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
Writing Instrument
Pencil required

Instructions

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

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

Sample Question	Sample Answer
Chicago is a	Ⓐ ● Ⓒ Ⓓ

(A) 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.

This page intentionally left blank.

GO ON TO THE NEXT PAGE.

BIOLOGY

SECTION I

Time—1 hour and 30 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.

1. The resting membrane potential depends on which of the following?

   I. Active transport

   II. Selective permeability

   III. Differential distribution of ions across the axonal membrane

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

2. The Krebs cycle in humans occurs in the

   (A) mitochondrial matrix
   (B) inner mitochondrial membrane
   (C) outer mitochondrial membrane
   (D) intermembrane space

3. A heterotroph

   (A) obtains its energy from sunlight, harnessed by pigments
   (B) obtains its energy by oxidizing organic molecules
   (C) makes organic molecules from CO_2
   (D) obtains its energy by consuming exclusively autotrophs

4. Regarding meiosis and mitosis, one difference between the two forms of cellular reproduction is that in meiosis

   (A) there is one round of cell division, whereas in mitosis there are two rounds of cell division
   (B) separation of sister chromatids occurs during the second division, whereas in mitosis separation of sister chromatids occurs during the first division
   (C) chromosomes are replicated during interphase, whereas in mitosis chromosomes are replicated during prophase
   (D) spindle fibers form during prophase, whereas in mitosis the spindle fibers form during metaphase

5. A feature of amino acids NOT found in carbohydrates is the presence of

   (A) carbon atoms
   (B) oxygen atoms
   (C) nitrogen atoms
   (D) hydrogen atoms

6. Which of the following is NOT a characteristic of bacteria?

   (A) Circular double-stranded DNA
   (B) Membrane-bound cellular organelles
   (C) Plasma membrane consisting of lipids and proteins
   (D) Ribosomes that synthesize polypeptides

GO ON TO THE NEXT PAGE.

7. Which of the following best explains why a population is described as the evolutionary unit?
   (A) Genetic changes can only occur at the population level.
   (B) The gene pool in a population remains fixed over time.
   (C) Natural selection affects individuals, not populations.
   (D) Individuals cannot evolve, but populations can.

8. The endocrine system maintains homeostasis using many feedback mechanisms. Which of the following is an example of positive feedback?
   (A) Infant suckling causes a mother's brain to release oxytocin, which in turn stimulates milk production
   (B) An enzyme is allosterically inhibited by the product of the reaction it catalyzes
   (C) When ATP is abundant the rate of glycolysis decreases
   (D) When blood sugar levels decrease to normal after a meal, insulin is no longer secreted

9. A scientist carries out a cross between two guinea pigs, both of which have black coats. Black hair coat is dominant over white hair coat. Three quarters of the offspring have black coats, and one quarter have white coats. The genotypes of the parents were most likely
   (A) bb × bb
   (B) Bb × Bb
   (C) Bb × bb
   (D) BB × Bb

10. A large island is devastated by a volcanic eruption. Most of the horses die except for the heaviest males and heaviest females of the group. They survive, reproduce, and perpetuate the population. Since weight is highly heritable and the distribution of weights approximates a binomial distribution, the offspring of the next generation would be expected to have
    (A) a higher mean weight compared with their parents
    (B) a lower mean weight compared with their parents
    (C) the same mean weight as members of the original population
    (D) a higher mean weight compared with members of the original population

11. All of the following play a role in morphogenesis EXCEPT
    (A) apoptosis
    (B) homeotic genes
    (C) operons
    (D) inductive effects

12. During the period when life is believed to have begun, the atmosphere on primitive Earth contained abundant amounts of all the following gases EXCEPT
    (A) oxygen
    (B) hydrogen
    (C) ammonia
    (D) methane

13. Villi and microvilli are present in the small intestine and aid in reabsorption by
    (A) increasing the surface area of the small intestine
    (B) decreasing the surface area of the small intestine
    (C) making the small intestine more hydrophilic
    (D) making the small intestine more hydrophobic

14. Which of the following does NOT take place in the small intestine?
    (A) Pancreatic lipase breaks down fats to fatty acids and glycerol.
    (B) Pepsin breaks down proteins to amino acids.
    (C) Pancreatic amylase breaks down carbohydrates into simple sugars.
    (D) Bile emulsifies fats into smaller fat particles.

