Sample Exam Questions

The sample exam questions that follow illustrate the relationship between the course framework and AP Biology Exam and serve as examples of the types of questions that appear on the exam. After the sample questions you will find a table that shows which skill, learning objective(s), and unit each question relates to. The table also provides the answers to the multiple-choice questions.

Section I: Multiple-Choice Questions

The following are examples of the kinds of multiple-choice questions found on the exam.

1. Insulin is a protein hormone that is secreted in response to elevated blood glucose levels. When insulin binds to its receptors on liver cells, the activated receptors stimulate phosphorylation cascades that cause the translocation of glucose transporters to the plasma membrane.

   Based on the information provided, which of the following best describes the role of insulin in this liver cell signal transduction pathway?

   (A) It acts as a ligand.
   (B) It acts as a receptor.
   (C) It acts as a secondary messenger.
   (D) It acts as a protein kinase.

2. Humans have a diploid number ("2n") of 46. Which of the following statements best predicts the consequence if meiosis did not occur during gametogenesis?

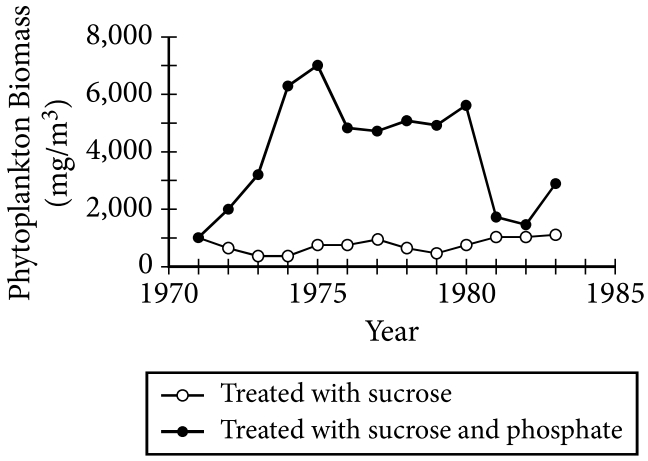
   (A) The gametes would get larger from one generation to the next.
   (B) The chromosome number would double with each generation.
   (C) The chromosome number would be halved with each generation.
   (D) The chromosome number would triple with each generation.

3. Mutations in the *MYO6* and *POU4F3* genes have been associated with a form of hereditary hearing loss in humans. Researchers studying the genes have proposed that *POU4F3* encodes a transcription factor that influences the regulation of *MYO6*.

   Which of the following questions will best help guide the researchers toward a direct test of their proposal?

   (A) Have mutations in other genes also been associated with hearing loss?
   (B) In what types of cells are the mutant forms of the *POU4F3* gene expressed?
   (C) Are mutations in the *MYO6* and *POU4F3* genes also found in mice?
   (D) Do mutations in the *POU4F3* gene affect *MYO6* mRNA levels in cells?

Questions 4–7 refer to the following material.



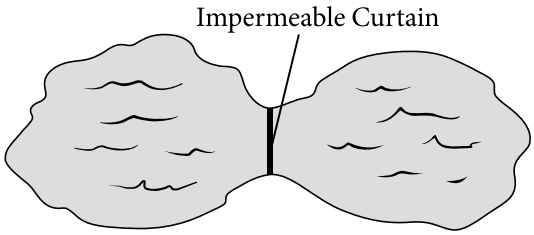


Figure 1. Phytoplankton biomass in two sides of a small lake that is divided by an impermeable curtain

In the early 1970s, researchers hypothesized that carbon was the limiting nutrient in many aquatic ecosystems. To test this hypothesis, the researchers divided a small lake in two roughly equal halves with an impermeable curtain that was fastened and sealed to the bedrock of the lake. Beginning in 1971 the researchers treated one side of the lake with sucrose and the other side with both sucrose and phosphate. From 1971 to 1983 the researchers monitored the phytoplankton biomass in both parts of the lake. The results are shown in Figure 1.

4. Which of the following claims is best supported by the data?
   (A) Carbon was a limiting factor for phytoplankton in the lake.
   (B) Phosphate was a limiting factor for phytoplankton in the lake.
   (C) Both carbon and phosphate were limiting factors for phytoplankton in the lake.
   (D) Neither carbon nor phosphate was a limiting factor for phytoplankton in the lake.

