



Practice Test 4

1. YOUR NAME: _____
 (Print) Last First M.I.

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 (Print) Number and Street

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5. YOUR NAME

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

2. TEST FORM

6. DATE OF BIRTH

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7. SEX

MALE

FEMALE



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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

60

Percent of Total Score

50%

Writing Instrument

Pencil required

Instructions

Section I of this examination contains 60 multiple-choice 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

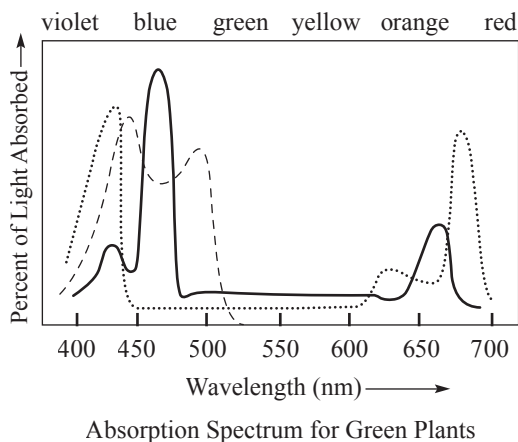
Many candidates wonder whether or not to guess the answers to questions about which they are not certain. Multiple-choice scores are based on the number of questions answered correctly. Points are not deducted for incorrect answers, and no points are awarded for unanswered questions. Because points are 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
60 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.



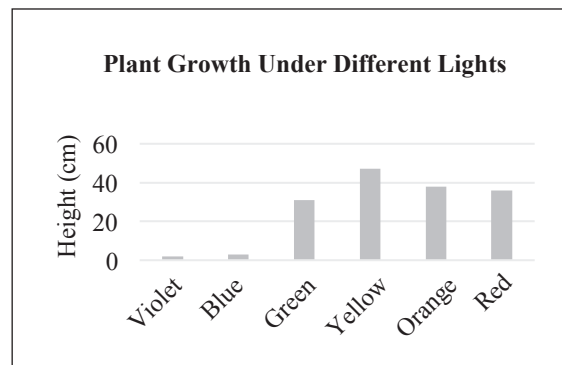
..... Chlorophyll *a*
 — Chlorophyll *b*
 - - - Carotenoids

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.

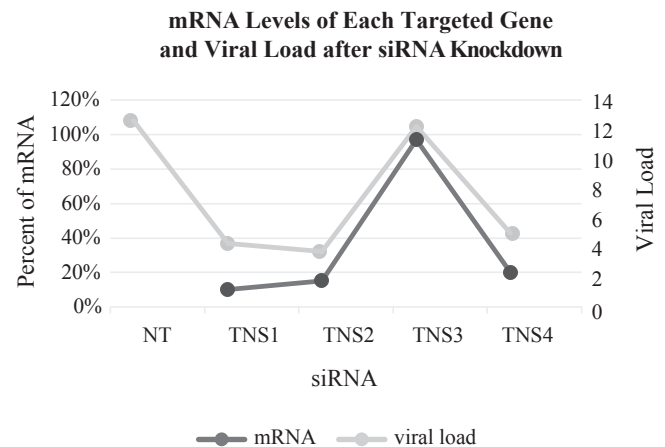
The following table identifies the stages of embryogenesis in humans. As the embryo develops, the cells differentiate, and their potency, or potential to become many types of cells, is reduced.

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, and mRNA reduction of each targeted gene was assessed. Afterwards, viral infection is attempted and the viral load is assessed as a result of the siRNA knockdown. A non-targeting (NT) siRNA that does not cause significant mRNA reduction is used as a control.



6. Which statement best describes the purpose of the NT siRNA control?
- (A) It was a negative control to ensure that the siRNA procedures in general were not affecting the viral load.
(B) It was a positive control to show that knocking down all known genes would cause a reduction in the viral load.
(C) It was a negative control to eliminate the need for using infectious viral particles in the experiment.
(D) It was a positive control to show that the knockdown process of reducing mRNA was successful.
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.