15. In animal cells, which of the following represents the most likely pathway that a secretory protein takes as it is synthesized in a cell?
    (A) Plasma membrane–Golgi apparatus–ribosome–secretory vesicle–rough ER
    (B) Ribosome–Golgi apparatus–rough ER–secretory vesicle–plasma membrane
    (C) Plasma membrane–Golgi apparatus–ribosome–secretory vesicle–rough ER
    (D) Ribosome–rough ER–Golgi apparatus-secretory vesicle–plasma membrane

GO ON TO THE NEXT PAGE.

16. All of the following statements are correct regarding alleles EXCEPT:
    (A) Alleles are alternative forms of the same gene.
    (B) Alleles are found on corresponding loci of homologous chromosomes.
    (C) A gene can have more than two alleles.
    (D) An individual with two identical alleles is said to be heterozygous with respect to that gene.

17. Once a plasmid has incorporated specific genes, such as the gene coding for the antibiotic ampicillin, into its genome, the plasmid may be cloned by
    (A) inserting it into a virus to generate multiple copies
    (B) treating it with a restriction enzyme in order to cut the molecule into small pieces
    (C) inserting it into a suitable bacterium in order to produce multiple copies
    (D) running it on a gel electrophoresis in order to determine the size of the gene of interest

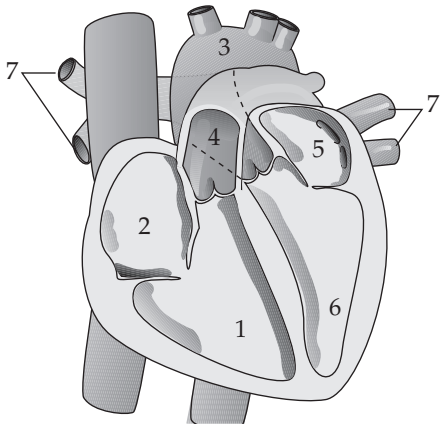
18. Although mutations occur at a regular and predictable rate, which of the following statements is the LEAST likely reason the frequency of mutation appears to be low?
    (A) Some mutations produce alleles that are recessive and may not be expressed.
    (B) Some undesirable phenotypic traits may be prevented from reproducing.
    (C) Some mutations cause such drastic phenotypic changes that they are removed from the gene pool.
    (D) The predictable rate of mutation results in ongoing variability in a gene pool.

19. Which of the following adaptive features would most likely be found in an animal living in a hot arid environment?
    (A) Long loops of henle to maximize water reabsorption
    (B) Storage of water in fatty tissues
    (C) Large ears to aid in heat dispersion
    (D) Short loops of henle to maximize water secretion

20. Which of the following best accounts for the ability of legumes to grow well in nitrogen-poor soils?
    (A) These plants make their own proteins.
    (B) These plants have a mutualistic relationship with nitrogen-fixing bacteria.
    (C) These plants are capable of directly converting nitrogen gas into nitrates.
    (D) These plants do not require nitrogen to make plant proteins.

21. Which of the following is most correct concerning cell differentiation in vertebrates?
    (A) Cells in different tissues contain different sets of genes, leading to structural and functional differences
    (B) Differences in the timing and expression levels of different genes leads to structural and functional differences
    (C) Differences in the reading frame of mRNA leads to structural and functional differences
    (D) Differences between tissues result from spontaneous morphogenesis

Question 22 refers to the diagram below.



22. Which of the following chambers or vessels carry deoxygenated blood in the human heart?
    (A) 4 only
    (B) 1 and 2 only
    (C) 5 only
    (D) 1, 2 and 4

GO ON TO THE NEXT PAGE.