5. The average growth rate of the phytoplankton population from 1971 to 1975 in the side of the lake treated with sucrose and phosphate is closest to which of the following?
   (A) 125 (mg/m^3)/year
   (B) 1,000 (mg/m^3)/year
   (C) 1,500 (mg/m^3)/year
   (D) 6,000 (mg/m^3)/year

6. Which of the following treatments would have been the best control treatment for the experiment?

   (A) An untreated section of the lake

   (B) A section of the lake that was treated with phosphate but not sucrose

   (C) A different lake that was treated with sucrose and phosphate

   (D) A small pool of the lake water maintained in a controlled laboratory environment

7. Which of the following was most likely a direct consequence of the addition of phosphate to the lake?

   (A) The amount of biomass in the first trophic level decreased.

   (B) The amount of biomass in the second trophic level decreased.

   (C) The amount of energy available to producers in the lake increased.

   (D) The amount of energy available to consumers in the lake increased.

8. The enzyme trypsin aids in protein digestion in the small intestine. The relative activity of trypsin at different pH values is shown in Figure 1.

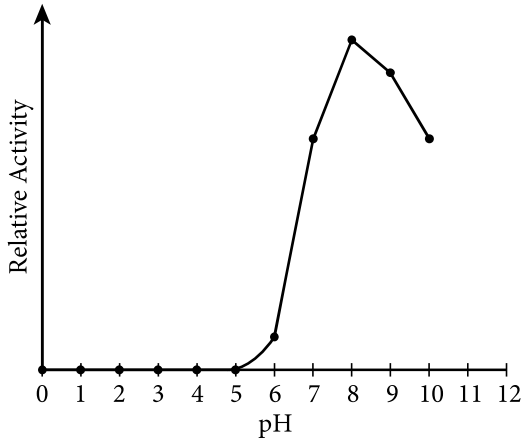


Figure 1. Effect of pH on the activity of trypsin

Which of the following statements best explains the activity levels of trypsin shown in Figure 1?

   (A) The small intestine releases inhibitor molecules that block the activity of trypsin unless it is at its optimum pH.

   (B) The number of effective collisions between trypsin and its substrate increase at higher pH values.

   (C) As pH values increase, the substrate concentration decreases, leading to an eventual decline in the rate of the trypsin-catalyzed reaction.

   (D) At extremely low pH values, trypsin is denatured and cannot function efficiently.

Different photosynthetic organisms have different types of chlorophyll molecules. The distribution of chlorophylls in several different groups of organisms is shown in Table 1. A plus sign (+) in the table indicates the presence of a chlorophyll, while a minus sign (–) indicates its absence.

Table 1. The distribution of chlorophylls in several groups of organisms

	Chlorophyll *a*	Chlorophyll *b*	Chlorophyll *c*	Chlorophyll *d*
Flowering plants	+	+	–	–
Green algae	+	+	–	–
Brown algae	+	–	+	–
Red algae	+	–	–	+
Cyanobacteria	+	–	–	–

9. Based on the data, which of the following most likely describes the evolutionary relationship among the organisms?

   (A) Because brown algae, red algae, and cyanobacteria lack chlorophyll *b*, they evolved before green algae and flowering plants did.

   (B) Because green algae and flowering plants contain chloroplasts, they evolved more recently than brown algae, red algae, and cyanobacteria did.

   (C) Because increasingly complex forms of chlorophyll are found in red algae, brown algae, green algae, and flowering plants, respectively, this reflects the order of their appearance.

   (D) Because all of the organisms contain chlorophyll *a*, the organisms share a common ancestor.

10. A student used a microscope to observe a wet-mount slide of red onion epidermal cells that were suspended in a 1% NaCl solution. The student then added a 15% NaCL solution to the slide and observed the changes that occurred. The student's observations are represented in Figure 1.

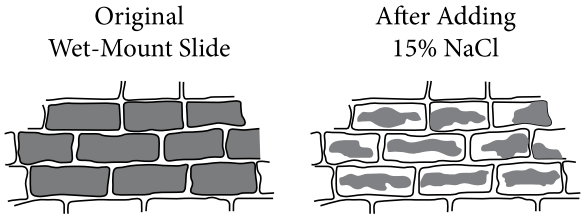


Figure 1. Student's observations of onion cells

Which of the following most directly explains the changes in the cells?

