Chapter 39
AP Biology Practice Test

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 Grade
50%
Writing Instrument
Pencil required

Instructions

Section I of this examination contains 69 multiple-choice questions. These are broken 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) 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.

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BIOLOGY

SECTION I

Time—1 hour and 30 minutes

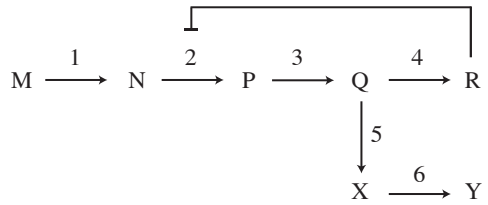
Part A: Multiple-choice Questions (63 Questions)

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

1. The stomach is a critical organ which performs all of the following functions EXCEPT

   (A) synthesizing pepsinogen to break down peptides into amino acids
   (B) mechanically breaking down of food by churning and mixing to produce chyme
   (C) generating HCl to denature peptides and destroy microbes
   (D) absorbing emulsified lipids and fats

Consider the following metabolic enzyme pathway:



2. A sudden increase in substance R will have which of the following results?

   (A) An increase in substance P
   (B) A decrease in substance M
   (C) Increased activity of enzyme 3
   (D) Decreased activity of enzyme 4

3. During an action potential, the membrane potential reaches a maximum at +35 mV. Which of the following occur at this voltage?

   I. Na^+/K^+ pumps close
   II. Voltage-gated Na^+ channels open
   III. Voltage-gated K^+ channels open

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

4. Which of the following best describes the role of the corpus luteum during the menstrual cycle?

   (A) It produces follicle-stimulating hormone (FSH) and luteinizing hormone (LH), which stimulate follicle development and release.
   (B) It produces estrogen, which triggers menstruation approximately 14 days after ovulation.
   (C) It produces progesterone, which promotes growth of glands and blood vessels in the endometrium following ovulation.
   (D) It produces testosterone, which triggers ovulation after a surge in LH production.

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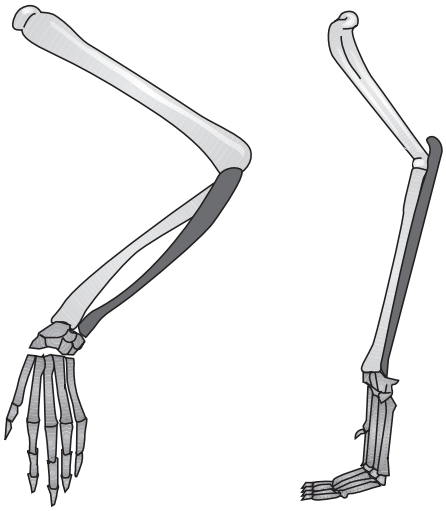
Consider the following appendages of a human arm and a dog's front leg:



5. These homologous structures reflect a common ancestry despite clear differences in function. Which of the following terms best describes the events that gave rise to these structures?

   (A) Divergent evolution
   (B) Convergent evolution
   (C) Sympatric speciation
   (D) Allopatric speciation

6. All of the following describe differences in translation and trafficking events for secreted and cytosolic proteins EXCEPT

   (A) cytosolic genes are normally translated by free ribosomes, whereas secreted genes are normally translated by ER-associated ribosomes
   (B) secreted genes often contain ER-targeting signal peptides, whereas cytosolic genes do not
   (C) cytosolic mRNA strands begin with the AUG start codon, whereas secreted mRNA strands begin with the UGA start codon
   (D) secreted proteins are trafficked through the secretory pathway, whereas cytosolic genes are not

7. Which of the following is NOT an assumption made with a population in Hardy-Weinberg equilibrium?

   (A) There will be no immigration or emigration into or out of the population.
   (B) There will be a sufficiently large population to limit allelic difference due to random chance.
   (C) There will be no mutations, which arise in the population.
   (D) There will be natural selection, which drives allelic variability.

8. Abandoned birds have been hatched under the wings of a glider aircraft and have learned flight and traditional migratory routes by following the aircraft. This represents an example of which of the following types of learning?

   (A) Imprinting
   (B) Habituation
   (C) Operant conditioning
   (D) Insight

9. Synapsis and crossing-over are critical events, which result in genetic diversity of the cell. Which step of meiosis does synapsis and crossing-over events occur?

   (A) Metaphase I
   (B) Metaphase II
   (C) Prophase I
   (D) Prophase II

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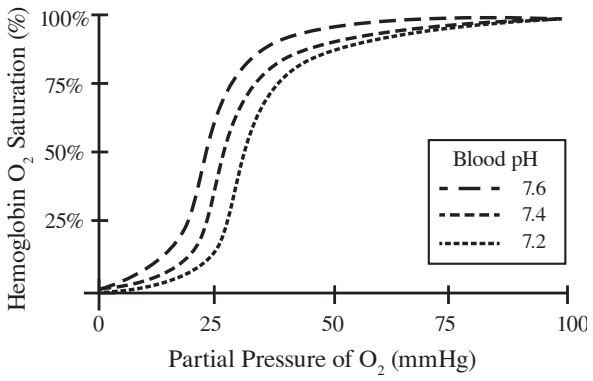
Questions 10-14

Pulse oximeters measure the amount of arterial oxygen saturation by evaluating transmission of red and infrared light through tissues such as a finger. Because deoxygenated hemoglobin absorbs more red light and less infrared light than oxygenated, a general ratio may be computed. An experiment was performed to evaluate the role of blood pH on the binding of oxygen to hemoglobin in mice. A pulse oximeter was applied and the blood pH was changed with an adjusted saline solution to 7.2, 7.4, or 7.6. The oxygen saturation was determined as the partial pressure of oxygen was increased in the graph below.



10. Which of the following best describes the relationship between blood pH and hemoglobin oxygen saturation in mice?

    (A) As blood becomes more acidic, the oxygen saturation in hemoglobin increases at the same partial pressure of oxygen.
    (B) As blood becomes more acidic, the oxygen saturation in hemoglobin decreases at the same partial pressure of oxygen.
    (C) As blood becomes more acidic, the oxygen saturation in hemoglobin remains the same until a partial pressure above 75 mmHg.
    (D) There is no relationship between blood pH and hemoglobin oxygen saturation.