23. In chick embryos, the extraembryonic membrane that provides nourishment to the fetus is the

(A) amnion
(B) chorion
(C) placenta
(D) egg yolk

24. Some strains of viruses can change normal mammalian cells into cancer cells in vitro. This transformation of the mammalian cell is usually associated with the

(A) formation of a pilus between the mammalian cell and the virus
(B) incorporation of the viral genome into the mammalian cell's nuclear DNA
(C) conversion of the host's genome into the viral DNA
(D) release of spores into the mammalian cell

25. The major difference between cartilage and bone is that cartilage

(A) is a part of the skeletal system
(B) is composed of collagen and salts
(C) lacks blood vessels and nerves
(D) secretes a matrix

26. All of the following are examples of events that can prevent interspecific breeding EXCEPT:

(A) The potential mates experience geographic isolation.
(B) The potential mates experience behavioral isolation.
(C) The potential mates have different courtship rituals.
(D) The potential mates have similar breeding seasons.

27. Which of the following is NOT a characteristic of asexual reproduction in animals?

(A) Daughter cells have the same number of chromosomes as the parent cell.
(B) Daughter cells are identical to the parent cell.
(C) The parent cell produces diploid cells.
(D) The daughter cells fuse to form a zygote.

28. Which of the following is the correct characteristic of arteries?

(A) They are thin-walled blood vessels.
(B) They contain valves that prevent backflow.
(C) They always carry oxygenated blood.
(D) They carry blood away from the heart.

29. Transpiration is a result of special properties of water. The special properties of water include all of the following EXCEPT

(A) cohesion
(B) adhesion
(C) capillary action
(D) hydrophobicity

30. Crossing-over occurs during which of the following phases in meiosis?

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

31. Which of the following about meiosis is NOT true?

(A) Meiosis produces two haploid gametes.
(B) Homologous chromosomes join during synapsis.
(C) Sister chromatids separate during meiosis I.
(D) Crossing over increases genetic variation in gametes.

32. A plant grows in the opposite direction of the gravitational force. This is an example of

(A) positive thignotropism
(B) negative phototropism
(C) positive phototropism
(D) negative gravitropism

GO ON TO THE NEXT PAGE.

33. In most ecosystems, net primary productivity is important because it represents the
    (A) energy available to producers
    (B) total solar energy converted to chemical energy by producers
    (C) biomass of all producers
    (D) energy available to heterotrophs

34. Hawkmoths are insects that are similar in appearance and behavior to hummingbirds. Which of the following is LEAST valid?
    (A) These organisms are examples of convergent evolution.
    (B) These organisms were subjected to similar environmental conditions.
    (C) These organisms are genetically related to each other.
    (D) These organisms have analogous structures.

35. Which of the following describes a symbiotic relationship?
    (A) A tapeworm feeds off of its host's nutrients causing the host to lose large amounts of weight.
    (B) Certain plants grow on trees in order to gain access to sunlight, not affecting the tree.
    (C) Remora fish eat parasites off of sharks; the sharks stay free of parasites and the remora fish are protected from predators.
    (D) Meerkats sound alarm calls to warn other meerkats of predators.

36. Destruction of all beta cells in the pancreas will cause which of the following to occur?
    (A) Glucagon secretion will stop and blood glucose levels will increase.
    (B) Glucagon secretion will stop and blood glucose levels will decrease.
    (C) Glucagon secretion will stop and digestive enzymes will be secreted.
    (D) Insulin secretion will stop and blood glucose levels will increase.

37. All of the following are stimulated by the sympathetic nervous system EXCEPT
    (A) dilation of the pupil of the eye
    (B) constriction of blood vessels
    (C) increased secretion of the sweat glands
    (D) increased peristalsis in the gastrointestinal tract

38. The calypso orchid, *Calypso bulbosa*, grows in close association with mycorrhizae fungi. The fungi penetrate the roots of the flower and take advantage of the plant's food resources. The fungi concentrate rare minerals, such as phosphates, in the roots and make them readily accessible to the orchid. This situation is an example of
    (A) parasitism
    (B) commensalism
    (C) mutualism
    (D) endosymbiosis

39. Which of the following are characteristics of both bacteria and fungi?
    (A) Cell wall, DNA, and plasma membrane
    (B) Nucleus, organelles, and unicellularity
    (C) Plasma membrane, multicellularity, and Golgi apparatus
    (D) Cell wall, unicellularity, and mitochondria