   (A) The degradation of DNA in the nuclei of the cells

   (B) The lysis of chloroplasts in the cells

   (C) The movement of water from the central vacuoles of the cells into the solution

   (D) The movement of NaCl from the solution into the cytoplasm of the cells

11. The human *TPM1* gene encodes members of the tropomyosin family of cytoskeletal proteins. Which of the following best explains how different proteins can be made in different cell types from the one *TPM1* gene?
    (A) Different introns are selectively converted to exons.
    (B) Different exons are retained or spliced out of the primary transcript.
    (C) The GTP cap is selectively added to and activates different exons.
    (D) Different portions of the primary transcript remain bound to the template DNA.

12. Scientists examined the folded structure of a purified protein resuspended in water and found that amino acids with nonpolar R groups were primarily buried in the middle of the protein, whereas amino acids with polar R groups were primarily on the surface of the protein. Which of the following best explains the location of the amino acids in the folded protein?
    (A) Polar R groups on the surface of the protein can form ionic bonds with the charged ends of the water molecules.
    (B) Polar R groups are too bulky to fit in the middle of the protein and are pushed toward the protein's surface.
    (C) Nonpolar R groups that cannot form hydrogen bonds with water are pushed into the middle of the protein.
    (D) Nonpolar R groups from different parts of the protein form covalent bonds with each other to maintain the protein's structure.

13. The apple maggot fly, *Rhagoletis pomonella*, is native to North America and originally fed on fruit of the wild hawthorn. Since the mid-1800s, a population of flies has emerged that instead feed on domesticated apples. Apple maggot flies typically mate on or near the fruit of their host plants. Many varieties of apples ripen three to four weeks before the hawthorn fruits do.

The different fruit preferences of the two fly populations will most likely have which of the following effects?
    (A) The flies that eat hawthorn fruit will increase in number, while the flies that eat apples will decrease in number because of the use of insecticides on apple trees.
    (B) The single fly species will evolve into two distinct species because of the lack of gene flow between the two populations.
    (C) The ability to survive on a diet of two different fruits will help the flies learn to eat many more types of fruit.
    (D) The flies that eat hawthorn fruit will lay some of their eggs on the earlier-ripening apples to minimize competition among the larvae.

Platelets are fragments of larger cells and normally circulate in the blood without adhering to blood vessel walls. When the wall of a blood vessel is damaged, collagen fibers in the wall are exposed to the interior of the blood vessel. The exposed fibers and chemicals released from the endothelial cells that line the blood vessel attract platelets, which start to form a plug and release other chemicals (Figure 1).

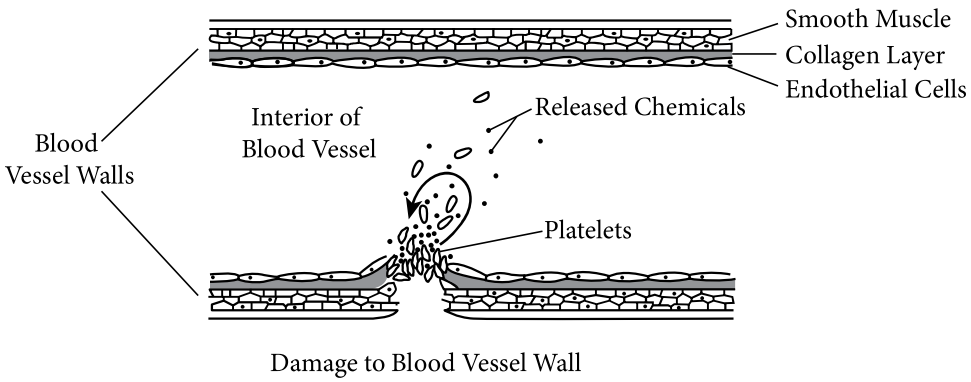


Figure 1. Formation of a platelet plug in a damaged blood vessel wall

14. Which of the following best explains the feedback mechanism illustrated in Figure 1?

    (A) This is an example of positive feedback, because the few platelets that initially bind attract more platelets to the damaged area.

    (B) This is an example of positive feedback, because it results from the interactions among collagen, endothelial cells, and platelets.

