BIOLOGY

SECTION I

Time—1 hour and 30 minutes

60 Questions

Directions: Each of the questions or incomplete statements below is followed by four suggested answers or completions. Select the one that is best in each case and then fill in the corresponding circle on the answer sheet.

1. Gel electrophoresis can be used to directly determine which of the following?

   (A) The amino acid sequence of a protein

   (B) The number of base pairs in a fragment of DNA

   (C) The organelle in a cell toward which a protein moves after its initial synthesis

   (D) Whether one allele of a gene is more subject to genetic drift than are other alleles of the same gene

2. Cystic fibrosis is an autosomal (non-sex-linked) recessive genetic disorder in humans. In a certain geographical area, the incidence of cystic fibrosis is currently estimated at 1 in 377 live births. Which of the following is most likely closest to the frequency of the recessive allele in the human population in the area after 10 generations, assuming that the population remains in Hardy-Weinberg equilibrium?

   (A) 0.003

   (B) 0.052

   (C) 0.098

   (D) 0.948

3. Which of the following describes a process that increases genetic diversity in prokaryotic cells?

   (A) Chromosomes segregate independently and form different combinations in daughter cells.

   (B) Homologous chromosomes exchange genetic material during meiosis.

   (C) Conjugation transfers DNA from one cell to the other cell.

   (D) A cell infected with two genetically different viruses can produce viruses with new allele combinations.

4. Water crosses the plasma membranes of certain eye cells at a higher rate than it does in other cell types. Which of the following best explains why the rate of water transport is higher in the eye cells?

   (A) The eye cells move water against the concentration gradient, which is faster than moving water with the concentration gradient.

   (B) The eye cells have protein channels that allow water to pass through in greater quantities than the phospholipid bilayer allows.

   (C) The eye cells have more ATP than other cells do, which allows them to use active transport to move water across the membrane more rapidly.

   (D) The eye cells modify water molecules so that they are positively charged, allowing them to cross the phospholipid bilayer more easily than unmodified water molecules.

5. DNA damage can lead to the release of the protein cytochrome *c* from mitochondria. Cytochrome *c* then activates the enzyme caspase-9, resulting in the release of more cytochrome *c*, followed by apoptosis.

   Which of the following best explains how the release of cytochrome *c* from mitochondria is regulated by feedback?

   (A) It is positive feedback because the release of cytochrome *c* from mitochondria contributes to the production of more mitochondria.

   (B) It is negative feedback because the release of cytochrome *c* from mitochondria results in an increase in cell death.

   (C) It is positive feedback because the release of cytochrome *c* from mitochondria contributes to the release of more cytochrome.

   (D) It is negative feedback because the release of cytochrome *c* from mitochondria is caused by DNA damage.

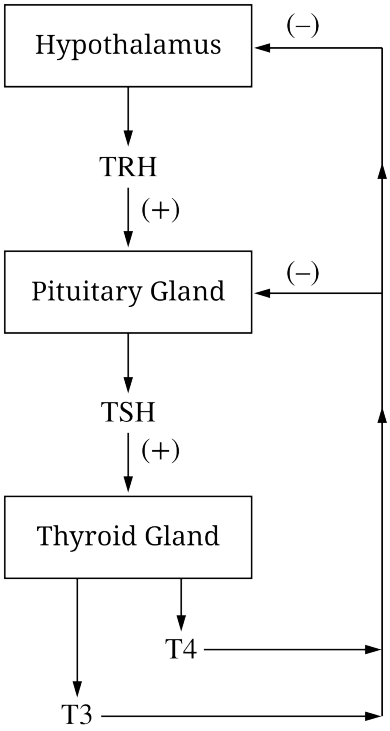


Figure 1. Regulation of hormones secreted by the thyroid gland. The + indicates stimulation and the − indicates inhibition.

6. Based on Figure 1, which of the following most likely occurs in response to an increase in the secretion of thyroid hormones T3 and T4?

   (A) The hypothalamus secretes more TRH to maintain the increase in thyroid hormone secretion.

   (B) The pituitary gland decreases secretion of TSH, which results in an increase in TRH secretion.

   (C) The thyroid hormones directly inhibit the hypothalamus, which results in a decrease in TRH secretion.

   (D) The thyroid gland increases secretion of T4 in order to cause a decrease in T3 secretion.

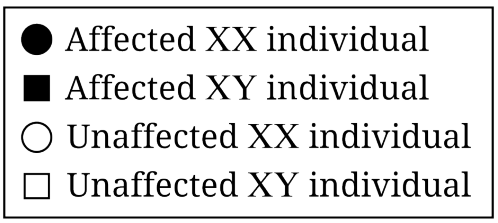
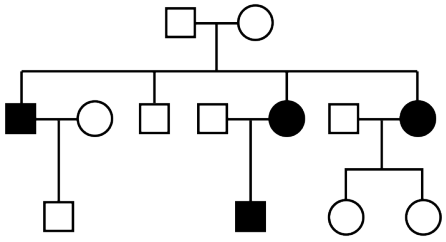


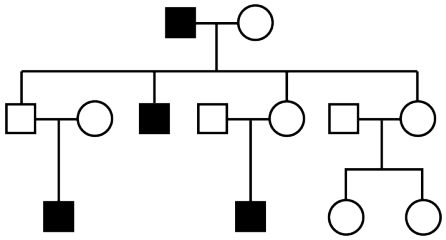
Figure 1. Key for interpreting a pedigree

7. Which of the following pedigrees represents the inheritance of a trait most likely associated with a gene on the Y chromosome?

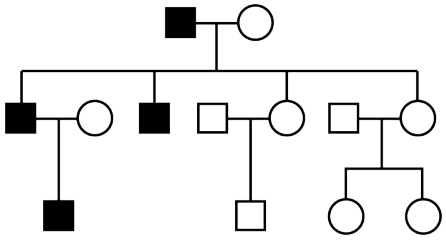
(A)



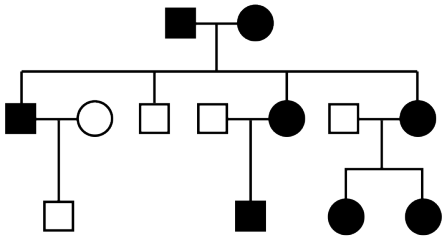
(B)



(C)



(D)



8. A scientist performed an experiment to test the ability of chloroplasts to produce ATP in the dark. The scientist maintained chloroplasts under dark conditions and placed them first in a pH 4 solution for 15 seconds and then in a pH8 solution containing ADP and P_i (inorganic phosphate). Under these conditions, the pH of the stroma increased to 8, the pH of the thylakoid space remained at 4, and the chloroplasts produced ATP.

   Which of the following best explains how the difference in pH between the stroma and the thylakoid space enabled the chloroplasts to produce ATP in the dark?

   (A) The difference in pH created a proton gradient that enabled protons to pass through ATP synthase, activating it to produce ATP.

   (B) The difference in pH enabled complexes of protons and ADP in the thylakoid space to move through ATP synthase to the stroma, producing ATP.

   (C) The difference in pH stimulated the electron flow needed to pump protons into the stroma and induce P_i and ADP to bond and form ATP.

   (D) The difference in pH caused the photosystems to release high energy electrons that provided enough energy for ADP and P_i to bond and form ATP.

9. Which of the following best explains why surface tension is created on the surface of bodies of water?

   (A) Water molecules are attracted to each other because the hydrogen atoms donate electrons to oxygen atoms.

   (B) Water molecules are attracted to each other because the sharing of electrons between hydrogen and oxygen is unequal.

   (C) Water molecules are attracted to substances dissolved in the water because most dissolved substances are positively charged.

   (D) Water molecules are attracted to substances dissolved in the water because most dissolved substances are negatively charged.

10. Pit vipers are snakes that have deep sensory openings (pits) between their nostrils and eyes. These pits enable the snakes to sense heat emitted by endotherms, such as mammals, allowing the snakes to find their prey. In an experiment, researchers discovered that nerve cells in the pits transcribe the gene *TRPA*1 400 times more often than do other nerve cells in the snakes. The researchers claim that the *TRPA*1 gene is involved in the snakes' ability to sense heat.

    Which of the following would be the best control to add to the researchers' experiment?

    (A) Measuring translation of *TRPA*1 mRNA in pit nerve cells

    (B) Measuring translation of *TRPA*1 mRNA in nerve cells of mammals

    (C) Measuring *TRPA*1 transcription in nerve cells of snakes lacking pits

    (D) Measuring *TRPA*1 transcription in nerve cells of mammals

11. Members of one population of the striped stem borer insect engage in mating behavior in the early hours of the night, whereas members of a second population mate much later during the night. Crossbreeding between individuals from the two populations produces offspring that mate at an intermediate time.

    Which of the following is the most likely cause of the different timing of mating behavior between the two populations?

    (A) Genetic variation between the populations

    (B) The seasonal difference in day length

    (C) The difference in learned behavior between the populations

    (D) Gene flow between the populations

12. Cyclin-dependent kinase 7 (CDK7) binds to cyclin H and a second accessory protein, MAT1, to form a complex of three proteins. Researchers investigating the role of CDK7 claim that formation of this complex promotes cell cycle progression.

    Which of the following supports the researchers' claim?

    (A) Decreased expression of CDK7 initiates DNA replication.

    (B) Decreased expression of CDK7 results in the formation of spindle fibers.

    (C) Increased expression of CDK7 causes cells to enter G_0.

    (D) Increased expression of CDK7 is associated with certain types of cancer.

13. Which of the following best describes a cell that is in the G_1 stage of the cell cycle?

    (A) The cell is growing in size and increasing its number of proteins and organelles.

    (B) The chromosomes within the cell are checked to make certain that they have been replicated correctly.

    (C) The chromosomes are replicating, and the amount of DNA in the cell is doubling.

    (D) The cell is in a resting stage and no longer dividing.

14. Cholinesterase is an enzyme that catalyzes the hydrolysis of the signaling molecule acetylcholine. Which of the following best explains how cholinesterase carries out its function?

    (A) Cholinesterase breaks covalent bonds within acetylcholine by the addition of a water molecule.

    (B) Cholinesterase breaks covalent bonds within acetylcholine by removing a water molecule.

    (C) Cholinesterase forms covalent bonds between acetylcholine and another molecule by the addition of a water molecule.

    (D) Cholinesterase forms covalent bonds between acetylcholine and another molecule by removing a water molecule.

15. Which of the following best describes the primary mechanism of transport whereby carbon dioxide moves from inside a cell to outside the cell?

    (A) Carbon dioxide is released when vesicles containing carbon dioxide fuse with the plasma membrane.

    (B) Carbon dioxide is actively pumped into the membrane between the halves of the bilayer and then passively diffuses out.

    (C) Carbon dioxide passively diffuses between the membrane lipids.

    (D) Carbon dioxide passively moves through membrane channel proteins.

