



Practice Test 3

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. Answer sheets are available in the back of this book and online in your Students Tools (More Free Content). 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.

BIOLOGY
SECTION I

60 Questions

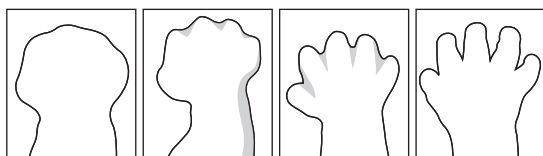
Time—90 minutes

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.

- Acid precipitation is caused by the release of molecules, such as sulfur dioxide and nitrogen oxide, into the atmosphere, where they chemically react with oxygen and water. The products of these reactions are acidic compounds that cause pollution. A scientist wants to propose a strategy to reduce acid precipitation. Which of the following strategies would be most effective?
 - Restrict the quantities and types of exhaust that factories are able to release into the atmosphere
 - Require industrial factories to release their exhaust higher in the atmosphere
 - Use buffers to neutralize large bodies of water with acidic pHs
 - Implement a purification system that removes heavy metals from industrial exhaust
- The Krebs cycle in humans releases
 - carbon dioxide
 - pyruvate
 - glucose
 - lactic acid
- A heterotroph
 - obtains its energy from sunlight, harnessed by pigments
 - obtains its energy by catabolizing organic molecules
 - makes organic molecules from CO_2
 - obtains its energy by consuming exclusively autotrophs
- Regarding meiosis and mitosis, one difference between the two forms of cellular reproduction is that in meiosis
 - there is one round of cell division, whereas in mitosis there are two rounds of cell division
 - separation of sister chromatids occurs during the second division, whereas in mitosis separation of sister chromatids occurs during the first division
 - chromosomes are replicated during interphase, whereas in mitosis chromosomes are replicated during the first phase of mitosis
 - spindle fibers form during interphase, whereas in mitosis the spindle fibers form during prophase
- A feature of amino acids that is NOT found in carbohydrates is the presence of
 - carbon atoms
 - oxygen atoms
 - nitrogen atoms
 - hydrogen atoms
- Which of the following is NOT a characteristic of prokaryotic cells?
 - Circular double-stranded DNA
 - Membrane-bound cellular organelles
 - Plasma membrane consisting of lipids and proteins
 - Ribosomes that synthesize polypeptides
- Which of the following best explains why a population is described as the evolutionary unit?
 - Genetic changes can occur only at the population level.
 - The gene pool in a population remains fixed over time.
 - Natural selection affects individuals, not populations.
 - Individuals cannot evolve, but populations can.
- The endocrine system maintains homeostasis using many feedback mechanisms. Which of the following is an example of positive feedback?
 - Infant suckling causes a mother's brain to release oxytocin, which in turn stimulates milk production.
 - An enzyme is allosterically inhibited by the product of the reaction it catalyzes.
 - When ATP is abundant, the rate of glycolysis decreases.
 - When blood sugar levels decrease to normal after a meal, insulin is no longer secreted.

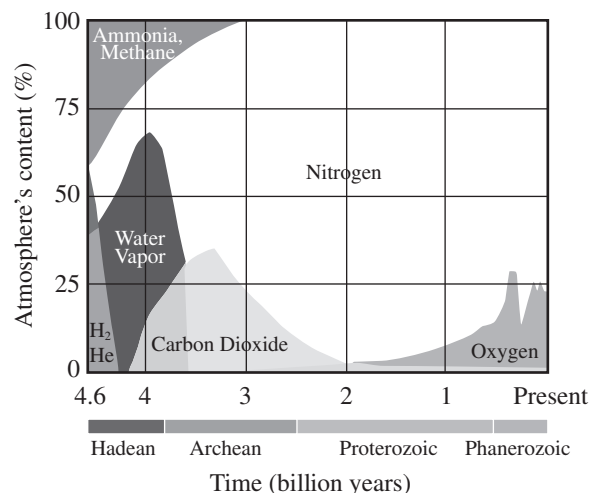
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9. A sample of double-stranded DNA from a chimpanzee contains 15,000 base pairs. How many nucleotides are contained in the sample?
- (A) 5,000
 (B) 15,000
 (C) 30,000
 (D) 45,000
10. A large island is devastated by a volcanic eruption. Most of the horses die except for the heaviest males and heaviest females of the group. They survive, reproduce, and perpetuate the population. If weight is a highly heritable trait, which statement most likely represents the change in population before and after the eruption?
- (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. Which of the following plays a role in the formation of fingers and toes in human embryos?