40. A sustained decrease in circulating Ca^{2+} levels might be caused by decreased levels of which of the following substances?
    (A) Growth hormone
    (B) Parathyroid hormone
    (C) Thyroid hormone
    (D) Calcitonin

41. The synthesis of new proteins necessary for lactose utilization by the bacterium *E. coli* using the *lac* operon is regulated
    (A) by the synthesis of additional ribosomes
    (B) at the transcription stage
    (C) at the translation stage
    (D) by differential replication of the DNA that codes for lactose-utilizing mechanisms

42. Which of the following statements about trypsin is NOT true?
    (A) It is an organic compound made of proteins.
    (B) It is a catalyst that alters the rate of a reaction.
    (C) It is operative over a wide pH range.
    (D) The rate of catalysis is affected by the concentration of substrate.

GO ON TO THE NEXT PAGE.

43. In DNA replication, which of the following does NOT occur?

(A) Helicase unwinds the double helix.
(B) DNA ligase links the Okazaki fragments.
(C) RNA polymerase is used to elongate both chains of the helix.
(D) DNA strands grow in the 5' to 3' direction.

44. A change in a neuron membrane potential from +50 millivolts to –70 millivolts is considered

(A) depolarization
(B) repolarization
(C) hyperpolarization
(D) an action potential

45. The energy given up by electrons as they move through the electron transport chain is used to

(A) break down glucose
(B) make glucose
(C) produce ATP
(D) make NADH

46. If a photosynthesizing plant began to release $^{18}O_2$ instead of normal oxygen, one could most reasonably conclude that the plant had been supplied with

(A) H_2O containing radioactive oxygen
(B) CO_2 containing radioactive oxygen
(C) $C_6H_{12}O_6$ containing radioactive oxygen
(D) NO_2 containing radioactive oxygen

47. All of the following statements describe the unique characteristics of water EXCEPT:

(A) It is a polar solvent.
(B) It forms hydrogen bonds with disaccharides.
(C) It can dissociate into hydrogen ions and hydroxide ions.
(D) It is a hydrophobic solvent.

48. Chemical substances released by organisms that elicit a physiological or behavioral response in other members of the same species are known as

(A) auxins
(B) hormones
(C) pheromones
(D) enzymes

49. Homologous structures are often cited as evidence for the process of natural selection. All of the following are examples of homologous structures EXCEPT

(A) the wings of a bird and the wings of a bat
(B) the flippers of a whale and the arms of a man
(C) the pectoral fins of a porpoise and the flippers of a seal
(D) the forelegs of an insect and the forelimbs of a dog

50. The sliding action in the myofibril of skeletal muscle contraction requires which of the following?

I. Ca^{2+}
II. ATP
III. actin

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

51. Certain populations of finches have long been isolated on the Galapagos Islands off the western coast of South America. Compared with the larger stock population of mainland finches, these separate populations exhibit far greater variation over a wider range of species. The variation among these numerous finch species is the result of

(A) convergent evolution
(B) divergent evolution
(C) disruptive selection
(D) stabilizing selection

52. Which of the following contributes the MOST to genetic variability in a population?

(A) Sporulation
(B) Binary fission
(C) Vegetative propagation
(D) Mutation

GO ON TO THE NEXT PAGE.

Directions: Each group of questions below concerns an experimental or laboratory situation or data. In each case, first study the description of the situation or data. Then choose the one best answer to each question following it and fill in the corresponding oval on the answer sheet.

Questions 53–55 refer to the following information and table.

A marine ecosystem was sampled in order to determine its food chain. The results of the study are shown below.

