



## Practice Test 5

Completely darken bubbles with a No. 2 pencil. If you make a mistake, be sure to erase mark completely. Erase all stray marks.

**1. YOUR NAME:** \_\_\_\_\_  
 (Print) Last First M.I.  
**SIGNATURE:** \_\_\_\_\_ **DATE:** \_\_\_\_/\_\_\_\_/\_\_\_\_  
**HOME ADDRESS:** \_\_\_\_\_  
 (Print) Number and Street  
 \_\_\_\_\_  
 City State Zip Code  
**PHONE NO. :** \_\_\_\_\_  
 (Print)

**5. YOUR NAME**

First 4 letters of last name				FIRST INIT	MID INIT
A	A	A	A	A	A
B	B	B	B	B	B
C	C	C	C	C	C
D	D	D	D	D	D
E	E	E	E	E	E
F	F	F	F	F	F
G	G	G	G	G	G
H	H	H	H	H	H
I	I	I	I	I	I
J	J	J	J	J	J
K	K	K	K	K	K
L	L	L	L	L	L
M	M	M	M	M	M
N	N	N	N	N	N
O	O	O	O	O	O
P	P	P	P	P	P
Q	Q	Q	Q	Q	Q
R	R	R	R	R	R
S	S	S	S	S	S
T	T	T	T	T	T
U	U	U	U	U	U
V	V	V	V	V	V
W	W	W	W	W	W
X	X	X	X	X	X
Y	Y	Y	Y	Y	Y
Z	Z	Z	Z	Z	Z

**IMPORTANT:** Please fill in these boxes exactly as shown on the back cover of your test book.

**2. TEST FORM**

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3. TEST CODE					4. REGISTRATION NUMBER				
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2	C	2	2	2	2	2	2	2	2
3	D	3	3	3	3	3	3	3	3
4	E	4	4	4	4	4	4	4	4
5	F	5	5	5	5	5	5	5	5
6	G	6	6	6	6	6	6	6	6
7		7	7	7	7	7	7	7	7
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**6. DATE OF BIRTH**

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<input type="radio"/> JUL	<input type="radio"/> 4	<input type="radio"/> 4
<input type="radio"/> AUG	<input type="radio"/> 5	<input type="radio"/> 5
<input type="radio"/> SEP	<input type="radio"/> 6	<input type="radio"/> 6
<input type="radio"/> OCT	<input type="radio"/> 7	<input type="radio"/> 7
<input type="radio"/> NOV	<input type="radio"/> 8	<input type="radio"/> 8
<input type="radio"/> DEC	<input type="radio"/> 9	<input type="radio"/> 9

**7. SEX**

MALE

FEMALE



**Section I** Start with number 1 for each new section. If a section has fewer questions than answer spaces, leave the extra answer spaces blank.

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# AP<sup>®</sup> Biology Exam

## SECTION I: Multiple-Choice Questions

**DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO.**

### At a Glance

**Total Time**

1 hour and 30 minutes

**Number of Questions**

69

**Percent of Total Score**

50%

**Writing Instrument**

Pencil required

### Instructions

Section I of this examination contains 69 multiple-choice questions. These are broken down into Part A (63 multiple-choice questions) and Part B (6 grid-in questions).

Indicate all of your answers to the multiple-choice questions on the answer sheet. No credit will be given for anything written in this exam booklet, but you may use the booklet for notes or scratch work. After you have decided which of the suggested answers is best, completely fill in the corresponding oval on the answer sheet. Give only one answer to each question. If you change an answer, be sure that the previous mark is erased completely. Here is a sample question and answer.

Sample Question

Sample Answer

Chicago is a

(A)  (B)  (C)  (D)

- (A) state
- (B) city
- (C) country
- (D) continent

Use your time effectively, working as quickly as you can without losing accuracy. Do not spend too much time on any one question. Go on to other questions and come back to the ones you have not answered if you have time. It is not expected that everyone will know the answers to all the multiple-choice questions.

### About Guessing

Many candidates wonder whether or not to guess the answers to questions about which they are not certain. Multiple-choice scores are based on the number of questions answered correctly. Points are not deducted for incorrect answers, and no points are awarded for unanswered questions. Because points are not deducted for incorrect answers, you are encouraged to answer all multiple-choice questions. On any questions you do not know the answer to, you should eliminate as many choices as you can, and then select the best answer among the remaining choices.

**BIOLOGY**  
**SECTION I**  
**69 Questions**  
**Time—90 minutes**

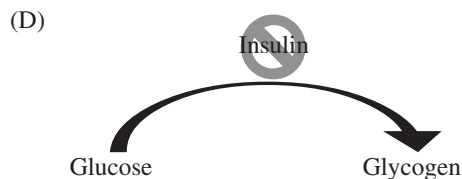
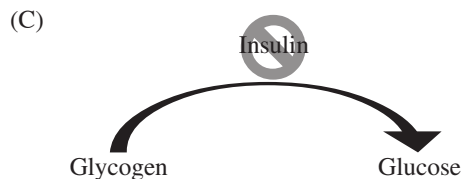
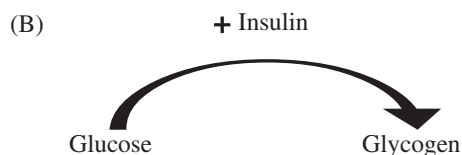
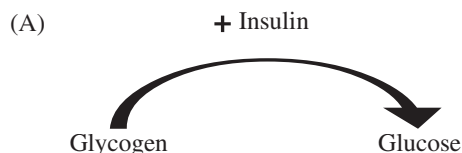
**Directions:** Each of the questions or incomplete statements below is followed by four suggested answers or completions. Select the one that is best in each case and then fill in the corresponding oval on the answer sheet.

Questions 1-3 refer to the following passage.

Glycogen synthase is an enzyme that incorporates UDP-glucose monomers into the polymer, glycogen. Glycogen anabolic metabolism is initiated in response to excess energy within the body wherein the polysaccharide, glycogen, is built to store excess glucose. Glycogen synthase is under the regulation of glucose-6-phosphate, a molecule which allosterically inhibits it and insulin which indirectly activates it in response to glucose levels in the body.

1. Which of the following most likely increases the enzymatic activity of glycogen synthase?
- (A) Insufficient levels of glycolysis and the Krebs cycle
  - (B) A large meal in a person in generally good health
  - (C) A low level of hydrogens pumped by the electron transport chain
  - (D) A large meal in someone that has not eaten for several days

2. Which of the following models best represents glycogenolysis, the process of glycogen catabolism?



3. Which of the following best describes the regulation of glycogen synthase by glucose-6-phosphate?
- (A) Glucose-6-phosphate increases glycogen formation by binding at the same place as UDP-glucose.
  - (B) Glucose-6-phosphate decreases glycogen formation by binding at the same place as UDP-glucose.
  - (C) Glucose-6-phosphate increases glycogen formation by binding at a different place as UDP-glucose.
  - (D) Glucose-6-phosphate decreases glycogen formation by binding at a different place as UDP-glucose.

**GO ON TO THE NEXT PAGE.**

Questions 4-5 refer to the following passage and figures.

Digestion physiologists collected amylase from three tissue sources from the human digestive system (the mouth, stomach, and pancreas). They varied the concentration of hydronium ions in the presence of each enzyme and starch. The enzyme that catalyzes the reaction shown in Figure 1. The results of the experiment are shown in Figure 2.