- (A) apoptosis
 (B) meiosis
 (C) operons
 (D) plasmids

12. Life is believed to have begun 3.5 million years ago. During this time, which of the following gases did the atmosphere on primitive Earth lack?



- (A) oxygen
 (B) carbon dioxide
 (C) ammonia
 (D) methane

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Questions 13–14 refer to the following passage.

The digestive system in humans can be divided into two parts: the alimentary canal and the accessory organs. The canal comprised of the esophagus, stomach, and intestines is where the food actually passes during its transition into waste. The accessory organs are any organs that aid in the digestion by supplying the organs in the alimentary canal with digestive hormones and enzymes.

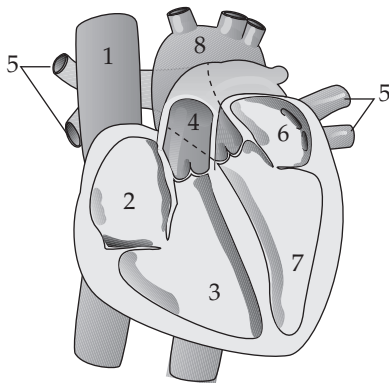
13. The small intestine is the main site of absorption. It can accomplish it so efficiently because of villi and microvilli that sculpt the membrane into hair-like projections. They likely aid in reabsorption by
- increasing the surface area of the small intestine
 - decreasing the surface area of the small intestine
 - making the small intestine more hydrophilic
 - making the small intestine more hydrophobic
14. The pancreas is a major accessory organ in the digestive system. Which of the following would destroy the function of the digestive products produced by the pancreas?
- A decrease in absorption rates within the alimentary canal
 - Removing the excess water from the food waste
 - Increased acidity due to the inability to neutralize stomach acid
 - An increase in peristalsis and subsequent diarrhea
15. In animal cells, which of the following represents the most likely pathway that a secreted protein takes as it is synthesized in a cell?
- Plasma membrane–Golgi apparatus–ribosome–secretory vesicle–rough ER
 - Ribosome–Golgi apparatus–rough ER–secretory vesicle–plasma membrane
 - Plasma membrane–Golgi apparatus–ribosome–rough ER–secretory vesicle
 - Ribosome–rough ER–Golgi apparatus–secretory vesicle–plasma membrane
16. A scientist analyzes the nucleotides contained in a sample of DNA from a firefly and finds that 30% of the nucleotides are adenine. What percentage of the nucleotides are cytosine?
- 20%
 - 30%
 - 50%
 - 70%
17. Once specific genes, such as the gene coding for ampicillin, have been incorporated into a plasmid, the plasmid may be used to carry out a transformation, which is
- inserting it into a bacteriophage
 - treating it with a restriction enzyme
 - inserting it into a suitable bacterium
 - running a gel electrophoresis
18. Although mutations occur at a regular and predictable rate, which of the following statements is a possible reason that the frequency of mutation often *appears* to be low?
- Some mutations produce alleles that are dominant and are always expressed.
 - Some undesirable phenotypic traits may be prevented from reproducing.
 - Some mutations cause neutral phenotypic changes that linger in the gene pool.
 - The predictable rate of mutation results in ongoing variability in a gene pool.
19. A scientist wants to test the effect of temperature on seed germination. Which of the following should be part of the experimental design?
- Use temperature as the dependent variable and alter the germination times.
 - Use temperature as the independent variable and measure the rate of germination.
 - Use temperature as the controlled variable and keep everything identical between groups.
 - Use the variable natural outside temperature as a control group.
20. A mustard plant seed undergoes a polyploidy event resulting in the new plant's pollen being unable to pollinate the plant that originally produced the seed despite them being less than a meter apart. This best exemplifies which of the following?
- Allopatric speciation because the plants remain in close contact
 - Allopatric speciation because there is a significant geographic barrier
 - Sympatric speciation because it is the simplest form of speciation
 - Sympatric speciation because the plants are not separated