TABLE 1. AVERAGE DIMENSIONS OF FOUR CELL TYPES

	Surface Area (mm^2)	Volume (mm^3)
Cell type 1	96	64
Cell type 2	60	10
Cell type 3	54	27
Cell type 4	24	8

16. Which of the cell types represented in Table 1 is most efficient at acquiring nutrients by diffusion?

    (A) Cell type 1

    (B) Cell type 2

    (C) Cell type 3

    (D) Cell type 4

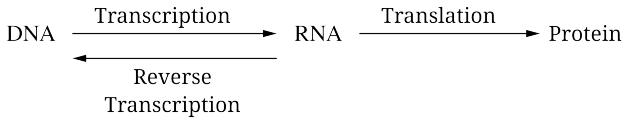


Figure 1. A model of a biological process

17. Which of the following processes requires all of the steps represented in Figure 1 ?

    (A) Cell signaling to increase gene expression in an animal cell

    (B) Replication of a retrovirus after it enters a host cell

    (C) Regulation of gene expression in a cell by microRNA

    (D) Production of plasmids in a bacterial cell

18. In plants the enzyme EPSP synthase catalyzes a reaction between two different substrates, S3P and PEP, to form a product used in the synthesis of three amino acids. The structure of glyphosate, the active chemical in many herbicides, is very similar to that of PEP.

    Which of the following explains how glyphosate most likely functions as an herbicide?

    (A) Glyphosate prevents synthesis of PEP the three amino acids by competing with for binding to the active site of EPSP synthase.

    (B) Glyphosate prevents synthesis of the three amino acids by binding to an allosteric site of EPSP synthase, increasing the likelihood that PEP will bind to the active site.

    (C) Glyphosate causes too much synthesis of the three amino acids by reducing the activation energy of the reaction catalyzed by EPSP synthase.

    (D) Glyphosate alters the structure of the three amino acids by binding to both S3P and PEP in the active site of EPSP synthase.

19. Hunting of African elephants for their tusks resulted in a 90% reduction in the size of one particular elephant population by 1992. Since then, protections of elephant populations have improved, and the population size has begun to increase. Before 1992, tuskless elephants were rare, but now a significant proportion of the female elephants in this population are tuskless. An allele of the gene *AMELX* appears to be responsible for the tuskless trait.

    Which of the following best explains the change in the relative proportion of tuskless elephants since 1992?

    (A) With human protections in place, tusks are less important to the protection of the herds and in particular to the females, so tusks are selected against.

    (B) Female tuskless elephants were more likely to have survived than were tusked females, resulting in a greater proportion of the offspring having the genes of the tuskless elephants.

    (C) Female elephants that survived removal of their tusks were more likely to pass the tuskless allele than the tusked allele of the *AMELX* gene to their female offspring.

    (D) Overhunting of the elephants caused the emergence of the tuskless mutation in the *AMELX* gene, leading to an increase in the frequency of the tuskless phenotype.

20. The process of hydrogenation is used in the food industry to convert lipids that are liquids at room temperature into solids at room temperature. The process involves the chemical addition of hydrogen atoms to the fatty acid tails of lipids, breaking some or all of the carbon-carbon double bonds in the fatty acid tails.

    Which of the following best explains why hydrogenation converts liquid lipids to solid lipids?

    (A) Hydrogenation makes the fatty acids more saturated, enabling them to be more densely packed together.

    (B) Hydrogenation makes the fatty acids less saturated, enabling them to be more densely packed together.

    (C) Hydrogenation makes the fatty acids more saturated, resulting in fewer lipid molecules fitting within a given space.

    (D) Hydrogenation makes the fatty acids less saturated, resulting in fewer lipid molecules fitting within a given space.

21. Which of the following best describes the position of the phospholipids within the phospholipid bilayer of the plasma membrane?

    (A) The hydrophilic heads face the inner region of the membrane, and the hydrophobic tails point outward.

    (B) The hydrophilic tails face the inner region of the membrane, and the hydrophobic heads point outward.

    (C) The hydrophobic heads face the inner region of the membrane, and the hydrophilic tails point outward.

    (D) The hydrophobic tails face the inner region of the membrane, and the hydrophilic heads point outward.

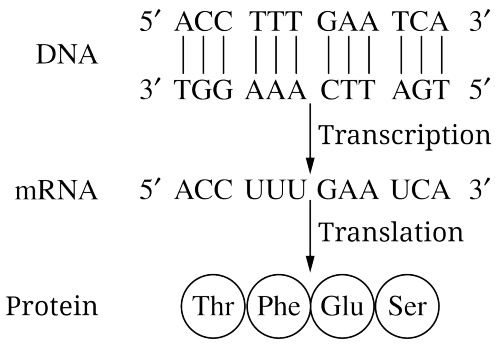


Figure 1. Model of a cellular process

22. Which of the following best describes the model shown in Figure 1?

    (A) The model shows how genetic information directs the synthesis of polypeptides.

    (B) The model shows how a mutation in the DNA results in a nonfunctional protein.

    (C) The model shows how information in the mRNA can be used to make both protein and DNA.

    (D) The model shows how proteins are needed for the synthesis of both DNA and RNA.

Questions 23-26

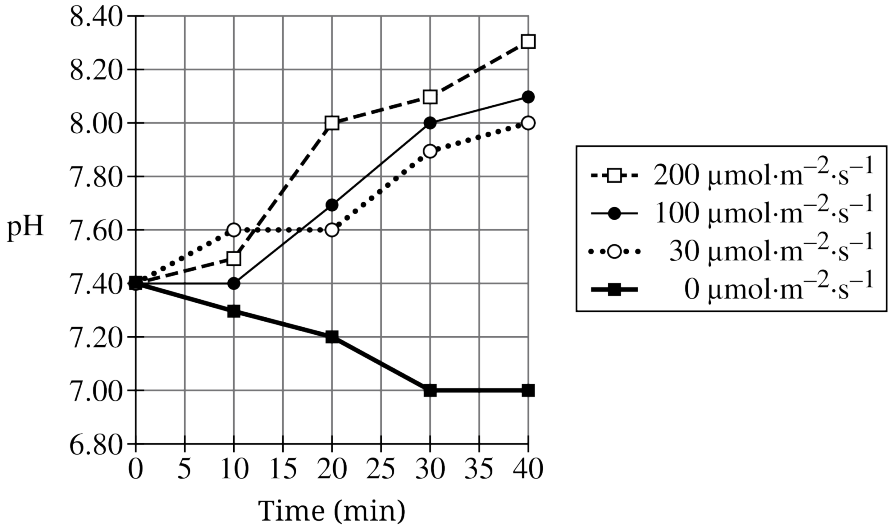


Figure 1. Effect of light intensity (μmol/m^{-2}·s^{-1}) on the pH of a solution containing algae

Students investigated the effect of light intensity on the rates of photosynthesis and cellular respiration in algae. They placed equal numbers of algal cells into test tubes containing a solution at pH 7.40. The test tubes were divided into four treatment groups, and each treatment group was exposed to a different light intensity. The pH in the tubes was measured every 10 minutes and used as an indicator of CO_2 concentration because produces an acidic solution when CO_2 dissolved in water (Figure 1).

23. Which of the following claims is best supported by the data?

    (A) Algae only carry out photosynthesis when exposed to 200 μmol/m^{-2}·s^{-1}.

    (B) Algae double the rate of photosynthesis when the light intensity doubles.

    (C) Algae that are exposed to 30 μmol/m^{-2}·s^{-1} of light perform photosynthesis instead of cellular respiration.

    (D) Algae that are exposed to 100 μmol/m^{-2}·s^{-1} of light have a greater rate of photosynthesis than of cellular respiration over time.

24. Scientists claim that changes in the rate of photosynthesis will be reflected by changes in pH.

    Which of the following best supports their claim?

    (A) Algae performing photosynthesis remove CO_2 from the solution, increasing pH.

    (B) Algae performing photosynthesis release CO_2 into the solution, decreasing pH.

    (C) Algae performing photosynthesis remove O_2 from the solution, decreasing pH.

    (D) Algae performing photosynthesis release O_2 into the solution, increasing pH.

25. Based on Figure 1, which of the following environmental changes will result in the greatest increase in the net photosynthetic productivity by the algae?

    (A) A change in light intensity from 0 μmol/m^{-2}·s^{-1} to 30 μmol/m^{-2}·s^{-1}.

    (B) A change in light intensity from 30 μmol/m^{-2}·s^{-1} to 100 μmol/m^{-2}·s^{-1}.

    (C) A change in light intensity from 100 μmol/m^{-2}·s^{-1} to 200 μmol/m^{-2}·s^{-1}.

    (D) A change in light intensity from 200 μmol/m^{-2}·s^{-1} to 30 μmol/m^{-2}·s^{-1}.

26. Based on Figure 1, which of the following was used as a control in the experiment?

    (A) A test tube placed directly in front of a light source

    (B) The 0 μmol/m^{-2}·s^{-1} light-intensity treatment

    (C) The 200 μmol/m^{-2}·s^{-1} light-intensity treatment

    (D) A test tube containing no algal cells

Questions 27-31

In a laboratory population of fruit flies, body color is determined by a single gene with a wild-type allele associated with black body color and a mutant allele associated with yellow body color. A group of researchers hypothesizes that the mutation in fruit flies that causes the yellow body is sex-linked. They also hypothesize that this mutation results in a change in the structure of the sex combs, bristle-like structures on the front legs of male flies that facilitate mating.

To determine the inheritance pattern of the mutant allele, researchers crossed yellow-bodied females with wild-type males. Flies from the F_1 generation were then crossed. The distribution of phenotypes observed in the F_1 and F_2 generations is shown in Table 1.

TABLE 1. DISTRIBUTION OF PHENOTYPES OBSERVED IN THE P, F_1, and F_2 GENERATIONS

	Wild-TypeFemales*	**Yellow-Bodied Females***	**Wild-TypeMales****	**Yellow-BodiedMales****
P generation	0	3	3	0
F_1 generation	38	0	0	41
F_2 generation	117	124	121	130

*Female fruit flies have two X chromosomes.
**Male fruit flies have one X chromosome and one Y chromosome.

27. Based on the researchers' hypothesis that the mutant allele is sex-linked, which of the following is closest to the expected number of wild-type females and the expected number of yellow-bodied males in the F_2 generation?

    (A) 123 wild-type females and 123 yellow-bodied males

    (B) 61 wild-type females and 184 yellow-bodied males

    (C) 123 wild-type females and 369 yellow-bodied males

    (D) 184 wild-type females and 61 yellow-bodied males

28. Using a *p*-value of 0.05, researchers performed a chi-square analysis of the distribution of phenotypes in the F_2 generation.

    Which of the following chi-square calculated values would cause the researchers to reject their null hypothesis?