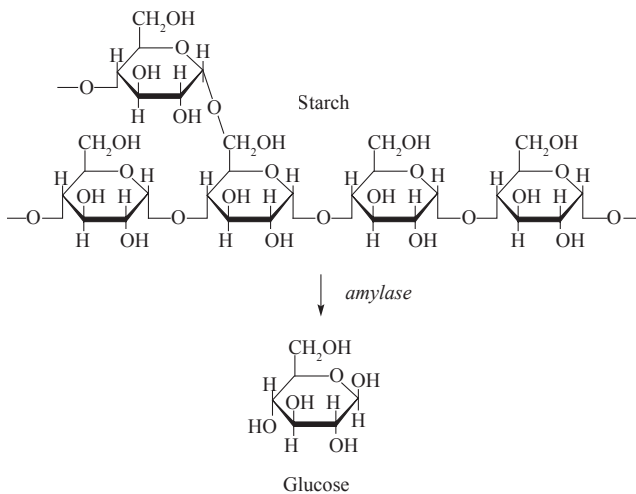


Figure 1 Reaction catalyzed by amylase

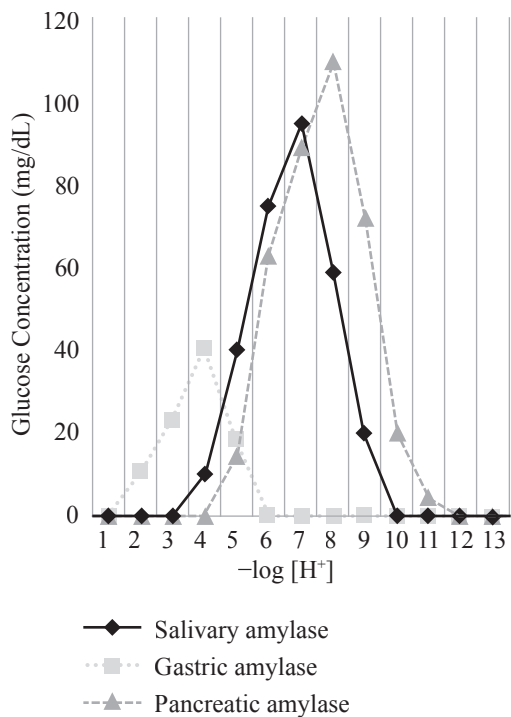


Figure 2 Glucose production by amylase varies with concentration of H<sup>+</sup> ions and source of the enzyme.

- If the scientists were to conduct future experiments, which explanation below best summarizes the results if each enzyme were placed in a solution of starch at a pH of 3?
  - Pancreatic amylase would lead to the fastest production of glucose due to highest reaction efficiency in basic conditions.
  - Pancreatic amylase would produce the highest concentration of glucose due to the importance of pancreatic hormonal secretions.
  - Gastric amylase would show the greatest enzymatic activity because it has been naturally selected for acidic conditions.
  - Gastric amylase would show the highest glucose levels because it functions greatest in basic conditions.
- The scientists expected to see a variance in enzyme reaction levels at varying concentrations of [H<sup>+</sup>] ions. What causes this difference in activity?
  - Increasing [H<sup>+</sup>] leads to increasing entropy, which is not energetically favorable and decreases reaction spontaneity.
  - High levels of [H<sup>+</sup>] ions lead to large temperature fluctuations that alter the active site of enzymes.
  - ATP phosphorylation is greatest around a pH of 7.
  - Changes in pH can cause denaturation of enzymatic active sites.

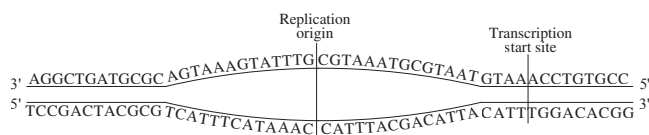
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Questions 6-7 refer to the following passage.

Comparative anatomy provided the first naturalists insight into the interrelatedness of species. In the early 19th century, Jean Baptiste Lamarck utilized a burgeoning fossil record and his own extensive studies of invertebrates to formulate a theory of evolution, which assumed that all traits and conditions, whether innate or acquired, could be passed genetically. His controversial work refuted the theories posited previously by theological naturalists that life was fixed since the origin of life, but they did not linger as the accepted model for long and were soon supplanted by Darwinism.

6. Which evidence below would directly refute Lamarck's proposed mechanism of evolution?
- (A) Through genetic analysis, emus, a flightless bird of Australia, have been shown to be closely related to tinamous, a flying bird native to Central and South America.
- (B) Iguanodontia are born with tail limbs even if both parents have lost their tails due to predator attacks.
- (C) Roundworms have been identified that are resistant to a virus that they have never been exposed to.
- (D) Brightly colored guppies are heavily selected against by their primary predators, the blue acara cichlid fish (*Aequidens pulcher*), and in populations containing these predators, progeny show diminished bright coloration.
7. Which experiment below would best determine whether comparative anatomy is useful in determining the relatedness of species?
- (A) Fossils of theropods, an order of dinosaurs, are compared to bones from a chicken to measure bone attachment similarities.
- (B) DNA extracted from a mosquito encased in amber is used to sequence the moa genome, an extinct bird species belonging to the order Dinornithiformes.
- (C) The wing tissues of fruit bats and several bird species are compared to mice forearms and then DNA from each species is compared using restriction enzyme analysis.
- (D) The amino acid sequence for proteases from 8 species of whale is determined using protein sequencing techniques.

Questions 8-10 refer to the following figure.



8. Which of the following correctly shows the initial ten nucleotides that will be created from the top strand in the figure by the enzyme DNA polymerase?
- (A) 5' G C A T T T A C G A 3'
- (B) 3' C G T A A A T G C T 5'
- (C) 5' G T T T A T G A A A 3'
- (D) 3' C A A A T A C T T T 5'
9. If the following mRNA is created from the transcription start site above, which of the following statements would be true?
- mRNA: 5' U G G A C A C G G 3'
- (A) The top strand of DNA was the template strand, and RNA polymerase created a strand of mRNA that is complementary to it.
- (B) The top strand of DNA was the template strand, and DNA polymerase created a strand of mRNA that is complementary to it.
- (C) The bottom strand of DNA was the template strand, and RNA polymerase created a strand of mRNA that is complementary to it.
- (D) The bottom strand of DNA was the template strand, and DNA polymerase created a strand of mRNA that is complementary to it.
10. During DNA replication, one strand is built in a continuous manner while the other strand is built in short segments. Which of the following is a caveat of DNA replication that makes this phenomenon necessary?
- (A) The DNA helix can only be unwound and opened in the 3' direction.
- (B) The DNA polymerase enzyme can only add base pairs to one side of a chain.
- (C) ATP is necessary to power DNA polymerase, and it is only accessible to one strand.
- (D) The RNA primer can only be added to one strand of a DNA molecule at a time.

**GO ON TO THE NEXT PAGE.**

Questions 11-13 refer to the following passage and figure.

The following figure is a Punnett square showing the possible gamete combinations from a mating between two pea plants for two gene loci. The first gene is for pea color (green (G) or yellow (g)) and the second gene is for pea plant height (tall (T) and short (t)).

	GT	Gt	gT	?
GT	GGTT	GGTt	GgTT	GgTt
Gt	GGTt	GGtt	GgTt	Ggtt
gT	GgTT	GgTt	ggTT	ggTt
gt	GgTt	Ggtt	ggTt	ggtt

11. What gamete is missing in the shaded box?
- (A) GgTt  
(B) Gt  
(C) gt  
(D) GT
12. What of the following ratios is shown in the Punnett square?
- (A) 9 tall and green: 3 tall and yellow: 3 short and yellow: 1 short and green  
(B) 1 GGTT:2 GGTt:1 GGtt:2 GgTT:2 Ggtt:4 GgTt:1 ggTT:2 ggTt:1 ggtt  
(C) 9 tall and green: 3 green and yellow: 3 tall and short: 1 short and yellow  
(D) 1 GGTT:1 GGTt:1 GGtt:2 GgTt:2 GgTT:2:Ggtt:1 ggTT:1 ggTt:1 ggtt
13. Based on the dominance illustrated in this Punnett square, if an individual heterozygous for the height gene was crossed with an individual that was homozygous recessive for the height gene, what percentage of the offspring would be tall?
- (A) 0%  
(B) 50%  
(C) 75%  
(D) 100%

Questions 14-16 refer to the following passage.

Paramecia are a genus of unicellular protozoans that are widespread in many aquatic environments. The organism is surrounded by a stiff but elastic membrane called a pellicle and a cell membrane. The organisms use a ciliated locomotion and are chemoheterotrophic, preying on bacteria. Some species are endosymbiotic with photosynthetic algae, deriving some nutrients from this source. Freshwater paramecia utilize a contractile vacuole to perform osmoregulation.

14. Why do freshwater paramecia require a contractile vacuole?
- (A) Freshwater has a lower water potential than the paramecia and water must be removed to ensure osmotic pressure does not become too great within the paramecia.  
(B) Paramecia have a lower water potential and must remove excess water that flows in through aquaporins.  
(C) Paramecia are hypotonic to freshwater and the contractile vacuole helps to pull in water necessary for photolysis.  
(D) Freshwater is hypotonic to saltwater and paramecia often reside in estuaries.
15. Kappa particles are endosymbionts that act similarly to mitochondria within paramecia. How do reactants necessary for kappa particle reactions get transported across paramecia's cellular membranes?
- (A) CO<sub>2</sub> is transported by simple diffusion through a channel.  
(B) Oxygen requires active transport to pass through the lipid bilayer.  
(C) Oxygen is a small nonpolar molecule that can be transported by simple diffusion.  
(D) Sugars such as glucose do not require facilitated diffusion to obtain a concentration gradient necessary for respiration.