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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 lead to structural and functional differences.
 - (C) Differences in the reading frame of mRNA lead to structural and functional differences.
 - (D) Differences between tissues result from spontaneous morphogenesis.

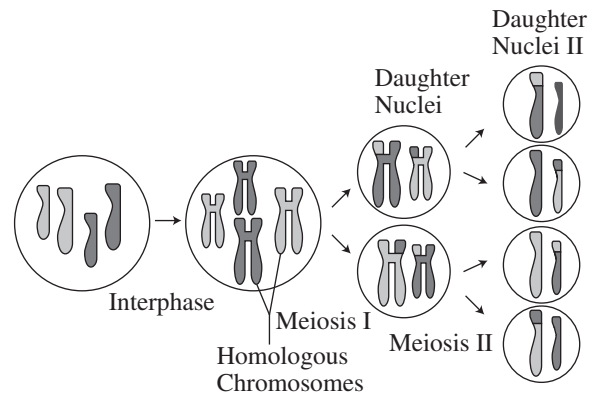
Questions 22–23 refer to the following passage.

Pumping blood through the human heart must be carefully organized for maximal efficiency and to prevent backflow. In the figure below, the blood enters the heart through the vena cava (1), passes through the right atrium and right ventricle and then goes through the pulmonary artery toward the lungs. After the lungs, the blood returns through the pulmonary vein and then passes into the left atrium and the left ventricle before leaving the heart via the aorta.



22. Which of the following chambers or vessels carry deoxygenated blood in the human heart?
- (A) 1 only
 - (B) 2 and 3
 - (C) 1, 2, 3, 4
 - (D) 4 and 5
23. Blood is pumped via heart contractions triggered by action potentials spreading through the heart muscle. If there is a sudden increase in blood in chamber 3, which chamber of the heart received an increased number of action potentials?
- (A) Left atrium
 - (B) Left ventricle
 - (C) Right atrium
 - (D) Right ventricle

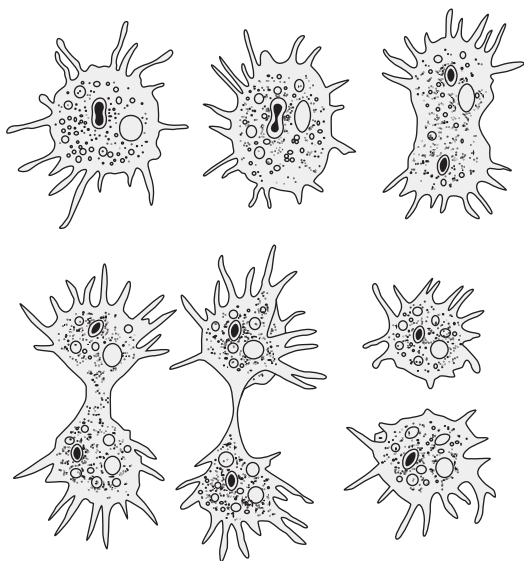
24. Some strains of viruses can change normal mammalian cells into cancer cells in vitro. Which of the following is the best explanation for this impact on the mammalian cell?
- (A) A pilus is formed between the mammalian cell and the virus.
 - (B) The viral genome incorporates into the mammalian cell's nuclear DNA.
 - (C) The host's genome is converted into the viral DNA.
 - (D) There is a viral release of spores into the mammalian cell.
25. Which of the following statements correctly describes meiosis?