    (A) 0.73

    (B) 2.16

    (C) 4.35

    (D) 7.98

29. Based on the data in Table 1, which of the following is the most likely inheritance pattern for the mutant allele?

    (A) The mutant allele is X-linked dominant.
    (B) The mutant allele is X-linked recessive.
    (C) The mutant allele is autosomal (non-sex-linked) recessive.
    (D) The mutant allele is Y-linked.

30. Which of the following most likely explains how the sex combs of yellow-bodied flies have a different structure than do the sex combs of wild-type flies?

    (A) The protein encoded by the mutant body color allele interferes with the development of sex combs.
    (B) The protein encoded by the mutant body color allele is only produced if a copy of the wild-type body color allele is present.
    (C) The gene associated with body color and the gene associated with sex comb development both exhibit codominance in flies.
    (D) The gene associated with body color and the gene associated with sex comb development are located far apart on the same chromosome in flies.

31. Which of the following best supports the claim that the fitness of yellow-bodied flies is lower than the fitness of wild-type flies?

    (A) Males with the yellow-body phenotype are selected by females for mating more often than are wild-type males.
    (B) Males with the yellow-body phenotype blend in with their environment and avoid detection by predators better than do wild-type males.
    (C) Males with the yellow-body phenotype reproduce less but produce a greater number of viable offspring than do wild-type flies.
    (D) Males with the yellow-body phenotype have weaker sex-comb bristles and decreased mating success compared with the bristles and mating success of wild-type males.

Questions 32-35

Mice live in territorial social groups, and each group has a single dominant male with the rest of the males in the group being subordinate. Male mice mark the area in which they live with their scent by leaving urine wherever they walk. There are two classes of proteins that are found in mouse urine, major urinary proteins (MUPs) and major histocompatibility complex (MHC) proteins. The proteins provide a unique scent for each mouse.

In an experiment, wild male mice were kept isolated in separate cages and their urination patterns were recorded. They were then combined into a single cage that was divided into two compartments by a mesh screen, and again their urination patterns were recorded (Figure 1).

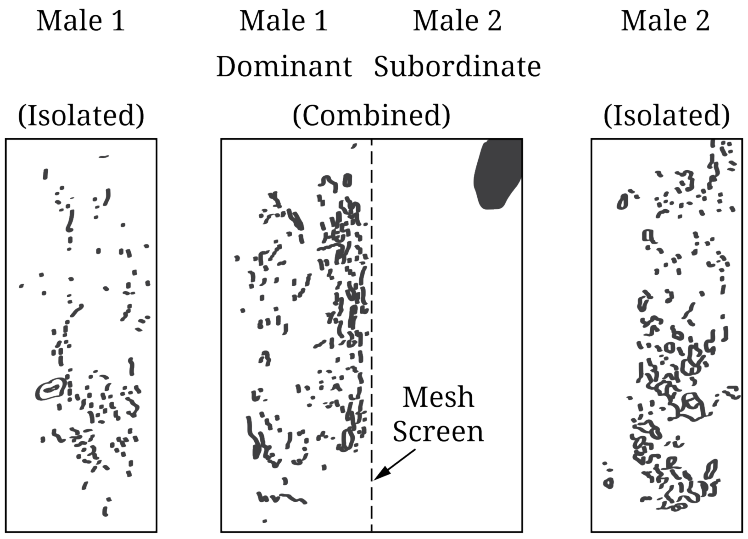


Figure 1. Urination patterns recorded during an experiment

32. Which of the following claims about communication and behavior in mice is best supported by the data from the experiment?

    (A) Subordinate males use scent to avoid territory occupied by a dominant male.

    (B) Dominant males use urine to communicate sex differences.

    (C) Subordinate males occupy more space when in the presence of a dominant male.

    (D) Dominant males occupy less space when in the presence of a subordinate male.

33. A researcher claims that the life spans of dominant males are longer than the life spans of subordinate males. Based on the results of the experiment, which of the following best supports the researcher's claim?

    (A) Dominant males have proteins in their urine that protect them from harmful genetic mutations.

    (B) Dominant males have proteins in their urine that enable them to communicate with subordinate males in their group.

    (C) Dominant males are able to move more freely throughout their territory, which gives them greater access to resources.

    (D) Dominant males are able to move more freely throughout their territory, which reduces the number of pathogens they are exposed to.

34. Which of the following best explains why particular MUP protein variants are associated with male dominance in individuals in populations of wild mice?

(A) Viral infections introduced new MUP alleles into affected populations.

(B) Environmental stress caused a decreased rate of mutations in the MUP genes of subordinate mice.

(C) Interbreeding between different mouse species introduced new MUP alleles into the populations.

(D) The MUP genes are located on a chromosome near genes associated with phenotypes of dominant males.

35. In addition to their role in urine scent marking, MHC proteins are used by body cells in both sexes of mice to distinguish self cells that originate in an individual's body from nonself cells that do not originate in an individual's body.

Which of the following best explains how MHC-related odor-producing molecules might be used to maintain genetic diversity in mouse populations?

(A) They could be used by female mice for mate selection to avoid mating with related individuals.

(B) They could be used by subordinate males to attract dominant males to the area to enrich the gene pool.

(C) They could be used by subordinate males to decrease competition with other males resulting in increased genetic diversity.

(D) They could be used by females to decrease bacterial infections that occur during pregnancy.

Questions 36-39

Researchers investigated the effects of nonnative trout on the behavior of native salmon inhabiting a freshwater stream. Juvenile trout compete with juvenile salmon for resources, and adult trout prey on juvenile salmon.

Researchers built enclosed channels in a freshwater stream. A transparent plastic mesh screen divided each channel into two sections, an upstream predator section and a downstream competitor section. Similar screens placed at the ends of each channel permitted the flow of water and small invertebrate organisms, eaten by juvenile members of both species of fish, through the channel. Juvenile salmon were placed in only the competitor section of each channel, in the absence or presence of juvenile trout, and in the absence or presence of adult trout placed only in the predator section (Figure 1). The researchers then recorded the percent of juvenile salmon that were active during the day and night, under the different conditions (Figure 2).

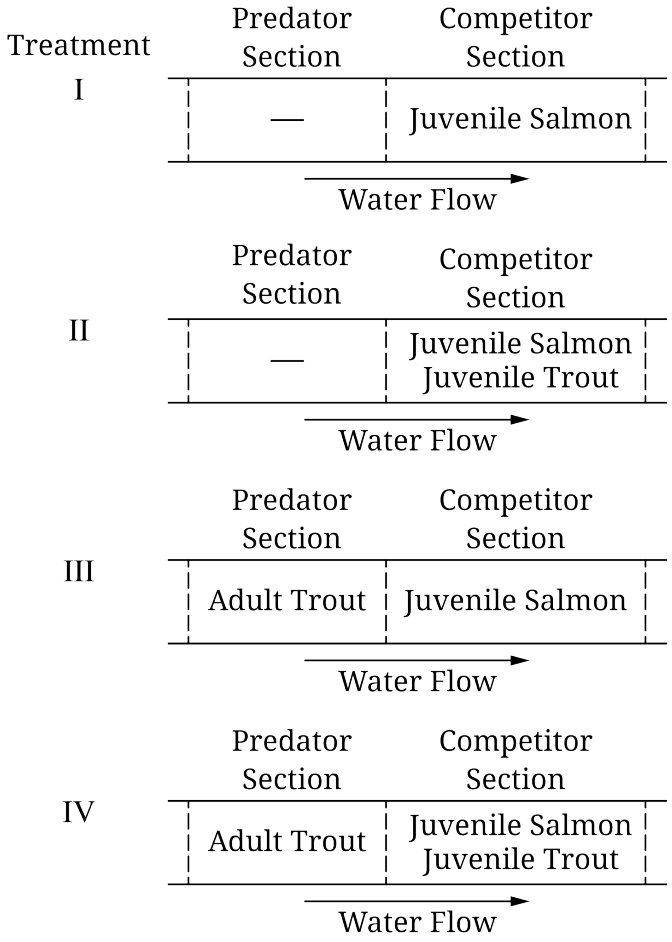


Figure 1. Experimental design of four freshwater stream channels used to monitor juvenile salmon behavior in the presence or absence of predator and/or competitor fish

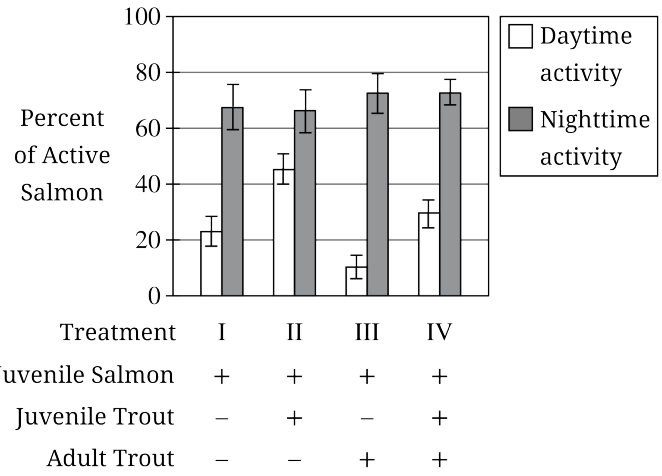


Figure 2. Activity of juvenile salmon in freshwater stream channels in the presence (+) or absence (−) of juvenile and/or adult trout. Error bars represent $\pm 2SE_{\bar{x}}$.

36. Which of the following descriptions of juvenile salmon activity is best supported by the data in Figure 2?

    (A) Daytime activity increases when only a predator is present.

    (B) Nighttime activity decreases when only a competitor is present.

    (C) Daytime activity increases when only a competitor is present.

    (D) Nighttime activity increases in the presence of competitors and predators.

37. The researchers claim that the risk to juvenile salmon from predation is about the same as the risk due to competition. Which of the following best supports the researchers' claim?

    (A) The daytime activity in treatment IV is about the same as the daytime activity in treatment I and intermediate between the daytime activity in treatments II and III.

    (B) In treatment III, the daytime activity is the lowest of all of the treatments and the nighttime activity is the highest of all of the treatments.

    (C) In treatment IV, the nighttime activity is twice as great as the daytime activity.

    (D) The nighttime activity is about the same in all four treatments.

38. A researcher claims that the predator avoidance behavior of juvenile salmon observed in the study has evolved because of natural selection. Which of the following data could best be used to support the claim?

    (A) The salmon that avoid predators have longer life spans as compared with salmon that do not avoid predators.

    (B) The salmon that avoid predators can grow to a larger size as compared with salmon that do not avoid predators.

    (C) The salmon that avoid predators are able to access more resources as compared with salmon that do not avoid predators.

    (D) The salmon that avoid predators have a greater number of viable offspring as compared with salmon that do not avoid predators.

39. The researchers hypothesize that juvenile salmon use chemical cues to detect predators that are nearby. Which of the following modifications to the experiment will help the researchers test their hypothesis?

    (A) Remove the mesh screen from the channel so that the predators have access to the juvenile salmon.

    (B) Change the light schedule so that there are twice as many nighttime hours as daytime hours.

