutated virus more strongly than the original
- C. The original antibodies will completely destroy the mutated virus before it replicates
- D. The vaccine becomes a treatment for the original disease rather than the mutated form

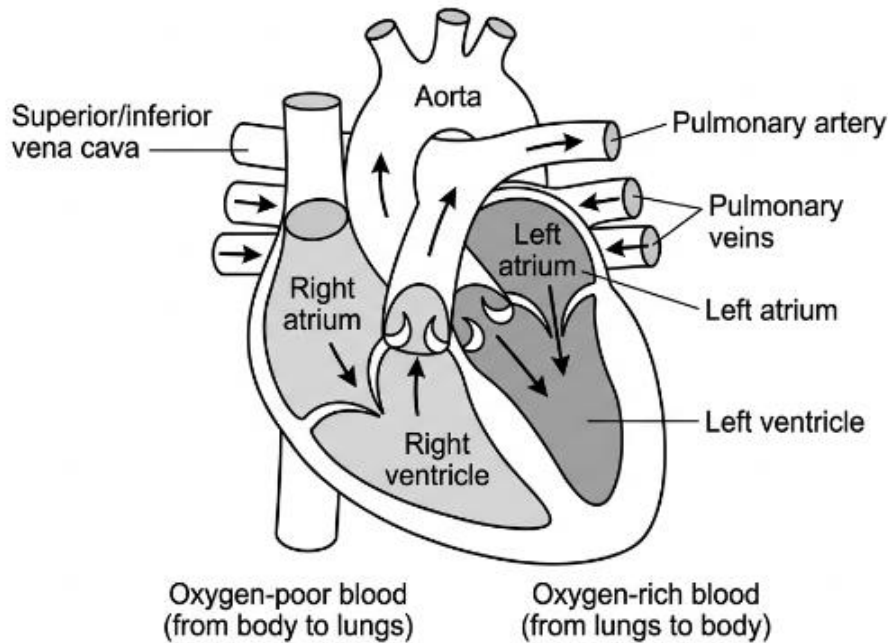
15. A 5-year-old child receives a chickenpox vaccine. Forty years later, that adult is exposed to chickenpox virus for the first time. Which combination of events would most likely occur?

- A. Memory cells rapidly mobilize → antibodies produced quickly → infection prevented or minimized rapidly
- B. Vaccine memory has been lost → first exposure → severe chickenpox develops as expected today
- C. The adult develops an entirely new disease unrelated to chickenpox infections at all here
- D. Memory cells attack the adult's own cells → autoimmune disease develops in response now

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

The human heart pumps blood through two circulation pathways: the pulmonary circulation (heart → lungs → heart) and the systemic circulation (heart → body → heart). The diagram below shows the four chambers of the heart with blood flow direction. Oxygen-poor blood is shown with one shading; oxygen-rich blood with another.

Human Heart — Four Chambers and Blood Flow



16. If the wall between the right and left ventricles had a hole (a condition called a ventricular septal defect), what would be the most likely consequence?

- A. Blood would flow more efficiently between the two ventricles and improve heart function
- B. Oxygen-poor and oxygen-rich blood would mix, reducing oxygen delivery to the body
- C. The heart would stop beating immediately because pressure could not be maintained
- D. Both ventricles would receive only oxygen-rich blood and never become oxygen-poor

17. The aorta carries blood from the:

- A. Right atrium to the lungs through the pulmonary artery vessel
- B. Left atrium to the lungs through the pulmonary veins overall
- C. Left ventricle to the body through the systemic circulation pathway
- D. Right ventricle to the body through the pulmonary circulation system

18. If the pulmonary artery were blocked (pulmonary embolism), what cascade of consequences would most likely follow?

- A. Blood backs up in right ventricle → less blood reaches lungs → oxygen drops → tissues suffer
- B. Blood flows backward through the heart → arrives at left atrium → reaches systemic circulation
- C. The aorta compensates by carrying blood directly to the lungs through new vessels formed
- D. Right and left ventricles begin pumping in unison rather than separately at all times

19. The left ventricle has a much thicker wall than the right ventricle. The most likely reason is:

- A. The left ventricle is closer to the lungs and receives more oxygen-rich blood overall daily
- B. The left ventricle pumps more blood per beat than the right ventricle pumps overall
- C. The left ventricle pumps blood a shorter distance than the right ventricle does daily
- D. The left ventricle pumps blood through the entire systemic circulation, requiring greater pressure

20. Categorize each vessel by what it carries: oxygen-rich or oxygen-poor blood. Which combination is correct?

- A. Aorta = oxygen-rich; pulmonary artery = oxygen-poor; pulmonary vein = oxygen-rich
- B. Aorta = oxygen-poor; pulmonary artery = oxygen-rich; pulmonary vein = oxygen-poor
- C. Aorta = oxygen-rich; pulmonary artery = oxygen-rich; pulmonary vein = oxygen-poor
- D. Aorta = oxygen-poor; pulmonary artery = oxygen-poor; pulmonary vein = oxygen-rich

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

Cells can be categorized in multiple ways: by their general type (prokaryotic vs. eukaryotic), by their level of organization (unicellular vs. multicellular organisms), and by their functional specialization (e.g., muscle, nerve, blood cells). The list below describes six cell types found in different organisms:

1. *Escherichia coli* — a single bacterium
2. Red blood cell from a human
3. Yeast — a single-celled fungus
4. Skin cell from an oak tree
5. Photosynthetic cell from a spinach leaf
6. Skeletal muscle cell from a mouse