    (C) This is an example of negative feedback, because a large clump of platelets can block the blood vessel and prevent blood flow through it.

    (D) This is an example of negative feedback, because the accumulation of platelets returns the open blood vessel wall to a closed state.

15. It is estimated that oxygen production first evolved in photosynthetic prokaryotes approximately 2.7 billion years ago. The first photosynthetic prokaryotes are presumed to be similar to today's cyanobacteria.

Which of the following best supports the claim that photosynthetic prokaryotes were responsible for the oxygen in Earth's atmosphere?

    (A) The light reactions of photosynthesis split carbon dioxide into carbon and oxygen.

    (B) The light reactions of photosynthesis split water into hydrogen ions and oxygen.

    (C) The Calvin cycle splits glucose into carbon, hydrogen, and oxygen.

    (D) The Calvin cycle splits water into hydrogen ions and oxygen.

Section II: Free-Response Questions

The following are examples of the kinds of free-response questions found on the exam. Note that on the actual AP Exam, there will be two long questions and four short-answer questions.

Read each question carefully. Write your response in the space provided for each part of each question. Answers must be written out in paragraph form. Outlines, bulleted lists, or diagrams alone are not acceptable and will not be scored.

Interpreting and Evaluating Experimental Results (Question 1 on the AP Exam)

In many countries, *Anopheles gambiae* mosquitoes are responsible for transmitting the parasite that causes malaria to people through their bites. A primary tool for mosquito control is the use of insecticidal nets sprayed with chemicals known as pyrethroids, which are relatively safe for people but toxic to mosquitoes. However, mosquito resistance to pyrethroids has now become widespread. Pyrethroids interfere with the function of a transmembrane sodium channel found in cells of the mosquitoes (Figure 1). In one common mutation to the channel protein, a phenylalanine is substituted for a leucine at amino acid position 1014. Scientists hypothesize that this mutation is responsible for some cases of pyrethroid resistance.

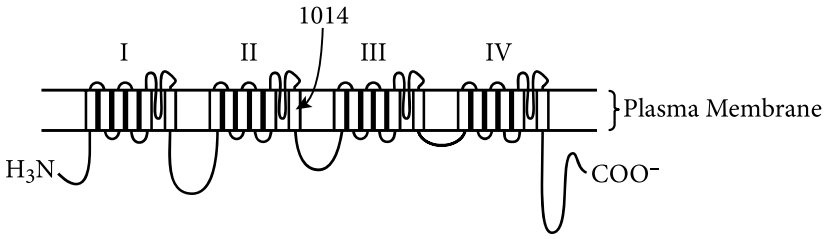


Figure 1. Schematic drawing of the transmembrane sodium channel targeted by pyrethroids and other insecticides. The arrow points to the position of amino acid 1014.

To investigate pyrethroid resistance, mosquitoes were collected four times over a two-year period from the following two regions.

- Region A: a southern vegetable-growing region where large amounts of insecticide are applied for crop protection
- Region B: a northern rice-growing region where very little insecticide is applied for rice protection

Scientists exposed the collected mosquitoes to filter papers soaked in two different pyrethroid insecticides, deltamethrin and permethrin, and the percent mortality of the mosquitoes was determined after 24 hours (Figure 2). The scientists simultaneously determined whether leucine or phenylalanine was encoded at position 1014 by each of the two copies of the sodium channel gene (Table 1).