    (C) Add rocks to the channel that the juvenile salmon can use to hide from predators.

    (D) Replace the mesh screen with a solid, transparent barrier that allows light to pass through.

Questions 40-44

Snowshoe hares are small mammals that live in forests throughout Canada and the northern United States. Hares feed primarily on vegetation and are preyed on by lynx and owls.

In the fall, the hares shed their brown coat (molt), and a new white coat grows in over a period of 40 days. In the spring, the hares molt again and their white coat is replaced with a brown coat over a period of approximately 30 to 50 days.

In a recent study, researchers observed that the majority of hares in an isolated population began the molting process during the same week in the fall, even though the ground was not snow covered. The majority of hares also began the molting process during the same week in the spring, even though the ground was still snow covered. The researchers formulated a hypothesis that the timing of the molting process is influenced by seasonal changes in the daylight period.

40. Which of the following would best support the claim that the timing of the molting process in certain species is influenced by seasonal changes in the daylight period?

    (A) More species that molt seasonally do so when the daylight period is the longest, than when the daylight period is the shortest.

    (B) More species that molt seasonally do so when the daylight period is the shortest, than when the daylight period is the longest.

    (C) More species that molt seasonally are found in the arctic, where the daylight period varies, than near the equator where the daylight period is relatively constant.

    (D) More species that molt seasonally are found near the equator, where the daylight period is relatively constant, than in the arctic, where the daylight period varies.

41. Several climate models for the original study area predict that the length of time the ground is covered in snow will decrease over time while the daylight periods will remain unchanged.

    Assuming that the researchers' hypothesis about the timing of molting and the climate models are correct, which of the following will be the most likely immediate effect of the decrease in time the ground is snow covered on the hare population?

    (A) The hare population will stop molting and maintain a single coat all year.

    (B) The hare population will migrate to an area with an even shorter time during which the ground is snow covered.

    (C) Hares will experience longer times with coat colors that do not blend with the ground color.

    (D) The process of molting from a white to a brown coat in hares will take longer.

42. To test their hypothesis, the researchers conducted a laboratory experiment in which groups of hares were exposed to gradually decreasing periods of daylight. The lengths of the daylight period when molting began were recorded.

    Which of the following experimental controls should have been included to ensure that the results could be attributed to changes in the daylight period and not to some other variable?

    (A) Adjusting the temperature in the lab to simulate seasonal temperature changes
    (B) Exposing one group of hares to a fixed daylight period for the duration of the experiment
    (C) Feeding the hares at various times of the day to simulate the availability of food in nature
    (D) Using lights of different intensities to simulate different weather conditions

43. A second isolated hare population has white coats all year, although the area is not covered by snow.

    Which of the following is a testable question the researchers can ask to explain the origin of the different coat color of the second population?

    (A) Do the genes associated with coat color in both populations have the same sequence of DNA nucleotides?
    (B) Are hares that have a white coat all year round better able to find food than those that change coat color?
    (C) Is the reproductive fitness greater in hares that have a white coat all year round than in those that change coat colors?
    (D) Is the same genetic code used to produce the enzymes involved in the production of coat color pigments in both populations?

44. If a viral infection significantly reduces the size of the snowshoe hare population, which of the following predicts the most likely effect on the community during that year?

    (A) The biomass of producers will decrease.
    (B) The biomass of the lynx will increase.
    (C) New predators will feed on the owls.
    (D) The lynx and owl populations will decrease.

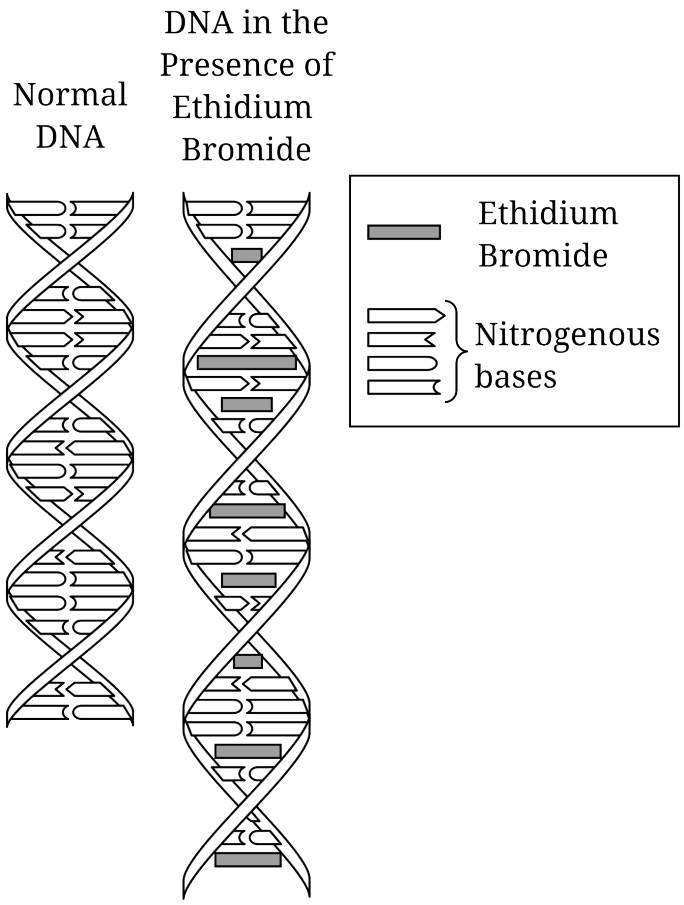


Figure 1. Model of DNA structure in the absence and presence of ethidium bromide

45. Ethidium bromide is a chemical that disrupts the replication of DNA. Based on the model shown in Figure 1, which of the following best describes the effect of ethidium bromide on DNA structure?

(A) It is inserted between complementary nitrogenous bases, causing the two strands of DNA to denature.

(B) It is inserted between complementary nitrogenous bases, causing hydrogen bonds to form between noncomplementary nitrogenous bases.

(C) It is inserted between sequential nitrogenous base pairs, increasing the length of the DNA molecule.

(D) It is inserted in place of certain nitrogenous base pairs, decreasing the length of the DNA molecule.

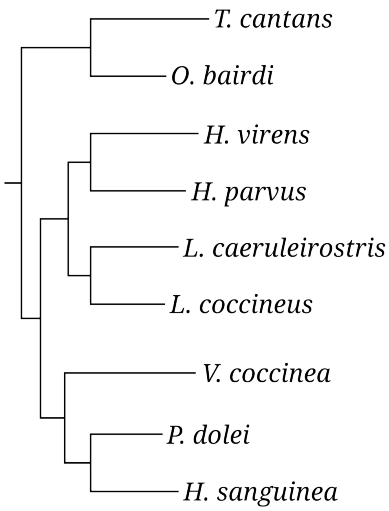


Figure 1. A hypothesized phylogenetic relationship among some members of the Hawaiian honeycreeper bird family

46. One hypothesized phylogenetic relationship among selected members of the Hawaiian honeycreeper bird family is shown in Figure 1. Based on the phylogenetic tree, birds in which of the following pairs share the most recent common ancestor?

    (A) *H. parvus and O. bairdi*

    (B) *L. coccineus and V. coccinea*

    (C) *L. caeruleirostris and H. virens*

    (D) *T. cantans and H. sanguinea*

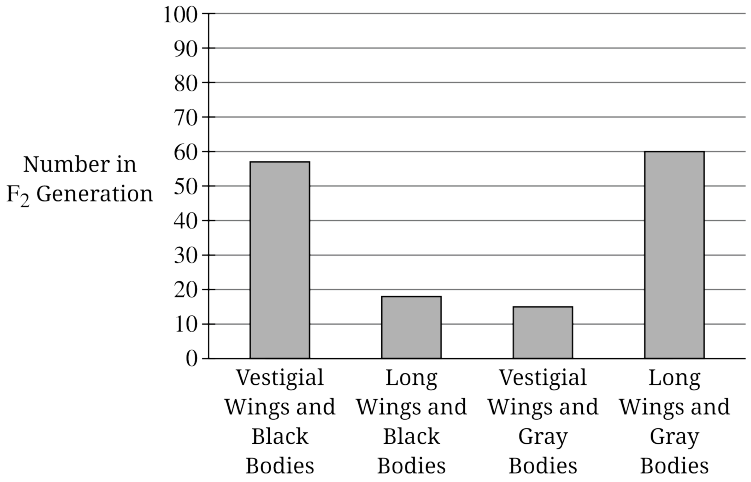


Figure 1. The distribution of phenotypes in the F_2 generation of fruit flies

47. In fruit flies, genes that control body color and wing length are linked. A researcher crossed a true-breeding fruit fly with long wings and a gray body with a true-breeding fruit fly with vestigial wings and a black body. All of the F_1 flies had long wings and gray bodies. The researcher then crossed the F_1 flies with true-breeding flies that have vestigial wings and black bodies. The number of flies with each phenotype in the resulting F_2 generation is shown in Figure 1.

    What percent of the F_2 generation flies carry chromosomes produced by crossing-over between the two linked genes?

    (A) 10%
    (B) 15%
    (C) 22%
    (D) 33%

TABLE 1. POLLINATOR VISITATION RATES TO TWO SPECIES OF *MIMULUS*

Mimulus Species and Flower Color	Bumblebees (10^{-3} visits/flower/hour)	Hummingbirds (10^{-3} visits/flower/hour)
M. lewisii (wild-type, pink)	15.4	0.021
M. lewisii (mutant, orange)	2.63	1.44
M. cardinalis (wild-type, red)	0.148	189
M. cardinalis (mutant, pink)	10.9	168

48. Plant species in the genus *Mimulus* have evolved specialized flower structures and colors that attract pollinators. Researchers identified mutant forms of two of the species, *Mimulus lewisii* and *Mimulus cardinalis*, that have different flower colors from the wild-type forms. They measured the number of visits by two pollinators, bumblebees and hummingbirds, to the flowers of the wild-type and mutant species (Table 1).

    Which of the following statements best describes the data shown in Table 1?

    (A) Bumblebees visited wild-type *M. lewisii* approximately 13 times more frequently than they did mutant *M. lewisii*.
    (B) Hummingbirds preferred wild-type *M. lewisii* over wild-type *M. cardinalis*.
    (C) Hummingbirds preferred the pink flower type in both *M. lewisii* and *M. cardinalis*.
    (D) Bumblebees visited mutant *M. cardinalis* approximately 70 times more frequently than they did wild-type *M. cardinalis*.

TABLE 1. RATE OF POLYPEPTIDE ELONGATION

Species	**Number of Amino Acids Added**	**Duration of Measurement (seconds)**
E. coli	1200	60
S. cerevisiae	800	80

49. During translation of an mRNA, amino acids are added one-by-one to the growing end of a polypeptide. Researchers wanted to determine whether there is a difference in the rate of amino acid addition in *E. coli*, a prokaryote, and *S. cerevisiae*, a single-celled eukaryote (Table 1).

