



Practice Test 4

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

3. TEST CODE 4. REGISTRATION NUMBER

0	A	0	0	0	0	0	0	0	0
1	B	1	1	1	1	1	1	1	1
2	C	2	2	2	2	2	2	2	2
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4	E	4	4	4	4	4	4	4	4
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6. DATE OF BIRTH

Month	Day	Year
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<input type="radio"/> JUL	<input type="radio"/> 4	<input type="radio"/> 4
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<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[®] 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

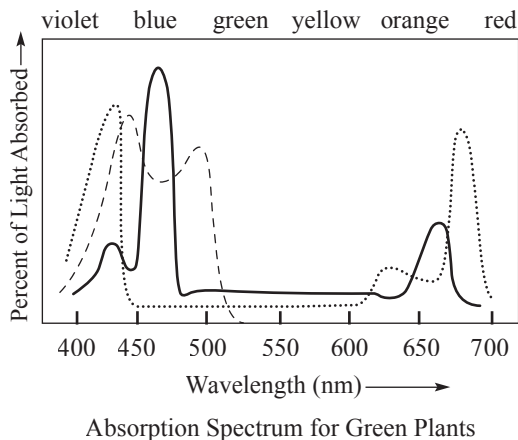
Many candidates wonder whether or not to guess the answers to questions about which they are not certain. Multiple choice scores are based on the number of questions answered correctly. Points are not deducted for incorrect answers, and no points are awarded for unanswered questions. Because points are 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 and figure.

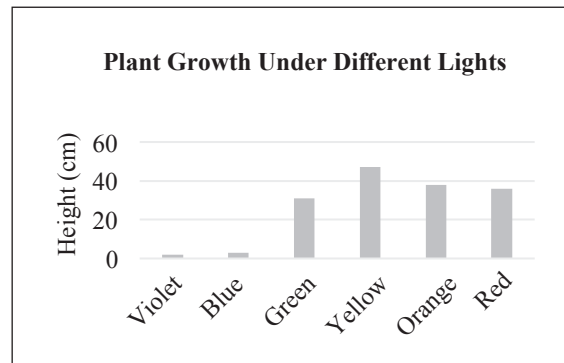
During photosynthesis, chlorophyll pigment absorbs sunlight that energizes its electrons. There are two types of chlorophyll pigment found in plants: chlorophyll *a* and chlorophyll *b*. Each pigment absorbs light at different optimal wavelengths, and unabsorbed light is reflected outward. To energize its electrons, it is important that light of absorbable wavelengths reaches the plant for photosynthesis to occur. The graph below demonstrates the absorbed spectrum of light for chlorophyll *a*, chlorophyll *b*, and another type of pigment found in plants called carotenoid.



..... Chlorophyll *a*
 — Chlorophyll *b*
 - - - Carotenoids

1. Approximately which color wavelengths would a plant containing chlorophyll *a* appear as to humans?
- (A) 400–450 nm
 (B) 450–600 nm
 (C) 675–700 nm
 (D) None of the above, because humans cannot see the visible light spectrum.

2. If carotenoids were capable of energizing electrons for photosynthesis in the same manner as chlorophyll, in approximately which wavelengths of light would they best perform photosynthesis?
- (A) less than 450 nm
 (B) 450–500 nm
 (C) 500–700 nm
 (D) greater than 700 nm
3. The following graph shows the height of a new species of plant when it is grown under lights of different wavelengths. What color does this plant likely appear to humans?



- (A) Violet
 (B) Green
 (C) Yellow
 (D) Red

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Questions 4–5 refer to the following passage and figure.

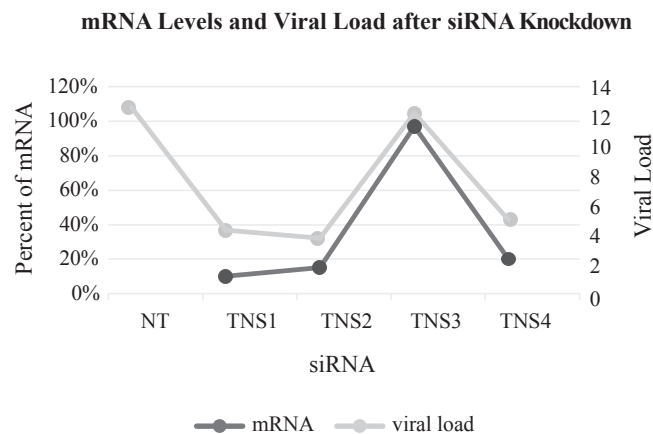
The following table identifies the stages of embryogenesis in humans. As the embryo develops, the cells differentiate, and their potency, or potential to become many types of cells, is reduced.

Stage	Cell Number	Regions/Layers	Potential
Zygote	1	none	Totipotent
Morula	16	none	Totipotent
Blastula	>100	Trophoblast Inner Cell Mass	Pluripotent
Gastrula	too numerous to count	Endoderm Ectoderm Mesoderm	Multipotent

4. Which of the following could be derived from a totipotent stem cell?
- I. Morula
 - II. Trophoblast
 - III. Endoderm
- (A) I only
(B) II only
(C) II and III
(D) I and II and III
5. If a cell in a morula becomes a cell of the trophoblast, it has become
- (A) more differentiated and less specialized
(B) less differentiated and more specialized
(C) more differentiated and more specialized
(D) less differentiated and less specialized

Questions 6–8 refer to the following passage and figure.

Four genes in the TNS family are identified as being involved in the viral entry of a particular virus. To evaluate this claim, the expression of each gene is reduced using RNA interference. Afterwards, viral infection is attempted and the viral load is assessed. A non-targeting (NT) siRNA is used as a control.



6. Which likely describes why there is no mRNA data for the NT siRNA treated sample?
- (A) NT siRNA is designed to NOT reduce expression of any specific gene.
(B) NT siRNA is designed to reduce the expression of ALL genes equally.
(C) NT siRNA reduces the expression to levels below the detectable threshold.
(D) NT siRNA enhances viral infection, and looking at mRNA is not necessary.
7. Which of the following conclusions is correct?
- I. TNS 1 is involved in viral infection.
 - II. TNS 2 is involved in viral infection.
 - III. TNS 3 is NOT involved in viral infection.
- (A) I only
(B) III only
(C) I and II
(D) I and II and III

GO ON TO THE NEXT PAGE.

8. Which of the following would NOT have been helpful as a control in this experiment?
- (A) An siRNA for a gene known to be involved in viral infection
 - (B) An siRNA for a gene known to make very little mRNA
 - (C) An siRNA for a gene known to NOT be involved with viral infection
 - (D) A second siRNA that targets each of the genes being studied

Questions 9–11 refer to the following passage.

Frederick Griffith showed in 1928 that when a heat-killed virulent strain of bacteria was mixed with a living non-virulent strain of bacteria, it resulted in an infection with living virulent bacteria. They called this process the transformation of the non-virulent bacteria.