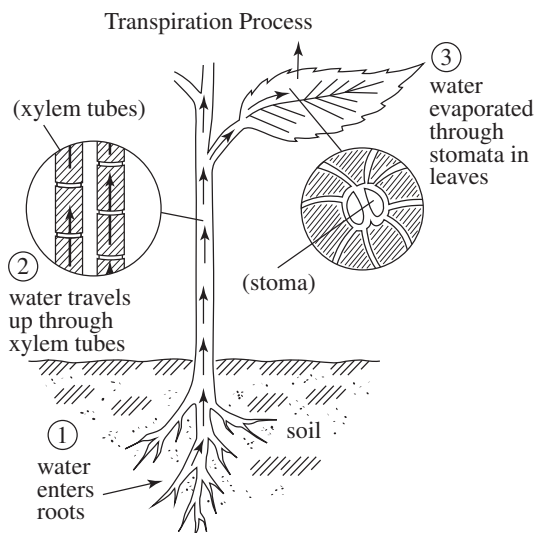
- (A) Meiosis produces four diploid gametes.
 - (B) Homologous chromosomes join during meiosis II.
 - (C) Sister chromatids separate during meiosis I.
 - (D) Crossing-over increases genetic variation in gametes.
26. A scientist wants to explore events that can prevent interspecies breeding. Which of the following breeding combinations would allow the scientist to investigate barriers to interspecies breeding?
- (A) A male and female from two different species of finches that live on different islands
 - (B) Two female sea turtles from the same species
 - (C) Two male blue-footed boobies that perform a mating dance
 - (D) A male and female bear from the same species with different colored fur

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27. Which of the following is a characteristic of asexual reproduction in animals?



- (A) Progeny cells have a different number of chromosomes from the parent cell.
 (B) Progeny cells are identical to the parent cell.
 (C) The parent cell produces haploid cells.
 (D) The progeny cells require another organism to form a zygote.
28. Transpiration is a result of special properties of water. Which of the following is a special property of water that makes transpiration possible?



- (A) nonpolarity
 (B) adhesion
 (C) high heat capacity
 (D) hydrophobicity

Questions 29–32 refer to the following passage.

An experiment was performed to assess the growth of two species of plants when they were grown in different pHs, given different volumes of water, and watered at different times of day over 6 weeks. Two plants were grown of each species and the average heights (in cm) are shown in the table.

		Species A	Species B
pH	2	3.2	4.1
	4	37.6	20.6
	7	62.3	22.4
	10	48.4	13.5
	13	4.1	2.7
Volume (mL)	10	4.9	12.4
	20	19.2	38.9
	40	56.2	45.6
	80	65.1	21.5
	160	2.6	1.8
Time	12:00 A.M.	62.3	20.3
	7:00 A.M.	61.1	21.8
	12:00 P.M.	66.7	18.4
	7:00 P.M.	65.3	19.3

29. For which conditions do the species have different preferences?
- (A) pH
 (B) Volume
 (C) Volume and watering time
 (D) pH and volume and watering time
30. What are the preferred growth conditions for Species B?
- (A) pH 7, 40 mL, any time of day
 (B) pH 10, 40 mL, 7:00 A.M.
 (C) pH 7, 80 mL, any time of day
 (D) pH 10, 80 mL, 12:00 P.M.
31. Which pH and volume were likely used for the watering time experiment?
- (A) pH 4 and 40 mL
 (B) pH 7 and 40 mL
 (C) pH 4 and 80 mL
 (D) pH 7 and 80 mL