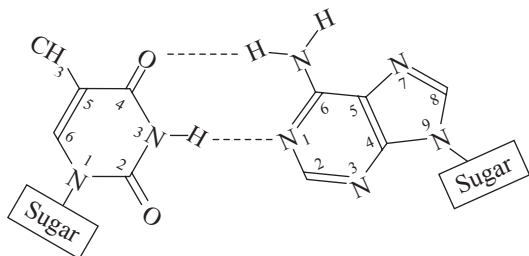
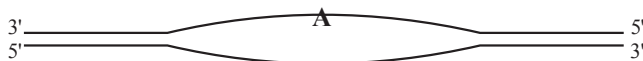
In 1944, Avery, McCarty, and MacLeod used laboratory techniques to separate the DNA, RNA, lipids, proteins, and carbohydrates present in a virulent bacterial strain and then they repeated Griffith's experiment to see which fraction was capable of transforming the non-virulent strain into a virulent strain. 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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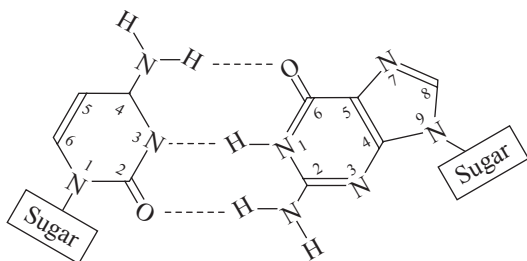
Questions 12–14 refer to the following passage and figures.

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)

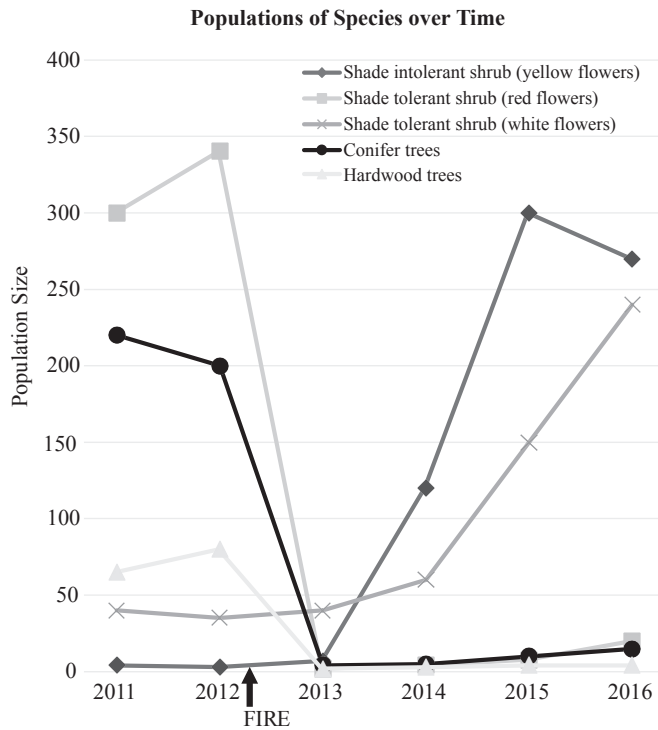
Guanine (G)

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

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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

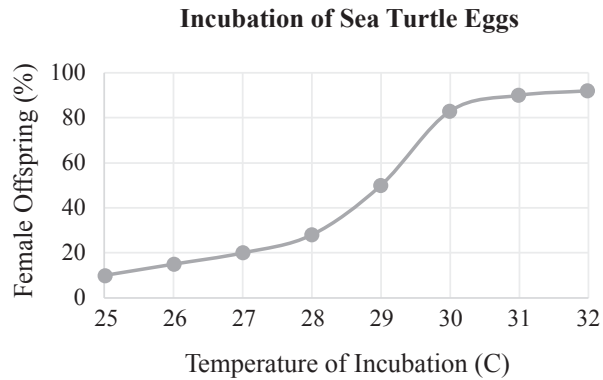
Questions 17–18 refer to the following figure.

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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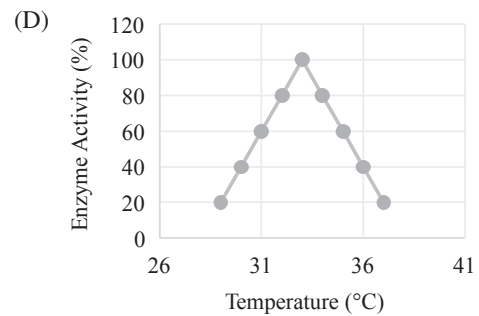
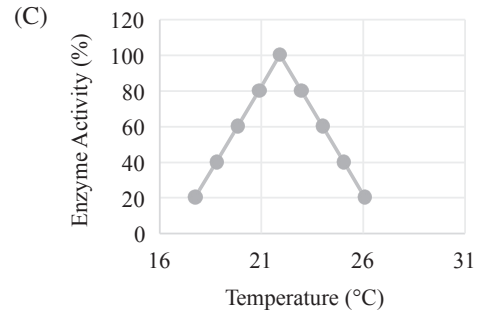
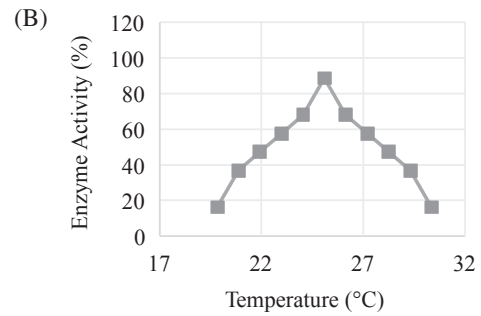
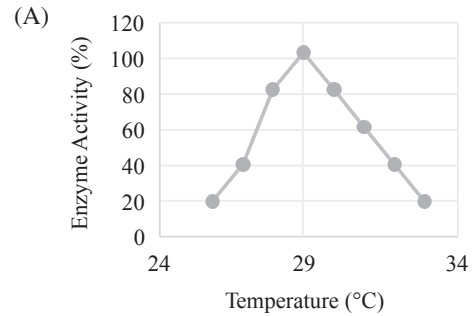
Questions 19–20 refer to the following figure.