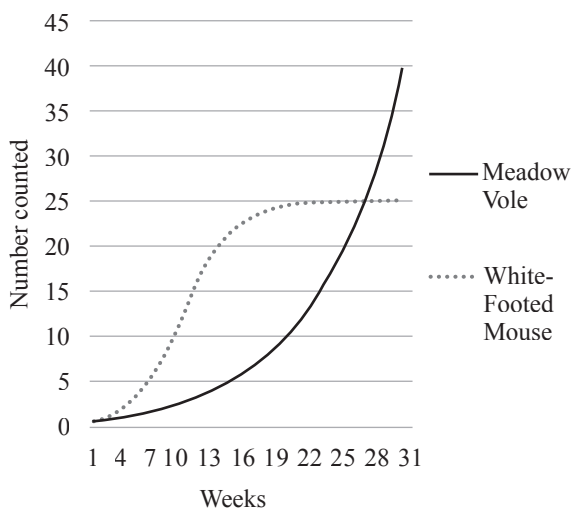
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16. The energetics of the contractile vacuole in paramecia are still being investigated by scientists. Which research outcome would demonstrate that active transport is being utilized?
- (A) Myosin, a protein requiring ATP hydrolysis to function, is found to be necessary for vacuole contraction.
  - (B) When the contractile vacuole sustains too great a pressure, it collapses, expelling the water from the paramecia.
  - (C) Aquaporins allow water to flow out of the pellicle, down their concentration gradient, when the vacuole becomes isotonic to its freshwater surroundings.
  - (D) When freshwater is below 0.24 M, water diffuses across a cell membrane through the phospholipid bilayer.

Questions 17-19 refer to the following passage and figure.

In Ontario, meadow voles and white-footed mice (*Peromyscus leucopus*) occur together in ecotones. Scientists in west-central Illinois sampled 10 switchgrass (*Panicum virginicus*)-dominated study plots during the summer months and took data on small mammal population sizes. Several other grasses were present in the study plots including blue joint grass, fowl manna grass, and prairie cordgrass. The following data was taken over a period of 32 weeks.



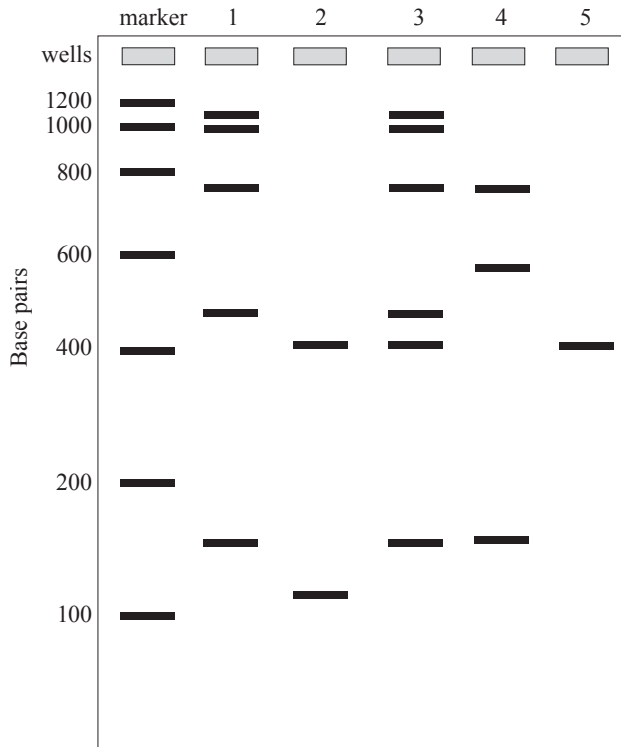
17. What is the carrying capacity for the meadow vole?
- (A) 32
  - (B) 41
  - (C) 25
  - (D) Not enough information to determine
18. Which observation would explain the meadow vole population growth?
- (A) Predation by coyotes predominantly contributed to reaching the carrying capacity.
  - (B) Meadow voles were the only species observed consuming the plentiful blue joint grass.
  - (C) At the 16 week mark, analyzed cheek swabs showed that the voles had contracted Hantavirus, which also presents as flu-like symptoms in the rodents.
  - (D) Meadow voles and white-footed mice were observed attempting to occupy the same niche.
19. Which of the following is the MOST likely explanation for the population growth of white-footed mice?
- (A) A new disease is discovered that affects the renal function of white-footed mice.
  - (B) The primary food source of the mice is fowl manna grass, which is only abundant in sufficient numbers to sustain a finite population.
  - (C) Meadow voles are aggressive toward white-footed mice due to the competition for grass seed, forcing migration from the area.
  - (D) Timber rattlesnakes, an indiscriminate rodent predator, were found living in the study plot sampling area.

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Questions 20-21 refer to the following passage and figure.

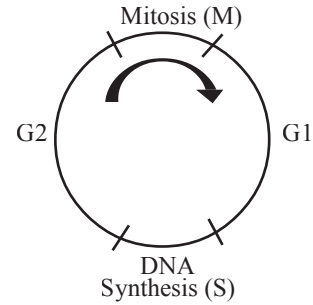
The DNA of 5 individuals was digested with a restriction enzyme. Gel electrophoresis was then performed to separate the fragments of digested DNA. The resulting banding patterns are shown below.



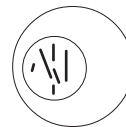
20. Which individual's DNA was digested in a way that yielded the tiniest fragment?
- (A) 1  
(B) 2  
(C) 3  
(D) 5
21. What was the approximate length of the undigested DNA from person 4?
- (A) 1250 bp  
(B) 1450 bp  
(C) 1650 bp  
(D) 1850 bp

Questions 22-24 refer to the following passage and figure.

The cell cycle is divided into 4 main phases, as illustrated in the figure below.



22. During which of the following transitions are cell cycle control mechanisms likely the most prevalent?
- (A)  $M \rightarrow G1$  and  $G2 \rightarrow M$   
(B)  $G1 \rightarrow S$  and  $G2 \rightarrow M$   
(C)  $S \rightarrow G2$  and  $M \rightarrow G1$   
(D)  $S \rightarrow G2$  and  $G2 \rightarrow M$
23. If the following cell is in G1 phase, which of the following images represents it in G2 phase?



- (A)
- (B)
- (C)
- (D)

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24. In humans, cyclin-dependent kinases (cdk) regulate the cell cycle. Each cdk partners with a cyclin protein, and different pairs control different parts of the cell cycle.

CDK	Cyclin	Cell Cycle Phase
Cdk1 (Cdc2)	Cyclins A and B	G2 to M phase transition, early M phase
Cdk2	Cyclins D1, D2, D3	G1 phase
Cdk2	Cyclin E	G1 to S phase
Cdk2	Cyclin A	S phase
Cdk4	Cyclins D1, D2, D3	G1 phase
Cdk6	Cyclins D1, D2, D3	G1 phase

If a healthy cell containing sister chromatids is arrested during its cell cycle, which of the cyclins might be damaged?

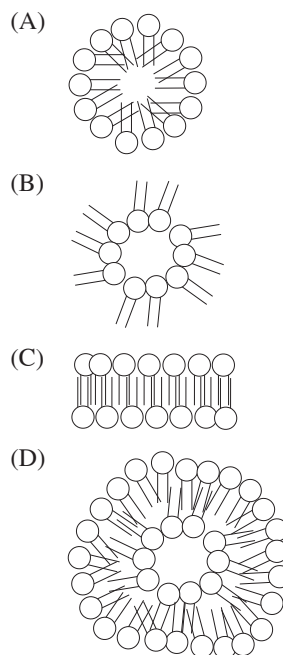
- (A) Cdk1
- (B) Cdk2
- (C) Cyclin A
- (D) Cyclin E

Questions 25-26 refer to the following passage and figure.

The three most common lipids in the body are triglycerides, phospholipids, and cholesterol. Both triglycerides and phospholipids begin with a glycerol backbone with fatty acids attached to it. Triglycerides have three fatty acids attached to their glycerol molecule. However, phospholipids have two fatty acids and one phosphate group.