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32. Which of the following would most improve the statistical significance of the results?
- (A) Let the plants grow for a longer period of time.
 - (B) Add more conditions to test, such as amount of light and amount of soil.
 - (C) Test the same plants with more pHs and more volumes and times of day.
 - (D) Increase the number of plants in each group.
33. Photoperiodism in plants, in which plants respond to the stimulus of the day lengthening or shortening, can be best compared to which of the following phenomena in animals?
- (A) Viral infection
 - (B) Increased appetite
 - (C) Meiotic cell division
 - (D) Circadian rhythms
34. In most ecosystems, gross primary productivity—the total amount of chemical energy that producers create in a given time—is not entirely available for the consumers to utilize due to which explanation below?
- (A) Not all solar energy is in the correct spectrum for plants to absorb it.
 - (B) Plants utilize some energy for the cellular respiration.
 - (C) Heterotrophs do not absorb energy from autotrophs.
 - (D) Very little biomass is available at the producer level.
35. Hawkmoths are insects that are similar in appearance and behavior to hummingbirds. Which of the following is a valid explanation for these similarities?
- (A) These organisms are examples of convergent evolution.
 - (B) These organisms were subjected to different environmental conditions.
 - (C) These organisms are genetically related to each other.
 - (D) These organisms have homologous structures.
36. Which of the following describes a mutualistic relationship?
- (A) A tapeworm feeds off 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 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.

37. The pancreas is an organ that makes insulin and glucagon in its beta and alpha cells, respectively. Insulin is released when blood glucose is high, and glucagon is released when blood glucose is low. Anti-beta cell antibodies, which bind to their target and inhibit functionality, will cause which of the following to occur?
- (A) Glucagon secretion will stop, and blood glucose levels will not decrease.
 - (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 not decrease.

Questions 38–39 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	

38. 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.
39. 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

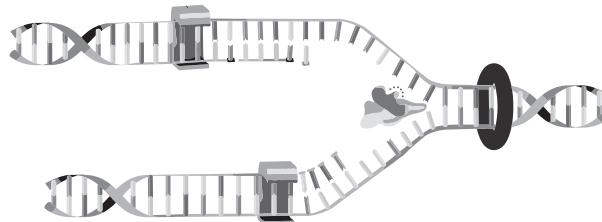
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Questions 40–41 refer to the following passage and table.

A scientist wanted to study how the enzyme catalase breaks down hydrogen peroxide. Catalase was extracted from vegetables by pureeing them with either 20°C water or 100°C water. The scientist made 2% and 16% hydrogen peroxide solutions. Filter paper was soaked in the blended catalase and placed into containers with the hydrogen peroxide solutions. The scientist measured the number of seconds, up to 100, it took for the disks to float to the top of the hydrogen peroxide solutions due to the bubbles produced in order to measure the enzyme's activity. The data is in the table below.

Concentration of H ₂ O ₂ Solution	Temperature of Catalase	Average Time to Float (s)
2%	20°C	45
2%	100°C	100+
16%	20°C	20
16%	100°C	100+

40. What happened to the catalase enzyme that caused it to stop functioning at the higher temperature?
- (A) The catalase enzyme did not stop functioning at any point.
 (B) The catalase enzyme worked to its full capacity and hit a limit of how much product it could produce per second.
 (C) The reaction ran out of substrate to continue producing bubbles.
 (D) The catalase enzyme's structure was changed, so the substrate was no longer able to bind.
41. According to the data, does catalase have greater functionality at higher or lower temperatures and concentrations?
- (A) Higher concentrations and lower temperatures
 (B) Higher concentrations and higher temperatures
 (C) Lower concentrations and lower temperatures
 (D) Lower concentrations and higher temperatures
42. 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
43. The synthesis of new proteins necessary for lactose utilization by the bacterium *E. coli* using the *lac* operon is regulated by the ability of RNA polymerase to bind and advance. This regulation can best be described as
- (A) bacterial regulation
 (B) pre-transcriptional regulation
 (C) pre-translational regulation
 (D) post-translational regulation
44. Trypsin is a digestive enzyme. It cleaves polypeptides after lysine and arginine amino acid residues. 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.
45. In DNA replication, which of the following occurs?