Type of Organism	Number of Organisms
Shark	2
Small crustaceans	400
Mackerel	20
Phytoplankton	1000
Herring	100

53. Which of the following organisms in this population are secondary consumers?
    (A) Sharks
    (B) Mackerels
    (C) Herrings
    (D) Small crusteceans

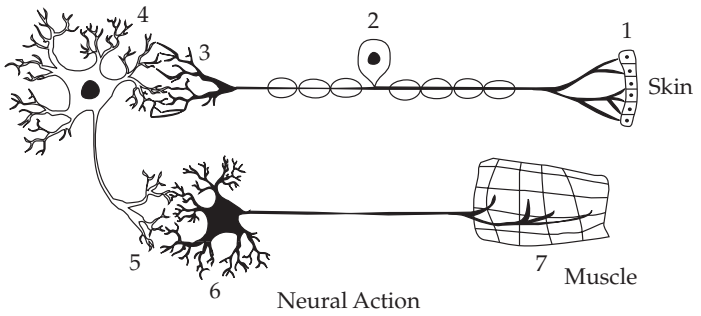
54. Which of the following organisms has the largest biomass in this food chain?
    (A) Phytoplanktons
    (B) Mackerels
    (C) Herrings
    (D) Sharks

55. If the herring population is reduced by predation, which of the following is most likely to occur in this aquatic ecosystem?
    (A) The mackerels will be the largest predator in the ecosystem.
    (B) The small crustacean population will be greatly reduced.
    (C) The plankton population will be reduced over the next year.
    (D) The small crustaceans will become extinct.

GO ON TO THE NEXT PAGE.

Questions 56–58 refer to the following information and diagram.

To understand the workings of neurons, an experiment was conducted to study the neural pathway of a reflex arc in frogs. A diagram of a reflex arc is given below.



56. Which of the following represents the correct pathway taken by a nerve impulse as it travels from the spinal cord to effector cells?

(A) 1-2-3-4
(B) 6-5-4-3
(C) 2-3-4-5
(D) 4-5-6-7

57. The brain of the frog is destroyed. A piece of acid-soaked paper is applied to the frog's skin. Every time the piece of paper is placed on its skin, one leg moves upward. Which of the following conclusions is best supported by the experiment?

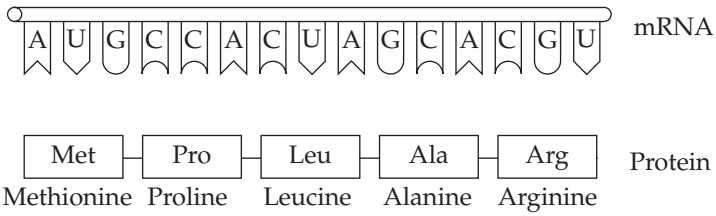
(A) Reflex actions are not automatic.
(B) Some reflex actions can be inhibited or facilitated.
(C) All behaviors in frogs are primarily reflex responses.
(D) This reflex action bypasses the brain.

58. A nerve impulse requires the release of neurotransmitters at the axonal bulb of a presynaptic neuron. Which of the following best explains the purpose of neurotransmitters, such as acetylcholine?

(A) They speed up the nerve conduction in a neuron.
(B) They open the sodium channels in the axonal membrane.
(C) They excite or inhibit the postsynaptic neuron.
(D) They open the potassium channels in the axonal membrane.

GO ON TO THE NEXT PAGE.

Questions 59–61 refer to the figure and chart below.



Formation of a Protein

The Genetic Code: Condons of mRNA that Specify a Given Amino Acid

First Position (5' end)	Second Position	Third Position (3' end) U	C	A	G
U	U	UUU Phenylalanine	UUC Phenylalanine	UUA Lucine	UUG Lucine
	C	UCU Serine	UCC Serine	UCA Serine	UCG Serine
	A	UAU Tytrosine	UAC Tytrosine	UAA	UAG
	G	UGU Cysteine	UGC Cysteine	UGA	UGG Tryptophan
C	U	CUU Leucine	CUC Leucine	CUA Leucine	CUG Leucine
	C	CCU Proline	CCC Proline	CCA Proline	CCG Proline
	A	CAU Histidine	CAC Histidine	CAA Glutamine	CAG Glutamine
	G	CGU Arginine	CGC Arginine	CGA Arginine	CGG Arginine
A	U	AUU Isoleucine	AUC Isoleucine	AUA Isoleucine	AUG
	C	ACU Threonine	ACC Threonine	ACA Threonine	ACG Threonine
	A	AAU Asparagine	AAC Asparagine	AAA Lysine	AAG Lysine
	G	AGU Serine	AGC Serine	AGA Arginine	AGG Arginine
G	U	GUU Valine	GUC Valine	GUA Valine	GUG Valine
	C	GCU	GCC	GCA	GCG
	A	GAU Aspartic Acid	GAC Aspartic Acid	GAA Glutamic acid	GAG Glutamic acid
	G	GGU Glycine	GGC Glycine	GGA Glycine	GGG Glycine