Phospholipids are amphipathic molecules since they have a hydrophilic phosphate head group and two hydrophobic fatty acid tails. Their dual polarity allows them to spontaneously form configurations that create hydrophobic spaces within which the fatty acids can be encapsulated while allowing the phosphate groups to encounter the naturally polar environment. This hydrophobic space is the hallmark feature of cell membranes and allows them to control the movement of polar molecules that are unable to cross the hydrophobic space.

25. Which of these shapes would NOT likely form spontaneously?

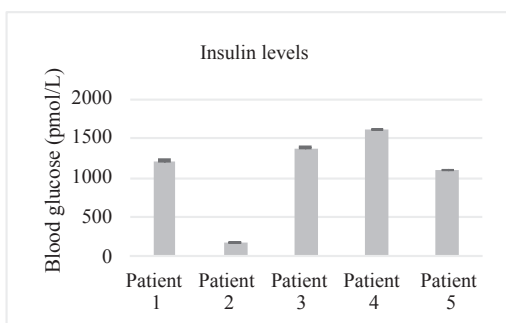
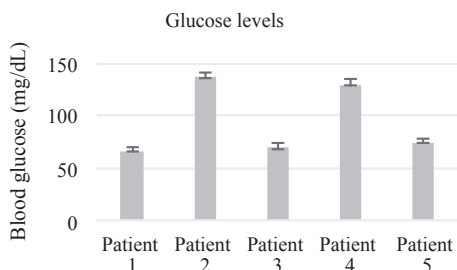


26. Which of these molecules would not be stopped by a cell membrane?

- (A) Water
- (B)  $\text{Na}^+$
- (C)  $\text{Cl}^-$
- (D) Fatty acid

Questions 27-28 refer to the following passage and figures.

*Diabetes mellitus* is a disease characterized by the inability of patients to uptake glucose out of their bloodstream. High blood glucose levels can cause severe systemic effects if left untreated. In Type I diabetes, this is caused by an autoimmune destruction of the beta cells of the pancreas, which produce the hormone insulin. Without proper levels of insulin, glucose is not removed from the blood. In Type II diabetes, the insulin receptor is downregulated and the cells lose the ability to respond to insulin. In several patients, blood glucose and insulin levels were measured. The results are shown below.



27. Which of the above patients likely have Type II diabetes?

- I. Patient 2
  - II. Patient 3
  - III. Patient 4
- (A) I only
  - (B) II only
  - (C) II and III
  - (D) III only

28. Which of the following would likely be found in patient 2?

- (A) Self-reacting antibodies to beta cells
- (B) Self-reacting antibodies to insulin
- (C) Self-reacting antibodies to glucose
- (D) Self-reacting antibodies to diabetes

Questions 29-30 refer to the following passage.

The simple polar nature of water molecules gives them special properties that enable them to sustain life. They are great at sticking to each other (cohesion) and they are great at sticking to other surfaces (adhesion). When water freezes, it forms a special matrix of molecules that gives it a lower density than when it is in a liquid state. It is also a universal solvent and can form many types of solutions. Its high heat capacity also allows it to serve as a temperature buffer, and it can take on heat without raising the body temperature too much. Without water, life on our planet would cease to exist.

29. Plants harness the properties of water during transpiration. Water molecules line up with xylem water transport vessels and interact both with each other and the xylem walls in order to travel up the plant and evaporate out of the stoma. Which properties of water directly help this to occur?

- I. Cohesion
  - II. Adhesion
  - III. Heat capacity
- (A) I only
  - (B) II only
  - (C) I and II
  - (D) I and II and III

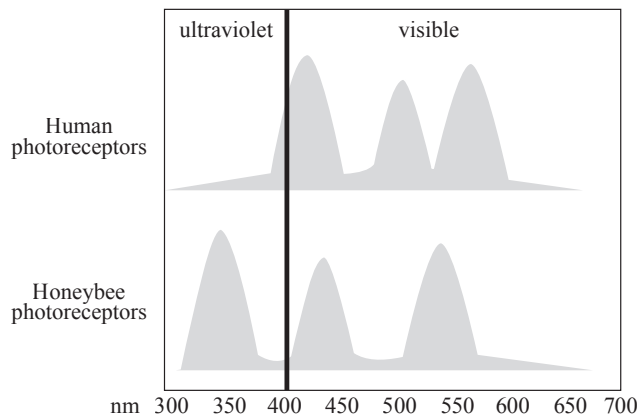
30. Which of the following is a benefit of water having a lower density in the frozen state than the liquid state?

- (A) Water is a universal solvent, and it can form many important biological solutions.
- (B) Water has an extremely high heat capacity, and it is a catalyst in our body.
- (C) Ice floats to the top of water and does not sink and crush the life beneath it.
- (D) Ice has a very high melting temperature, and polar ice caps keep our planet cool.

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Questions 31-33 refer to the following passage and figure.

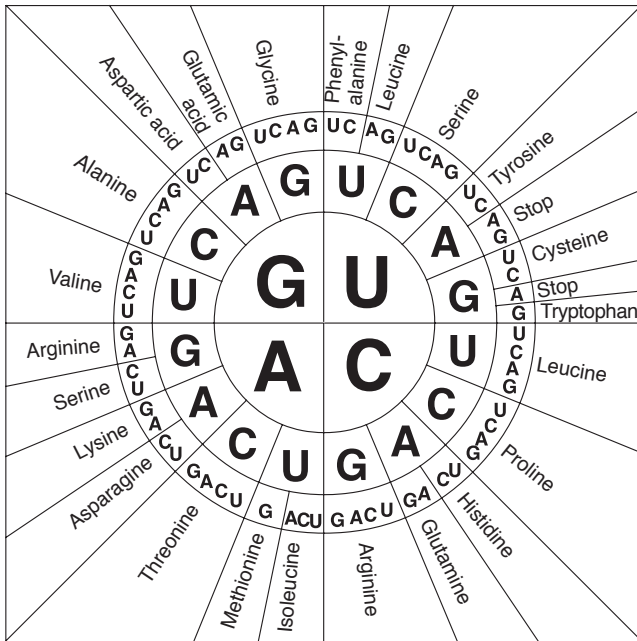
Coevolution is the process whereby natural selection promotes an advantageous interaction between two species. Adaptations that support this interaction are naturally selected for in each species, and over time their fitness increasingly depends on this interaction. Flowers and pollinators have long experienced coevolution. For example, the beautiful colors of many flowers are perfectly suited to the visual spectrum of their pollinators. The figure below shows the peak wavelengths of the three photoreceptors of the human eye and of the eye of a honeybee.



31. Based on the passage, what color wavelength would you expect the pigment of a flower pollinated by a hummingbird to have?
- (A) 540  
(B) 430  
(C) 340  
(D) Not enough information given
32. The above graph implies all of the following EXCEPT?
- (A) Humans and honeybees can both see flower pigments around 540 nm.  
(B) Humans are unable to experience flower pigments below 400 nm as well as bees.  
(C) Bees are always better at seeing flower pigment than humans.  
(D) Humans are better than bees at experiencing flower pigments around 475 nm.
33. If a predator arrived that preferentially ate flowers with a pigment below 400nm, which of the following would you expect to occur if flowers and bees continued to coevolve?
- (A) The flower pigment would become even lower, and the honeybee photoreceptor's peaks would shift to the right  
(B) The flower pigment would become even higher, and the honeybee photoreceptor's peaks would shift to the right  
(C) The flower pigment would become even lower, and the honeybee photoreceptor's peaks would shift to the left  
(D) The flower pigment would become even higher, and the honeybee photoreceptor's peaks would shift to the left

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Questions 34-35 refer to the following figure.



34. Adding all of the following sequences at the site marked with an arrow will give a frameshift mutation EXCEPT?



- (A) G
- (B) GGU
- (C) AG
- (D) TTTT

35. Using the codon table provided, for the following polypeptide, which nucleotide is found at the 3' end of the mRNA sequence that was translated to make the following polypeptide?

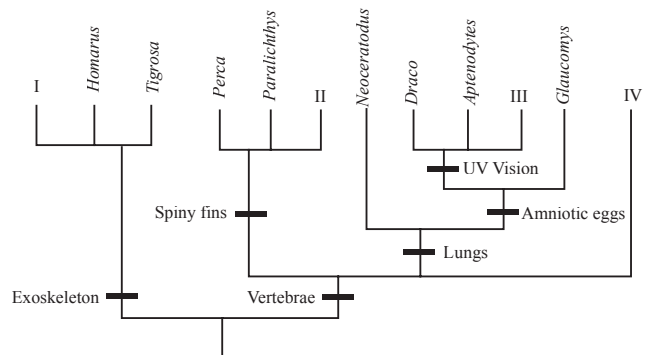
N-term Methionine—Serine—Arginine—Leucine—  
Proline—Tryptophan—C-term

- (A) A
- (B) U
- (C) C
- (D) G

36. Which of the following sequences will NOT stop translation shortly after initiation?

- (A) AUGUAACUCGAU
- (B) AUGUGACUUCU
- (C) AUGUAGGCGCCG
- (D) AUGCCCGCGAUC

Questions 37-38 refer to the following figure.