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 essential 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

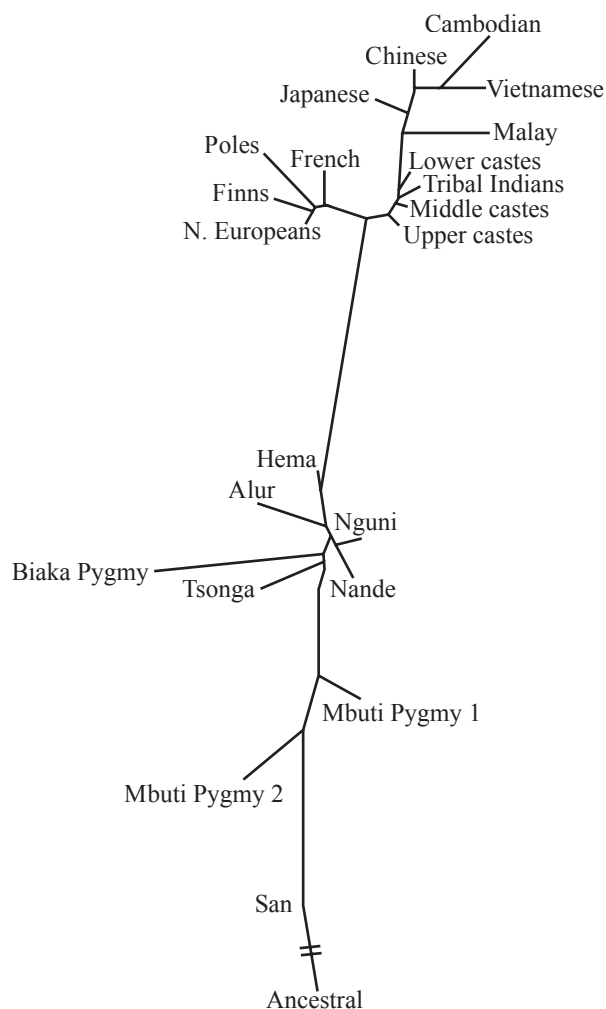
21. According to the passage, HER2 is found
- on tumor cells only
 - on healthy cells, but it is found more often on tumor cells
 - on healthy cells only
 - on healthy cells, but is found less often on tumor cells
22. Which of the following is likely true for a cell with mutated ER leading to loss of 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?
- Blocking the binding of estrogen and ER
 - Increasing the production of estrogen
 - Decreasing the production of ER
 - Blocking the role of ER in the cell cycle

Questions 24–25 refer to the following passage.

Interactions between biotic and abiotic factors are what makes an ecosystem stable. Some interactions are obvious, but others occur underground beyond our sight. Mycorrhizae are a type of symbiotic relationship between fungi and plant roots. Special growth patterns allow the two species to easily share water, nutrients, and sugars. The plant is better at making sugar than the fungi, and the fungi have lots of tiny little strands, which provide the plant a huge surface area.

24. How might the fungi be helping the plant?
- Preventing the plant from touching the soil
 - Giving it more capacity to suck up water
 - Decreasing the osmotic pressure in the root
 - Assisting in the light-independent reactions of photosynthesis
25. If the plant devised a way to block sugar transport to the fungi, the relationship could best be described as
- mutualistic
 - parasitic
 - commensal
 - individual

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 Tribal Indians.
- (C) Cambodians and Vietnamese have a common ancestor that Chinese do not share.
- (D) Mbuti pygmy 1 and Mbuti pygmy 2 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 an RNA-dependent DNA polymerase?
- (A) A bacterial strain that has a plasmid in addition to its genomic chromosome
- (B) A virus that has an 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 around only 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'

GO ON TO THE NEXT PAGE.

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.