21. Which of the six cells listed above are PROKARYOTIC?

- A. Cells 1, 2, and 3 — all small, simple cells in the listed organisms
- B. Cells 4, 5, and 6 — all cells that come from larger multicellular organisms
- C. Only cell 1 — *E. coli* is the only prokaryote in the list above
- D. None of the cells listed are prokaryotic in this collection of six

22. Which cells in the list are from UNICELLULAR organisms?

- A. Cells 1 and 6 only — bacteria and muscle cells live independently as cells
- B. Cells 4 and 5 only — plant cells can survive outside the plant tissue alone
- C. Cells 1 and 3 only — bacteria and yeast each live as single cells
- D. All six cells are from unicellular organisms in this complete list

23. Which of the listed cells is most likely to perform PHOTOSYNTHESIS?

- A. Cell 1 (E. coli) — bacteria use sunlight directly for energy production
- B. Cell 2 (red blood cell) — it carries oxygen which is needed for photosynthesis
- C. Cell 6 (muscle cell) — it requires energy that comes from sunlight indirectly always
- D. Cell 5 (spinach leaf cell) — leaf cells contain chloroplasts for photosynthesis directly

24. A cell is observed to lack a nucleus but contain DNA in a free-floating circular form, plus ribosomes and a cell membrane. To which category does this cell belong?

- A. Eukaryotic cell — because it contains DNA and ribosomes inside the cell membrane
- B. Prokaryotic cell — because the DNA is not enclosed in a membrane-bound nucleus
- C. Animal cell — because it lacks a cell wall like animal cells do not have one
- D. Plant cell — because it contains photosynthetic structures inside the organelles found

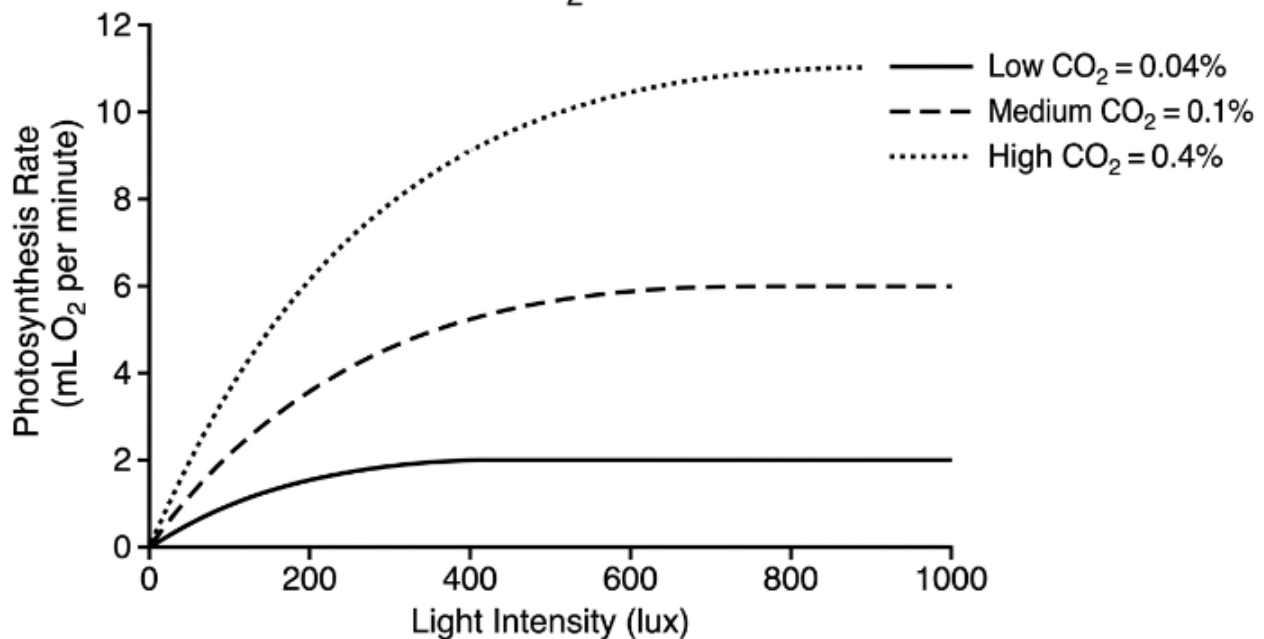
25. A red blood cell (cell 2) is unusual among human cells in that it loses its nucleus when it matures. The most likely trade-off this represents is:

- A. Reduced surface area for gas exchange in exchange for greater oxygen capacity overall
- B. Loss of division or repair ability in exchange for more space for hemoglobin
- C. Loss of mitochondria in exchange for the ability to perform photosynthesis directly
- D. Loss of cell membrane in exchange for direct contact with bloodstream nutrients flowing

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

Researchers measured the rate of photosynthesis in pondweed at different light intensities and at three CO₂ concentrations: low (0.04% — the level of atmospheric CO₂), medium (0.1%), and high (0.4%). The graph below shows oxygen production rate as a function of light intensity for each CO₂ level.