11. How does the oxygen binding of fetal hemoglobin compare to adult hemoglobin?

    (A) Fetal hemoglobin has higher binding affinity.
    (B) Fetal hemoglobin has lower binding affinity.
    (C) Fetal hemoglobin has equal binding affinity.
    (D) There is no difference in the structures of fetal and adult hemoglobin.

12. How does the absorption of red and infrared light at higher blood pH values differ from lower pH values by pulse oximetry in 50 mmHg O_2?

    (A) There will be higher red and lower infrared absorptions at higher blood pH.
    (B) There will be higher infrared and lower red absorptions at higher blood pH.
    (C) There will be equal red and infrared absorptions at higher blood pH.
    (D) The results cannot be determined from the information provided.

13. In which of the following cardiovascular structures would the lowest oxygen saturation be detected?

    (A) Aorta
    (B) Pulmonary artery
    (C) Pulmonary vein
    (D) Capillary beds in the finger

14. Erythrocytes (red blood cells) carry high concentrations of hemoglobin. Where are erythrocytes made?

    (A) Liver
    (B) Spleen
    (C) Kidney
    (D) Bone marrow

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15. Which of the following types of genetic mutations will be least likely to alter the length of the resulting protein?

    (A) Missense mutation
    (B) Nonsense mutation
    (C) Insertion
    (D) Duplication

16. During photosynthesis, what is the purpose of the light-independent reactions?

    (A) The light-independent reactions generate NADPH and ATP to be used by the light dependent reactions to produce sugar.
    (B) The light-independent reactions generate chlorophyll to be used in the light dependent reactions to produce sugar.
    (C) The light-independent reactions use NADPH, ATP, and CO_2, to generate sugar.
    (D) The light-independent reactions convert sugar into cellulose for storage until needed.

17. An experiment was performed crossing different species of pea plants. In one cross between two heterozygotes of the same species, for pea color the ratio of dominant to recessive plants for color was much less than the expected 9:3:3:1 ratio. Assuming pea color is controlled by two genes, which of the following best explains this result?

    (A) The deviation in phenotypic ratio for pea color was due to incomplete dominance.
    (B) The deviation in phenotypic ratio for pea color was due to codominance.
    (C) The deviation in phenotypic ratio for pea color was due to linkage.
    (D) The deviation in phenotypic ratio for pea color was due to epistasis.

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Questions 18-19

Four new species of archaea named A – D, were recently discovered in the thermal pools in Yellowstone National Park. The nucleotide sequences were determined for the bacterial rRNA and the table below reflects differences between species.

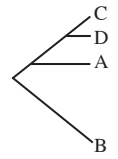
Nucleotide Differences

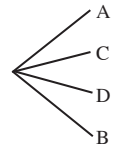
Species	A	B	C	D
A	0	16	5	6
B		0	19	21
C			0	2
D				0

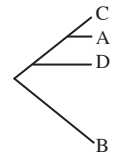
18. What is the role of rRNA in the cell?

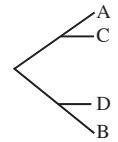
(A) rRNA encodes the messages for genes which are then translated by ribosomes in the cytoplasm.
(B) rRNA anticodons are paired with codons by ribosomes to assemble nascent peptides during translation.
(C) rRNA is the nucleic acid component of ribosomes and binds RNA messages during translation.
(D) rRNA encodes a gene in the nucleus of a cell prior to transcription by host polymerases.

19. Which of the phylogenetic trees below is most consistent with the archaea rRNA data provided?

(A) 

(B) 

(C) 

(D) 

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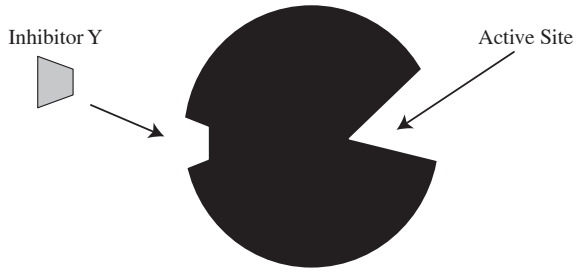
20. Shown below is an enzyme that is inhibited by binding of inhibitor Y. Which of the following accurately describes the function of this inhibitor?



(A) Inhibitor Y competes with substrate for access to the active site.
(B) Inhibitor Y binds an allosteric site causing a conformational change to block the active site.
(C) Inhibitor Y binds the substrate preventing its subsequent binding to the active site.
(D) Inhibitor Y blocks translation of the enzyme.

21. What is the order from largest to smallest of structures containing chlorophyll in a plant cell?

(A) Mitochondria, Chloroplasts, Grana, Thylakoids
(B) Chloroplasts, Grana, Stoma, Thylakoids
(C) Chloroplasts, Grana, Thylakoids, Antenna Complexes
(D) Chloroplasts, Thylakoids, Grana, Stoma

22 A bacterial cell is treated with radiolabeled sulfur-35 (^{35}S) methionine and cysteine, if bacteriophages infect the cell. What component, if any, of the progeny bacteriophage structure will contain the most ^{35}S?

(A) Bacteriophage Genome
(B) Capsid (Bacteriophage Protein Coat)
(C) Envelope (Bacteriophage Membrane)
(D) Bacteriophage Nuclear Envelope

23. The DNA sequence of a gene begins with the following:

TAC CCC ATC GGC CCT

Which of the following would be the sequence of transcribed mRNA from the DNA segment shown above?

(A) ATG GGG TAG CCG GGA
(B) GCA AAA CGA TTA AAG
(C) AUG GGG UAG CCG GGA
(D) AGG GCC GAU GGG GUA

24. Over the last fifty years, an abrupt decrease in average temperature on an island has resulted in a gradual change from wind-blown forests of short conifers to open fields containing permafrost and few trees. Which of the following transitions in the biome is occurring?

(A) Taiga to deciduous forest
(B) Taiga to tundra
(C) Tundra to taiga
(D) Tundra to grasslands

25. Sentry meerkats stand on alert to detect predators and will continue to bark if they spot a predator to warn fellow meerkats to hide despite often drawing the attention of the predator to themselves. This is an example of which of the following types of social behaviors?