    Based on the data in Table 1, how does the rate of polypeptide elongation in *E. coli* compare with the rate of polypeptide elongation in *S. cerevisiae*?

    (A) The rate in *E. coli* is one-tenth the rate in *S. cerevisiae*.

    (B) The rate in *E. coli* is half the rate in *S. cerevisiae*.

    (C) The rate in *E. coli* is one-and-one-half times the rate in *S. cerevisiae*.

    (D) The rate in *E. coli* is twice the rate in *S. cerevisiae*.

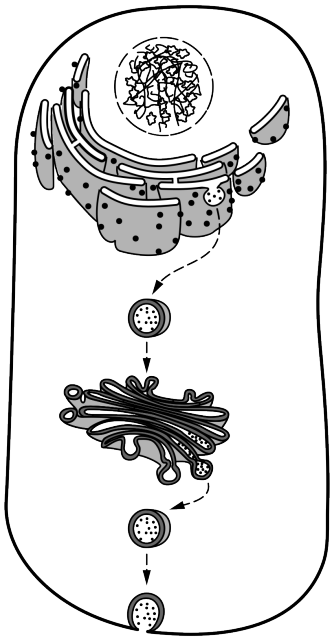


Figure 1. The path of insulin export from a cell

50. Insulin is a protein hormone that helps to regulate blood sugar levels. Figure 1 shows the path of insulin from its production in a cell to its export out of the cell.

    Based on Figure 1, which of the following best describes how insulin leaves the cell?

    (A) A transport protein carries insulin from the cytosol through the plasma membrane by facilitated diffusion.

    (B) A transport protein in the plasma membrane moves insulin by active transport from the Golgi complex through the plasma membrane.

    (C) A vesicle containing insulin moves through the plasma membrane by simple diffusion.

    (D) A vesicle containing insulin fuses with the plasma membrane, enabling exocytosis of insulin.

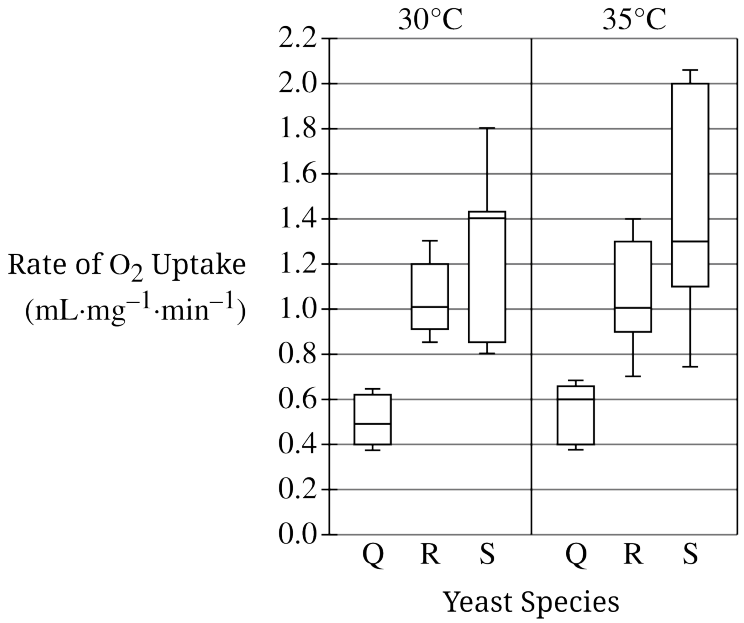


Figure 1. The rate of O_2 uptake for three species of *Saccharomyces* yeast at 30°C and 35°C

51. Researchers studied the effect of increased temperature on the rate of respiration of three species of *Saccharomyces* yeast (Q, R, and S) by measuring the rate of oxygen uptake in each species at 30°C and at 35°C (Figure 1).

    Based on Figure 1, which of the following statements about the effect of the temperature increase on the respiratory rate of one of the species, Q, R, or S, is most likely true?

    (A) The median O_2 uptake rate for species S at 35°C is 0.1 $\mu L \cdot mg^{-1} \cdot min^{-1}$ less than it is at 30°C.

    (B) The range from minimum to maximum O_2 uptake rate for species R at 35°C is 0.1 $\mu L \cdot mg^{-1} \cdot min^{-1}$ more than it is at 30°C.

    (C) The median O_2 uptake rate for species Q at 35°C is the same as it is at 30°C.

    (D) The range of the O_2 uptake rate for species S at 35°C is the same as it is at 30°C.

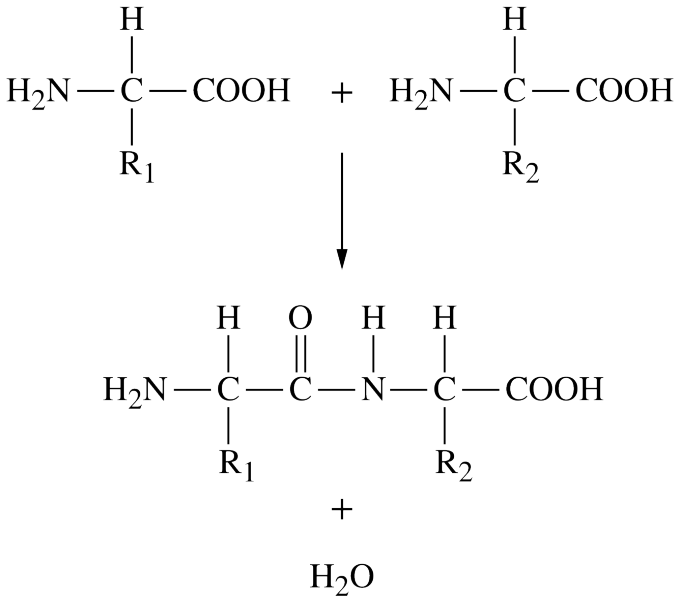


Figure 1. A representation of a reaction involved in the formation of a biological molecule

52. Which of the following best explains the reaction represented in Figure 1?

(A) It is a dehydration synthesis reaction involved in the formation of a lipid.

(B) The reaction is the hydrolysis of a nucleic acid and results in the formation of a nucleotide.

(C) The reaction is the hydrolysis of a nucleic acid and results in the formation of a phospholipid.

(D) It is a dehydration synthesis reaction involved in the formation of a polypeptide.

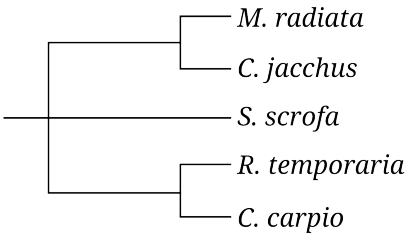
TABLE 1. PERCENT HOMOLOGY OF *MEF2A* NUCLEOTIDE SEQUENCES

Species	*M. radiata*	*C. jacchus*	*S. scrofa*	*C. carpio*	*R. temporaria*
M. radiata		90.3	71.5	42.7	50.9
C. jacchus			70.6	42.1	50.5
S. scrofa				40.8	48.9
C. carpio					44.5
R. temporaria					

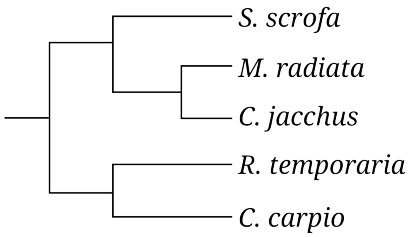
53. The *MEF2A* gene is critical for muscle development in many vertebrates. A researcher sequenced the *MEF2A* gene from five vertebrate species and calculated the percent homology between the nucleotide sequences from each pair of species (Table 1).

Which of the following cladograms is the most accurate representation of the data in Table 1?

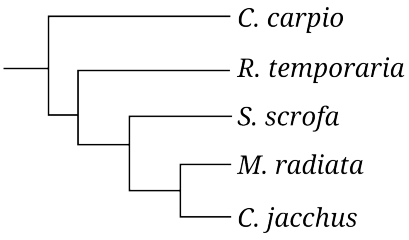
(A)



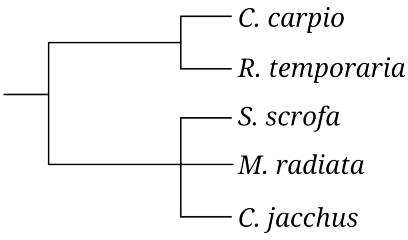
(B)



(C)



(D)



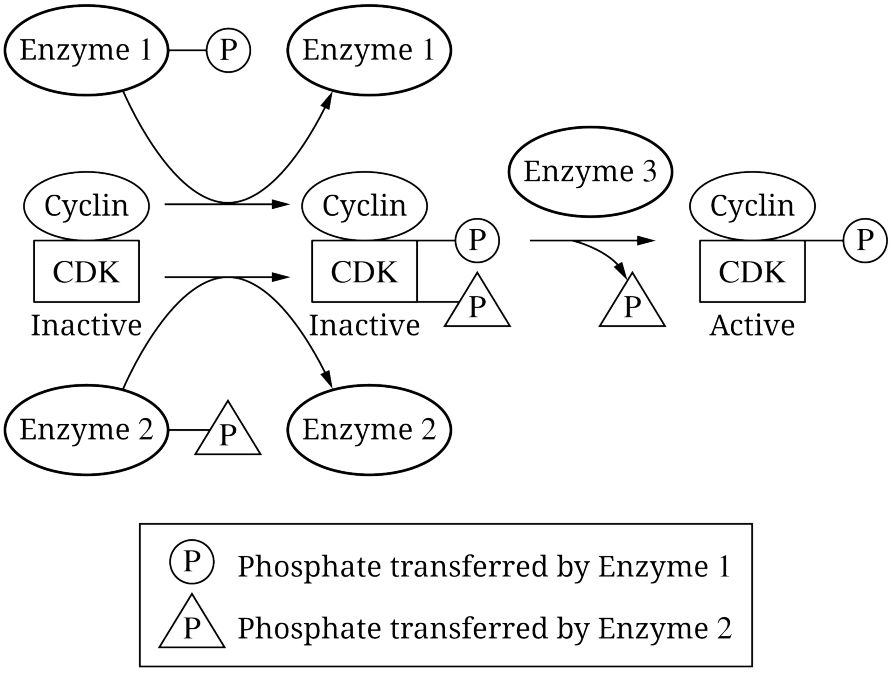


Figure 1. Activation of a cyclin-CDK complex

54. The regulation of a certain cyclin-CDK complex involves the activity of three enzymes (Figure 1), and the activation of this complex is required for cells to progress through the cell cycle.

Based on Figure 1, which of the following describes a cell in which cell cycle progression continues?