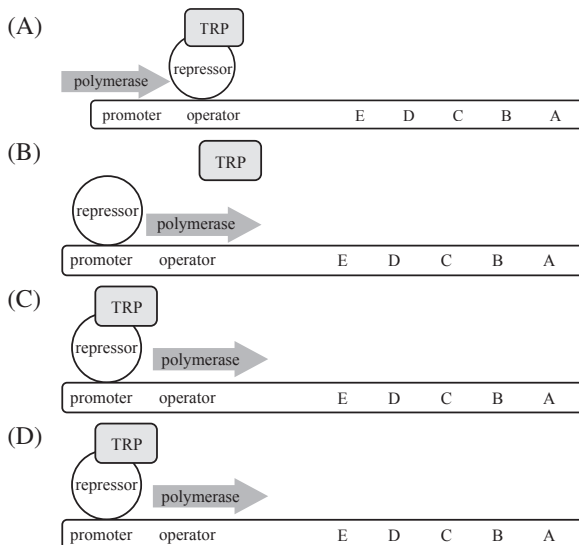
32. Which of the following molecules would be LEAST affected by a viral pandemic affecting rhizobia?
- (A) Proteins
 - (B) RNA
 - (C) DNA
 - (D) Carbohydrates
33. Which of the following facts would classify the relationship as mutualistic?
- (A) If the legumes were harmed during the process of nitrogen 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 in 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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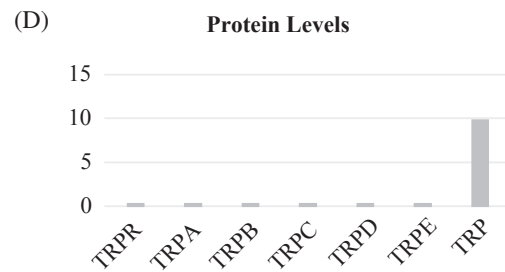
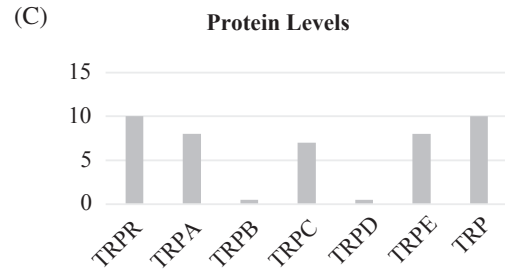
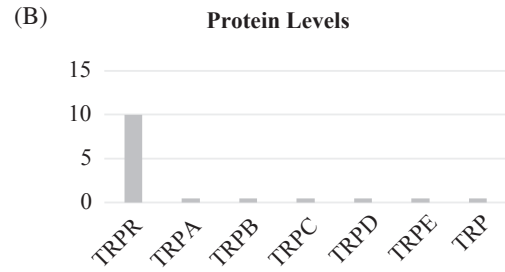
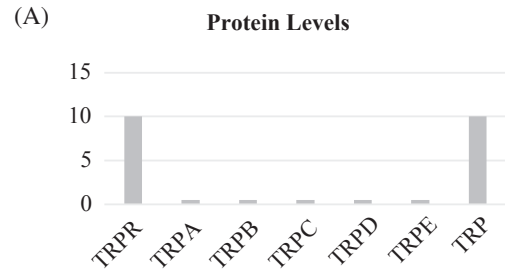
Questions 35–38 refer to the following passage.

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) Expression of the *trpR* gene regardless of tryptophan levels
 (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?



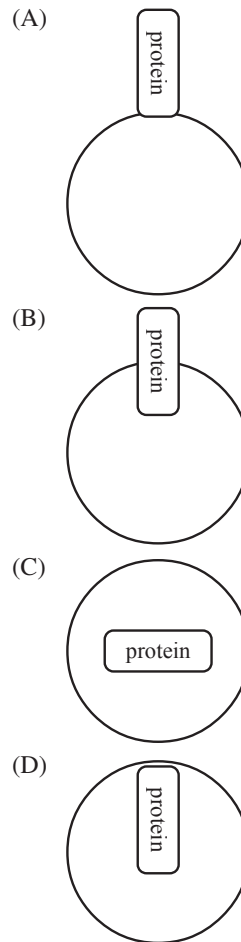
39. A virus is used to infect a plate of bacteria resistant to the antibiotic ampicillin and sensitive to the antibiotic tetracycline. New progeny viruses are collected and allowed to infect a culture of bacteria that is sensitive to both ampicillin and tetracycline. When ampicillin is added, some bacteria 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) Resistant to lysosomal enzymatic degradation
 (B) Can maintain stability for extended periods of time
 (C) Contains both intracellular and extracellular domains
 (D) Able to attach 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 -70 mV. 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, an electrical signal sent by nerve cells, why is a sodium-potassium pump needed to transport sodium and potassium across the cell membrane?
- (A) Potassium gets stored in the lipid bilayer and must be removed by the pump.
(B) Sodium is a large nonpolar molecule.
(C) The pump utilizes passive transport to move sodium.
(D) Sodium and potassium are charged and the membrane is not permeable to ions.
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.