(A) Agonistic behavior
(B) Dominant hierarchy
(C) Territoriality
(D) Altruistic behavior

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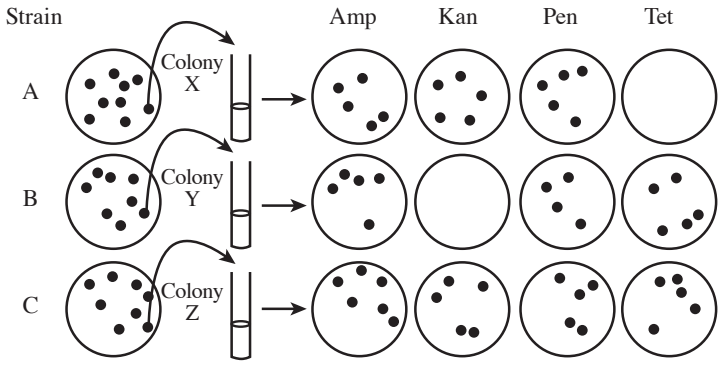
Questions 26-30

New hospital strains of *E. coli* (named A, B, and C) are being evaluated for sensitivity to antibiotics. The bacteria have been spread on plates to isolate pure cultures. The pure colonies were selected, suspended in growth media, and spread on plates containing antibiotics ampicillin (Amp^+), kanamycin (Kan^+), penicillin (Pen^+), or tetracycline (Tet^+). The plates were incubated at 37°C for 24 hours. The experimental setup and results are shown below.



26. Based on the data shown, which strain is the least sensitive to the antibiotics tested?

    (A) Strain A
    (B) Strain B
    (C) Strain C
    (D) They are all equally sensitive.

27. A patient has an infection with *E. coli* strain B. Which of the antibiotics should be prescribed?

    (A) Ampicillin
    (B) Kanamycin
    (C) Penicillin
    (D) Tetracycline

28. Suppose a follow-up experiment is performed which shows that the *E. coli* strains are practically genetically identical and only very in their expression of antibiotic resistance genes. All of the following hypotheses are supported by these new findings EXCEPT

    (A) *E. coli* strains A, B, and C are derived from a single common bacterial strain.
    (B) *E. coli* strains A, B, and C have acquired different plasmids, small pieces of DNA, which confer resistance to specific antibiotics.
    (C) *E. coli* strain C has a unique flagellum and attachment proteins, which has provided an advantage in acquiring resistance genes.
    (D) *E. coli* strain C evolved from strain B.

29. Which of the following cellular structures would you NOT expect to find in *E. coli*?

    (A) Ribosomes
    (B) Plasma membrane
    (C) Cell wall
    (D) Nucleus

30. Assuming there are no bacteriophages present, the process by which the bacteria likely acquired the resistance genes from their environment is called

    (A) transduction
    (B) transfection
    (C) transformation
    (D) PCR

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31. A catalyst has been added to an exergonic reaction. What impact will the catalyst have on the energetics of the reaction?

    (A) The catalyst will reduce the energy of the products making the reaction more spontaneous.
    (B) The catalyst will reduce the energy of the reactants making the reaction more spontaneous.
    (C) The catalyst will lower the activation energy making the reaction more efficiently proceed to completion.
    (D) The catalyst will raise the activation energy making the reaction more efficiently proceed to completion.

32. The pancreas secretes a variety of digestive enzymes into the small intestine. Trypsin and chymotrypsin are secreted by the pancreas and are most similar to which of the following?

    (A) Lipase
    (B) Pepsin
    (C) Amylase
    (D) Lactase

33. Which of the following immune cells is responsible for producing antibodies?

    (A) Phagocytes
    (B) B cells
    (C) Cytotoxic T cells
    (D) Helper T cells

34. Which of the following organs of the digestive system is considered an accessory organ, meaning that it is not part of the GI tract?

    (A) Stomach
    (B) Small intestine
    (C) Liver
    (D) Esophagus

35. Global warming has caused the size of some species of cacti to decrease. The change in cactus size has triggered a decrease in the size of cactus wrens, which nest in holes in cacti. This is an example of which of the following types of selection?

    (A) Sexual selection
    (B) Stabilizing selection
    (C) Disruptive selection
    (D) Directional selection

36. In a community, prairie dogs eat grasses, brush, and flowering plants and are in turn eaten by foxes and coyotes? Which of the following accurately describes the niche of prairie dogs in this community?

    (A) Producers
    (B) Primary consumers
    (C) Secondary consumers
    (D) Decomposers

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37. The nervous system will develop from which of the following germ layers during organogenesis?

(A) Mesoderm
(B) Endoderm
(C) Zygoderm
(D) Ectoderm

38. Which of the following are similarities between smooth muscle and cardiac muscle cells?

I. They have a single nucleus.
II. They are under involuntary control.
III. They are striated.

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

39. Robert Wadlow had gigantism and remains the tallest human being in recorded history at a final height of 8 feet 11 inches tall. Scientists attribute his height due to excessive production of growth hormone, produced by which of the following?

(A) Hypothalamus
(B) Adrenal gland
(C) Pituitary gland
(D) Thyroid gland

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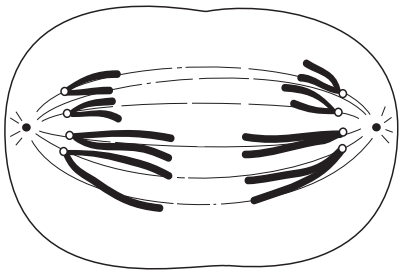
Questions 40-43:

Scientists evaluating inhibitors of mitosis and have identified a chemical called CIS, which results in all mitotic cells being arrested at the stage shown below.



40. During which stage of mitosis are the cells arrested?

    (A) Prophase
    (B) Metaphase
    (C) Anaphase
    (D) Telophase

41. Which of the following is a possible explanation for how the inhibitor is arresting the cells?

    (A) The inhibitor is blocking the complete contraction of the microtubules.
    (B) The inhibitor is preventing the separation of the chromatids at the centromere.
    (C) The inhibitor is blocking the dissolution of the nuclear membrane.
    (D) The inhibitor is blocking the formation of mitotic spindles.