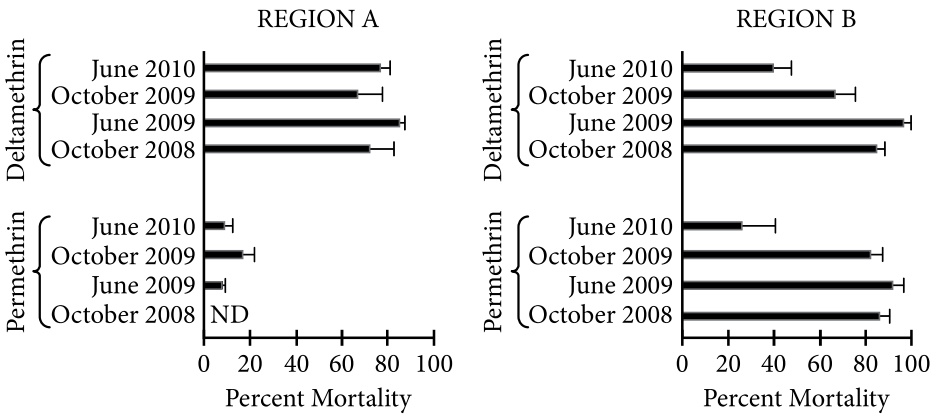


Figure 2. Susceptibility of *A. gambiae* mosquitoes from two regions to the pyrethroids deltamethrin and permethrin. A mosquito strain that is susceptible to the insecticides displayed at least 95% mortality in all experiments, and mosquitoes exposed to untreated filter paper displayed less than 10% mortality. Error bars represent standard deviation. "ND" means no data are available.

Table 1. Frequencies of leucine and phenylalanine at position 1014 of the sodium channel

Region	Date	Total Mosquitoes Tested	Homozygous for Leucine	Heterozygous for Leucine and Phenylalanine	Homozygous for Phenylalanine
A	October 2008	39	3	5	31
A	June 2009	29	-	5	24
A	October 2009	28	-	1	27
A	June 2010	46	-	9	37
B	October 2008	27	20	5	2
B	June 2009	26	18	7	1
B	October 2009	34	20	8	6
B	June 2010	44	12	20	12

(a) **Describe** the most likely cause of the amino acid substitution in the sodium channel protein. **Explain** how the substitution of a single amino acid in the channel protein could cause pyrethroid resistance in mosquitoes.

(b) **Identify** the dependent variable in the experiment whose data are graphed in Figure 2. **Identify** the positive control in the experiment. **Justify** exposing some mosquitoes to untreated filter paper each time the experiment was performed.

(c) Based on the data in Figure 2, **describe** whether mosquitoes from region A or from region B are more likely to exhibit greater evolutionary fitness if exposed to permethrin in their native environment over the time period of the

experiment. Based on the data in Figure 2, **describe** any significant change in the susceptibility of mosquitoes from region B to each of the two insecticides over the two-year period. Use the data in Table 1 to **calculate** the frequency of the allele coding for phenylalanine in each population of mosquitoes in October 2008. Round your answers to two decimal places.

(d) Using mosquitoes from insecticide-free areas, the scientists developed mosquito strains with amino acid substitutions at other positions in the sodium channel protein. They exposed the mosquito strains to nonpyrethroid insecticides. **Predict** the susceptibility of the mosquitoes to the insecticides. The scientists claim that the mosquito population of region B evolved resistance over the period of the experiment and that resistance arose as a result of the immigration of resistant mosquitoes from other regions. Based on the data in Table 1 and the information provided, **provide evidence** to support the scientists' claim.

Analyze Model or Visual Representation (Question 5 on AP Exam)

In humans, the gene that determines a particular condition has only two alleles, one of which (*B*) is completely dominant to the other (*b*). The phenotypes of three generations of a family with respect to the condition are shown in the pedigree in Figure 1. Individuals are numbered.