	CG	GU	
	AU	UG	
anticodon base	UA	IU	codon base
	GC	IA	
		IC	

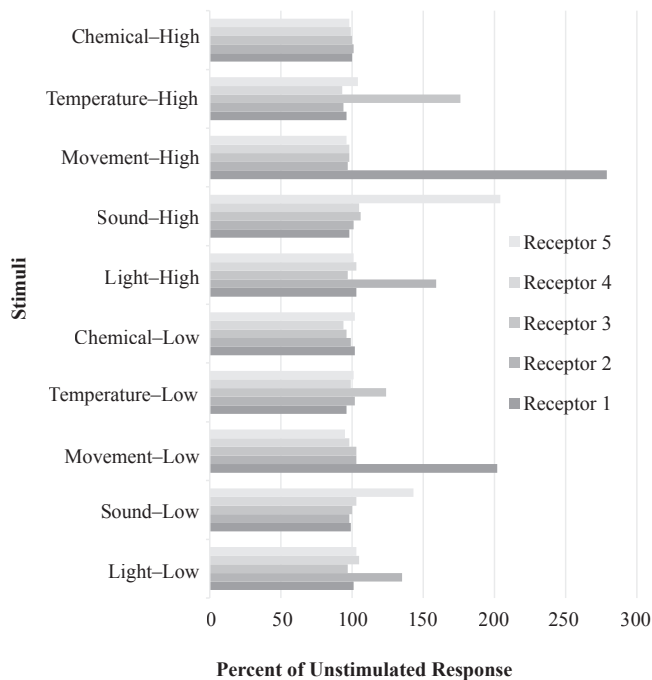
46. Which of the following is the result of wobble pairing?
- (A) There are several possible codons for a given anticodon.
(B) There are more amino acids than there are nucleotide bases.
(C) There are more inosines in mRNA than there are in tRNA.
(D) Some codons will have only one possible anticodon.
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

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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

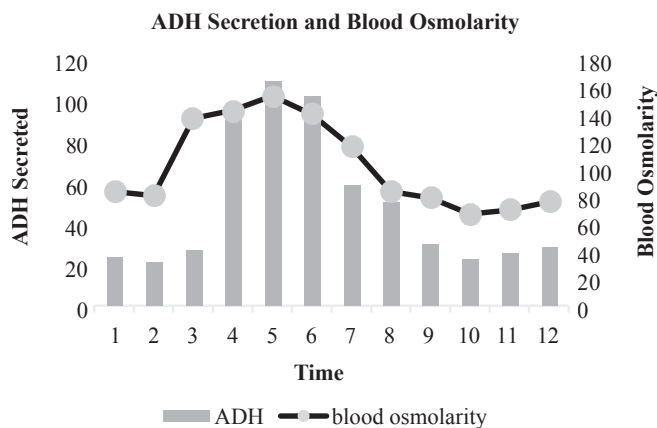


48. What information is required to compile the above results?
- The total response to all levels of stimuli
 - The exact magnitude of each stimulus
 - The magnitude of response in the absence of a stimulus
 - The largest response of each receptor to a stimulus
49. Receptor 4 could be which type of receptor?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

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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 increase.

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 describes 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.