42. The cell shown above may be any of the following types of cells EXCEPT

    (A) spermatocyte
    (B) hepatocyte (liver cell)
    (C) lymphocyte (white blood cell)
    (D) epithelial cell

43. Which of the following events is expected to happen next after the inhibitor degrades?

    (A) The chromosomes will align in the center of the cell.
    (B) The nuclear envelope will reappear and the cell will begin cytokinesis.
    (C) Synapsis and crossing-over will occur.
    (D) Complete copies of the cells' genetic material will be made in preparation for cell division.

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44. A missense mutation has resulted in a change from a glycine to a proline. This change is limiting development of a critical alpha helix due to increased restriction in the flexibility of the polypeptide backbone. Which of the following levels of protein structure has been most affected?

    (A) Primary
    (B) Secondary
    (C) Tertiary
    (D) Quaternary

45. Down syndrome is a condition associated with trisomy of chromosome 21. Trisomy most often occurs due to which of the following types of defects during cell replication?

    (A) Translocation
    (B) Nondisjunction
    (C) Duplication
    (D) Deletion

46. A baby boy has been born to a man with an A blood type and a woman with an O blood type. Assuming the child has an older sibling with an O blood type, what is the probability that the he will have an A blood type?

    (A) 0
    (B) $\frac{1}{4}$
    (C) $\frac{1}{2}$
    (D) $\frac{2}{3}$

47. Which of the following structures of the respiratory tract is the primary location of gas exchange?

    (A) Terminal bronchioles
    (B) Bronchi
    (C) Alveoli
    (D) Tracheae

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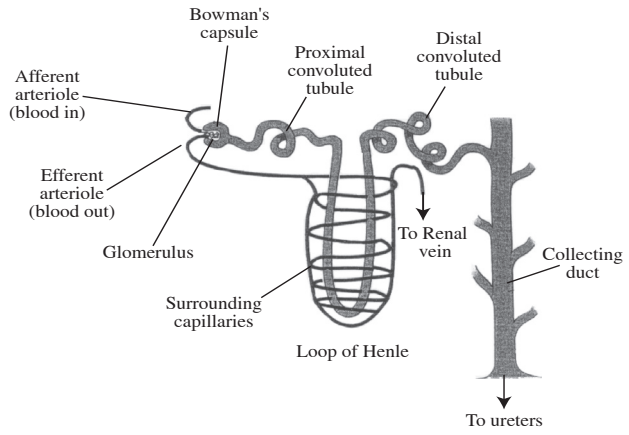
Questions 48-51: Refer to the image below of a nephron to answer the following questions.



48. Aldosterone plays a critical role in regulating blood pressure through absorption of extra sodium from the filtrate into the blood. Which of the following structures of the nephron does aldosterone target?

(A) Bowman's capsule
(B) Proximal convoluted tubule
(C) Loop of Henle
(D) Distal convoluted tubule

49. Coffee is an antidiuretic hormone (ADH) inhibitor and acts on the collecting duct of the nephron. Which of the following directly occurs due to the ADH inhibition activity of coffee?

(A) Coffee increases water reabsorption leading to increased urine production.
(B) Coffee decreases water reabsorption leading to increased urine production.
(C) Coffee increases sodium reabsorption leading to increased urine production.
(D) Coffee decreases sodium reabsorption leading to increased urine production.

50. Which of the following should NOT be found in the filtrate in Bowman's capsule?

(A) Salt
(B) Water
(C) Urea
(D) Albumin

51. Many organisms produce urea as a waste byproduct. Where does urea come from?

(A) Urea is a byproduct of lipid catabolism.
(B) Urea is a byproduct of nucleic acid catabolism.
(C) Urea is a byproduct of protein catabolism.
(D) Urea is a byproduct of carbohydrate catabolism.

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52. During an action potential, which of the following best describes the movement of potassium ions?

(A) At the threshold potential, voltage-gated potassium channels open allowing potassium ions to rush into the cell causing depolarization.
(B) At the threshold potential, voltage-gated potassium channels open allowing potassium ions to rush out of the cell causing repolarization.
(C) At the peak potential, voltage-gated potassium channels open allowing potassium ions to rush into the cell causing depolarization.
(D) At the peak potential, voltage-gated potassium channels open allowing potassium ions to rush out of the cell causing repolarization.

53. What is the role of helicase during DNA replication?

(A) Helicase adds nucleotides to existing strands creating a new helix.
(B) Helicase unwinds the double helix into two strands.
(C) Helicase ligates together the Okazaki fragments in the lagging strand.
(D) Helicase catalyzes the synthesis of RNA primers for polymerization.

54. Chlorofluorocarbons (CFCs) are being phased out of use in aerosol cans following the Montreal Protocol to reduce their influence on which of the following?

(A) Greenhouse effect
(B) Ozone depletion
(C) Acid rain
(D) Deforestation

55. The pituitary gland is commonly referred to as the master gland due to its hormonal influence on other glands. Which of the following pituitary hormones results in subsequent secretion of thyroxine?

(A) Adrenocorticotropic hormone (ACTH)
(B) Luteinizing hormone (LH)
(C) Growth hormone (GH)
(D) Thyroid-stimulating hormone (TSH)

56. A racecar driver sustains brain damage following a car accident. Upon evaluation in the emergency room, the driver is unable to see clearly and is having difficulty hearing. Which of the following parts of the brain was most likely damaged?

(A) Cerebrum
(B) Cerebellum
(C) Pons
(D) Hypothalamus

57. A plant has three independently assorting traits AaBbCcDd. What fraction of the gametes are expected to have the genes abcd?

(A) 0
(B) $\frac{1}{2}$
(C) $\frac{3}{8}$
(D) $\frac{1}{16}$

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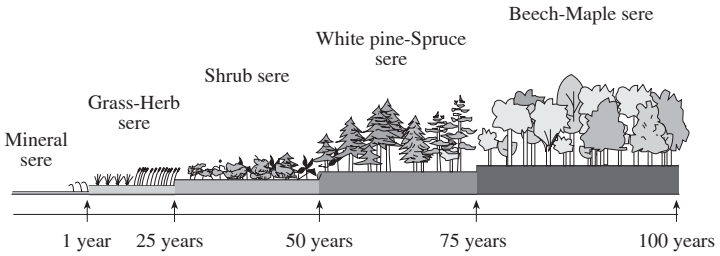
Questions 58-59: Refer to the image below of ecological succession to answer the following questions.