59. Which of the following DNA strands would serve as a template for the amino acid sequence shown above?

(A) 3´ -ATGCGACCAGCACGT- 5´
(B) 3´ -AUGCCACUAGCACGU- 5´
(C) 3´ -TACGGTGATCGTGCA- 5´
(D) 3´ -UACGGUGAUCGUGCA- 5´

60. If a mutation occurs in which uracil is deleted from the messenger RNA after methionine is translated, which of the following represents the resulting amino acid sequence?

(A) serine–histidine–serine–threonine
(B) methionine–proline–glutamine–histidine
(C) methionine–proline–leucine–alanine–arginine
(D) methionine–proline–alanine–arginine–arginine

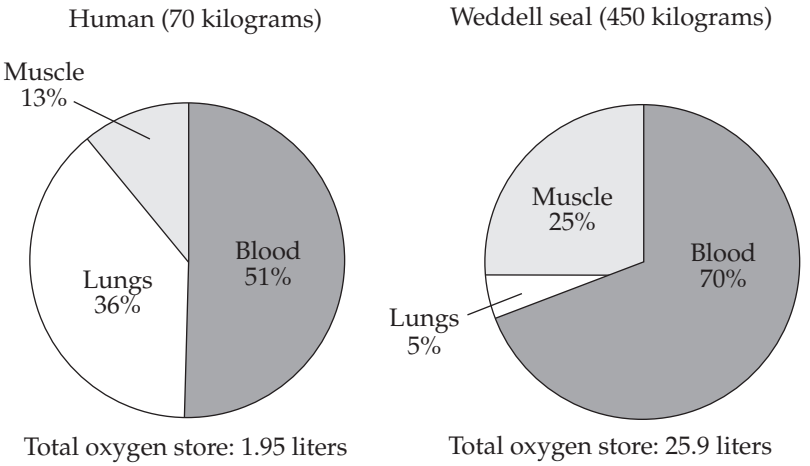
61. The mRNA above was found to be much smaller than the original mRNA synthesized in the nucleus. This is due to the

(A) addition of a poly(A) tail to the mRNA molecule
(B) addition of a cap to the mRNA molecule
(C) excision of exons from the mRNA molecule
(D) excision of introns from the mRNA molecule

GO ON TO THE NEXT PAGE.

Questions 62–63 refer to the following information.

A scientist studies the storage and distribution of oxygen in humans and Weddell seals to examine the physiological adaptations that permit seals to descend to great depths and stay submerged for extended periods. The figure below depicts the oxygen storage in both organisms.



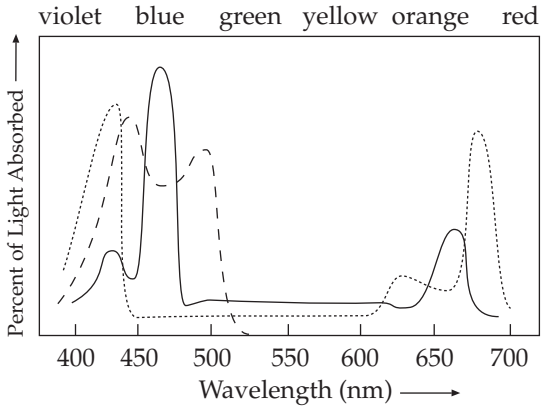
62. Compared with humans, approximately how many liters of oxygen does the Weddell seal store per kilogram of body weight?
    (A) The same amount of oxygen
    (B) Twice the amount of oxygen
    (C) Three times the amount of oxygen
    (D) Five times the amount of oxygen

63. During a dive, a Weddell seal's blood flow to the abdominal organs is shut off and oxygen-rich blood is diverted to the eyes, brain, and spinal cord. Which of the following is the most likely reason for this adaptation?
    (A) To increase the number of red blood cells in the nervous system
    (B) To increase the amount of oxygen reaching the skeletomuscular system
    (C) To increase the amount of oxygen reaching the central nervous system
    (D) To increase the oxygen concentration in the lungs

GO ON TO THE NEXT PAGE.