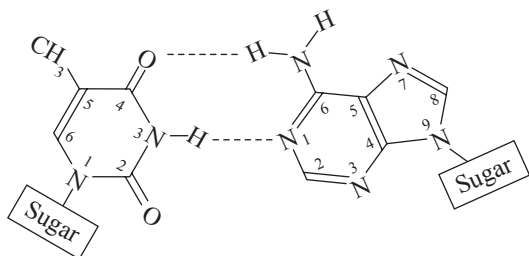
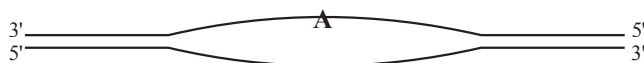
In 1944, Avery, McCarty and MacLeod used laboratory techniques to separate the DNA, RNA, lipids, proteins, and carbohydrates present in a virulent bacterial strain and then they repeated Griffiths experiment to see which fraction was capable of transforming the non-virulent strain into a virulent strain. Since the DNA fraction was the only one that transformed the bacteria, they concluded that DNA must be the macromolecule that gives characteristics in bacteria.

9. Which of the following conclusions could be made in 1929?
- (A) A heat-resistant molecule can be passed to living bacteria and change its characteristics.
 - (B) A DNA molecule cannot be killed by heat treatment when it is inside a bacterium.
 - (C) Heat-killed bacteria can come back to life when they are mixed with virulent bacteria.
 - (D) A virulent bacterial strain will always win out against a non-virulent strain of bacteria.
10. Which of the following, if true, would most negate Avery, McCarty, and MacLeod's conclusion?
- (A) If it was shown that the fraction of lipids did not contain lipids
 - (B) If it was shown that the RNA fraction also contained trace amounts of DNA
 - (C) If it was shown that the DNA fraction also contained bits of protein
 - (D) If it was shown that the DNA fraction was much larger than the RNA fraction
11. Which of the following best describes the process of transformation as it is used above?
- (A) Acquisition of any DNA by bacteria causes it to acquire new traits.
 - (B) The traits in bacteria are determined by the DNA that is present.
 - (C) DNA is capable of giving any species the traits of another species.
 - (D) Bacteria are revived after being heat-killed if they get new DNA.

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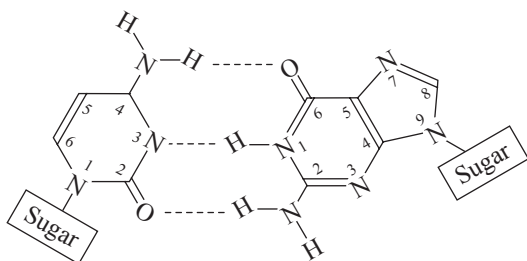
Questions 12–14 refer to the following passage and figures.

A DNA molecule is a double helix formed from two strands of DNA that base pair together with hydrogen bonds. Adenine preferentially binds with thymine, and cytosine preferentially pairs with guanine. The two strands form an anti-parallel conformation in the helix with the 3' hydroxyl end of one strand aligning with the 5' phosphate end of the other strand and vice-versa.



Thymine (T)

Adenine (A)



Cytosine (C)

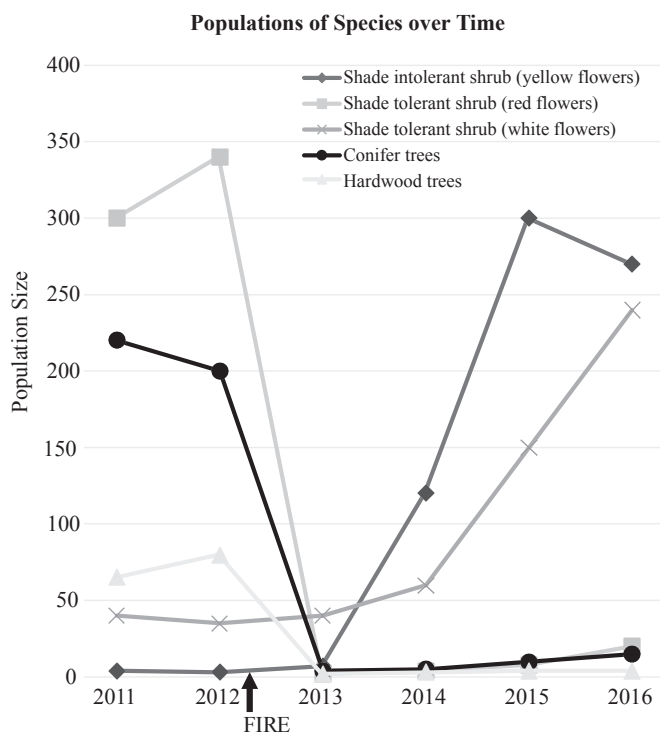
Guanine (G)

12. If a DNA dependent DNA polymerase were attached at site A, which statement best describes its movement?
- It will travel towards the right and build a copy of the top DNA strand.
 - It will travel towards the left and build a copy of the top DNA strand.
 - It will travel towards the right and build a complement of the top DNA strand.
 - It will travel towards the left and build a complement of the top DNA strand.

13. The lagging strand cannot be built continuously during DNA replication for which of the following reasons?
- The DNA polymerase enzyme only travels in one direction, and when the helix opens in the opposite direction of the polymerase, there is limited space for the polymerase to travel, only building small segments at a time.
 - The two strands of DNA are opening and closing asynchronously, and the polymerase must copy the limited small segments that are available to it before the helix closes.
 - The lagging strand will not be used for the production of mRNA, and a continuous segment is only required for the coding strand that will code for the eventual mRNA.
 - An RNA primer is needed during DNA replication, and the lagging strand is the last strand to receive an RNA primer during replication. The lagging strand must be built after a short delay.
14. As the base pairs align to form a double helix, which are easier to separate?
- A-T because it has 3 hydrogen bonds
 - A-T because it has 2 hydrogen bonds
 - G-C because it has 3 hydrogen bonds
 - G-C because it has 2 hydrogen bonds

GO ON TO THE NEXT PAGE.

Questions 15–16 refer to the following figure.



15. If the fire never occurred, which prediction about the population in 2016 is the most supported by the data?
- (A) The white-flowered, shade tolerant shrubs would disappear from the region.
- (B) The number of shade intolerant shrubs would increase, and the conifers would disappear.
- (C) Conifers would claim the territory of all colors of the shade tolerant shrubs.
- (D) Hardwood trees would increase in number, and conifers would decrease.
16. Which of the following could describe the growth patterns of the red- versus white-colored, shade tolerant shrubs?
- I. Red flowers were selected for before the fire.
- II. White flowers had increased fitness under the selective pressure of the fire.
- III. White flowers are tolerant to fire and were always the most fit.
- (A) I only
- (B) II only
- (C) I and II
- (D) I and II and III

Questions 17–18 refer to the following figure.

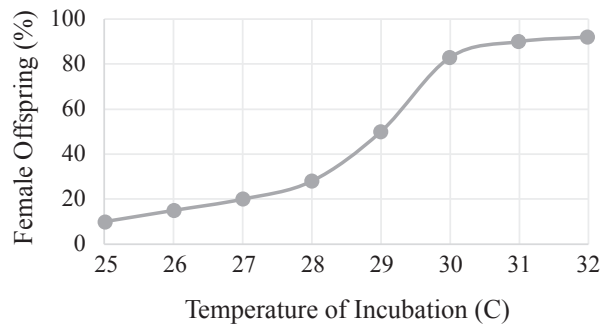
Fish	Urine Volume	Blood Osmolarity
Saltwater Fish	Low	Medium
Freshwater Fish	High	Medium

17. What describes the urine output for the saltwater and the freshwater fish?
- (A) The freshwater has a large volume of urine because freshwater is less dilute than the inside of the fish and the urine is necessary to change the osmolarity of the water surrounding the fish.
- (B) The saltwater fish doesn't need a large volume of urine because it is fine with a large amount of salt. It does not need to discard it as waste.
- (C) The freshwater fish drinks a lot of water. It must urinate a lot so it does not rupture from too much water because it cannot control how much it drinks.
- (D) The saltwater fish has less solute than the environment and constantly loses water to the environment. It needs low volume of urine to retain water.
18. Salmon spend some time in saltwater and some time in freshwater. Which of the following would you expect for the salmon at different phases of life?
- (A) Saltwater salmon should have a lower blood osmolarity and a higher urine volume than freshwater salmon.
- (B) Freshwater salmon should have a higher blood osmolarity and a higher urine volume than saltwater salmon.
- (C) Saltwater salmon should have the same blood osmolarity and a higher urine volume than saltwater salmon.
- (D) Freshwater salmon should have the same blood osmolarity and a higher urine volume than saltwater salmon.