58. A forest is dominated mostly by confers with a small number of young deciduous trees? Based on the scale above, approximately how old is the forest?

(A) 15 years old
(B) 35 years old
(C) 65 years old
(D) 90 years old

59. Suppose a forest fire hits an old forest of mostly beech and maple trees? How will the pace of secondary succession compare to the initial ecological succession in the area?

(A) The growth of the secondary community will be faster than the initial ecological succession.
(B) The growth of the secondary community will be slower than the initial ecological succession.
(C) The growth of the secondary community will be about the same as the initial ecological succession.
(D) The growth of the secondary community will depend on whether lichens survived the forest fire.

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60. Salivary amylase and pancreatic amylase perform very similar functions in digesting carbohydrates. Which of the following provides an rationale for why humans have both enzymes?

    (A) Salivary amylase rapidly digests starch, whereas the pancreatic amylase rapidly digests cellulose.
    (B) Salivary amylase is inactivated in the stomach due to low pH and further carbohydrate digestion is required in the small intestine.
    (C) Salivary amylase is only functionally active in combination with the mechanical action of chewing, whereas pancreatic amylase is much more versatile.
    (D) Salivary amylase and pancreatic amylase are remnants of evolution from other primates.

61. An animal cell is bathed in a hypertonic solution. Which of the following is expected to occur?

    (A) The cell will remain the same size due to equivalent movement of water into and out of the cell.
    (B) The cell will shrink due to movement of water out of the cell.
    (C) The cell will expand due to movement of water into the cell.
    (D) The cell will stay the same size due to its cell wall, but its membranes will shrink.

62. Calcium is critical for a wide variety of physiologic functions include neural transmission and muscle contractions. Decreased serum concentrations of calcium will trigger release of which of the following hormones?

    (A) Calcitonin
    (B) Parathyroid hormone (PTH)
    (C) Adrenocorticotropic hormone (ACTH)
    (D) Oxytocin

63. Fermentation is an important process for eukaryotes. However, the end products for organisms often differ. What are the end products of human and yeast fermentation, respectively?

    (A) Lactic acid and methanol
    (B) Lactic acid and ethanol
    (C) Ethanol and pyruvate
    (D) Ethanol and glutaraldehyde

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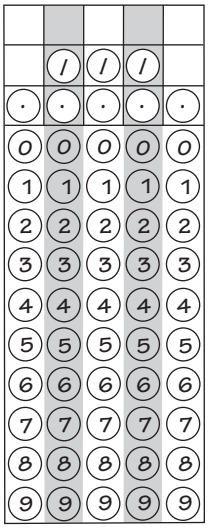
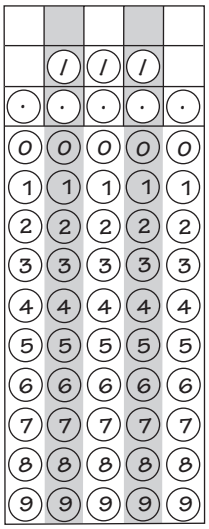
Part B: Grid-in Questions (6 Questions)

Directions: This section consists of questions that require numeric answers. Calculate the correct answer to each question.

64. In pea plants, purple flowers (F) are dominant over white flowers (f), and green pods (P) are dominant over yellow pods (p). Suppose a student performed a cross between a purple-flowered pea plant with green pods that is heterozygous for both traits and a yellow-flowered pea plant with green pods that is heterozygous for pod color. Assuming independent assortment, what fraction of progeny pea plants will have purple flowers and green pods? Give your answer in fraction form.



65. Earwax moisture is a human trait controlled by a single gene. Wet earwax is dominant over dry earwax. Assume that 4% of a population has dry earwax and that the population is in Hardy-Weinberg equilibrium. What is the frequency of the dominant allele in the population? Provide your answer to the nearest tenth.



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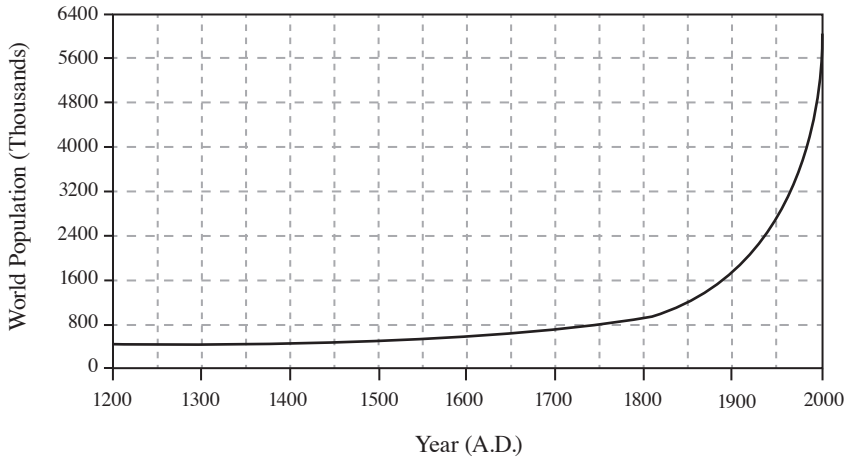
66. The world population has grown steadily over the last 800 years despite as shown in the figure below. In 1450, the black plague pandemic struck Europe killing approximately 1 in 4 people. What was the world population at the time of the black plague. Give your answer in millions of people to the nearest tenth place.