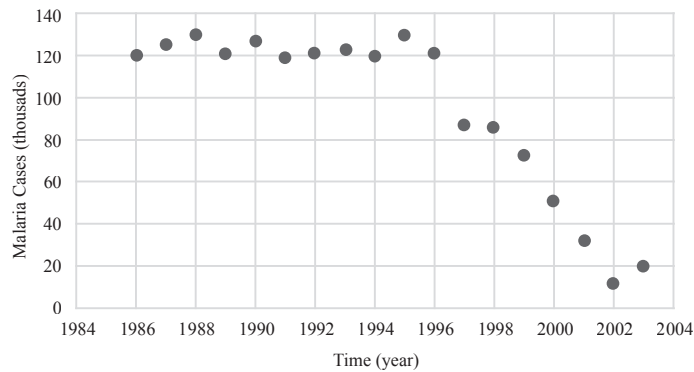
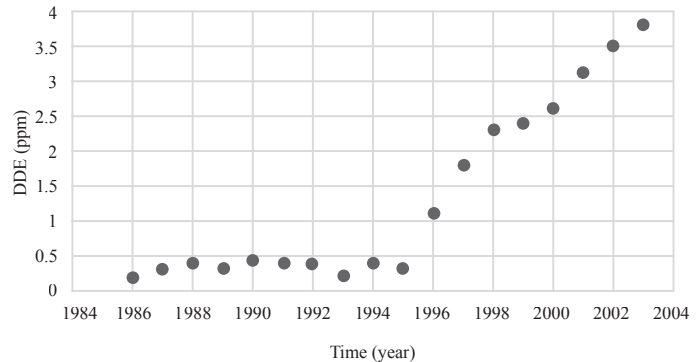
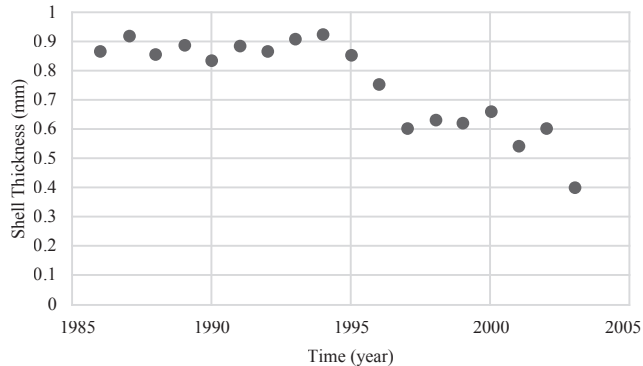
55. If cytochrome C were labeled with a dye consisting of large hydrophilic molecules that were allowed to diffuse over time, which regions would be dyed?

- (A) Extracellular space
- (B) Cytosol
- (C) Intermembrane space
- (D) Matrix

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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 the figures below.



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 a strong effect on insect infestations, and Condors rapidly adapt to new food sources following exposure to the pesticide.
57. In the years 2007 and 2008, 60,000 malaria cases were reported. Which statement best explains 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 to 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 do 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 would they observe to be most like schooling?
- (A) Two hundred people line dancing at a country dance club
 - (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

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

6 Questions

Writing Time—90 minutes

Directions: Questions 1 and 2 are long free-response questions that should require about 25 minutes each to answer and are worth 8–10 points each. Questions 3 through 6 are short free-response questions that should require about 10 minutes each to answer and are worth 4 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 unless specifically requested.

1. Cancer cells are recognized by their ability to escape normal regulation of cell division, proliferating out of control and often invading local tissues or metastasizing to distant locations. Cancer is caused by mutagenic agents that initiate tumor and by nonmutagenic agents that promote the tumor. Both types of agents affect gene expression, stimulate cell proliferation, and alter the balance of mutant and nonmutant cells. The following tables show the relative risks (RR) of tobacco and alcohol use for cancer of the endolarynx, epilarynx, and hypopharynx structures located in the throat. A relative risk of 1.0 indicates increased risk relative to a control group.

RR for Alcohol & Tobacco by Site			
Cigarettes/day	Endolarynx	Epilarynx	Hypopharynx
0	1.0	1.0	1.0
1–7	2.5	2.3	5.5
8–15	7.5	6.7	13.7
16–25	14.6	11.0	18.0
26+	17.0	9.4	20.0
g Alcohol/day			
0–20	1.0	1.0	1.0
21–40	0.88	0.87	1.57
41–80	1.08	1.53	3.15
81–120	1.71	5.10	5.59
121+	2.50	10.6	12.5

Table 1

Combined Effect of Alcohol & Tobacco on RR				
g Alcohol per day	Number of Cigarettes per day			
	0–7	8–15	16–25	26+
Endolarynx				
0–40	1.0	7.0	12.9	15.0
41–80	2.8	8.3	16.1	18.7
81–120	4.3	12.8	24.8	28.9
121+	6.3	18.7	36.5	42.5
Epilarynx				
0–40	1.0	12.4	17.7	17.9
41–80	9.1	23.9	33.9	34.4
81–120	20.9	54.6	77.6	78.6
121+	45.2	118.3	168.2	170.5

Table 2

- (a) **Explain** how the cell-cycle is essential in cells and how a failure in apoptosis can lead to cancer.
- (b) **Describe** how the control group(s) in this experiment was (were) treated. **Identify** the dependent variables in the experiment. **Identify** the independent variables.
- (c) **Explain** the conclusions that can be made about which tissues are more susceptible to tumor formation. Use the data to **identify** the healthy number of cigarettes to smoke and/or healthy amount of alcohol to ingest.
- (d) If a person that smoked 20 cigarettes/day decided to quit smoking and began drinking 50 g alcohol/day, **describe** if they would increase, decrease, or not change their cancer risk.

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2. A rodent researcher was interested in pika metabolism. Pikas prefer colder climates and live in mountainous regions. They are closely related to rabbits and hares and are easily identified by their round body and tailless appearance. Pikas' primary predators are weasels, which they try to avoid with their top speed of 15 mph.