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Questions 19–20 refer to the following figure.

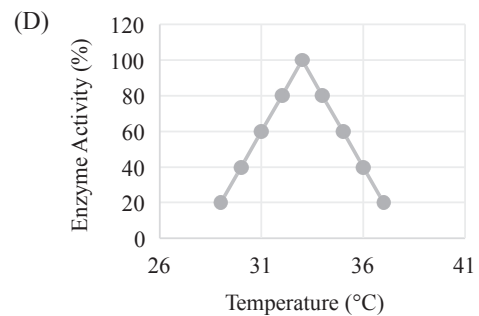
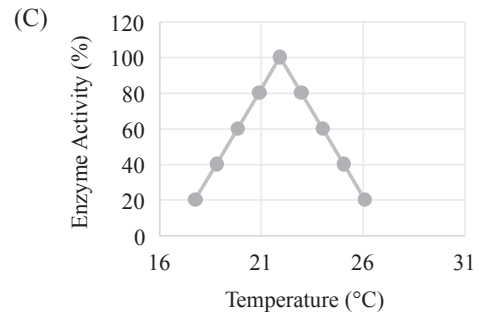
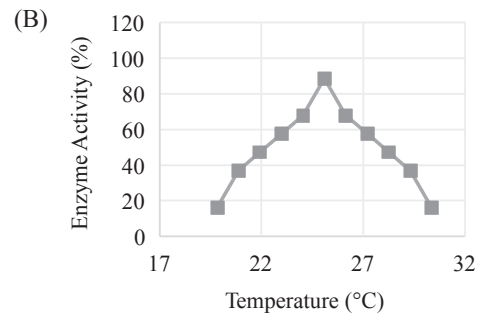
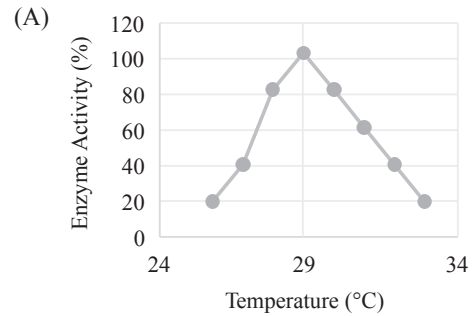
Incubation of Sea Turtle Eggs



19. At which temperature would you expect 40 male turtles and 160 females turtles to be born?

- (A) 26.5
- (B) 38.2
- (C) 29.7
- (D) 31.4

20. Temperature is a key element in determining the activity of enzymes. If a particular enzyme must be active for female offspring to occur, which of the following enzyme activity versus temperature graphs represents that enzyme?



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Questions 21–23 refer to the following passage and table.

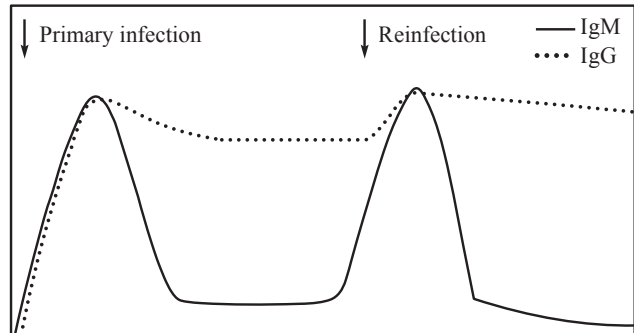
Breast cancer is not a one-size-fits-all disease. Tumors in the breasts can occur due to many different factors. Depending on the characteristics of the tumor cells, the treatment and prognosis can vary greatly. The table below lists two (of many) known tumor markers. Each of these genes is often found to be overexpressed in breast cancer cells.

Tumor Marker	Function	Drug
Estrogen Receptor (ER)	Docking site for the hormone estrogen, which causes changes in transcription that can lead to cell division	Tamoxifen
Human Epidermal Growth Factor Receptor 2 (HER2)	Promotes cell division and growth	Herceptin

21. According to the passage, HER2 is found
- on tumor cells only
 - on healthy cells, but it is found more often on tumor cells
 - on healthy cells only
 - on healthy cells, but is found less often on tumor cells
22. Which of the following is likely true for a cell with mutated ER leading to loss of function?
- It does not respond to estrogen as well.
 - It binds to progesterone instead of estrogen.
 - It divides more quickly than other cells.
 - It is no longer under cell cycle control.
23. Which of the following is NOT a likely function of tamoxifen?
- Blocks the binding of estrogen and ER
 - Increases the production of estrogen
 - Decreases the production of ER
 - Blocks the role of ER in the cell cycle

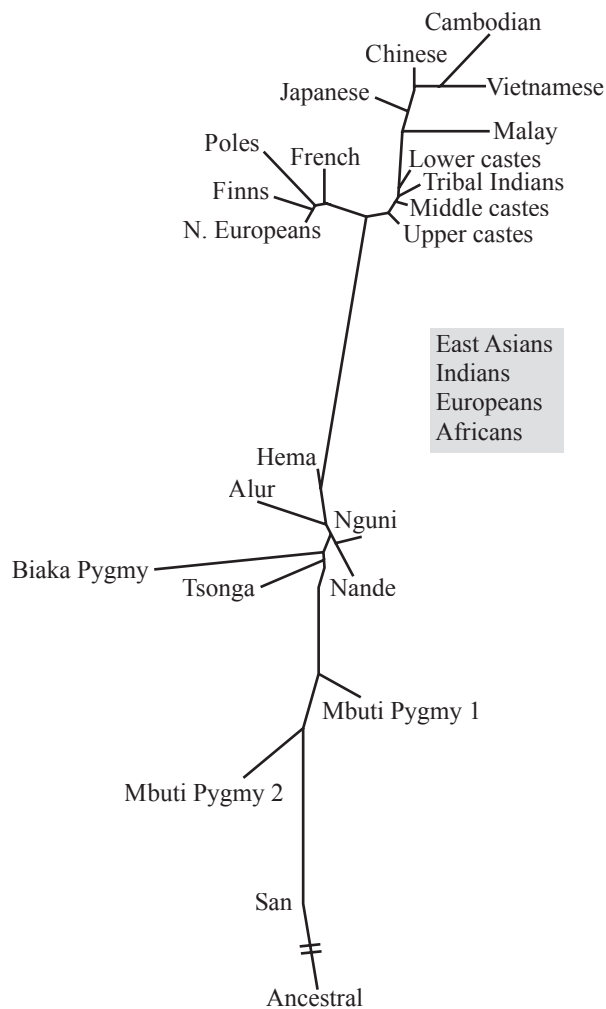
Questions 24–25 refer to the following passage and figure.