	/	/	/	
.	.	.	.	.
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

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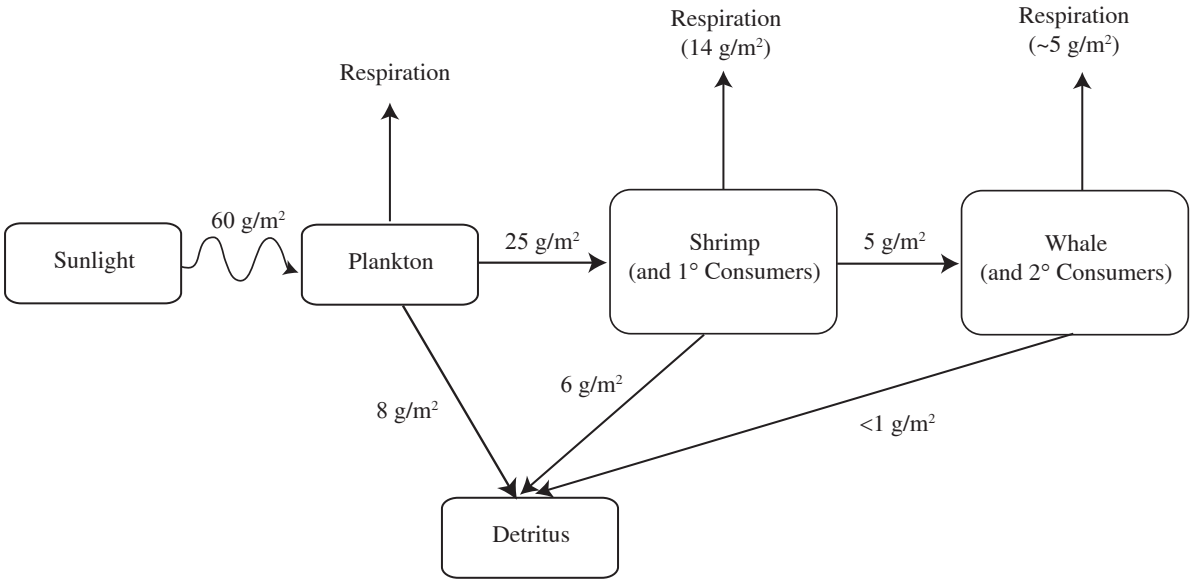
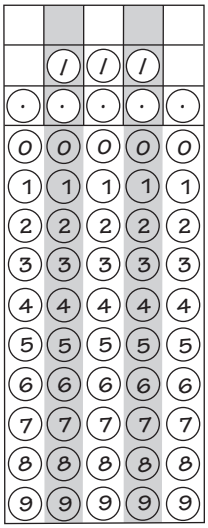
67. Shown below is the carbon flow for an aquatic food web. What is the carbon (in g/m^2) released by respiration of plankton. Provide your answer to the nearest whole number.





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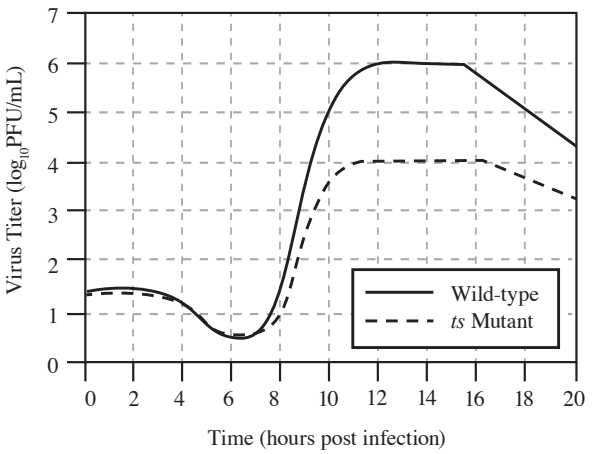
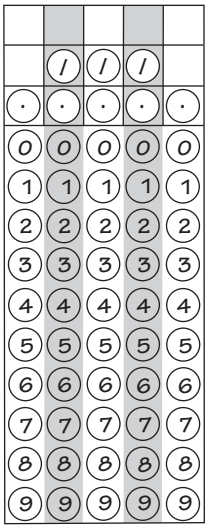
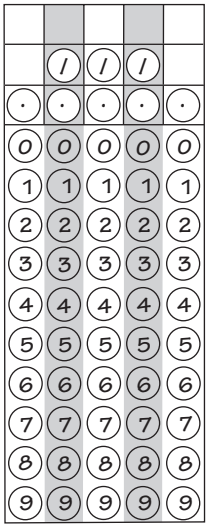
68. A graduate student performs an experiment comparing a wild-type strain and a temperature-sensitive (*ts*) mutant strain of a virus to evaluate the defect in replication of the virus at elevated temperature. In the experiment, the student inoculated 25 cm^2 flasks with 20 plaque-forming units (PFU) of virus. The virus was incubated at 40° C and took samples for virus titers every 2 hours. The results of the experiment are shown below. At peak (maximum) titers, approximately what fold greater titers was observed by the wild-type strain compared to the *ts* mutant? Express your answer rounded to the nearest whole number.





69. Hemophilia is a sex-linked disorder characterized by the inability to properly form clotting. A couple discuss with a family geneticist about the chances that their unborn child will inherit hemophilia. The child's father has hemophilia and its mother's father had hemophilia. The couple does not yet know the gender of their child. What are the odds that they will have a boy that also has hemophilia? Express your answer as a whole number percentage.