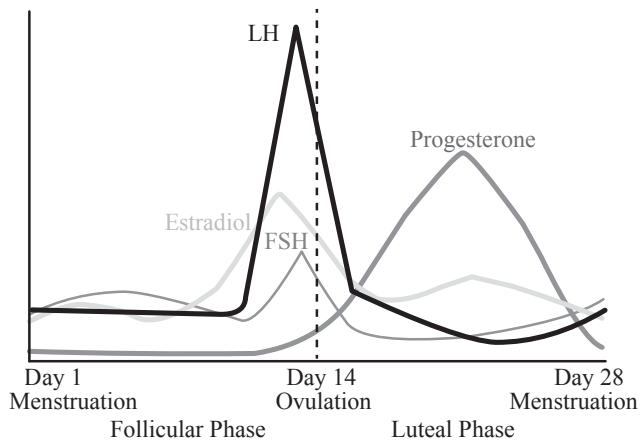
37. Which of the genera contains species with lungs?

- (A) Tigrosa
- (B) Spiny fins
- (C) Paralichthys
- (D) Glaucomys

38. A new organism is discovered that is a vertebrate that hatches from leathery amniotic eggs but is found (through sequencing of a highly conserved Krebs cycle enzyme) to be equally related to organisms from the genera *Perca* AND *Paralichthys*. Which position would you expect this organism to be located on the cladogram?

- (A) I
- (B) II
- (C) III
- (D) IV

39. The following graph illustrates the levels of four hormones as they change throughout the ovarian cycle. Estrogen and progesterone are direct negative regulators of the release of FSH and LH at the anterior pituitary and indirect inhibitors upstream at the hypothalamus. Which of the following statements is true regarding the relationship between FSH/LH and estrogen/progesterone?



- (A) The high levels of progesterone during the luteal phase are triggered by the drop in FSH and LH at the anterior pituitary after ovulation has been completed.
- (B) The drop in LH, FSH, and estrogen after ovulation is due to the sustained increase in progesterone during the luteal phase and pituitary repression.
- (C) The decrease in FSH around the time of ovulation is due to the surge in LH just before ovulation and negative feedback on the hypothalamus.
- (D) The decrease in both estrogen and progesterone leads to an increase in both FSH and LH as one cycle ends and the next begins due to removed repression.

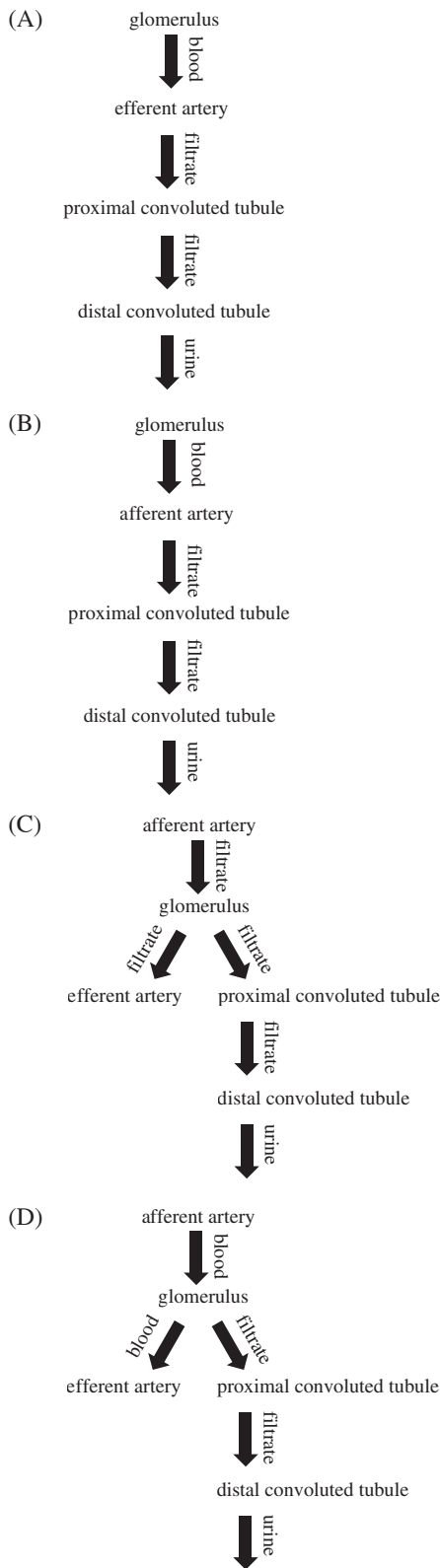
40. When the kidneys filter the blood, a portion of the blood (called the filtrate) is shunted out of the glomerular capillaries and across a barrier leading into the kidney. The rest of the blood passes on to the efferent artery and is not filtered by the kidney. Blood pressure within the glomerular capillaries controls the rate and content of the filtrate entering the proximal convoluted tubule of the kidney. Too much pressure can cause damage to the glomerular barrier, which causes larger blood proteins such as albumin to enter the kidney and pass into the urine. Glomerular damage can also occur in untreated diabetes due to prolonged elevated glucose levels and high blood pressure. Which of the following is a likely symptom of untreated diabetes?

- I. Glomerular damage  
 II. Albumin in the urine  
 III. Elevated glucose levels

- (A) I only  
 (B) I and II  
 (C) III only  
 (D) I, II, and III

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41. Which of the following diagrams best depicts the function of the kidney?



Questions 42-44 refer to the following figure.

Zymogen	Activation Process	Enzyme	Function
Trypsinogen	Cleavage by Enteropeptidase	Trypsin	Digestion
Pepsinogen	pH- Acidic	Pepsin	Digestion
Angiotensinogen	Cleavage by Renin	Angiotensin I	Vasoconstriction
Chymotrypsinogen	Cleavage by Trypsin	Chymotrypsin	Digestion
Fibrinogen	Cleavage by Thrombin	Fibrin	Blood clotting

42. Which of the following best describes a zymogen?
- (A) An enzyme that performs a function in the body such as digestion
  - (B) An uncleaved version of an enzyme that must be cleaved for full function
  - (C) An enzyme that works in a chain with other enzymes to perform a function
  - (D) An inactive form of an enzyme that must be activated before gaining function
43. Angiotensin I is involved in the regulation of blood pressure. Angiotensin I is converted into Angiotensin II by an enzyme called ACE. Angiotensin II leads to vasoconstriction, which leads to an elevation of blood pressure. Which of the following statements is likely true?
- (A) Angiotensinogen is released in response to high ACE levels.
  - (B) ACE is released in response to high blood pressure.
  - (C) Angiotensin II levels are directly related to the levels of ACE.
  - (D) Renin is released in response to high blood pressure.
44. Low levels of Chymotrypsin could be a result of:
- I. A mutation in trypsin
  - II. A mutation in chymotrypsinogen
  - III. A mutation in enteropeptidase
- (A) I only
  - (B) II only
  - (C) I and II
  - (D) I, II, and III

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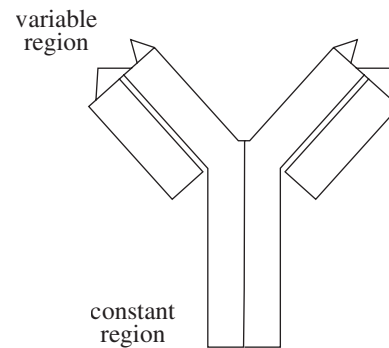
Questions 45-46 refer to the following passage.

Approximately 450 million years ago, life moved out of the sea and onto land. In order to live on land, the first land plants needed the ability to conserve water or they would dry out in the hot sun. Later, as plants further adapted, they developed a standing structure, a vessel transport system, and the ability to disperse seeds.