Humans make several types of antibodies called isotypes. There are five important isotypes: IgG, IgM, IgA, IgE, and IgD. The different isotypes are found in different parts of the body and on different types of immune cells. The following graph shows the prevalence of two isotypes at different points of an infection.



24. Which best describes the purpose of IgG demonstrated in the graph?
- It is stimulated by infection and is on memory B cells.
 - It is stimulated by IgM levels during an infection.
 - It becomes nonresponsive to antigen over time.
 - It is formed from IgM that has switched isotypes.
25. An antibody monomer consists of a constant stem region and two arms that are each capable of binding to identical antigens (it is shaped like the letter Y). Different isotypes are polymers of identical monomers. For example, IgA is a dimer, and IgM is a pentamer. What is a likely benefit of IgM?
- It can cross-link several antigens together.
 - It can cross membranes without assistance.
 - It can be made without the addition of ATP.
 - It can bind more than one type of antigen.

Questions 26–27 refer to the following figure.



26. In the phylogenetic tree shown above, which of the following statements is true?
- (A) Upper and lower castes do not share a common ancestor.
- (B) The French are the common ancestor of Poles and Indians.
- (C) Cambodians and Vietnamese have a common ancestor that Chinese do not share.
- (D) Mbuti pygmy 1 and Mbuti pygmy are the closest related groups on the tree.
27. In the phylogenetic tree shown above, how many common ancestors do Tsonga and Japanese have?
- (A) 0
- (B) 4
- (C) 6
- (D) 12

Questions 28–31 refer to the following passage.

DNA and RNA polymerases build DNA and RNA, respectively. DNA polymerases typically have proofreading capabilities, whereas RNA polymerases typically do not. DNA-dependent DNA polymerases are used during DNA replication. DNA-dependent RNA polymerases are used during transcription.

28. Which of the following would require a RNA-dependent DNA polymerase?
- (A) A bacterial strain that has a plasmid in addition to its genomic chromosome
- (B) A virus that has a RNA genome and integrates into the host genome
- (C) A plant cell that is being treated with RNA interference technology
- (D) Any eukaryotic cell about to undergo post-transcriptional processing
29. What is the likely reason that DNA polymerases proof-read and RNA polymerases don't?
- (A) Thymine is tough to base pair with, but uracil is easy to bond to.
- (B) DNA requires base pairing to form a double helix and RNA is single stranded.
- (C) DNA is passed from generation to generation, but RNA is only around for a short time.
- (D) There is more than one type of RNA (mRNA, tRNA, rRNA), and that makes proofreading difficult.
30. Which of the following explains why RNA viruses are always changing?
- (A) Their genome gets changed due to many mistakes during replication.
- (B) RNA viruses are single-stranded and they can take many shapes.
- (C) RNA does not need to travel in a capsid and gets exposed to chemicals.
- (D) There are thousands of types of RNA viruses in the world.
31. What strand would likely be created from the following RNA sequence by an RNA-dependent-RNA polymerase enzyme?
- 5' AUGUUUAGCGCUGGAUAC 3'
- (A) 5' GUAUCCAGCGCUAAACAU 3'
- (B) 5' AUGUUUAGCGCUGGAUAC 3'
- (C) 5' TACAAATCGCGACCTATG 3'
- (D) 5' CAUAGGUCGCAUUUGUA 3'

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Questions 32–34 refer to the following passage.

Atmospheric nitrogen (N_2) does not react well with other things; however, ammonia (NH_3) is a form of nitrogen that can be readily used by many organisms. The process of turning N_2 into NH_3 (nitrogen fixation) is an essential process, but it is not one that many organisms are capable of. Bacteria called diazotrophs perform much of the natural nitrogen fixation on the planet. Legume plants have developed a symbiotic relationship with nitrogen-fixing rhizobia bacteria. The bacteria inhabit special nodules along the legume roots and provide the plant with fixed-nitrogen to use in cellular processes.

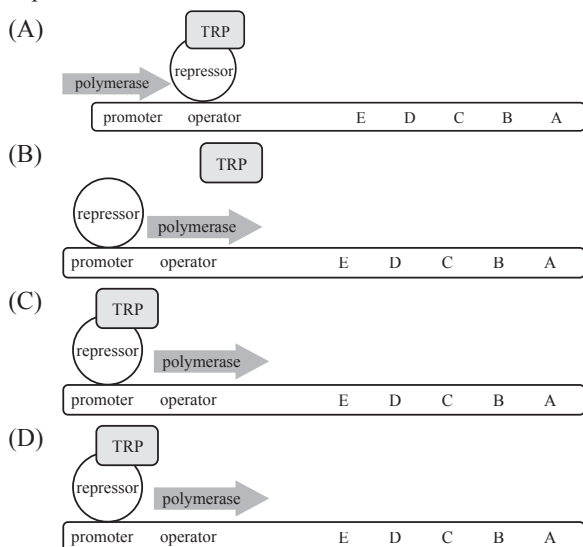
32. Which of the following molecules would be LEAST affected by a viral pandemic affecting rhizobia?
- (A) Proteins
 - (B) RNA
 - (C) DNA
 - (D) Carbohydrates
33. Which of the following facts would classify the relationship as mutualistic?
- (A) If the legumes were harmed during the process of nitrogen fixation
 - (B) If the rhizobia were harmed during the process of legume colonization
 - (C) If the legumes received another benefit apart from fixed-nitrogen
 - (D) If the rhizobia received a benefit from the legumes they colonize
34. Nitrogen fixation can also be accomplished synthetically through a chemical process known as the Haber process. Which of the following experiments would BEST show if synthetically fixed nitrogen or naturally fixed nitrogen was better for legume plant growth?
- (A) Two groups of plants are created, each containing a different species. They are measured to be identical in every possible way and are planted in two conditions. One type of soil includes rhizobia bacteria, and the other includes synthetically fixed nitrogen. After a specific length of time, the height and width of each plant are measured.
 - (B) Two groups of plants are created, containing three plants, each of a different species. They are measured to be identical in every possible way and are planted in two conditions. One type of soil includes rhizobia bacteria, and the other includes synthetically fixed nitrogen. After a specific length of time, the height and width of each plant are measured.
 - (C) Two large groups of plants are created, each containing equal distributions of three different species. They are measured to be identical several ways and are planted in two conditions. One type of soil includes rhizobia bacteria, and the other includes synthetically fixed nitrogen. After a specific length of time, the height and width of each plant are measured.
 - (D) Two large groups of plants are created, each containing equal distributions of three different species. They are measured to be identical in every possible way and are planted in two conditions. One type of soil includes rhizobia bacteria, and the other includes synthetically fixed nitrogen. After a specific length of time, the height and width of each plant are measured.