END OF SECTION I

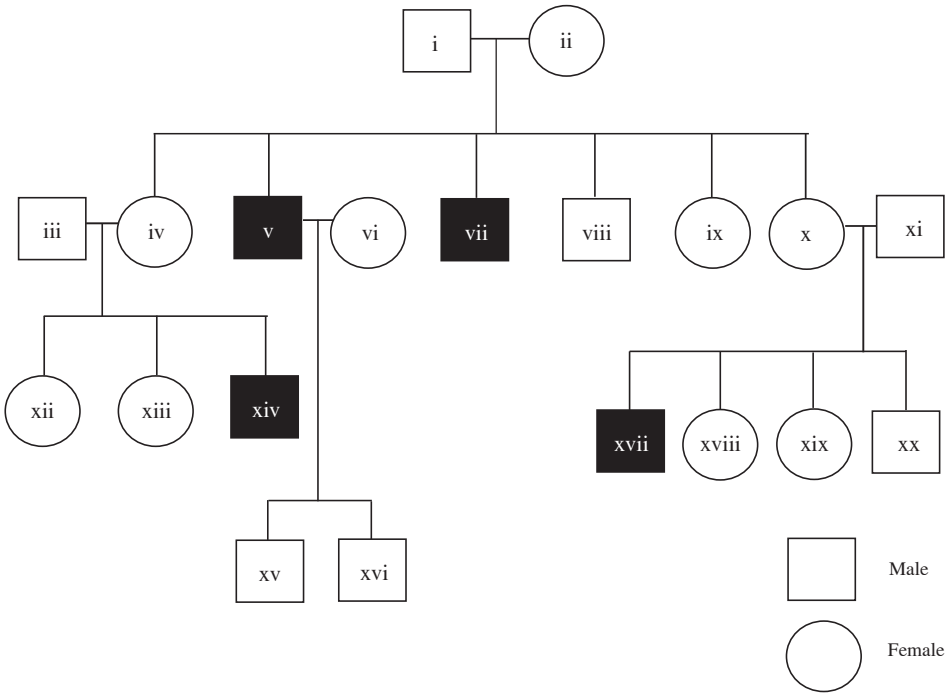
BIOLOGY

SECTION II

Time – 1 hour and 30 minutes

Directions: Questions 1 and 2 are long free-response questions, which should require approximately 20 minutes each to answer. Questions 3 – 8 are short free-response questions, which should require approximately 6 minutes to complete each. Read through each question or prompt carefully and write your complete response. It is important to read carefully before you begin writing.

1. A biologist has been studying a family of wolves, which are afflicted with an apparent genetic disease. Below is a pedigree exhibiting the occurrence of the disease through three generations. Ecological surveys have shown that the disease is generally quite rare in wolves and no wolves, which have joined the pack showed any sign of the disease.



a. Using the data provided in the pedigree above, **explain** what type of genetic disease (e.g. autosomal, sex-linked) is afflicting the family of wolves and whether or not the disease is domain. **Justify** your answer.

b. If wolf xvii breeds with xii, **calculate** what is the likelihood that their first female pup will be afflicted with the disease.

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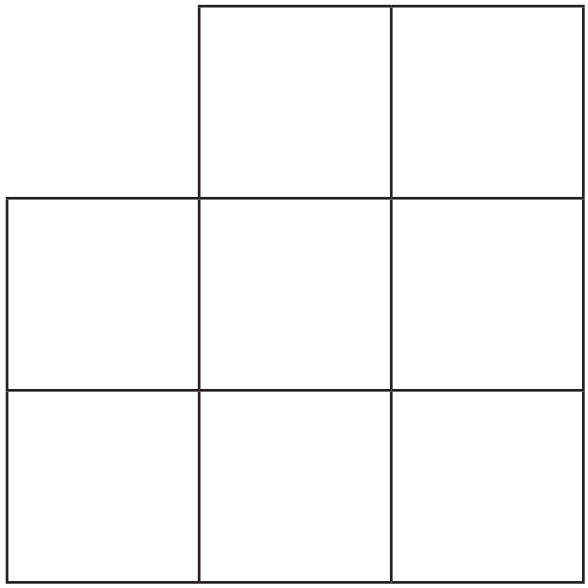
c. **Draw** a Punnett square using the box provided below to display the cross between wolves v and vi. Be sure to include the genotypes of the parents in your cross. **Explain** using your results why neither male pup of the wolves has the disease. Include in your answer what you would expect to see, if the wolves have a female pup.



d. In a greater genomic study that the frequency of the allele associated with the disease was determined to be 0.1. **Calculate** what would be the frequency of affected individuals in this population assuming Hardy-Weinberg equilibrium?

e. Suppose the parents of the patriarch wolf (i) and matriarch wolf (ii) were discovered and neither parent for either wolf had the disease or a history of the disease. **Explain** how the disease likely entered the family.

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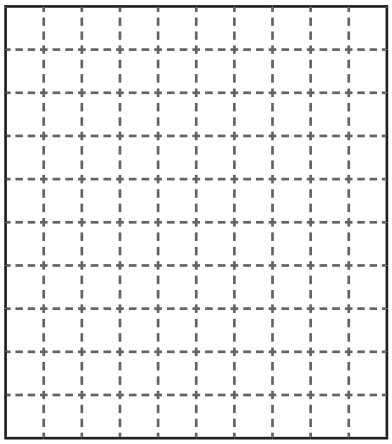
2. A scientist has recently discovered a new DNA ligase in a species of thermophilic bacteria. The DNA ligase performs similar functions to other eukaryotic ligases; however, the scientist quickly hypothesizes that the ligase may be more resistant to degradation at higher temperatures than most ligases due to the optimal growth temperature of the bacteria. To evaluate the activity of the new DNA ligase, the scientist determines the relative activity of enzyme over changes in temperature as shown below.

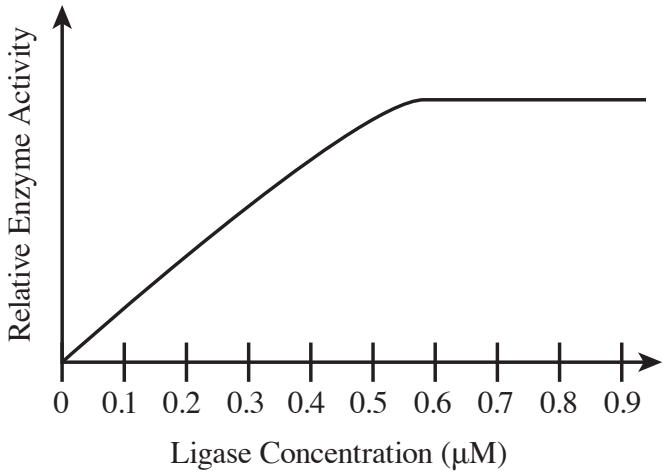
LIGASE ACTIVITY VERSUS TEMPERATURE

Temperature (°C)	4	25	37	45	60	75	90
Relative Activity (%)	0	5	18	40	70	97	30

a. **Draw** a graph using the data above and provided axes, which show the impact of temperature on the change in the relative activity of the recently discovered DNA ligase. **Explain** the shape of the curve between 75° to 90°.



b. A follow-up experiment is performed to determine the maximum activity of the enzyme toward a fixed amount of substrate at 72° C. **Explain** using the curve below why increases in enzyme concentration above 0.5 μM have no effect on enzyme activity.