Photosynthesis Rate vs. Light Intensity at Three CO₂ Concentrations



26. At low CO₂ concentration (0.04%), the photosynthesis rate plateaus at a maximum of approximately:

- A. 11 mL O₂/min when light intensity reaches about 900 lux on the curve
- B. 6 mL O₂/min when light intensity reaches about 700 lux on the curve
- C. 2 mL O₂/min when light intensity reaches about 400 lux on the curve
- D. 0 mL O₂/min regardless of the light intensity provided to the plant

27. Why does the photosynthesis rate plateau (stop increasing) at low CO₂ when light intensity continues to rise?

- A. Light is no longer absorbed by chlorophyll once intensity exceeds a critical threshold value
- B. The plant has died from too much light exposure at this intensity level shown
- C. Oxygen produced by photosynthesis blocks further oxygen release at this point completely
- D. CO₂ becomes the limiting factor once light is no longer in short supply

28. If a researcher predicted that doubling CO₂ from 0.4% to 0.8% would further increase the plateau rate, this prediction would be:

- A. Correct, since each successive doubling of CO₂ doubles the photosynthesis rate further
- B. Incorrect, since higher CO₂ would poison the plant before it could be utilized at all
- C. Partly correct — additional CO₂ should help until another factor (such as light) becomes limiting
- D. Impossible to evaluate, since the data do not relate to predictions beyond the highest tested point

29. If a fourth experimental condition tested 0.04% CO₂ at 2,000 lux (twice the maximum light intensity shown), the rate would most likely be:

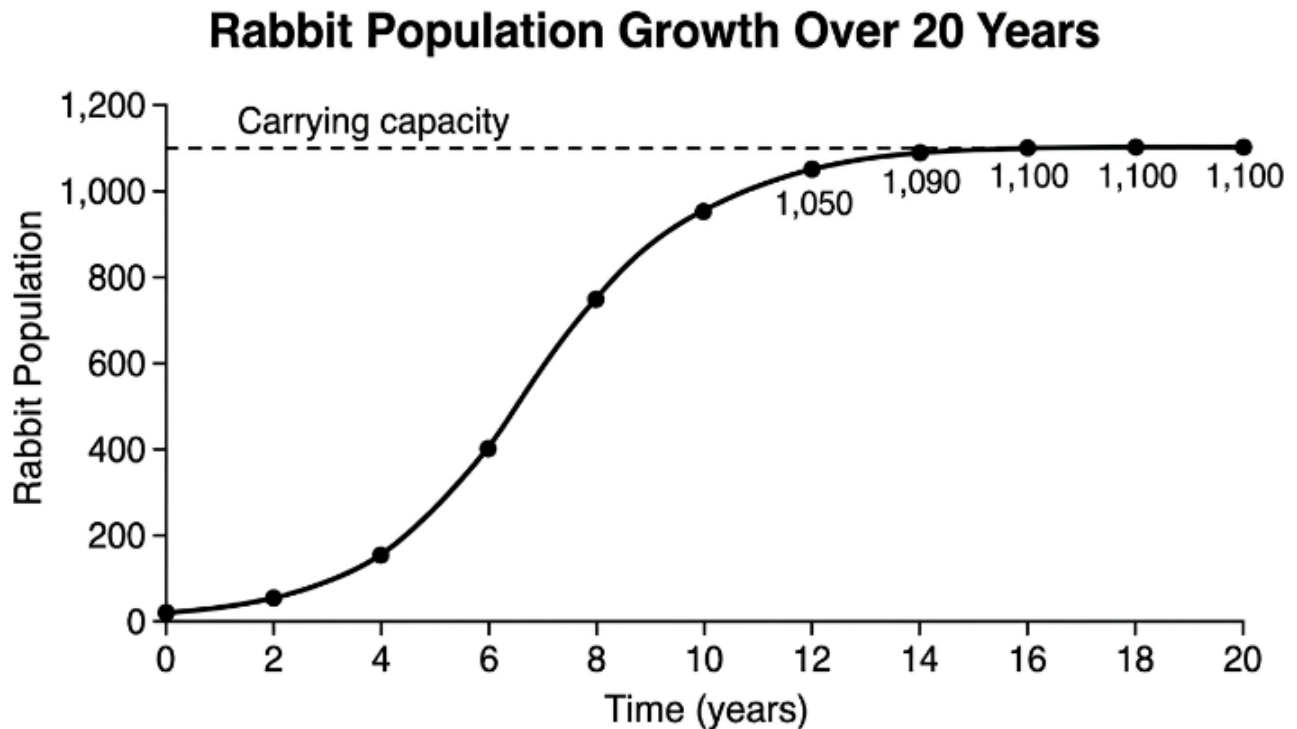
- A. About 22 mL O₂/min — twice the high-CO₂ maximum from the existing data shown
- B. About 4 mL O₂/min — double the low-CO₂ maximum from the existing data shown
- C. About 2 mL O₂/min — the same as the plateau already reached at lower light intensities
- D. About 0 mL O₂/min — the plant would stop photosynthesizing at very high light intensity

30. If a greenhouse operator wanted to maximize photosynthesis rate, the data suggest investing in:

- A. CO₂ enrichment AND bright lighting together, since both interact to set the maximum rate
- B. CO₂ enrichment alone, regardless of how much light reaches the plants in the greenhouse
- C. Bright lighting alone, regardless of CO₂ levels available to the plants growing here
- D. Neither, since the data show no relationship between CO₂ and light intensity at all

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

A population of rabbits is introduced to a previously rabbit-free island. The population growth is tracked over 20 years and shown in the graph below.