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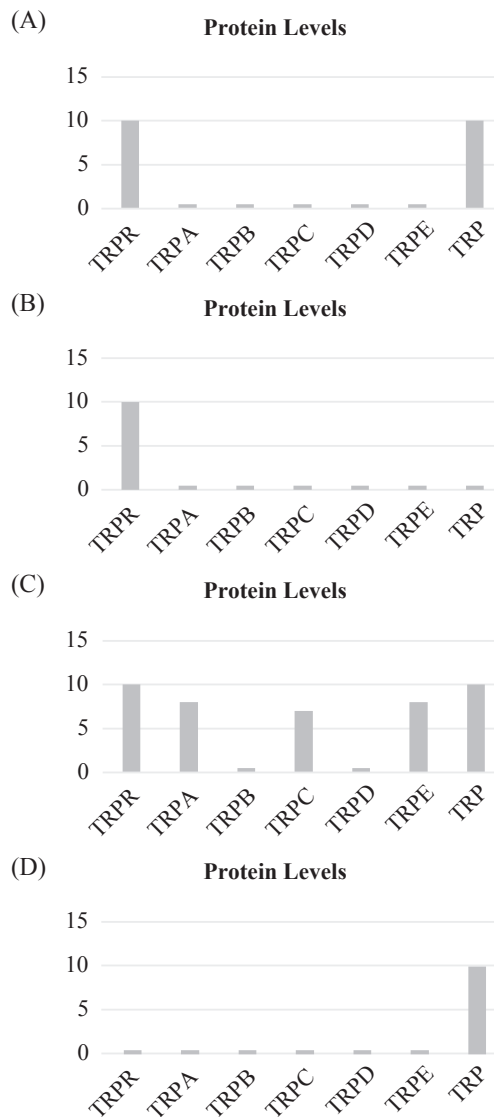
Questions 35–38 refer to the following passage.

Transcription is often a carefully regulated process, with many factors determining if a gene product should be expressed. In the example shown below, the *trp* operon in some bacteria is a group of genes that work together to code for production of tryptophan. The promoter for the genes that code for tryptophan synthesis (*trpE*, *trpD*, *trpC*, *trpB*, and *trpA*) is located before an operator site through which the RNA polymerase must pass to initiate transcription. When tryptophan is present, a repressor (encoded by *trpR*) binds to the operator site and prevents transcription.

35. Which of the following could be true if there was a mutation in the *trpR* gene?
- (A) The repressor protein would not bind as well to the operator site.
 (B) RNA polymerase will no longer bind to the promoter.
 (C) Tryptophan levels will not increase transcription.
 (D) Tryptophan will bind directly to the operator site.
36. The direct relationship between tryptophan and the *trp* operon depends on which of the following?
- (A) Equal parts of the repressor protein and tryptophan proteins
 (B) Constant transcription and translation of the *trpR* gene
 (C) Ongoing synthesis of tryptophan to unlock the repressor
 (D) More than one promoter for RNA polymerase to bind at
37. Which diagram best shows the system when tryptophan is present?



38. Which of the following graphs supports the information given on the *trp* operon?



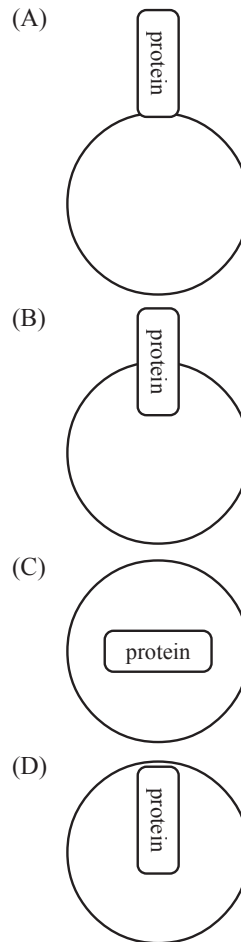
39. A virus is used to infect a plate of bacteria resistant to the antibiotic ampicillin and sensitive to the antibiotic tetracycline. New progeny viruses are collected and allowed to infect a culture of bacteria that is sensitive to both ampicillin and tetracycline. When ampicillin is added, some bacteria survive. What would be expected if tetracycline was added?
- (A) They would survive because they acquired tetracycline resistance through viral transduction.
 (B) They would survive because they failed to acquire tetracycline sensitivity through viral transduction.
 (C) They would die because they acquired tetracycline sensitivity through viral transduction.
 (D) They would die because they failed to acquire tetracycline resistance through viral transduction.

Questions 40–42 refer to the following passage.

The secretory pathway is a shipping route from the endoplasmic reticulum to the cell membrane. Things destined for secretion pass through the Golgi apparatus, which is an organelle that packages proteins it receives from the endoplasmic reticulum into transport vesicles. These proteins might be destined for incorporation in the membrane or they might be secreted from the cell via either constitutive or regulated secretion. Constitutively secreted proteins arrive at the membrane and are shipped without the requirement of further shipping signals. Regulated secretion requires the appropriate signal for the release of the protein from the cell. The Golgi also ships non-secreted proteins that will be incorporated into the intracellular lysosome, which is sometimes thought of as the stomach of the cell. It is the site of destruction of unwanted contents within the cell.

40. Which of the following is a benefit of regulated secretion?
- (A) The proteins can be released more quickly after translation.
 (B) The proteins can be built into larger complexes.
 (C) The response to a stimulus can be limited and specific.
 (D) The proteins can pass through the cell membrane.

41. Which of the following best depicts a vesicle with a protein destined for the cell membrane?



42. A lysosomal protein should have which of the following characteristics?
- (A) Resists lysosomal enzymatic degradation
 (B) Maintains stability for extended periods of time
 (C) Contains both intracellular and extracellular domains
 (D) Attaches to the intracellular side of the cell membrane

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Questions 43–45 refer to the following passage.

The membrane potential of a cell is the difference in the charge on the intracellular side of the plasma membrane and the charge on the extracellular side. Most cells in the human body have a resting membrane potential of approximately -70mV . This is established primarily by the sodium-potassium ATPase that pumps three sodium out of and two potassium into the cell. The membrane potential of a cell is particularly important in neurons where action potentials are generated via a rush of Na^+ ions down their concentration gradient.

43. What type of transport does the sodium potassium pump perform?
- (A) Simple diffusion
(B) Facilitated diffusion
(C) Passive transport
(D) Active transport
44. When a neuron fires an action potential, how does the resting membrane potential change?
- (A) It becomes more negative moving from the axon to the soma.
(B) It becomes more positive moving from the axon to the soma.
(C) It becomes more negative moving from the soma to the axon.
(D) It becomes more positive moving from the soma to the axon.
45. The following are all likely consequences of a failing sodium potassium pump EXCEPT?
- (A) Action potentials would not be possible.
(B) The inside of the cell would become less negative.
(C) There would be more potassium outside the cell.
(D) There would be less sodium inside the cell.

Questions 46–47 refer to the following passage and figure.

The table below shows Watson-Crick base pairing (white) and wobble pairing (shaded) for RNA. There is even another nucleotide base that appears in tRNA anticodons. The wobble pairing can be seen between the nucleotide in the third position on the anticodon and the nucleotide in the 3' most position on an mRNA codon. C: cytosine; A adenine; G: guanine; U: uracil; I: inosine.