45. Which of the following is a possible explanation of how plants became adapted to land?
- (A) Due to a single random mutation, a plant grew one day with a waxy cuticle coating, guard cells, and stomata. This made it capable of living on land because these features help to conserve water.
  - (B) A plant living near the edge of the water was randomly pushed on land by a wave of water, and it soon developed a special waxy cuticle to prevent water loss.
  - (C) In water dwelling plants, a waxy cuticle was selected for because it gave them an advantage. Eventually, it became so protective that when plants washed up on shore, they did not dry out in the sun.
  - (D) Plants near the edge of the water were being destroyed by a virus; this selective pressure caused them to prefer land.
46. Apart from the adaptations listed in the passage, what else was essential for plants to move to land?
- (A) Animals to assist with pollination and seed dispersal
  - (B) A niche benefit to being on land instead of the sea
  - (C) The ability to perform photosynthesis to make sugar
  - (D) A second photosystem for performing photosynthesis

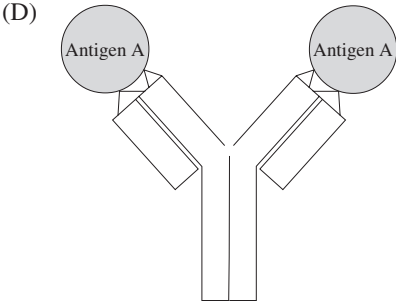
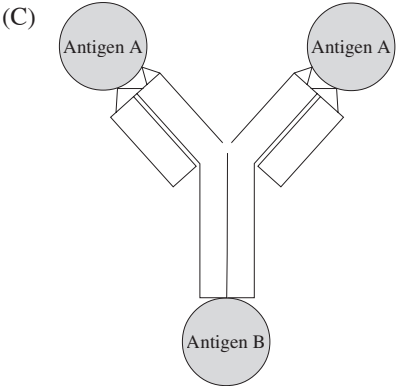
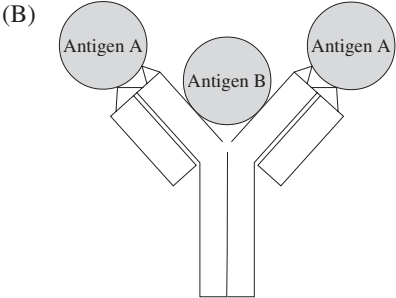
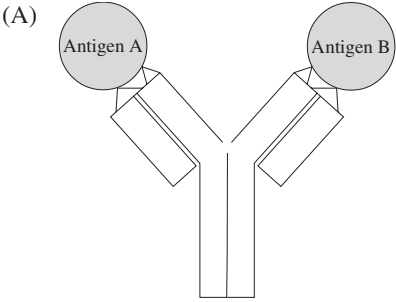
Questions 47-49 refer to the following passage and figure.

Antibodies are special immune molecules that are built to recognize things. Our body makes an estimated  $10^8$  different antibodies. Most of the structure of each antibody is the same. This is the constant region. The constant region interacts with other immune molecules in the body; therefore, it needs to be the same for all antibodies. The differing region amongst the antibodies is the variable region. This is where an antibody binds to a special partner called an antigen. Each antibody has a unique variable region that only binds to a unique antigen. Most antibodies have two arms, each with the same variable region that is capable of binding to the same particular antigen.



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47. Which of the following best represents the binding between antibody and antigen?



48. What would likely be the consequence of having a mutation that affects the constant region?

- (A) Each antibody would now have even more antigen binding variable regions available
- (B) The body would be unable to bind to antigens on both of its arms at the same time
- (C) Less versions of the variable region would make the body less likely to respond to a pathogen
- (D) The antibody would be unable to signal to other immune cells that it has found a pathogen

49. Once an antibody has engaged with a pathogen, the immune system remembers that pathogen and can combat it more efficiently in the future. Vaccines provide small doses of a modified pathogen in order to trigger an immune response to a pathogen without actually getting a full-scale infection. If a scientist were to design a vaccine for a newly discovered virus, what part of the virus should be included in order to trigger an antibody-mediated immune response?

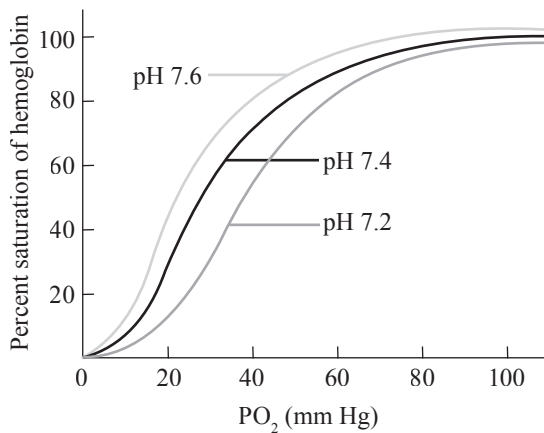
- (A) A segment of the viral genome
- (B) A viral protein found on the outside of the virus shell
- (C) The constant region of a host antibody
- (D) The variable region of an antibody that binds the virus

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Questions 50-52 refer to the following passage and figure.

Cells in the human body need to acquire oxygen and expel carbon dioxide waste during the process of cellular respiration. Oxygen is primarily carried within the blood attached to the protein hemoglobin, which is on red blood cells. On the other hand, carbon dioxide is primarily carried within the blood as an ion after it reacts with water to become  $\text{HCO}_3^-$ . The formation of  $\text{HCO}_3^-$  releases  $\text{H}^+$ , which drastically lowers the pH.

When pH is low, hemoglobin shifts into a tense formation that makes it bind oxygen with less affinity. In the absence of dissolved  $\text{CO}_2$ , the relaxed state of hemoglobin binds oxygen cooperatively, with up to 4 oxygen molecules binding to a single hemoglobin molecule. Cooperative binding means that after the first molecule is bound, it is easier for the others to bind.



50. Which statement best describes the graph?

- (A) Four oxygens can bind to hemoglobin, but only at high pH.
- (B) Hemoglobin prefers to bind to carbon dioxide when the pH is high.
- (C) The saturation of hemoglobin is reduced when more oxygen is present.
- (D) Hemoglobin's affinity for oxygen changes with the amount of oxygen and the pH.

51. In a capillary just outside of a muscle cell that is performing fermentation, the pH would be closest to?

- (A) 7.2
- (B) 7.4
- (C) 7.6
- (D) 7.8

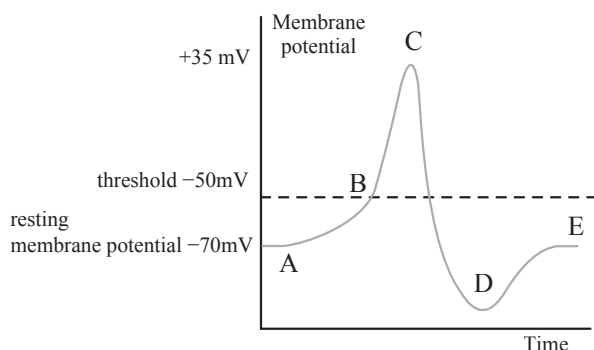
52. In the graph above, a curve that is shifted even further to the right would represent which of the following scenarios?

- I. A higher level of  $\text{CO}_2$
  - II. A lower pH
  - III. A stronger affinity for oxygen
- (A) II only
  - (B) I and II
  - (C) II and III
  - (D) I, II, III

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Questions 53-55 refer to the following passage and figure.

Action potentials are a type of signal propagated in neurons and muscle cells. The resting membrane potential (the electrical charge inside the cell minus the charge outside of the cell) is crucial for this type of signaling. Each action potential represents a disruption in the membrane potential due to the influx or efflux of charged ions. The sodium potassium pump uses active transport to set up gradients down, which sodium ( $\text{Na}^+$ ) and potassium ( $\text{K}^+$ ) can flow into and out of the cell, respectively, during the conduction of an action potential.



53. At which point on the graph is it likely that sodium channels open and allow an extremely large amount of sodium to flow into the cell very quickly?
- (A) A  
(B) B  
(C) C  
(D) E
54. Which of the following could be occurring in the cell at point A?
- (A) A slightly positive influx occurs due to external stimulation.  
(B) A slightly negative influx occurs due to external stimulation.  
(C) All ion flux ceases when the cell is below threshold.  
(D) Ion flux reverses until the threshold is met within the cell.
55. The sodium potassium pump is responsible for maintaining the resting membrane potential ( $-70\text{mV}$ ) of a typical cell that is not currently undergoing an action potential. Which of the following describes the nature of the sodium potassium pump as it actively pumps  $\text{Na}^+$  and  $\text{K}^+$  ions?
- (A) It pumps 3  $\text{Na}^+$  in and 2  $\text{K}^+$  out.  
(B) It pumps 2  $\text{Na}^+$  in and 3  $\text{K}^+$  out.  
(C) It pumps 3  $\text{K}^+$  in and 2  $\text{Na}^+$  out.  
(D) It pumps 2  $\text{K}^+$  in and 3  $\text{Na}^+$  out.