31. The graph shows what type of population growth curve?

- A. Exponential growth — the population continues to double at a constant rate throughout time
- B. Linear growth — the population increases by exactly the same number each year

- C. Decay growth — the population decreases steadily after introduction to the island shown
- D. Logistic (S-shaped) growth — slow start, exponential phase, then plateau at carrying capacity

32. The carrying capacity of this island for rabbits is approximately:

- A. 750 rabbits — the population reached at year 8 during exponential growth phase
- B. 1,100 rabbits — the level at which the population stabilizes by year 14
- C. 1,500 rabbits — well above the highest level shown in any of the data
- D. 20 rabbits — the size of the initial population introduced to the island

33. Predict the population at year 25, assuming conditions remain stable:

- A. About 1,500 rabbits — the population continues to grow steadily over time on
- B. About 1,100 rabbits — the population remains stable at carrying capacity level
- C. About 500 rabbits — the population gradually declines back toward initial levels
- D. About 0 rabbits — the population goes extinct after reaching carrying capacity overall

34. Between years 4 and 10, the population grew rapidly. The most likely reason for this exponential phase is:

- A. Predators arrived on the island and reduced rabbit numbers to enable rebound growth
- B. Disease eliminated weaker rabbits, leaving only fast-reproducing individuals behind
- C. Food was scarce, forcing rabbits to reproduce more rapidly out of survival instinct
- D. Resources were abundant relative to population size, allowing maximum reproduction

35. What would the curve most likely look like if the island had only half the resources (food, shelter, water)?

- A. The same S-curve would result, with carrying capacity reached at the same level
- B. The population would grow exponentially without ever reaching a plateau at all
- C. The population would never grow above the initial 20 rabbits introduced to the island
- D. The S-curve would still form but plateau at a much lower carrying capacity

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

Animals often face trade-offs between conflicting evolutionary pressures. The table below shows three traits of a hypothetical species of mouse that lives in a grassland inhabited by hawks (a predator).

Trait	Benefit	Cost
Bright fur color	Attracts mates more easily	Increases visibility to hawks
Large body size	Discourages predation	Requires more food, slower reproduction
Cautious behavior	Reduces predation risk	Less time to forage and mate

36. The bright fur color trait illustrates a classic trade-off between:

- A. Sexual selection (attracting mates) and natural selection (avoiding predators)
- B. Genetic drift and natural selection acting in opposite directions over time slowly
- C. Mutation rate and selection pressure on the same trait simultaneously over time
- D. Behavior and physiology — two independent dimensions of trait variation among mice

37. If hawks suddenly disappeared from the grassland, which traits would most likely change in the mouse population over generations?

- A. Bright fur would become rarer because predators no longer threaten the mice anywhere
- B. Large body size would become more common because food is now in short supply
- C. Cautious behavior would become more common because new threats might appear later
- D. Bright fur would become more common because the predation cost has been eliminated

38. The trade-off involved in large body size is best summarized as:

- A. Increased reproduction in exchange for increased predation risk overall in life
- B. Increased predator defense in exchange for higher food requirements daily
- C. Increased food capture in exchange for slower reproduction over time daily
- D. Decreased predator defense in exchange for faster reproduction rates daily here

39. A mutation appears in the population producing an extremely cautious mouse that almost never leaves its burrow. Predict the consequence:

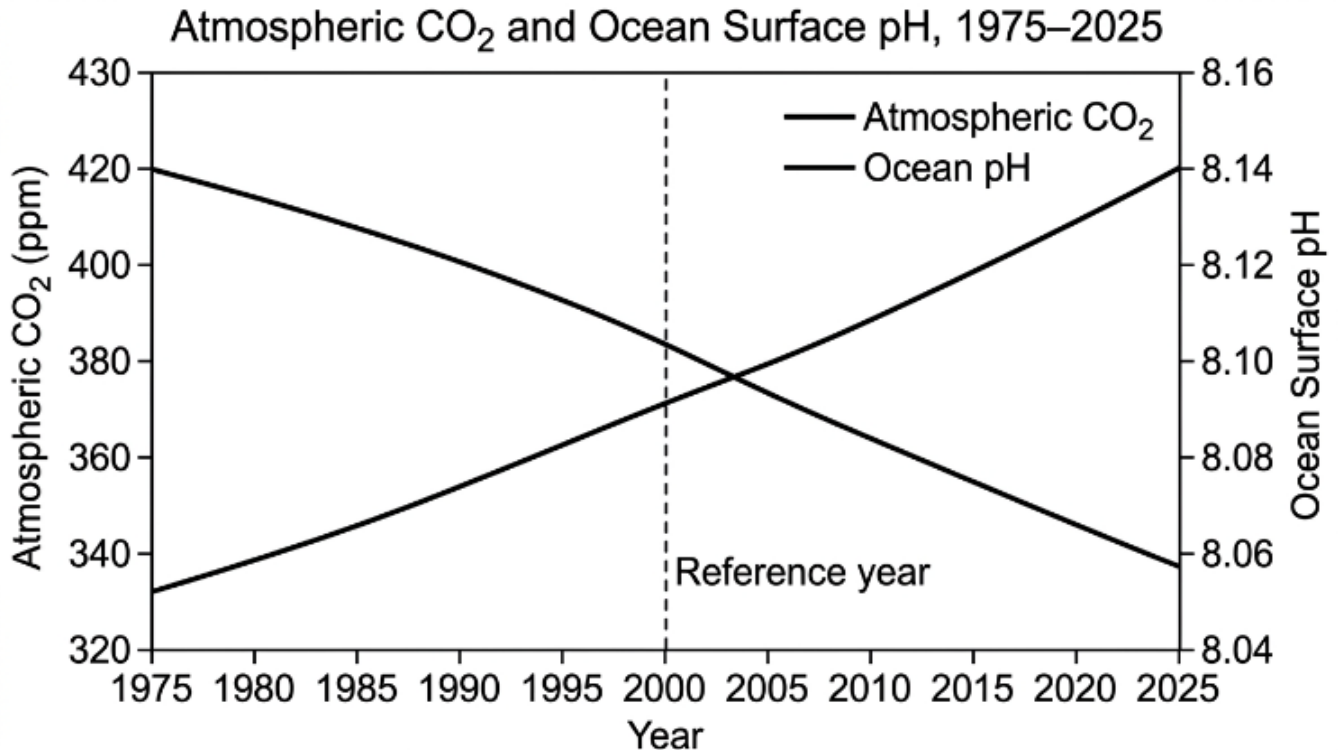
- A. Reduced predation but also reduced foraging and mating — possibly fewer offspring overall
- B. Increased predation because hawks specifically target cautious mice for some reason
- C. Faster population growth because cautious mice always survive longer than bold ones
- D. No effect on the population because behavior is unrelated to reproductive success at all