C	G
A	U
G	U
I	U
I	A
I	C

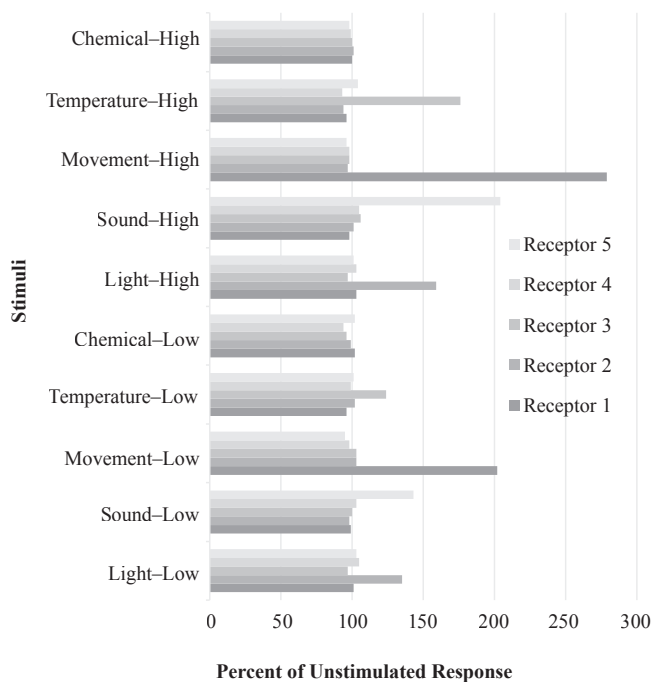
46. Which of the following is the result of wobble pairing?
- (A) There are more codons than there are anticodons.
(B) There are more amino acids than there are nucleotide bases.
(C) There are more inosines in mRNA than there are in tRNA.
(D) Some codons will only have one possible anticodon.
47. If the mRNA and the tRNA are oriented in an antiparallel direction during translation, what position on the tRNA is the wobble position?
- (A) Always on the 5' end of the anticodon
(B) Always on the 3' end of the anticodon
(C) Sometimes on the 5' end and sometimes on the 3' end
(D) Neither, tRNA is not linear like mRNA

GO ON TO THE NEXT PAGE.

Questions 48–50 refer to the following passage and figure.

Table 1 shows different types of receptors found in the body, and the graph that follows shows the response to various stimuli of several unknown types of receptors.

Stimulus	Type	Example
Light	Photoreceptors	Eye
Movement	Mechanoreceptors	Ear
Pressure	Baroreceptors	Blood vessels
Temperature	Thermoreceptor	Skin
Chemical	Promotes cell division and growth	Nose

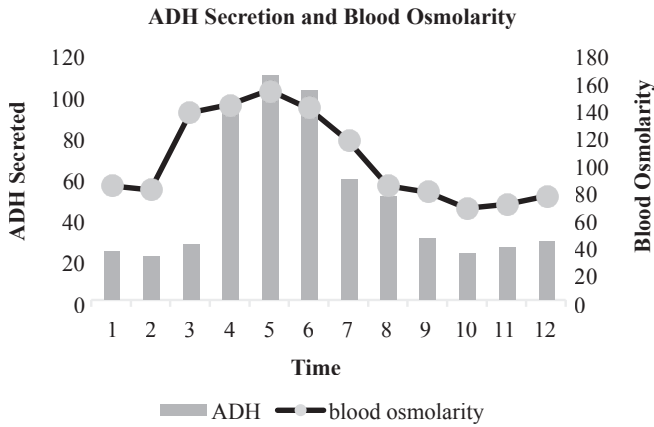


48. What information is required to compile the above results?
- The total response to all levels of stimuli
 - The exact magnitude of each stimulus
 - The magnitude of response in the absence of a stimulus
 - The largest response of each receptor to a stimulus
49. Receptor 4 could be which type of receptor?
- Movement
 - Sound
 - Pressure
 - Temperature
50. Where in the body would you likely find Receptor 1?
- The walls of the aorta
 - The retina of the eye
 - The inner ear
 - The mammary glands

GO ON TO THE NEXT PAGE.

Questions 51–53 refer to the following passage and figure.

The following graph represents the amount of antidiuretic hormone released by the posterior pituitary to regulate blood volume and the corresponding overall blood osmolarity at the same time.



51. Which of the following likely occurred at 2 hours?
- (A) The person drank a very large glass of water.
 (B) The person drank a beverage isotonic to their blood.
 (C) The person drank a beverage hypotonic to their blood.
 (D) The person drank a beverage hypertonic to their blood.
52. Which best describes the relationship between blood osmolarity and ADH?
- (A) Blood osmolarity increases upon ADH secretion.
 (B) ADH increases upon increased blood osmolarity.
 (C) ADH has a longer effect than blood osmolarity.
 (D) Blood osmolarity has a longer effect than ADH.
53. Caffeine is an inhibitor of ADH. Which of the following would you expect to occur to the blood osmolarity if the person above had consumed caffeine?
- (A) The osmolarity would increase higher than usual and then decrease.
 (B) The osmolarity would increase the same amount, but would not decrease.
 (C) The osmolarity would decrease and then increase.
 (D) The osmolarity would decrease, but would not decrease.

Questions 54–55 refer to the following passage.

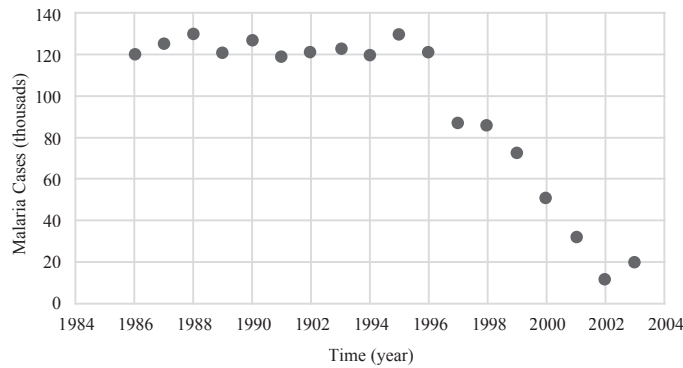
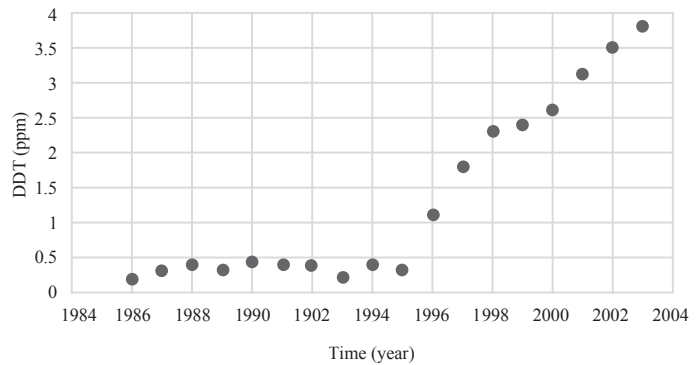
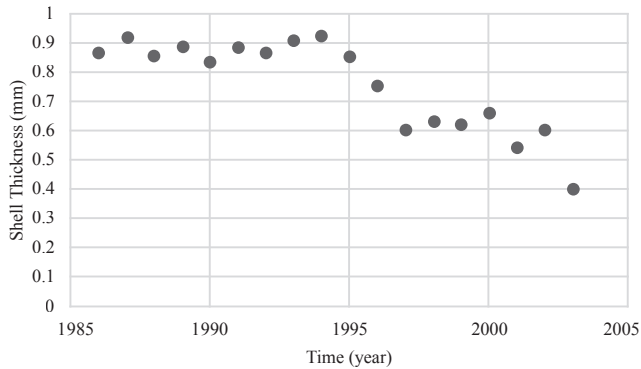
Mitochondria have an outer and an inner lipid bilayer. Within the inner membrane of the mitochondria sits the electron transport chain. There are four transmembrane proteins that span the membrane. Another protein, cytochrome C, is a peripheral membrane protein on the inner mitochondrial membrane, facing the intermembrane space. Within the membrane itself is a sixth member, a lipid molecule called ubiquinone. The members in the chain pass electrons sequentially, and the transmembrane segments pump hydrogen ions from the matrix into the intermembrane space.