(A) A cell in which enzyme 1 is functional, and enzyme 2 and enzyme 3 are nonfunctional

(B) A cell in which enzyme 1 is nonfunctional, and enzyme 2 and enzyme 3 are functional

(C) A cell in which enzyme 1 and enzyme 2 are functional, and enzyme 3 is nonfunctional

(D) A cell in which enzyme 1 and enzyme 3 are nonfunctional, and enzyme 2 is functional

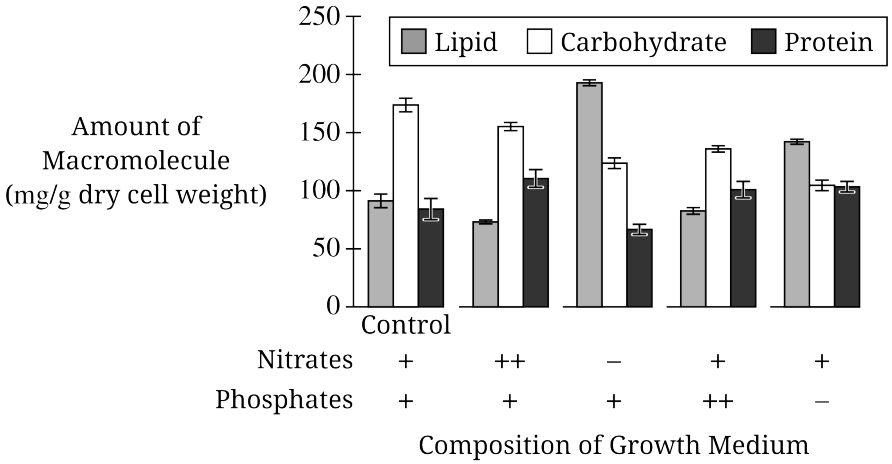


Figure 1. Effect of different abiotic factors on the macromolecule content of bacterial cells. Cells were grown in media with a standard amount (+), twice the standard amount (++), or a reduced amount (−) of each substance. Error bars represent $\pm 2SE_{\bar{x}}$.

55. To test the effect of different abiotic factors on the macromolecule content of bacterial cells, researchers grew identical samples of bacterial cells on growth media in which the amount of nitrates and phosphates differed. The amounts of carbohydrates, lipids, and proteins in each sample of cells were then determined (Figure 1).

Based on Figure 1, use of which of the following growth media resulted in a decrease in the amount of protein but an increase in the amount of lipids compared with the control?

(A) Medium with a standard amount of nitrates and a reduced amount of phosphates

(B) Medium with a reduced amount of nitrates and a standard amount of phosphates

(C) Medium with twice the standard amount of nitrates and a standard amount of phosphates

(D) Medium with a standard amount of nitrates and twice the standard amount of phosphates

TABLE 1. DISTRIBUTION OF CONTROL AND EXPERIMENTAL CELLS IN DIFFERENT STAGES OF THE CELL CYCLE AFTER 24 HOURS

	G_1	S	G_2	M
Control	96	59	48	81
Experimental	142	142	0	0

56. Researchers claimed that cells treated with radiation are unable to progress through the cell cycle. They tested their claim by exposing a group of cells to radiation (experimental group). A group of unexposed cells served as the control group. After 24 hours, they determined the number of cells in each stage of the cell cycle and confirmed that all differences were statistically significant.

Based on Table 1, which of the following best supports the researchers' claim?

(A) In the experimental group, no cells were able to enter G_2.

(B) In the control group, the number of cells in G_2 was less than the number of cells in M.

(C) In the control group, the number of cells in each stage decreased as the cell cycle continued.

(D) In the experimental group, the number of cells in G_1 was the same as the number of cells in S.

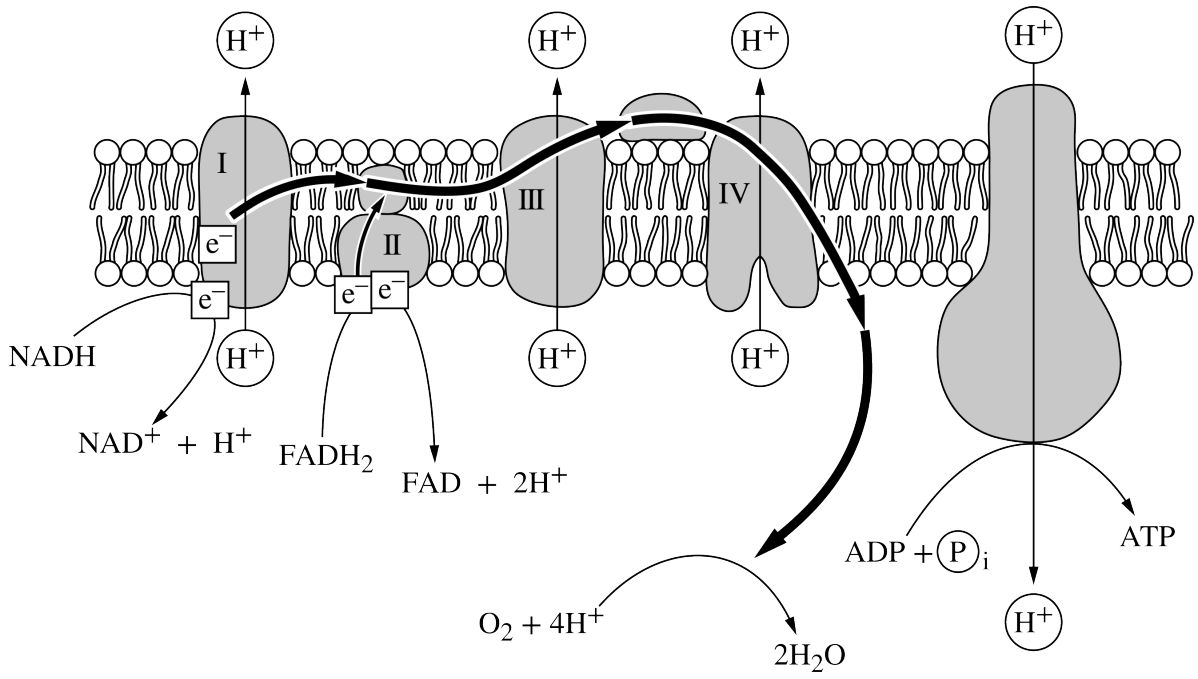


Figure 1. The electron transport chain of cellular respiration. The bold arrows passing through the complexes in the membrane represent the path of electron flow in mitochondria.

57. Compound X binds to complex IV of the mitochondrial electron transport chain and prevents complex IV from accepting electrons.

Based on Figure 1, which of the following best explains why the cells of an animal exposed to compound X have an increased ratio of NADH to NAD^+?

(A) NADH increases because compound X directly prevents ATP synthase from producing the ATP necessary for the oxidation of NADH to NAD^+.

(B) NADH increases because the binding of compound X to complex IV also prevents the transport of NAD^+ out of the mitochondria.

(C) NADH cannot be oxidized NAD^+ to because complexes I, II, and III cannot accept electrons if electrons cannot be passed to complex IV.

(D) NADH cannot be oxidized NAD^+ to because H_2O cannot bind to the active site of complex IV if this complex cannot accept electrons.

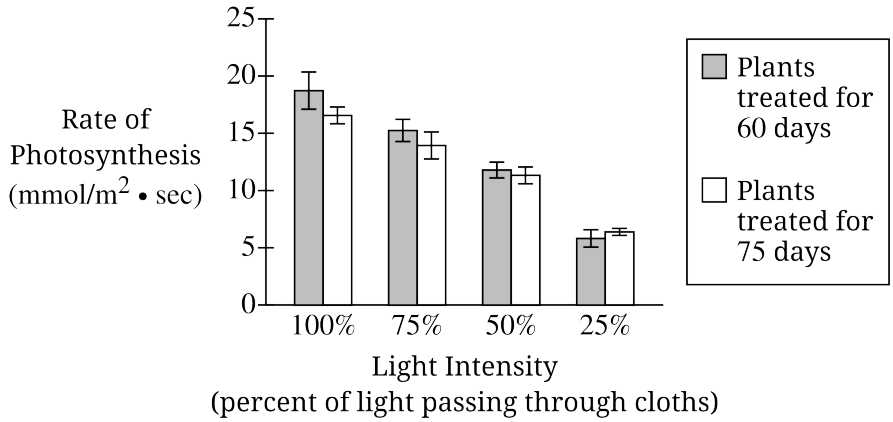


Figure 1. Effect of light intensity and growth period on the rate of photosynthesis in sage plants. Error bars represent $\pm 2SE_{\bar{x}}$.

58. Using light-filtering cloths, scientists exposed sage plants to four different light intensities. Half of the sage plants were exposed to light for 60 days, while the other half were exposed to light for 75 days. The rate of photosynthesis in each plant was then determined (Figure 1).

    Which of the following statements best describes the data?

    (A) At 100% light intensity, the rate of photosynthesis was higher in plants that were treated for 60 days than in plants that were treated for 75 days.

    (B) At 75% light intensity, the rate of photosynthesis was unaffected by an increase in treatment time.

    (C) At 50% light intensity, the rate of photosynthesis was the same as the rate of photosynthesis at 75% light intensity, regardless of the length of treatment time.

    (D) At 25% light intensity, the rate of photosynthesis was higher in plants treated for 75 days than it was in plants treated for 60 days.

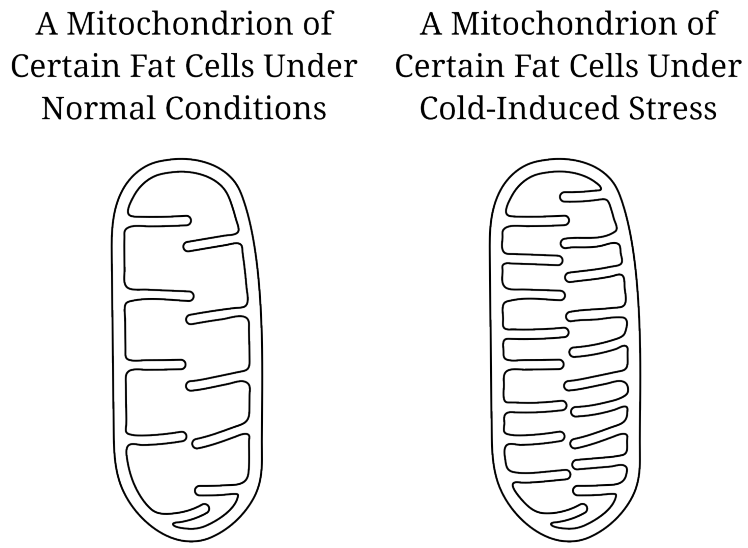


Figure 1. Model of a mitochondrion in cells under normal conditions and in cells experiencing cold-induced stress

59. In a certain type of fat cells, cold temperatures trigger a series of events that include changes to the structure of the mitochondria. A model of a mitochondrion from these fat cells under normal environmental conditions and when experiencing cold-induced stress is shown in Figure 1.

    Which of the following best explains how the changes in mitochondrial structure observed when the cell experiences cold-induced stress affect cellular respiration?

    (A) The volume of the mitochondrial intermembrane space decreases, preventing the reactions of the Krebs cycle from occurring.