40. The general principle illustrated by these trade-offs is that:

- A. Traits are favored by selection only when their benefits outweigh their costs in context
- B. Traits are favored only if they reduce predation, with no other factors mattering at all
- C. Traits become more common only if they appear in many individuals at the same time
- D. Traits are completely unrelated to selection pressures and arise from random forces alone

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

Ocean acidification occurs when atmospheric CO₂ dissolves into seawater and forms carbonic acid (H₂CO₃), lowering the ocean's pH. The graph below shows average ocean surface pH and atmospheric CO₂ concentration over 50 years.



41. Based on the graph, the average ocean surface pH has changed by approximately how much between 1975 and 2025?

- A. Increased by about 0.08 units (from 8.06 to 8.14) over the 50 years shown
- B. Decreased by about 0.4 units (from 8.4 to 8.0) over the 50 years shown
- C. Decreased by about 0.08 units (from 8.14 to 8.06) over 50 years shown
- D. Remained constant at about 8.10 units throughout the 50-year period shown

42. The most direct cause of ocean pH decline is:

- A. Industrial pollutants and acid rain falling on the ocean surface from the atmosphere
- B. Volcanic activity releasing acid directly into the ocean from underwater volcanoes
- C. Atmospheric CO₂ dissolving in seawater and forming carbonic acid (H₂CO₃)
- D. Reduced ocean salinity from melting freshwater ice altering ocean chemistry overall

43. If atmospheric CO₂ continues to rise, predict what would happen to ocean pH:

- A. pH would continue to decline as more CO₂ dissolves and forms more carbonic acid
- B. pH would rise dramatically as ocean ecosystems compensate for the chemical change
- C. pH would oscillate randomly between high and low values without any predictable pattern
- D. pH would return to 8.14 because oceans buffer themselves to pre-industrial levels eventually

44. Many marine organisms (corals, mollusks) build shells from calcium carbonate. Acidification reduces shell-building because:

- A. Acid eats away existing shells through direct chemical contact damage over time slowly
- B. Lower pH increases the rate at which shells dissolve in ocean water entirely fast
- C. Lower pH reduces available carbonate ions needed for calcium carbonate formation
- D. Acid causes shell-building organisms to migrate to deeper water far from surfaces

45. A coral reef ecosystem experiences ocean acidification. Predict the cascading consequences:

- A. Coral grows faster → reef expands → more fish habitat → biodiversity increases dramatically
- B. Coral becomes more resistant to acid → reef remains unchanged → no consequences occur
- C. Coral attracts new species → new shellfish move in → reef diversifies into new forms
- D. Coral weakens or dies → reef structure degrades → fish habitat lost → biodiversity declines

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

A coastal nation is deciding how to meet growing seafood demand. Two main options are: (1) commercial wild fishing — catching fish from the ocean using boats, nets, and lines; or (2) aquaculture — farming fish in enclosed coastal pens or land-based tanks. Each option has different effects on ecosystems, food supply, and the economy.

Factor	Wild Fishing	Aquaculture
Fish supply	Limited by wild populations	Limited by farm capacity
Environmental impact	Bycatch, overfishing	Pollution from fish waste, disease
Economic structure	Many small boats and crews	Larger farms, fewer workers
Cost per kg of fish	Variable (depends on catch)	More predictable

46. Which factor would most directly limit how much fish a wild fishing operation can supply?

- A. The size of the boats used by the fishing crews in this operation overall
- B. The number of customers ordering fish at any given time of the year
- C. The predictability of cost per kilogram of fish caught from the ocean
- D. Reproductive rates and total size of wild fish populations available there

47. One trade-off of aquaculture compared to wild fishing is:

- A. More environmental damage AND less reliable supply over time consistently
- B. More predictable supply BUT increased pollution from concentrated fish waste
- C. Fewer workers needed AND complete elimination of all environmental damage
- D. Lower costs to fishermen AND higher quality fish for consumers in markets

48. A coastal community traditionally supported by small wild fishing operations transitions to large aquaculture facilities. Predict the most likely cascade of community-level consequences:

- A. Increased small boat employment → more wild fish caught → ecosystem benefits → community thrives
- B. Decreased small boat employment → fewer jobs for individual fishers → community economic structure changes
- C. No change in employment → same fish supply → no community-level economic consequences result here
- D. Increased fishing pressure on wild fish → larger wild populations → more sustainable ocean ecosystems