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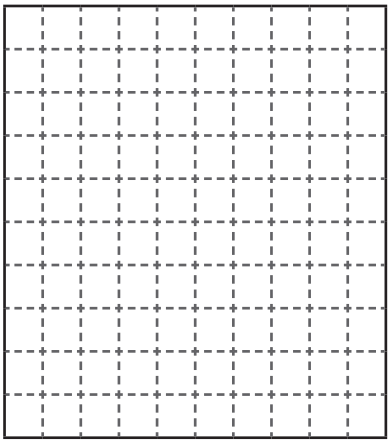
c. Assume that the hypothesis that DNA ligase activity is optimized for the optimal temperature of the organism in which it grows is correct. **Draw** a graph that displays what you believe the relative activity of a DNA ligase isolated from an enteric (gut) strain of *E. coli* would like over changes in temperature. **Justify** your drawing based on the hypothesis provided.



d. Although the discovery of the ligase is important, ligases from other thermophilic organisms have been recovered. The data shown below displays the optimum temperature for ligase activity of several different types of organisms and the environments which they were found. **Define** which of the following organisms share similar ligase characteristics to the one described above and what environment you would most likely find the yeast growing. **Justify** your answers.

Organism	Environment	Temperature for Optimum Ligase Activity (°C)
Thermobacillus Archaea	Volcanic Hot Springs	92
Hyperthermococcus Archaea	Volcanic Hot Springs	88
Thermoaquaticus Bacteria	Volcanic Hot Springs	83
Pyrospirallis Bacteria	Deep Sea Thermal Vents	76
Thermoacidophilus Fungi	Deep Sea Thermal Vents	72
Tyropyrococcus Bacteria	Deep Sea Thermal Vents	56

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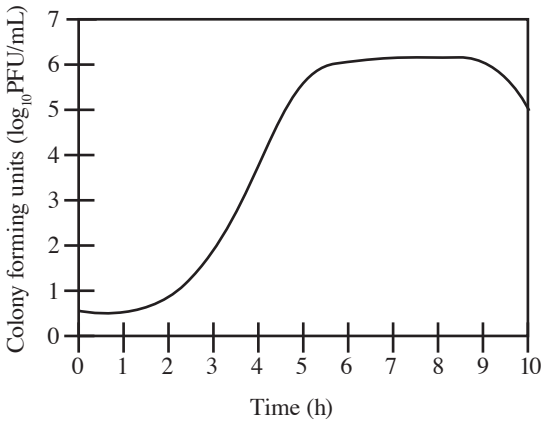
3. The kakapo (*Strigops habroptilus)* is a flightless, ground-dwelling parrot which used to roam the undergrowth of forests in New Zealand. However, introduction of cats by European colonization of the islands has resulted in a severe collapse of the population of kakapo. The last remaining native populations were discovered in the forested mountainous region in the Southern Alps of the south island. Interestingly, the leaping and gliding ability of the kakapo, which is an excellent climber, has increased in steadily over the last 100 years.

   a. **Propose** a hypothesis for why the kakapo has recently seen an increase in leaping and gliding ability.

   b. **Explain** an experiment for how you would test the hypothesis written in part (a) and how the data acquired would help you address your hypothesis.

4. A population of *E. coli* is being grown from a single colony selected on a plate in a 1 L flask in 250 mL of LB broth (growth media) at 37° C. The population growth is shown below.



Write a paragraph where you **explain** the biological events occurring that defines the shape of the curves between a) 2 and 5 hours and b) after 9 hours.

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5. A unique population of algae has been discovered growing at a depth of 30 meters below the surface of the ocean. Two distinct populations of algae which appear to have similar structural and growth characteristics to the newly discovered species have been identified at a shallow depth of only 10 meters below the surface.

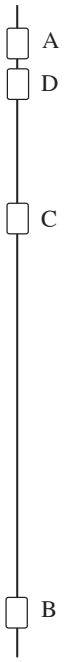
   a. **Describe** TWO different types of data that you could collect that would answer the question: is the deep-growing population of algae discovered related to the two populations growing at 10 meters?

   b. **Explain** how the data acquired in part (a) would help you directly answer the question.

6. A geneticist has recently determined the relative genetic locations of the genes (A – D) controlling eye color for fruit flies. The genetic map is shown below. The geneticist begins to setup crosses to test their results.

   a. Suppose that the geneticist sets up crosses between organisms to evaluate every possible pair of genes. **Describe** which cross will result in the greatest deviation from the expected ratio based on independent assortment?

   b. Gene A encodes for the base color of the eyes. There are three distinct allele variants: α (red), β (blue), and γ (yellow). The α and β alleles exhibit incomplete dominance and γ is recessive. **Describe** what color would the eyes of a fruit fly that is heterozygous for the α and β alleles be? Justify your answer.



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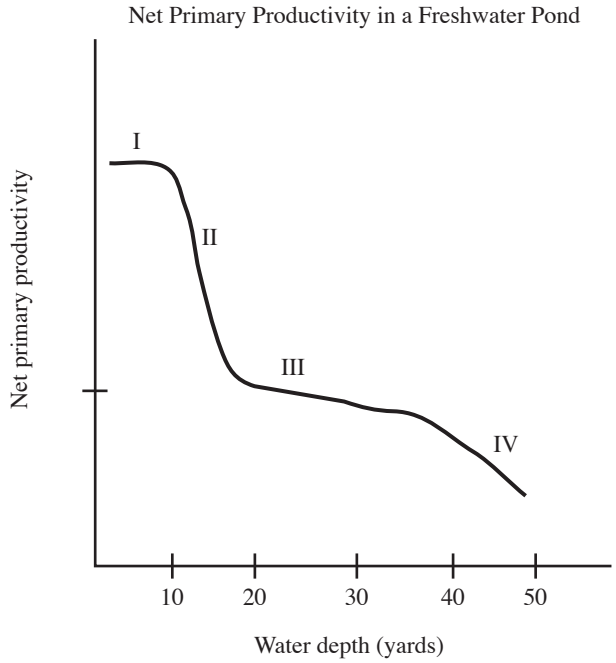
7. Explain the data shown below in the graph. Include a description of the different metabolic process and their relative rates at the different parts of the graph (I, II, III, and IV).



8. The human immune system involves both specific and non-specific defense mechanisms to protect against diseases caused by pathogens.

   a. Explain three types of non-specific defense mechanisms that can prevent entry and/or proliferation of a pathogen in a human.

   b. Explain three parts of the specific defense mechanisms that can help fight pathogens after initial exposure.

STOP

END OF EXAM