    (B) The surface area of the inner membrane decreases, preventing the transport of oxygen molecules into the mitochondria.

    (C) The volume within the mitochondria increases, providing more space for the reactions of glycolysis to take place.

    (D) The surface area of the inner membrane increases, providing more space for the components of the electron transport chain.

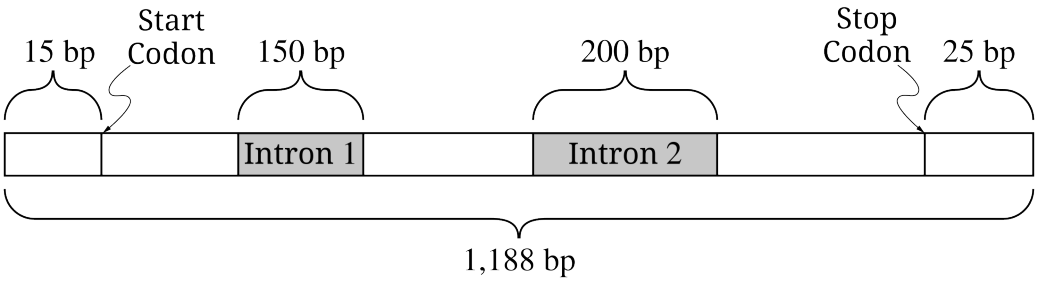


Figure 1. A model of the pre-mRNA transcribed from a gene

60. Which of the following is closest to the number of amino acids encoded by the mRNA produced from the pre-mRNA shown in Figure 1?

(A) 265

(B) 396

(C) 838

(D) 1,188

STOP
END OF SECTION I

BIOLOGY

SECTION II

Time—1 hour and 30 minutes

6 Questions

Directions: Questions 1 and 2 are long free-response questions that require about 25 minutes each to answer. Questions 3 through 6 are short free-response questions that require about 10 minutes each to answer.

Read each question carefully and completely. Answers must be written out in paragraph form. Outlines, bulleted lists, or diagrams alone are not acceptable.

You may plan your answers in this orange booklet, but no credit will be given for anything written in this booklet. **You will only earn credit for what you write in the separate Free Response booklet.**

1. In order to investigate the possible toxic effects of chemicals on organisms living in rivers, scientists collected water samples from locations downstream of four factories that released wastewater into a river.

   The scientists established six treatment groups of bulbs of the common onion, *Allium cepa*, to which they added clean freshwater, an aqueous solution of 300mM mutagen X, or a water sample from one of the four river locations (A through D). Mutagen X is a compound that causes chromosomal mutations. After incubating the bulbs for 24 hours, the scientists removed root tips emerging from the bulbs in each treatment group and examined individual root tip cells under a microscope.

   The scientists examined 6,000 root tip cells from each slide and recorded both the total number of cells that were in some stage of mitosis and the total number of mitotic cells in which either the chromosomes or the mitotic arrangement of the chromosomes appeared to be abnormal (Table 1). They calculated the mitotic index, the percent of all cells examined that were in mitosis. The mitotic index of treatment groups 2 through 6 was then determined relative to the mitotic index of cells in freshwater, which was set at 100 (Figure 1).

TABLE 1. MITOTIC APPEARANCE OF ROOT TIP CELLS AFTER TREATMENT

Treatment Group	**Solution Added to Bulbs**	**Number of Cells in Mitosis**	**Number of Cells with Chromosomal or Mitotic Abnormalities**
1	Freshwater	301	6
2	Mutagen X	144	117
3	Water from location A	150	41
4	Water from location B	210	35
5	Water from location C	186	29
6	Water from location D	270	5

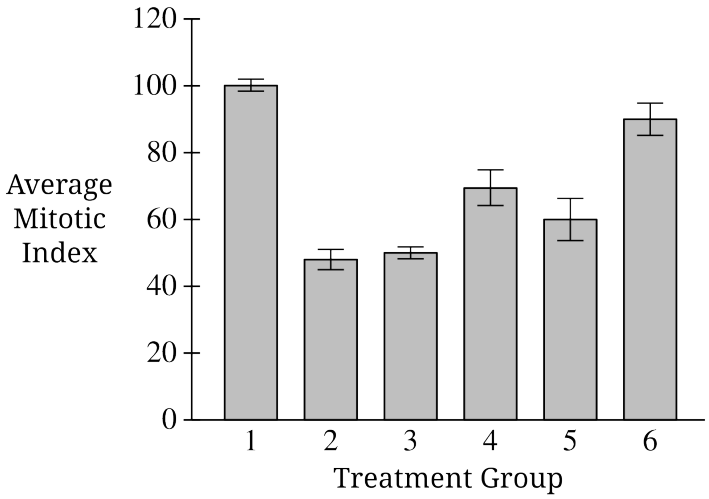


Figure 1. Average mitotic index of root tip cells in each treatment group after 24 hours of incubation. Error bars represent $\pm 2SE_{\bar{x}}$.

(a) **Describe** the structural features of the two ends of a single nucleotide chain. **Explain** how the addition of a chemical that disrupts hydrogen bonds will alter the structure of DNA isolated from onion root tip cells.

(b) Based on Table 1, **identify** an independent variable in the scientists' investigation. **Justify** the use of mutagen X in one of the treatment groups. **Justify** the scientists' examining the same number of cells in each treatment group.

(c) Based on the data in Table 1 and Figure 1, **describe** the general relationship between the mitotic index and the percent of cells with chromosomal or mitotic abnormalities.

(d) The scientists then analyzed the DNA from root tip cells of *A. cepa* bulbs that were maintained in water from location A for one week and then transferred to freshwater for one week. Assuming mutations do not result in cell death, use the data in Table 1 and Figure 1 to **predict** how the amount of cells with mutations in these bulbs will compare with the amount of cells expected to have mutations in bulbs maintained in freshwater and in bulbs maintained in water from location A for the full two-week period. Based on the data, provide reasoning to **justify** your prediction. **Explain** why the mitotic index of cells in a root tip might be altered by a mutation that affects the mitotic spindle.

2. Once thought of as only a toxic by-product of cellular metabolism, the chemical hydrogen peroxide (H_2O_2) is now known to play an integral role in maintaining cell homeostasis. Recent research suggests that H_2O_2 is one of a small group of molecules that can be transported across the plasma membrane through aquaporins, where it can affect cell signaling. To investigate the transport of H_2O_2 through aquaporins, researchers made four different groups of liposomes (spherical vesicles surrounded by a phospholipid bilayer). One group of liposomes was constructed as a simple vesicle of phospholipids (group A). Into the phospholipid bilayer of the three other groups of liposomes, researchers embedded either a type of human aquaporin (group B) or one of two types of plant aquaporin (groups C and D). The rate at which H_2O_2 was transported into the liposomes of each group was then determined (Table 1).

TABLE 1. RATE OF HYDROGEN PEROXIDE TRANSPORT INTO LIPOSOMES

Group	Type of Aquaporin Embedded in Liposome Phospholipid Bilayer	Average Rate of transport (μL/s$\pm 2SE_{\bar{x}}$)
A	None	0.9±0.1
B	Human	1.4±0.1
C	Plant I	1.7±0.1
D	Plant II	1.8±0.1

Figure 1 shows a simplified model of the relationship between H_2O_2 concentration and an intracellular signaling pathway. When the concentration of H_2O_2 is low, the enzyme Tpx 1 is active, leading to the activation of the transcription factor Pap 1 in a reaction that consumes H_2O_2. Once activated, Pap 1 moves to the nucleus, where it can activate transcription of a group of Pap 1-regulated genes.

As the concentration of H_2O_2 starts to increase, Tpx 1 becomes inactivated, allowing for even more H_2O_2 to accumulate, because it is no longer consumed in the activation of Pap1. The accumulation of H_2O_2 leads to the activation of the enzyme Sty 1, which then activates transcription factor Atf 1. Atf 1 moves to the nucleus and activates transcription of a group of Atf 1-regulated genes.

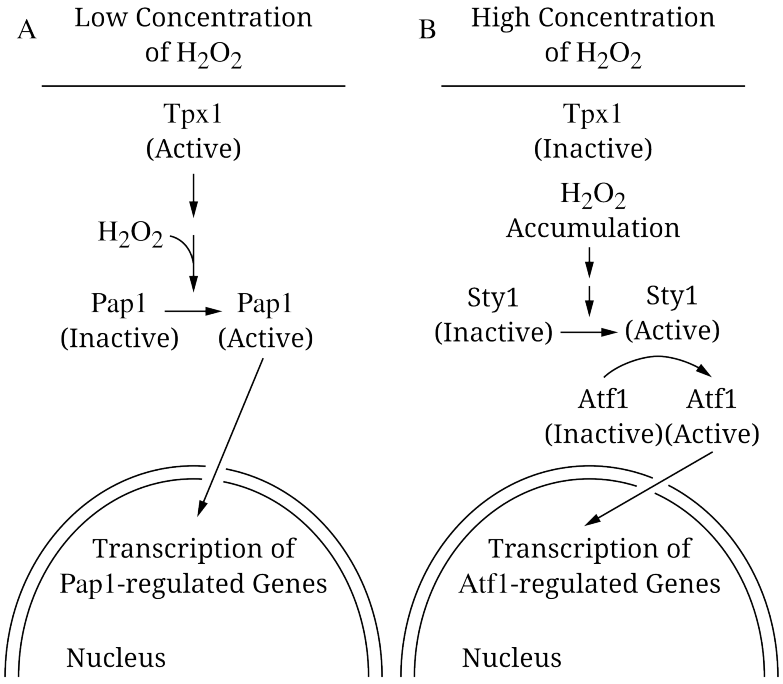
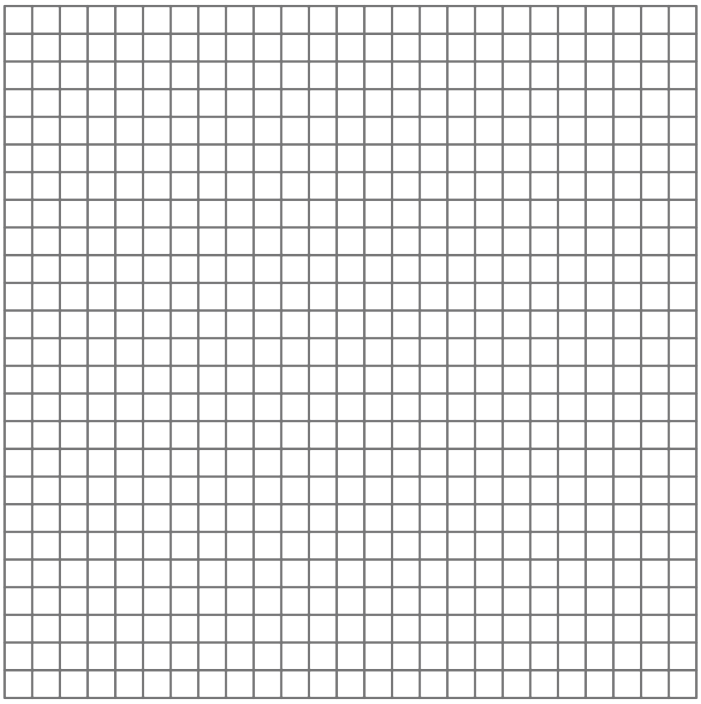


Figure 1. Simplified model of a signaling pathway involving H_2O_2 at both low (A) and high (B) intracellular concentrations of H_2O_2

(a) **Describe** the advantage to a cell of having aquaporins when the substances that pass directly through aquaporins can also pass through the phospholipid bilayer.