54. Which of the following likely describe cytochrome C and ubiquinone?
- (A) Both are mostly hydrophobic.
 (B) Both are mostly hydrophilic.
 (C) Ubiquinone is hydrophilic, and cytochrome C is mostly hydrophobic.
 (D) Ubiquinone is hydrophobic, and cytochrome C is mostly hydrophilic.
55. If cytochrome C were labelled with a dye consisting of large hydrophilic molecules that were allowed to diffuse over time, which regions would be dyed?
- (A) Extracellular Space
 (B) Cytosol
 (C) Intermembrane space
 (D) Matrix

GO ON TO THE NEXT PAGE.

Questions 56–58 refer to the following passage and figures.

DDT is a powerful insecticide that was first shown to kill the Colorado Potato beetle, an invasive species in Europe. The pesticide has been shown to be effective at eradicating mosquitoes of the genus *Anopheles*, which transmits malaria. DDT breaks down over time into a similar chemical called DDE. Between the years 1986 and 2003, scientists sampled three River systems in the Sierra region of Ecuador, while also measuring the egg shell thickness of Andean Condors. They worked with epidemiologists at nearby health centers and obtained the data in Figure 2.



56. Which of the following is the most likely explanation for the data in the figures?
- (A) DDT affects how calcium carbonate, which is responsible for the strength of eggshells, deposits onto biological membranes.
- (B) Ecuadorian mosquitoes have a mutation that causes them to become stronger when exposed to DDT, which enabled them to infest Condor nests.
- (C) Andean condors fish from the river systems, removing the predators of most mosquitoes.
- (D) DDE has been shown to have strong effect on insect infestations, and Condors rapidly adapt to new food sources following exposure to the pesticide.
57. In the year 2007, 60,000 malaria cases were reported. What was the likely source of these numbers?
- (A) Andean condors began to nest in the Costa region of Ecuador to escape the challenges to the species.
- (B) Due to an atypically warm and humid summer, there were more mosquitoes than usual.
- (C) Scientists introduced an additional pesticide to the region to protect the Andean Condors.
- (D) Mosquitoes resistant to DDT emerged in the early 2000s and were naturally selected over time.
58. What concentration of DDE would decrease eggshell thickness by 20%?
- (A) 0.2 ppm
- (B) 1.1 ppm
- (C) 2.6 ppm
- (D) 3.2 ppm

Questions 59–60 refer to the following passage.

Many species of fish are famous for their shoaling or schooling behavior. Shoaling is intentional grouping behavior, but each fish still moves independently within the shoal. In schooling behavior, the fish are grouped and they swim in the same direction and change direction in a coordinated manner.

59. Some people believe that schooling helps fish conserve energy, similarly to birds flying in formation. This is thought to be due the physical forces acting on the entire school rather than just upon a single fish. Which of the following would DISPROVE this theory?
- (A) Fish in the school take longer to fatigue than solitary fish.
- (B) The combined water resistance of a school of fish is less than that of the combined water resistances of solitary fish.
- (C) Fish swimming away from a predator survive longer in school formation than they did in shoal formation.
- (D) The heart rates of fish in the school are higher than those in the shoal after swimming the same distance.
60. If extraterrestrials came to Earth, which human behavior is most like schooling?
- (A) Many cars traveling on a winding highway in the same direction
- (B) A large group of people gathering to watch a parade
- (C) A group of school children on a playground
- (D) A couple in a ballroom dancing competition

Questions 61–63 refer to the following passage.

The unit of contraction within skeletal muscle cells is called the sarcomere. A sarcomere contracts when the filamentous protein myosin stretches into a high-energy conformation and binds to the filamentous protein actin. When the myosin returns to its low-energy, relaxed conformation, actin is pulled, and the sarcomere contracts. The following steps relate ATP to each step of this process.

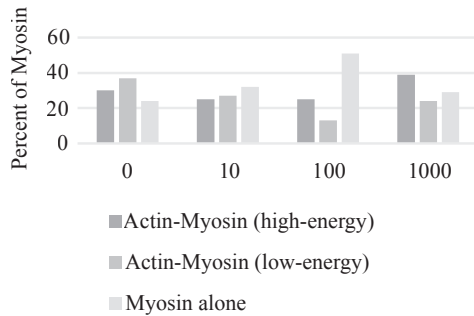
- 1—Myosin binds to actin (ADP is attached)
- 2—Myosin returns to low energy conformation (ADP is released)
- 3—Myosin releases actin (ATP binds)
- 4—Myosin stretches to high energy conformation (ATP is hydrolyzed)

61. What is bound to myosin when it is in its high-energy conformation?
- I. Actin
II. ATP
III. ADP
- (A) II only
(B) III only
(C) I and II
(D) I and III
62. If the cell runs out of ATP, what would be the state of the sarcomere?
- (A) Myosin is bound to actin in the high-energy conformation.
- (B) Myosin is alone in the high-energy conformation.
- (C) Myosin is bound to actin in the low-energy conformation.
- (D) Myosin is alone in the low-energy conformation.

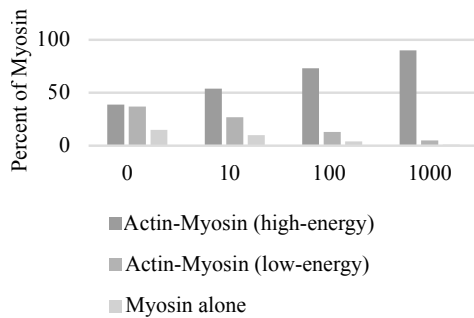
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63. A calcium ion is required for the binding of myosin to actin. If a calcium chelator, such as EDTA, is added to a muscle cell, which of the following graphs shows how it will affect muscle contraction?

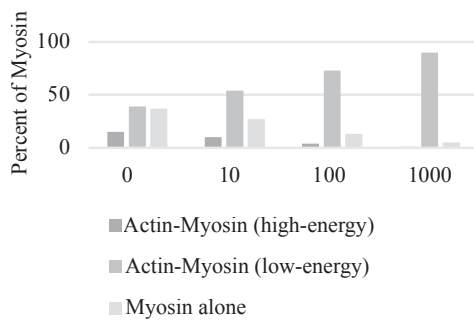
(A) Confirmations of Myosin vs nM of EDTA



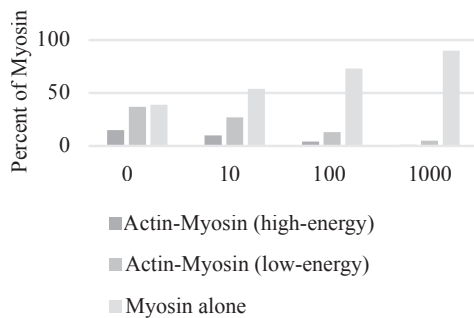
(B) Confirmations of Myosin vs nM of EDTA



(C) Confirmations of Myosin vs nM of EDTA



(D) Confirmations of Myosin vs nM of EDTA



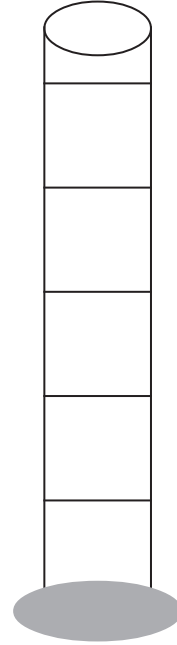
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Directions: Part B consists of questions requiring numeric answers. Calculate the correct answer for each question.