Questions 56-59 refer to the following passage and figure.

The following table shows the population sizes of 5 organisms that live together in a lake, as estimated every 6 months for 3 years. In the years preceding 2011, similar population sizes were seen to those recorded in Spring 2011. However, in May of 2011 a virus wiped out nearly all of the phytoplankton. The results can be seen rippling throughout the food chain.

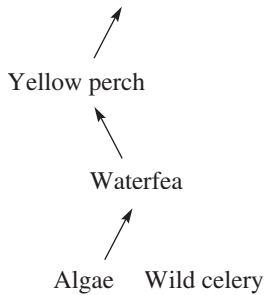
Scientific name	Common name	Spring 2011	Fall 2011	Fall 2012	Spring 2013	Fall 2013
<i>Micropterus dolomieu</i>	Smallmouth Bass	1,200	1,150	1,100	400	475
<i>Perca flavescens</i>	Yellow Perch	1,600	1,525	1,200	350	525
Zooplankton	Waterflea	25,000,000	20,000,000	4,500	8,000	12,000
<i>Valisneria americana</i>	Wild Celery	35,000	70,000	70,000	70,000	70,000
Phytoplankton	Algae	40,000,000	5,000	8,500	15,000	21,000

56. Which of the following events is supported by the data?
- (A) A new consumer arrived during the summer of 2011 that prefers wild celery to phytoplankton.  
(B) Everything relies on the phytoplankton (directly or indirectly) except for the wild celery.  
(C) Yellow perch changed their feeding habits during winter of 2012 and started eating wild celery.  
(D) Smallmouth bass and yellow perch directly rely on phytoplankton as a food source.

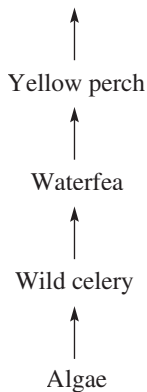
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57. Based on the effects caused by a loss of phytoplankton, which of the following best represents the food web for this lake?

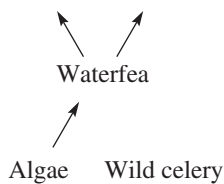
(A) Smallmouth bass



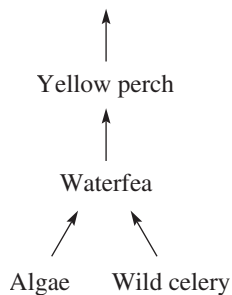
(B) Smallmouth bass



(C) Yellow perch Smallmouth bass



(D) Smallmouth bass



58. What is the carrying capacity of wild celery?

- (A) 35,000
- (B) 70,000
- (C) 75,000
- (D) 80,000

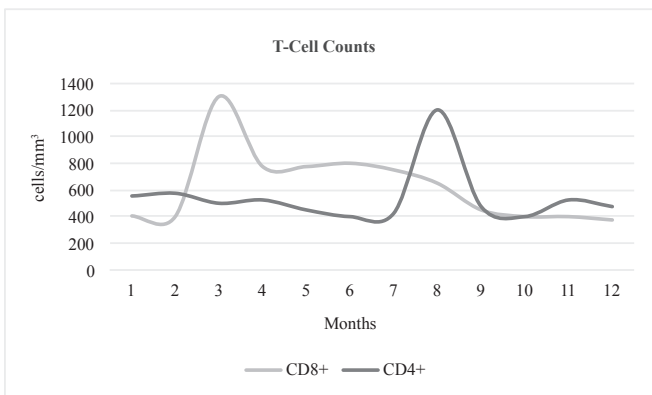
59. Which of the following changes would likely occur if a virus destroyed the wild celery in the winter of 2013?

- (A) The wild celery population would decrease, but everything else would remain the same.
- (B) The wild celery population would decrease, and everything else would begin to decrease shortly after.
- (C) The wild celery population would decrease, and everything else would begin to increase shortly after.
- (D) The wild celery population would not change, because viruses cannot infect plants.

**GO ON TO THE NEXT PAGE.**

Questions 60-63 refer to the following passage and figure.

T-cells are a type of cell that is part of our adaptive immune response. T-cells are so named because of their development in the thymus. T-cells come in two distinct types, although there are many other subsets within these two categories. Cytotoxic T-cells patrol the body and investigate things presented by a special complex called MHC-I. MHC-I molecules are on each of our cells and present things found within the cell to the cytotoxic T-cells for inspection. If the T-cells detect a problem inside one of our cells, it is destroyed. They are important for identifying problems inside our cells, such as cancer or a hidden invader such as a virus or an intracellular bacterium. Cytotoxic T-cells are also called CD8+ T-cells because they have the cell surface marker CD8 on their surface. CD4+ T-cells are different because they inspect things presented by MHC-II molecules that are found on other immune cells, like B-cells. B-cells inspect extracellular things in the body and then they present any possible enemies to the CD4+ cells, which are also called helper T-cells. If the CD4+ cells agree that the B-cells have found something dangerous, then they work together to mount an attack.



60. Which of the following situations is the LEAST likely to cause a spike in CD8+ T-cells?
- (A) A breast cell that is dividing uncontrollably
  - (B) A virus infected cell in an otherwise healthy liver
  - (C) Lungs with intracellular mycobacterium tuberculosis
  - (D) A toxin that blocks neurotransmitters in the brain

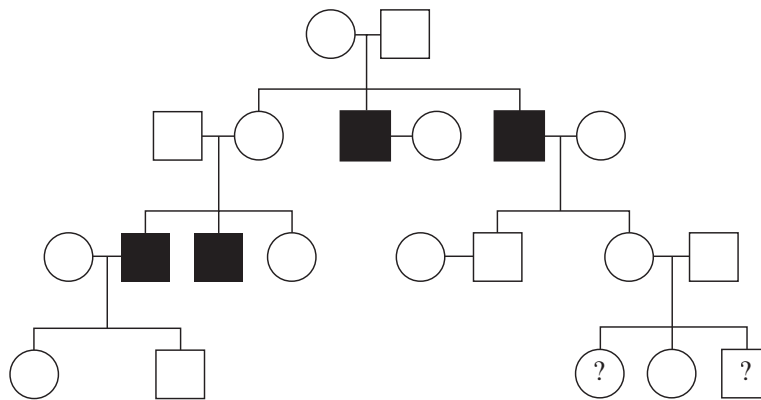
61. Which of the following would likely be true for an individual without any MHC-II?
- (A) They cannot identify invaders at all.
  - (B) They can only identify invaders within our cells.
  - (C) They can only identify invaders outside of our cells
  - (D) They can identify tumor cells but not any infectious pathogens.
62. Which of the following best describes the graph shown above?
- (A) The patient was infected by a virus and 5 months later was infected by an extracellular bacterium.
  - (B) The patient was diagnosed with cancer and 5 months later they went into remission.
  - (C) The patient was infected by a fungus and 5 months later they were diagnosed with cancer.
  - (D) The patient was infected by a virus and the severe infection lasted for 5 months.
63. On which of the following cells would you expect to find an MHC-II?
- (A) A dendritic immune cell
  - (B) An alveolar lung cell
  - (C) A smooth muscle cell
  - (D) An epithelial skin cell

GO ON TO THE NEXT PAGE.

**Directions:** Part B consists of questions requiring numeric answers. Calculate the correct answer for each question.

Questions 64-65 refer to the following passage and figure.

The following pedigree, outlines a family with a history of an X-linked genetic disease. Females are shown with circles and males are shown with squares. Individuals that married into the family should be considered normal. The phenotypes of the individuals marked with the ? are unknown at this time.



64. In the above pedigree, what is the probability that the male marked with “?” will have the genetic disease? Give your answer as a percent.

65. What is the probability that the female marked with the “?” will have the genetic disease? Give your answer as a percent.