(b) Using the template in the space provided for your response, **construct** an appropriately labeled graph that represents the data in Table 1. **Determine** the type(s) of aquaporins that transport(s) H_2O_2 at a rate that is different from the rate at which the plant type II aquaporins transport H_2O_2.



(c) Based on the data in Table 1, **identify** the rate in μL/s at which can be transported by simple diffusion through the phospholipid bilayer. **Calculate** the difference between the average microliters of H_2O_2 transported into group A liposomes in five minutes and the average microliters of H_2O_2 transported into group C liposomes in five minutes.

(d) An enzyme called Srx 1 is required for the activation of Tpx 1. Researchers identified a mutation that results in a nonfunctional form of Srx 1. Based on the model in Figure 1, **predict** the effect of this nonfunctional Srx 1 on the expression of Pap 1-regulated genes AND Atf 1-regulated genes. Provide reasoning to **justify** your prediction.

3. Vernal ponds, ponds that fill with water each spring and then evaporate in late summer, pose particular challenges to the organisms that live in them. Copepods, a type of crustacean, produce eggs that survive in dry sediment (the soil and other solid material at the bottom of a pond) for long periods of time. Once the water returns, the copepod larvae emerge from the eggs and begin to eat, consuming primarily algae. However, algae often emerge from the sediment later than the copepod larvae do, and the algal populations grow slowly in cool spring temperatures.

   To investigate whether the copepods that live in vernal ponds have other adaptations to allow them to supplement their diet of algae, scientists examined related species that they categorized as large-bodied or small-bodied copepods. After examining the mouthparts of each species, the scientists determined a mouthpart carnivory score for each. A high score indicates a tendency toward a more carnivorous diet. The scientists also recorded the gut contents of each species in both early spring and summer. They hypothesized that large-bodied copepods have mouth adaptations that enable them to eat small animals that emerge early from sediments, while the small-bodied copepods do not have such adaptations.

   (a) **Describe** the effect of periodic changes in resource availability on population density.

   (b) **Justify** the researchers' performing their measurements and analyzing gut contents in both early spring and summer.

   (c) **State** a null hypothesis for this investigation.

   (d) Climate change is causing water in vernal ponds to evaporate earlier in the summer. Scientists claim that under these conditions, copepod species with a lower mouthpart carnivory score are more likely to go extinct in these vernal ponds than are species with a greater mouthpart carnivory score. Provide reasoning to **support** the scientists' claim.

4. During the Late Devonian Period, there was a massive loss of marine biodiversity. An analysis of fossil marine invertebrates that existed during the Late Devonian has revealed that the rate of extinction was relatively constant, as compared with the rates of extinction before and after the Late Devonian. The fossil evidence also suggests that frequent increases in sea level during the Late Devonian effectively removed geographical barriers and allowed generalist species (species that can inhabit a wide range of habitats) to migrate into new areas.

   (a) **Describe** how the geographical separation of two populations can lead to speciation.

   (b) **Explain** how a decrease in biodiversity during the Late Devonian could occur even though the extinction rate was relatively constant.

   (c) Scientists claim that the modern rate of biodiversity loss may be even greater than that observed during the Late Devonian. In recent decades, the number of invasive species has increased. **Predict** the most likely effect of the current increase in invasive species on speciation rates of native species.

   (d) Provide reasoning to **justify** your prediction in part (c).

5. ATCase is a complex enzyme involved in the production of the nucleotide CTP. ATCase is composed of many subunits that are grouped into two functional domains. The catalytic domain of ATCase (C in Figure 1) contains an active site which binds two substrates (S1 and S2) and catalyzes a chemical reaction, resulting in the formation of two products (P1 and P2). P2 then acts as a substrate in the pathway leading to CTP production. The regulatory domain of ATCase (R in Figure 1) contains an allosteric site capable of binding with the nucleotides CTP and ATP.

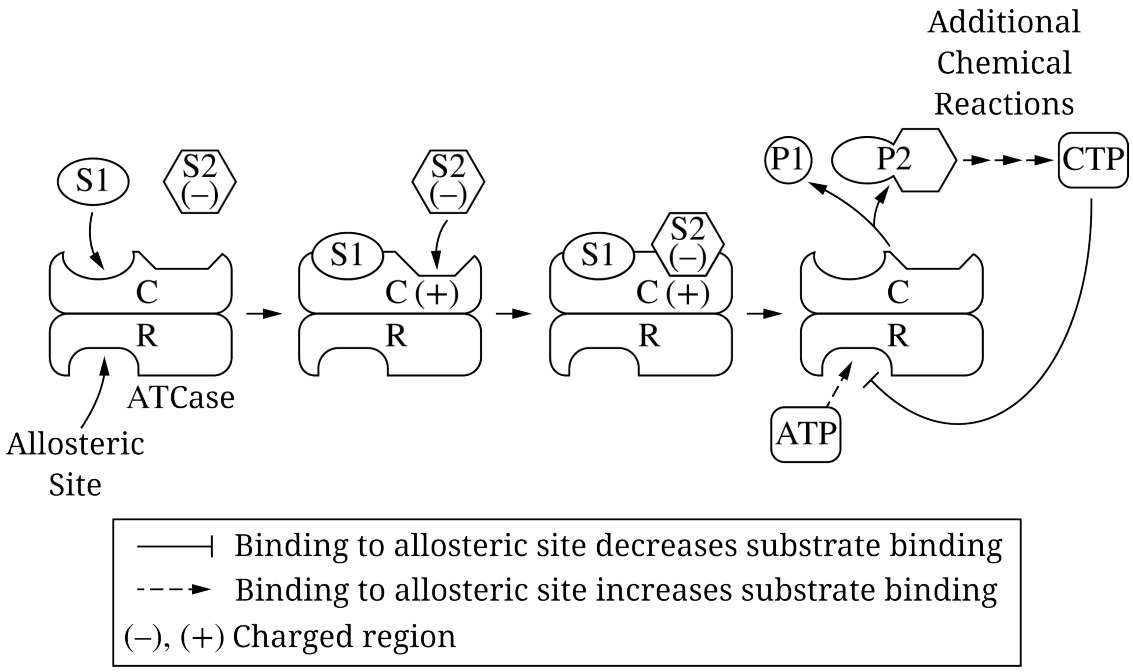
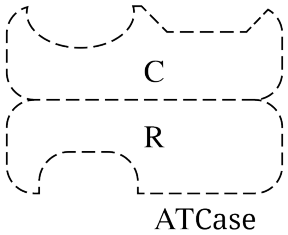


Figure 1. Simplified model of the regulation of an ATCase-catalyzed reaction

(a) **Describe** the effect that the binding of a noncompetitive inhibitor has on the structure of an enzyme.

(b) Based on Figure 1, **explain** how the binding of S1 increases the likelihood that S2 will bind.

(c) Researchers studying ATCase observed that, when ATCase is heated at 60°C for 4 minutes, it is still able to form P1 and P2, but the presence of regulatory molecules has no effect on substrate binding. Using the template in the space provided for your response, **represent** the effect of the increased temperature on ATCase structure by modifying the model of ATCase provided.



(d) **Explain** how the concentration of CTP in a cell contributes to the regulation of CTP production.

6. Crossing-over between homologous chromosomes during meiosis is necessary for the proper segregation of the chromosomes. In the fly species *Drosophila melanogaster*, two conserved genes, *mei* − 9 and *pch*2, are thought to play a role in crossing-over. The protein encoded by *mei* − 9 is part of a large protein complex required for the pairing of homologous chromosomes, while the protein encoded by *pch*2 is associated with a delay in prophase I that is believed to serve as a cell cycle checkpoint.

To investigate the role of *mei* − 9 and *pch*2 in crossing-over, researchers determined the frequency of recombination for each of four regions of chromosome 2 in wild-type flies (WT), flies expressing a mutant form of *mei* − 9 (mei-9-mut flies), and flies expressing mutant forms of both *mei* − 9 and *pch*2 (mei-9-mut/pch2-mut flies). The frequency of recombination of each region in both types of mutant flies is shown in Figure 1 as a percentage of the frequency of recombination observed in WT flies.

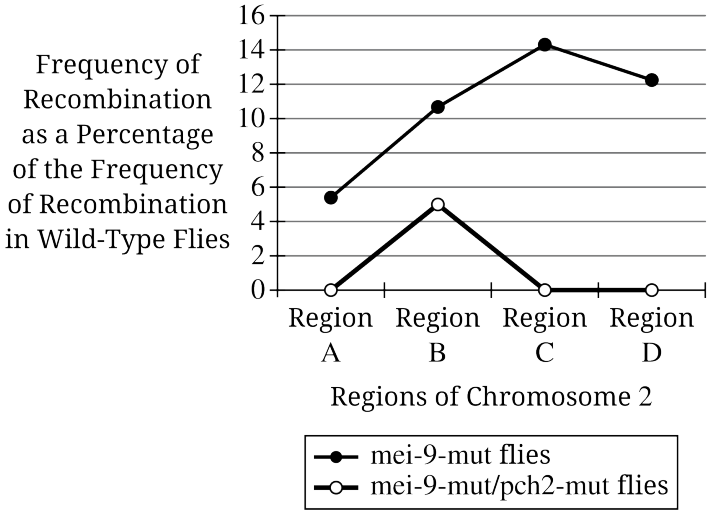


Figure 1. Frequency of recombination of four regions of chromosome 2 in mei-9-mut flies and mei-9-mut/pch2-mut flies as a percentage of the frequency of recombination in the same region in wild-type flies

(a) Based on the data in Figure 1, **identify** the region of chromosome 2 with the greatest frequency of recombination in mei-9-mut/pch2-mut flies.

(b) Based on the data in Figure 1, **describe** the frequency of recombination in mei-9-mut flies compared with the frequency of recombination in WT flies.

(c) Scientists hypothesize that the function of the protein encoded by wild-type *pch*2 allows some of the defects caused by the *mei* − 9 mutation to be overcome, increasing the likelihood that crossing-over will occur. Use the data in Figure 1 to **evaluate** their hypothesis.

(d) Based on the information provided, **explain** why the fertility of mei-9-mut flies might be reduced compared with that of WT flies.

STOP
END OF EXAM