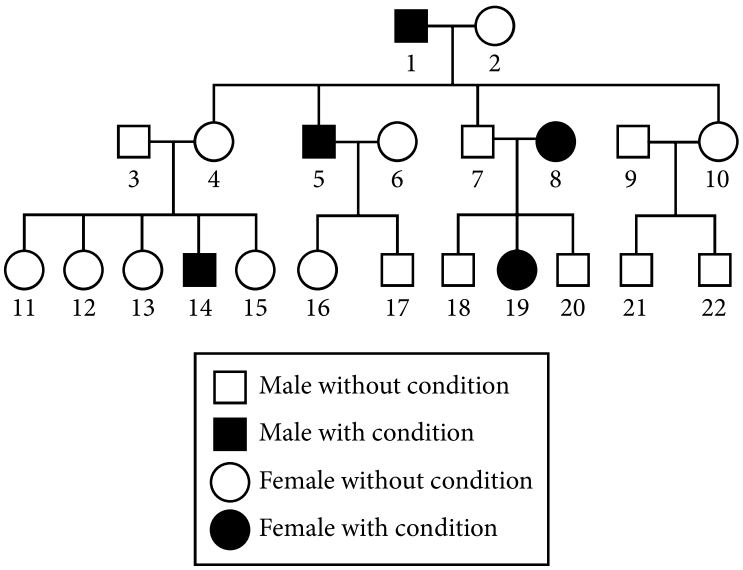
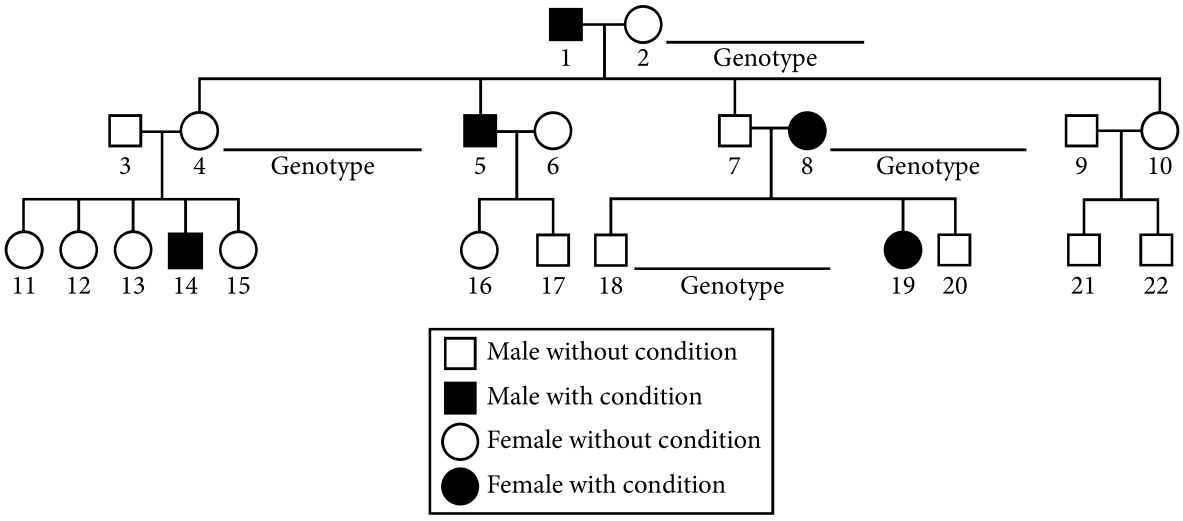


Figure 1. Inheritance of a particular condition over three generations of a family

(a) **Describe** the process in eukaryotes that ensures that the number of chromosomes will not double from parent to offspring when gametes fuse during fertilization.

(b) **Explain** how any one chromosome in individual 16 contains DNA that came from both individuals 1 and 2.

(c) **Use the template** figure of the pedigree and the allele designations *B* and *b* to **indicate** the genotypes of individuals 2, 4, 8, and 18.



(d) Based on the pedigree, **explain** whether the inheritance pattern of the condition is sex-linked or autosomal and dominant or recessive.

Answer Key and Question Alignment to Course Framework

Multiple-Choice Question	Answer	Skill	Learning Objective	Unit
1	A	1.A	IST-3.B	4
2	B	6.E.a	IST-1.F	5
3	D	3.A	IST-2.C	6
4	B	4.B.c	SYI-1.G	8
5	C	5.A.c	SYI-1.G	8
6	A	3.C.b	SYI-1.G	8
7	D	6.E.a	ENE-1.N	8
8	D	2.B.b	ENE-1.F	3
9	D	4.B.b	EVO-2.B	7
10	C	2.B.b	ENE-2.H	2
11	B	1.C	IST-1.N	6
12	C	1.B	SYI-1.B	1
13	B	1.C	EVO-3.F	7
14	A	2.C	ENE-3.C	4
15	B	6.B	ENE-1.I	3

Free-Response Question	Question Type	Skill	Learning Objective	Unit
1	Interpreting and Evaluating Experimental Results	1.A, 1.C, 3.B, 3.C.a, 3.C.b, 3.C.c, 4.B.b, 4.B.c, 5.A.a, 6.B	EVO-1.E, EVO-1.H, EVO-1.L, IST-2.E, SYI-1.C	1, 6, 7
5	Analyze Model or Visual Representation	1.A, 2.B.b, 2.D.b, 2.C	IST-1.H, IST-1.I	5

The scoring information for the questions within this course and exam description, along with further exam resources, can be found on the **AP Biology Exam Page** on AP Central.