64. You are given a large bottle of 20 mM NaCl solution and you need to make 10 mL of a 15 mM solution. What volume of the 20 mM NaCl will you need to make your diluted (mL) solution?

	/	/	/	
.
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

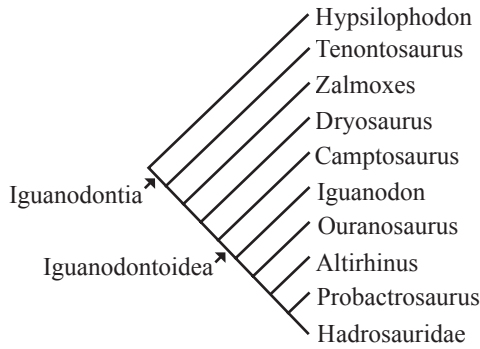
65. In order to measure your solution, you find an old graduated cylinder. However, the volume readings on the side of the cylinder are worn away, and all that exists are the lines. You have a ruler and you measure the height of the cylinder from base to the top line as 39.81 cm and you measure the diameter to be 2 cm. Calculate the volume reading in mL (cm^3) of the lowest line on the cylinder, assuming the lines are evenly spaced. Use 3.14 to represent π in your calculation. Your answer should contain 4 digits.



	/	/	/	
.
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

GO ON TO THE NEXT PAGE.

66. In the following cladogram, a common ancestor (*) and species derived from it are illustrated. How many species have four or more common ancestors with Iguanodon?



	/	/	/	
.
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

- Questions 67–68 refer to the following passage.

Blood type is determined by two unlinked genes. The first gene can code for protein A, protein B, or no proteins (called O). The second gene can code for the Rh protein (Rh+) or code for no Rh protein (Rh-). A person will form antibodies against any blood proteins that are different from his or her own.

A woman with the blood genotype A/A; Rh-/Rh- and a man with the blood genotype B/O; Rh+/Rh- have a child.

67. What percentage of their children are likely to have the A blood type? Give answer as a decimal.

	/	/	/	
.
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

GO ON TO THE NEXT PAGE.

68. What percentage of the children will be able to donate blood to their mother? Give answer as a decimal.

	/	/	/	
.
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. In a closed population, squirrel teeth can be either long or short. The long teeth allele is classically dominant. If there are 80 squirrels with long teeth and 40 squirrels with short teeth, what is the frequency of heterozygotes? Round to 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

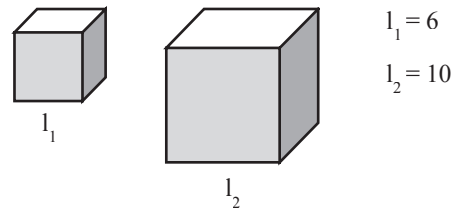
Directions: Questions 1 and 2 are long free-response questions that should require about 22 minutes each to answer and are worth 10 points each. Questions 3 through 8 are short free-response questions that should require about 6 minutes each to answer. Questions 3 through 5 are worth 4 points each, and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

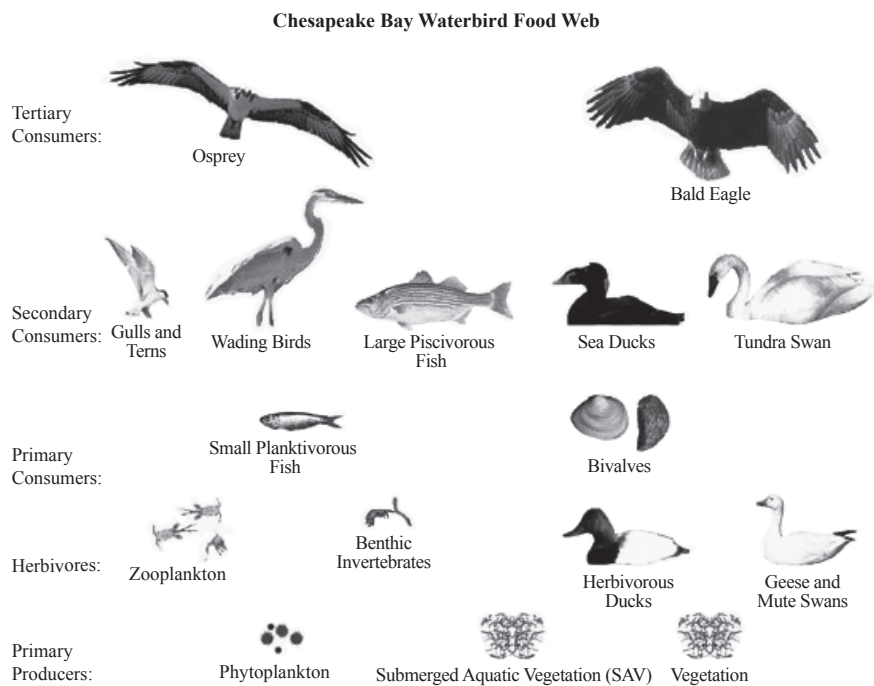
- There are four categories of macromolecules.
 - Identify** the four categories and **provide** one specific example of each.
 - Describe** the basic structure and function of each type. Be sure to **include** the individual building blocks and how they come together to form larger polymers and **explain** how their structure is important for their function.
- While hiking along a looping forest trail in a mountainous region, you take pictures of the beautiful things around you. Later, you notice that a particular type of plant with tiny white flowers is very prevalent in your pictures at the beginning of the trail and the end of the trail, but that an identical looking plant with tiny red flowers is prevalent along the middle of your journey along the trail.
 - Describe** how you can determine if they are the same species.
 - Discuss** reasons why the red plants are only in the middle and the white plants are only at the beginning/end of the trail loop.
 - Create** three hypotheses for the distribution of the plants.
 - Describe** how you would test each hypothesis in an experiment (or separate experiments).
 - Select** one hypothesis that you will pretend is true and **show** example data (either in table or graph form) from your experiments that would lead you to that conclusion.
- Describe** three of the unique properties of water that make it essential to life and **explain** how each of these properties contributes.
- There are two types of synapses in the body: physical and chemical. Physical synapses are direct physical connections between cells that allow them to pass information between them. Chemical synapses are connections where neither cell is in physical contact with the other cell, but information can still be passed from one cell to the other. **Explain** how a chemical synapse functions and where you might find one in the body. Be sure to **include** the parts of the two cells involved and how the information is sent and received. You may **draw** a synapse for your response with clear text descriptions.

GO ON TO THE NEXT PAGE.

5. **Describe** evolutionary fitness and **explain** how an adaptation could increase evolutionary fitness for a species even though it leads to an increased rate of predation for that species.
6. In the lungs, a large surface area is essential to maximize gas exchange (In humans, the surface area in the lungs could nearly cover a tennis court!), but the volume of the lungs must be kept relatively small so they fit into the chest cavity. Given the two cubes below, **explain** which of them would be better at gas exchange. **Include** the surface area-to-volume ratio in your explanation.



7. **Identify** examples of producers and different levels of consumers in the following food web. **Describe** the impact of an invasive species that competes with the phytoplankton and zooplankton and has no natural consumers. Using one species as an example, **create** a graph showing mock population levels before the arrival of the invasive species and the impact on population afterwards.



8. DNA errors can cause mutations to occur at any time. **Describe** the difference between germline and somatic cells in the human body and **explain** the difference in repercussions of a mutation in a germline cell and a mutation in a somatic cell.

STOP

END OF EXAM