The researcher collected pika tissue samples from adipose (fat), brain, and skeletal muscle and measured NADH levels through an ELISA analysis.

	Mean NADH levels (mM)	Standard Error of the Mean
Adipose	8.9	1.2
Brain	27.6	4.8
Skeletal Muscle	20.8	5.3

- (a) High NADH levels inhibit enzymatic reactions that produce precursors to NADH. **Describe** what phenomenon is occurring and **explain** how this process is energetically beneficial.
- (b) **Construct** a graph plotting the mean NADH levels and standard represented by error bars.
- (c) **Identify** which tissue showed the greatest variability in NADH levels. **Explain** how you know this. **Explain** why NADH levels would be expected to be higher in skeletal muscle versus adipose tissue.
- (d) Oxygen levels decrease at higher altitudes. **Predict** which step of cellular respiration would be higher in pikas living at these high altitudes. **Justify** your prediction.

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3. *Amphioxus* is a chordate that has an embryological development similar to that of human. Cleavage of the fertilized zygote results in the formation of a morula. The blastula stage follows; the blastula is composed of about 500 cells. Gastrulation then occurs, resulting in three distinct germ layers. The experiments below studied the effect of irradiation on embryological development from zygote to gastrula. Only non-irradiated cells formed normal embryos.

Experiment 1

To determine the effects of radiation on embryological development, *Amphioxus* zygotes were exposed to gamma radiation, while unexposed zygotes served as controls. The timing of morula, blastula, and gastrula formation was closely watched.

Figure 1 illustrates the results for controls and two samples of irradiated zygotes with unique developmental patterns.

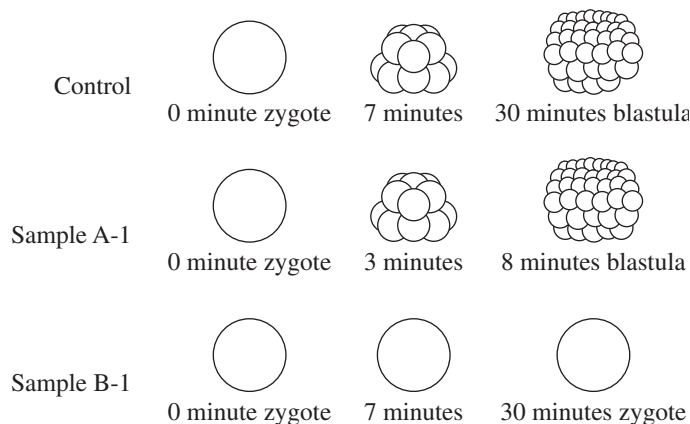


Figure 1

Experiment 2

Irradiated sample A-1 was analyzed for the production of a protein which induces mitosis. It was significantly above normal levels. When non-irradiated controls were exposed to these increased levels of mitosis-inducing protein, blastulas were formed within 8 minutes.

Experiment 3

Irradiated sample B-1 was analyzed for the production of mitosis-inducing protein. It was found that levels of this protein were significantly below normal. When the B-1 sample was exposed to higher levels of the protein at 30 minutes, the endoderm, mesoderm, and ectoderm layers were detected at 40 minutes. Induction protein produced by this sample was analyzed and found to have the same amino acid sequence as that produced by non-irradiated controls.

- Explain** how gene regulation is important for embryo development.
- In Experiment 2, **identify** the purpose of exposing non-irradiated controls to the mitosis-inducing protein.
- If high levels of the mitosis-inducing protein were given to sample B-1 after 5 minutes rather than after 30 minutes in Experiment 3, **explain** how the timing of the embryo's development would be affected.
- Justify** your prediction.

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4. After millions of years living in darkness, a species of blind cavefish has lost an ancient system of DNA repair in most members of the species. That DNA repair system, found in organisms including bacteria, fungi, plants, and most other animals, harnesses energy from visible light to repair DNA damage induced by ultraviolet (UV) light. Only placental mammals were previously known to lack this system. This system was found to be turned off in 84% of the population of the blind cavefish. The only way to have the DNA repair system turned off is to have two recessive alleles for the protein that turns on the system.
- (a) If there are 20,000 blind cave fish in a population, **identify** how many individuals are heterozygous for the gene that turns on the DNA repair system (if the population is assumed to be in Hardy-Weinberg equilibrium).
- (b) **Explain** a Hardy Weinberg assumption that could have been violated in this population and why that violates Hardy-Weinberg equilibrium.
- (c) DNA repair in other organisms is typically performed by an enzyme whose expression is controlled by several transcription factors. **Predict** the cause of these cavefish losing this system of DNA repair.
- (d) **Justify** that prediction.
5. Malaria is one of the world's oldest known diseases. It involves alternating chills and fever with severe hemolysis (erythrocyte destruction) and liver damage. It is caused by the protozoan parasite *Plasmodium*, which is transmitted by the female *Anopheles* mosquito, which is itself a parasite, requiring a blood meal as source for egg production. The protist is transmitted from an infected mosquito's salivary glands to a human host. Once in the bloodstream, it travels to the liver and invades the liver cells. Asexual reproduction occurs and active protozoa are released from lysed liver cells into the bloodstream where they can also infect red blood cells, reproduce, and lyse them. Some of these mature protozoa produce special sexual reproducing cells. A new *Anopheles* host is required to complete the life cycle. This new host is infected when it bites the infected human. See Figure 1.