49. Which engineering principle is most central to choosing between these two food production methods?

- A. Sustainability — long-term balance between food production and ecosystem health
- B. Aesthetic appeal — how attractive the food production looks to passing visitors
- C. Novelty — choosing the newest method because it must be technologically better
- D. Tradition — choosing the older method because it has been used for centuries already

50. A hybrid approach combines moderate wild fishing with moderate aquaculture, with regulations on both. The most likely benefit of this combined approach is:

- A. Eliminates all environmental impact while doubling total fish supply for the community
- B. Reduces costs to zero by removing the need for any boats or farms or workers
- C. Distributes risk between sources and reduces single-system pressures on ecosystems
- D. Maximizes employment in both industries while completely eliminating pollution issues

Practice Exam 34: Full Answer Key with Explanations

1. C — When skin sensors detect cold, they signal the hypothalamus, which triggers heat-conserving responses: vasoconstriction (reducing blood flow to skin to keep heat in the core) and shivering (rapid muscle contractions that generate heat). This pathway returns body temperature toward 37°C without conscious effort. This is the classic cold-response branch of the thermoregulation loop.

2. B — The hypothalamus serves as the body's thermostat, comparing actual body temperature to the 37°C set point and triggering corrective responses. Without a functioning hypothalamus, the body has no central regulator and simply drifts with environmental temperature, much like an ectotherm (cold-blooded animal). This loss of homeostasis can be life-threatening in extreme environments.

3. D — Evaporation is endothermic — the conversion of liquid water to water vapor requires energy. The energy needed to evaporate sweat is drawn from heat in the surrounding skin and underlying tissues, cooling them. This is why humid conditions (where sweat evaporates poorly) reduce the effectiveness of sweating as a cooling mechanism.

4. A — Blocking sweating during hot exercise eliminates the body's primary cooling mechanism, causing core body temperature to rise. As temperature climbs past about 40°C, the heat-sensitive proteins

(enzymes) begin to denature, disrupting cellular metabolism and organ function. The end result is heat stroke — a medical emergency that can cause permanent organ damage or death.

5. B — In negative feedback, the system's response opposes the original disturbance: when temperature rises above set point, cooling responses are triggered; when temperature falls below, heating responses are triggered. The "negative" refers to the opposing direction of the correction, not to anything emotional. This pattern is found in nearly all homeostatic regulation in the body.

6. B — The blue blood glucose curve reaches its peak at approximately 160 (relative units) at the 1-hour mark following the meal, then declines as insulin drives glucose uptake into cells. This pattern of postprandial glucose rise and return is the normal physiological response in healthy individuals. Persistent peaks above 200 mg/dL would suggest impaired glucose regulation.

7. A — Insulin release is triggered by rising blood glucose levels detected by pancreatic beta cells. The brief delay (about 30 minutes after the glucose peak) reflects the time needed for beta cells to sense the change and release stored insulin into the bloodstream. This negative feedback ensures insulin acts to lower glucose rather than anticipating meals.

8. C — Around 5 hours after the meal, blood glucose drops to about 85 (below the 100 baseline) due to continued insulin action and depletion of dietary glucose. Glucagon rises in response, signaling the liver to break down stored glycogen into glucose and release it into the bloodstream. This restores blood glucose toward normal — the opposite branch of the regulatory loop.

9. D — Insulin is the signal that tells body cells (especially muscle, liver, and fat cells) to take up glucose from the bloodstream. Without insulin, cells cannot absorb the incoming dietary glucose, so glucose accumulates in the blood and stays high. This hyperglycemia is the defining feature of untreated Type 1 diabetes.

10. C — Insulin and glucagon have opposing (antagonistic) effects on blood glucose: insulin lowers glucose by promoting cellular uptake, while glucagon raises glucose by stimulating glycogen breakdown. This push-pull relationship keeps blood glucose tightly controlled within a narrow physiological range. Together they exemplify hormonal antagonism in homeostatic regulation.

11. A — The booster response (peak 90 at week 10, just 2 weeks after the booster dose) is much faster and reaches much higher antibody levels than the first response (peak 30 at week 4, 4 weeks after the first dose). This dramatic difference is the basis for using boosters to strengthen immune protection. It is also the reason that natural reinfections often produce no symptoms in previously exposed individuals.

12. B — Memory B cells produced during the first exposure persist in the body and can recognize the same antigen if it reappears. When the booster dose arrives, these memory cells immediately divide and produce antibodies, bypassing the slow primary recognition phase. This is the molecular basis of immunological memory and the reason vaccines provide lasting protection.

13. D — Without memory cells, the body has no record of the previous exposure and must build the immune response from scratch. The result resembles the primary response: slower, weaker, and peaking

at a lower antibody level. This is why immunosuppressed patients often require modified vaccination schedules.

14. A — Antibodies bind to specific antigens through complementary three-dimensional shapes. If the virus mutates its antigen shape (antigenic drift or shift), existing antibodies may no longer fit the new shape and thus provide reduced or no protection. This is why annual flu vaccines must be updated to match the currently circulating viral strains.

15. A — Long-lived memory B cells produced after the childhood vaccination remain in the body for decades, recognizing the chickenpox antigen if it reappears. When the adult encounters the actual virus, these memory cells mobilize rapidly, producing antibodies that prevent or minimize infection. Lifelong vaccine-induced memory is the foundation of effective public health vaccination programs.