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

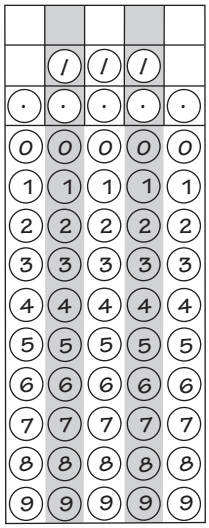
64. An experiment was conducted to observe the light-absorbing properties of chlorophylls and carotenoids using a spectrophotometer. The pigments were first extracted and dissolved in a solution. They were then illuminated with pure light of different wavelengths to detect which wavelengths were absorbed by the solution. The results are presented in the absorption spectrum below.



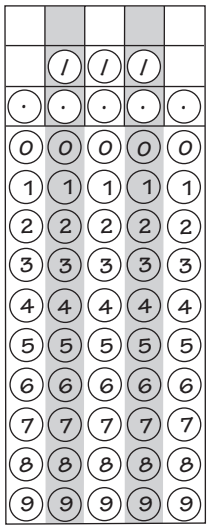
Absorption Spectrum for Green Plants

Chlorophyll *a*
Chlorophyll *b*
Carotenoids

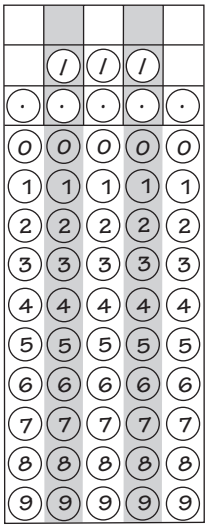
At approximately what wavelength does chlorophyll *a* maximally absorb light?



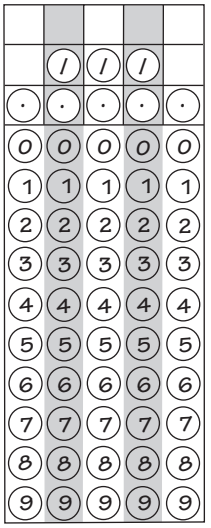
65. A woman with blood genotype I^Ai and a man with blood genotype I^Bi have two children, both type AB. What is the probability that a third child will be blood type AB?



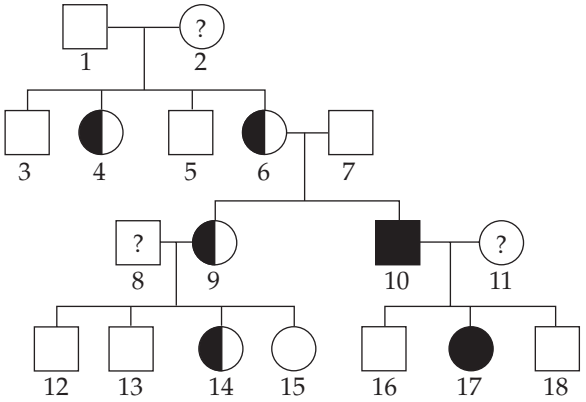
66. The trophic level efficiency of large herbivores such as elks is frequently only about 5 percent. In tons, what volume of plants would be required to maintain 24,000 lbs of elk?



67. If the genotype frequencies of an insect population are AA = 0.49, Aa = 0.42, and aa = 0.09, what is the gene frequency of the recessive allele?

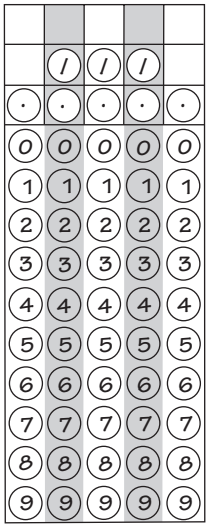


GO ON TO THE NEXT PAGE.