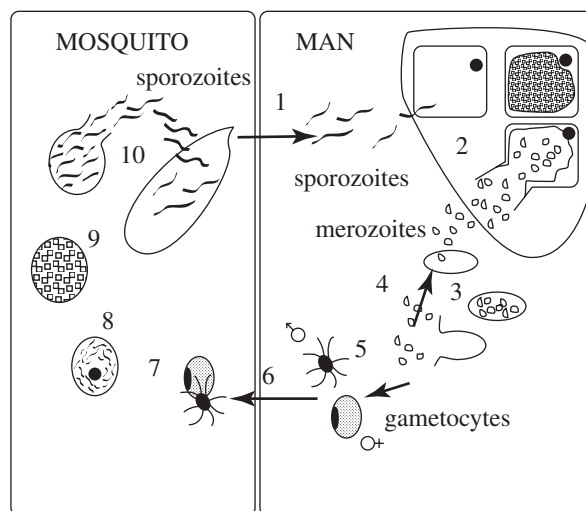


Figure 1 Life cycle of *Plasmodium*

Adapted from: *Malaria: Obstacles and Opportunities*, by Stanley C. Oaks, Jr., Violaine S. Mitchell, Greg W. Pearson and Charles C.J. Carpenter, eds. © 1991 by National Academy Press, Washington, D.C.

- (a) **Describe** benefits of two organisms being in a symbiotic relationship.
- (b) **Explain** which hosts are required for the sexual life cycle of *Plasmodium*.
- (c) Destruction of oxygen-carrying red blood cells is the phase of the disease causing the most symptoms. **Identify** which numbers in the figure represents this stage.
- (d) **Explain** why destruction of oxygen-carrying cells leads to the most symptoms in the body at the cellular level.

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6. The fruit fly, *Drosophila melanogaster*, is an ideal organism on which to study genetic mechanisms. This organism has simple food requirements, occupies little space, and the reproductive life cycle is complete in about 12 days at room temperature, allowing for quick analysis of test crosses. In addition, fruit flies produce large numbers of offspring, which allows for sufficient data to be collected quickly. Many *Drosophila* genes are homologous to human genes, and are studied to gain a better understanding of what role these proteins have in humans.

To understand the inheritance patterns of certain genes in *Drosophila*, the following experiments were carried out. Assume that the alleles for red eyes, brown body, and normal wings are dominant and the alleles for white eyes, ebony body, and vestigial wings are recessive.

Experiment 1:

A red-eyed female and a white-eye male were crossed. The subsequent generation of flies was also crossed. The phenotypic results of both generations are shown below:

Generation	Red-eyed female	White-eyed female	Red-eyed male	White-eyed male
Parental	1	0	0	1
F ₁	9	0	13	0
F ₂	27	0	12	14

Experiment 2:

Five of the red-eyed female *Drosophila* from the F₁ generation of Experiment 1 were crossed with white-eyed males. The result of this cross is shown below:

Generation	Red-eyed female	White-eyed female	Red-eyed male	White-eyed male
F ₁	5	0	0	10
F ₂	8	8	9	8

Experiment 3:

A male heterozygous for body color and wing type is crossed with an ebony, vestigial-winged female. The results of the cross are shown below:

Phenotype	Male	Female
Brown body, normal wings	32	30
Brown body, vestigial wings	2	1
Ebony body, normal wings	1	3
Ebony body, vestigial wings	28	33

- (a) **Identify** the percentage of flies in the F₂ generation in Experiment 1 that were homozygous recessive.
- (b) **Describe** the difference between the red-eyed female in Experiment 1 and the red-eyed female in Experiment 2.
- (c) Assume that the gene for body color and wing size are on the same chromosome. **Calculate** the recombination frequency in experiment 4.
- (d) **Explain** why gene linkage is an exception to one of Mendel's laws.

STOP

END OF EXAM