16. B — The septal wall normally separates oxygen-rich blood (left ventricle) from oxygen-poor blood (right ventricle). A hole allows mixing of the two blood streams, so some oxygen-poor blood enters the systemic circulation and some oxygen-rich blood is sent back to the lungs. Less oxygenated blood reaches body tissues, causing reduced exercise tolerance and other symptoms.

17. C — The aorta is the largest artery in the body and exits the left ventricle, carrying oxygen-rich blood to systemic circulation that supplies the entire body except the lungs. The aorta delivers blood at the highest pressure in the system because the left ventricle is the strongest chamber of the heart. This arrangement is the central feature of mammalian circulation.

18. A — A blocked pulmonary artery prevents blood from flowing from the right ventricle to the lungs. Blood backs up in the right side of the heart, less blood is oxygenated in the lungs, oxygen levels in returning blood drop, and tissues throughout the body suffer hypoxia. Pulmonary embolism is a medical emergency that can rapidly cause death.

19. D — The left ventricle must generate enough pressure to push blood through the entire systemic circulation — every artery, capillary, and vein outside the lungs. The right ventricle only needs to push blood through the much shorter and less resistive pulmonary circulation to the lungs. The mismatch in workload produces the mismatch in muscle wall thickness.

20. A — Blood becomes oxygen-rich in the lungs and oxygen-poor in the body tissues. The pulmonary VEIN brings oxygen-rich blood FROM the lungs to the heart (an exception to the rule that veins carry oxygen-poor blood), and the pulmonary ARTERY carries oxygen-poor blood TO the lungs (an exception to the rule that arteries carry oxygen-rich blood). The aorta carries oxygen-rich blood from the left ventricle.

21. C — Prokaryotic cells lack a membrane-bound nucleus. Of the six cells listed, only *E. coli* (a bacterium) is prokaryotic; the others are all eukaryotic (with membrane-bound nuclei), regardless of whether they come from unicellular or multicellular organisms. Yeasts are eukaryotic despite being unicellular.

22. C — Unicellular organisms exist as single, independent cells. *E. coli* (cell 1) and yeast (cell 3) are both single-celled organisms; the red blood cell, oak skin cell, spinach leaf cell, and mouse muscle cell

are all parts of multicellular organisms. Being a single cell taken from a multicellular body does not make the organism unicellular.

23. D — Photosynthesis requires chloroplasts, which contain chlorophyll and convert light energy into chemical energy. Spinach leaf cells contain abundant chloroplasts and are highly photosynthetic — their entire purpose in the plant is to capture light. None of the other listed cells (bacteria, blood, muscle, or root-related cells) contain chloroplasts in significant quantity.

24. B — The defining feature of prokaryotic cells is the absence of a membrane-bound nucleus. The free-floating circular DNA in the cytoplasm, combined with ribosomes and a cell membrane (but no nuclear envelope), is the classic prokaryotic anatomy. This pattern is found in all bacteria and archaea.

25. B — Mature red blood cells eject their nucleus during development, gaining maximum interior space for hemoglobin, the oxygen-carrying protein. The trade-off is that they lose the ability to synthesize proteins, divide, or repair damage — so they survive only about 120 days before being replaced. This anatomical specialization maximizes oxygen-carrying capacity at the cost of cellular longevity.

26. C — Reading the low-CO₂ curve (0.04%), the rate plateaus at approximately 2 mL O₂/min once light intensity reaches about 400 lux. Beyond that point, increasing light has no effect on rate because something other than light has become the rate-limiting factor. This is a classic example of a limiting factor in photosynthesis.

27. D — The light reactions of photosynthesis can only proceed as fast as the Calvin cycle can use their products, and the Calvin cycle requires CO₂ to fix carbon into sugars. When CO₂ is scarce, no amount of additional light can speed the overall process because there isn't enough substrate to use. CO₂ becomes the limiting factor.

28. C — Doubling CO₂ would help photosynthesis as long as CO₂ is the limiting factor, but each successive increase in CO₂ will eventually run into another constraint (light intensity, enzyme capacity, temperature). The plateau rate increases until a different factor takes over as the new limiting factor. This is Liebig's Law of the Minimum applied to photosynthesis.

29. C — At low CO₂ (0.04%), the rate plateaus at about 2 mL O₂/min regardless of how high light intensity is increased. Doubling the light from 1,000 to 2,000 lux would not raise the rate above this CO₂-limited plateau because CO₂ remains the limiting factor. More light cannot compensate for a deficit in another required input.

30. A — The graph shows that both CO₂ and light intensity influence photosynthesis rate, with whichever factor is scarcer setting the rate. To maximize photosynthesis, both must be at high levels — bright lighting alone or CO₂ enrichment alone will hit the limit of the other factor. Commercial greenhouses commonly combine CO₂ enrichment with high-intensity LED lighting for this reason.

31. D — The S-shaped (sigmoid) curve is the signature of logistic growth: a slow lag phase as the population establishes itself, an exponential phase of rapid growth when resources are abundant, and a plateau at carrying capacity when the population has matched the resources available. This three-phase pattern is observed in virtually every population introduced to a finite habitat.

32. B — Carrying capacity (K) is the stable population level a habitat can support indefinitely. The graph shows the population leveling off and stabilizing at about 1,100 rabbits by year 14 and staying there through year 20, meeting the definition of carrying capacity. Below K, the population grows; above K, the population shrinks.