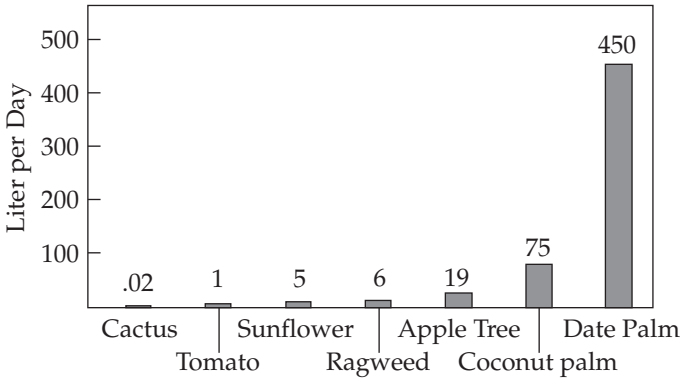


Family Tree for Color Blindness

68. Based on the pedigree above, what is the probability that a male child born to individuals 6 and 7 will be color-blind?

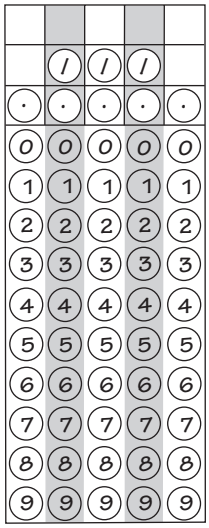


69. The loss of water by evaporation from the leaf openings is known as transpiration. The transpiration rates of various plants are shown below.



Transpiration Rates for Plants

How many liters of water per week are lost by a coconut palm?



END OF SECTION I

This page intentionally left blank.

BIOLOGY
SECTION II
Planning time—10 minutes

Writing time—1 hour and 30 minutes

Directions: Questions 1 and 2 are long-form essay questions that should require about 20 minutes each to answer. Questions 3 through 8 are short free-response questions that should require about 6 minutes each to answer. Read each question carefully and write your response. Answers must be written out. Outline form is not acceptable. It is important that you read each question completely before you begin to write.

1. Cell size is limited by the surface area to volume ratio of the cell membrane.
   a. **Discuss** why cell size is limited by this ratio.
   b. **Describe** two adaptations that increase surface area in organisms.
   c. **Describe** the processes by which small polar and small nonpolar molecules can cross cell membranes according to their concentration gradients and give an example of each type of molecule.

2. Sickle-cell anemia is a genetic disorder caused by the abnormal gene for hemoglobin S. A single substitution occurs in which glutamic acid is substituted for valine in the sixth position of the hemoglobin molecule. This change reduces hemoglobin's ability to carry oxygen.
   a. **Discuss** the process by which mutation occurs in base substitution.
   b. Biologists used gel electrophoresis to initially identify the mutant gene. **Explain** how gel electrophoresis could be applied to the identification of the gene mutation. **Discuss** the use of restriction enzymes.
   c. Hemoglobin S is transmitted as a simple Mendelian allele. **Describe** the outcome if a female who does not carry the abnormal allele mates with a male homozygous for the disease. **Include** a Punnett square and phenotypic and genotypic ratios.

3. The cell membrane is an important structural feature of a nerve cell.
   a. **Discuss** what ions and concentration are associated with the resting state of a neuron.
   b. **Describe** the role of membranes in the conduction of a nerve impulse.

4. **Discuss** the Krebs cycle, the electron transport chain, and oxidative phosphorylation.
   a. **Explain** why these steps are considered aerobic processes.
   b. **Discuss** the location at which **each** stage occurs.

GO ON TO THE NEXT PAGE.

5. **Describe** three main differences between meiosis and mitosis.

6. **Define** homologous structures and give an example.

7. **Describe** the three ways that genetic information is transmitted laterally between bacteria.

8. **Describe** why viruses are typically not considered to be alive.

STOP

END OF EXAM