	/	/	/	
.	.	.	.	.
0	0	0	0	0
1	1	1	1	1
2	2	2	2	2
3	3	3	3	3
4	4	4	4	4
5	5	5	5	5
6	6	6	6	6
7	7	7	7	7
8	8	8	8	8
9	9	9	9	9

	/	/	/	
.	.	.	.	.
0	0	0	0	0
1	1	1	1	1
2	2	2	2	2
3	3	3	3	3
4	4	4	4	4
5	5	5	5	5
6	6	6	6	6
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8	8	8	8	8
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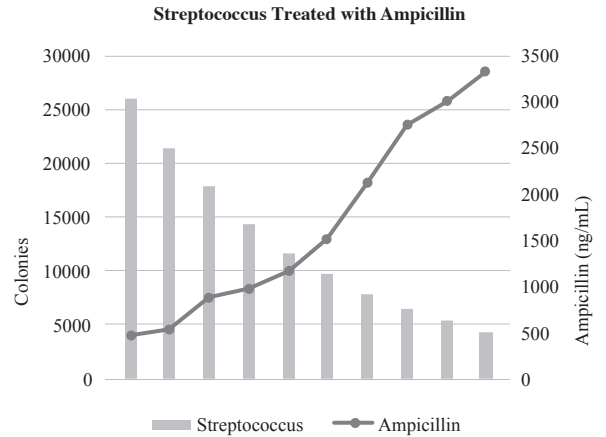
66. Students crossed fast plants with trichomes and purple stems with wild type fast plants that have no hairs and green stems and discovered that all the offspring have trichomes and purple stems. The class breeds this new generation together with the parent genotypes for several generations of plants. The following data was collected from the final generation of plants.

Trait	Number of plants
Green stem	371
Purple stem	471
Contains trichomes	522
Does not contain trichomes	320

What percentage of the final generation are heterozygous for stem color? Assume the plants are in Hardy-Weinberg equilibrium and express answers as number between 0 and 1 with 3 decimal places.

	/	/	/	
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2	2	2	2	2
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4	4	4	4	4
5	5	5	5	5
6	6	6	6	6
7	7	7	7	7
8	8	8	8	8
9	9	9	9	9

67. In the graph below, how much ampicillin is required to reduce the initial population of streptococcus by 50%. Give your answer in ng/mL.



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1	1	1	1	1
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4	4	4	4	4
5	5	5	5	5
6	6	6	6	6
7	7	7	7	7
8	8	8	8	8
9	9	9	9	9

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68. During the Krebs cycle, a cell makes 3 NADH, 1 FADH<sub>2</sub> to pass to the electron transport chain, and each NADH pumps enough hydrogen ions to create 2.5 ATP and each FADH<sub>2</sub> pumps enough hydrogen ions to make 1.5 ATP. If each glucose molecule causes two turns of the Krebs cycle, how many ATP will be formed from the H<sup>+</sup> pumped from the electron carriers made in the Krebs cycle?

	/	/	/	
.	.	.	.	.
0	0	0	0	0
1	1	1	1	1
2	2	2	2	2
3	3	3	3	3
4	4	4	4	4
5	5	5	5	5
6	6	6	6	6
7	7	7	7	7
8	8	8	8	8
9	9	9	9	9

69. A plant cell has an initial water potential of  $-3.5$  bars and is placed in an open beaker that has a concentration of NaCl of  $0.25$  M at  $25^{\circ}\text{C}$ . What is the water potential of the solution? Give your answer with 2 decimal places.

	/	/	/	
.	.	.	.	.
0	0	0	0	0
1	1	1	1	1
2	2	2	2	2
3	3	3	3	3
4	4	4	4	4
5	5	5	5	5
6	6	6	6	6
7	7	7	7	7
8	8	8	8	8
9	9	9	9	9

**STOP**

**END OF SECTION I**

**IF YOU FINISH BEFORE TIME IS CALLED, YOU MAY CHECK YOUR WORK ON THIS SECTION. DO NOT GO ON TO SECTION II UNTIL YOU ARE TOLD TO DO SO.**

## BIOLOGY

## SECTION II

## 8 Questions

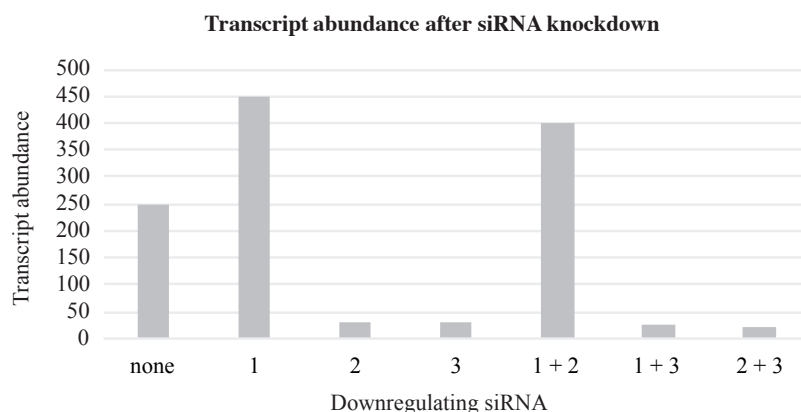
Planning Time—10 minutes

Writing Time—80 minutes

**Directions:** Questions 1 and 2 are long free-response questions that should require about 22 minutes each to answer and are worth 10 points each. Questions 3 through 8 are short free-response questions that should require about 6 minutes each to answer. Questions 3 through 5 are worth 4 points each, and questions 6 through 8 are worth 3 points each.

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

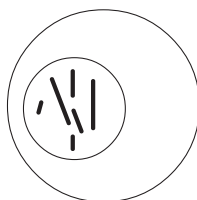
1. As living things, cells are constantly at work. This work requires energy.
  - (a) **Explain** the benefit of having the universal energy molecule, Adenosine Triphosphate.
  - (b) **Describe** the three main processes of cellular respiration that lead to its creation. **Include** key molecules involved, the location of each process, and **explain** the purpose of creating reduced electron carriers.
  - (c) How is cellular respiration different in an anaerobic state?
  - (d) Rather than eating, plants harvest energy from the sun during photosynthesis. **Compare** photosynthesis to cellular respiration and **explain** why cellular respiration is still necessary in plants.
2. (I) Regulation is essential in the body. Homeostasis must be carefully monitored and regulated. A major point of regulation is pre-transcriptional regulation. This process often involves un-transcribed sequences of DNA upstream of the transcription start site.
  - **Describe** 2 examples of homeostasis and **relate** stimuli to necessary changes in gene expression.
  - **Explain** how upstream un-transcribed regions of DNA can impact transcription levels.
- (II) In the following experiment, several proteins (1, 2, and 3) suspected of being transcription factors of Gene X were down-regulated using siRNA molecules. The effect on the transcription of Gene X after downregulation of genes 1, 2, and 3 by siRNA was measured by RT-qPCR.



- **Identify** these three proteins as activators or repressors and **explain** your conclusions using the data. **Draw** a proposed model where you show possible interactions between these proteins and the upstream region of Gene X.

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3. **Describe** the two main components of every virus. **Explain** why viruses are not considered to be alive, and **explain** the impact this has on their “life-cycle.”
4. Most humans would agree that it would give a great advantage to them if they could fly. However, there are still not any humans that can fly. **Explain** how adaptations and natural selection occur and **argue** why humans cannot be blamed for not acquiring this trait.
5. **Discuss** the importance of genetic variation in evolution. **Describe** two ways that genetic variation occurs and **predict** the evolutionary impact if new genetic variation stopped occurring.
6. Mitosis and meiosis are the two types of cell division that occur in the body. Using the following somatic cell as a model, **compare** mitosis and meiosis. **Include** the purpose of each process and the outcome compared to the initial model cell. Assume the model cell has recently finished mitosis and has just entered interphase.



7. Within organisms and within cells, organization and separate spaces are important. **Explain** how organisms and cells keep things separated. Give at least 3 examples and **describe** why the separation is necessary.
8. An experiment was performed where the tidal volume (amount of air exhaled during one breath) and saliva were collected from guinea pigs that were exposed to air containing different essential oils, some of which have been linked to asthma. Salivary samples were collected hourly for a 5-hour period. The level of  $\delta$ -Valerolactam was also measured to assess its use as a biomarker for asthma. All levels were averaged for each experimental group and the data were reported in the table below.

Essential oil	Unscented	Pine (10 pp(B))	Pine (100 pp(B))	Juniper (10 pp(B))	Juniper (100 pp(B))
Tidal flow (mL/k(B))	5.8	5.3	5.4	2.1	1.4
Salivary $\delta$ -Valerolactam levels (ng/mL)	0.1	0.3	1	122	324

- (a) Pose one question that the scientists were trying to answer with this experiment?
- (b) State a testable hypothesis that would address the scientists' question.
- (c) Describe the effectiveness of  $\delta$ -Valerolactam as a biomarker for asthma.

**STOP**

**END OF EXAM**

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