33. B — Once a population reaches carrying capacity, it tends to remain near that level as long as environmental conditions stay the same. Extrapolating from the stable plateau at 1,100, the population at year 25 should still be near 1,100 rabbits. Random fluctuations around K are normal but the average remains stable.

34. D — During the exponential phase, abundant food, water, shelter, and few competitors mean each rabbit can survive and reproduce at near-maximum rates. The result is rapid population growth that compounds with each generation. Resource abundance relative to population size is the defining condition for exponential growth.

35. D — Carrying capacity is determined by available resources. Cutting resources in half would cut the carrying capacity to a lower value (perhaps about 550 rabbits), but the overall shape of the curve — lag, exponential, plateau — would remain S-shaped. This is why logistic growth models are useful for predicting how habitat changes affect populations.

36. A — Bright fur attracts mates (a benefit favored by sexual selection) but makes the mouse easier for hawks to spot (a cost imposed by natural selection from predation). These two evolutionary forces pull in opposite directions, and the trait that persists in the population reflects the balance between them. Peacock tails and bright male songbird plumage are classic examples of the same trade-off.

37. D — Without hawks, the predation cost of bright fur disappears, leaving only the mating benefit. Bright fur mice would now experience higher reproductive success without the offsetting cost of predation, and their alleles would increase in frequency over generations. This is how predator removal can dramatically alter prey populations' traits.

38. B — Large body size discourages hawks from attempting an attack (predator-defense benefit) but requires more food to sustain and slows reproduction because larger animals usually have longer development times (cost). This trade-off appears across many species — large body size often correlates with predator defense and longer generation time.

39. A — An extremely cautious mouse avoids predation almost entirely (benefit) but cannot forage enough or mate enough to produce offspring (cost). Reproductive success is the ultimate measure of fitness in natural selection — surviving without reproducing leaves no genetic legacy. The intermediate level of caution that balances safety and reproduction typically wins out.

40. A — Natural selection favors traits whose net contribution to reproductive success (benefits minus costs) is positive in a given environment. A trait that helps with one challenge but creates problems with another may or may not be favored depending on how the balance plays out. This is why the same trait can be advantageous in one environment and disadvantageous in another.

- 41. C** — Ocean surface pH dropped from 8.14 in 1975 to 8.06 in 2025 — a decrease of about 0.08 units over the 50-year period. While 0.08 sounds small, the pH scale is logarithmic, so this represents about a 30% increase in hydrogen ion concentration. The change is large enough to affect many marine species.
- 42. C** — Atmospheric CO₂ dissolves in seawater and reacts with water to form carbonic acid (H₂CO₃), which then dissociates into bicarbonate (HCO₃⁻) and hydrogen ions (H⁺). The added H⁺ ions lower the pH. This direct chemical link between atmospheric CO₂ and ocean pH is what makes ocean acidification a direct consequence of fossil fuel emissions.
- 43. A** — As long as atmospheric CO₂ continues to rise, more CO₂ will dissolve into seawater and produce more carbonic acid, continuing to lower pH. The ocean has no mechanism for quickly reversing this trend, and natural buffering systems (carbonate chemistry) are gradually being overwhelmed. Extrapolating from current trends predicts continued, accelerating pH decline.
- 44. C** — Shell-forming organisms need carbonate ions (CO₃²⁻) to combine with calcium and build calcium carbonate (CaCO₃) shells. Lower pH (more H⁺) shifts the carbonate equilibrium so that more carbonate is converted to bicarbonate, leaving fewer carbonate ions available for shell-building. This is the chemical basis of why acidification harms corals, mollusks, and many plankton.
- 45. D** — Coral reefs are foundation species — their physical structure provides habitat for thousands of fish and invertebrate species. When acidification weakens coral skeletons, the reef structure degrades; without the reef, dependent species lose their habitat, and biodiversity declines dramatically. This cascade is why ocean acidification is sometimes called "the other CO₂ problem" alongside warming.
- 46. D** — Wild fish populations can only be harvested at rates that the population can replace through reproduction. Exceeding that rate (overfishing) depletes the population. Reproductive rates and total population size therefore set the absolute ceiling on sustainable wild fish supply, regardless of how many boats are deployed or how skilled the fishers are.
- 47. B** — Aquaculture provides a predictable, steady supply because fish are raised in controlled conditions independent of weather and wild population fluctuations (benefit). However, concentrating thousands of fish in small areas generates large amounts of waste, antibiotics, and other pollutants that escape into surrounding waters (cost). Both effects appear together as part of the same trade-off.
- 48. B** — Wild fishing supports many small operators (one boat, a few crew members each), while aquaculture concentrates production in larger facilities employing fewer workers per unit of fish produced. The transition would reduce overall jobs in the community and shift economic structure from many small operators to a few larger employers. Such transitions have transformed many fishing communities globally.
- 49. A** — Both fishing methods can supply food but each has long-term consequences for ecosystem health. Sustainability — the principle of balancing immediate production with long-term ecosystem capacity — is the central engineering criterion for evaluating food systems. Methods that maximize short-term yield while degrading the resource base eventually fail.

50. C — Relying entirely on one method exposes the community to the risk of that method failing (a wild fishery collapse, a disease outbreak in farmed fish). A hybrid approach distributes the food supply across two independent systems, so problems in one are not catastrophic. This is the same engineering principle of redundancy that underlies diverse supply chains and energy grids.