- (A) Topoisomerase 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.

46. Which of the following is true about genetic variation?
- (A) Mutation is the greatest source of genetic variation.
 (B) Ecosystems with high levels of genetic variation are not resistant to stress.
 (C) Mitosis provides genetic variation to most somatic cells.
 (D) Crossing-over prevents plants from undergoing speciation.
47. Approximately how many ATP will be generated from the electron transport chain from the two pyruvate molecules that enter the Krebs cycle?
- (A) 2
 (B) 10
 (C) 15
 (D) 18

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48. If a plant undergoing the light-dependent reactions of photosynthesis began to release $^{18}\text{O}_2$ instead of normal oxygen, one could most reasonably conclude that the plant had been supplied with
- H_2O containing radioactive oxygen
 - CO_2 containing radioactive oxygen
 - $\text{C}_6\text{H}_{12}\text{O}_6$ containing radioactive oxygen
 - NO_2 containing radioactive oxygen
49. Yeast haploid cells secrete pheromones to other yeast to indicate they want to mate, and others respond by growing toward these potential mates. The pheromones bind to a receptor, which eventually leads to increased expression of transcription factors required for this growth. This best exemplifies which of the following?
- Chemical inhibition due to the intracellular binding site
 - Passive transport since the haploid cells require less energy
 - Mitotic division due to anaphase elongation
 - Signal transduction affecting cell function
50. Homologous structures are often cited as evidence for the process of natural selection. Which of the following is an example of a pair of analogous structures?
- the forearms of a cat and the wings of a bat
 - the flippers of a whale and the arms of a man
 - the pectoral fins of a porpoise and the flippers of a seal
 - the forelegs of an insect and the forelimbs of a dog
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
- convergent evolution
 - divergent evolution
 - disruptive selection
 - stabilizing selection
52. Which of the following contributes the MOST to genetic variability in a population?
- Sporulation
 - Binary fission
 - Vegetative propagation
 - Mutation

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.

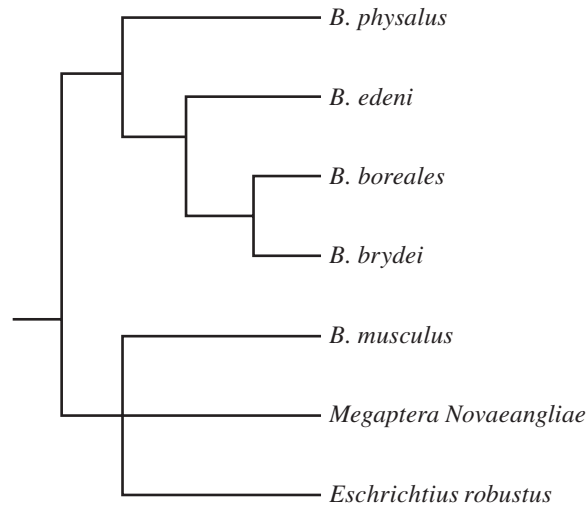
Type of Organism	Number of Organisms
Shark	2
Small crustaceans	400
Mackerel	20
Phytoplankton	1,000
Herring	100

53. Which of the following organisms in this population are secondary consumers?
- Sharks
 - Phytoplankton
 - Herrings
 - Small crustaceans
54. Which of the following organisms has the largest biomass in this food chain?
- Phytoplankton
 - Mackerels
 - Herrings
 - Sharks
55. If the herring population is reduced by predation, which of the following would most likely be a secondary effect on the ecosystem?
- The mackerels will be the largest predator in the ecosystem.
 - The small crustacean population will be greatly reduced.
 - The phytoplankton population will be reduced over the next year.
 - The small crustaceans will become extinct.

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Questions 56–57 refer to the following information and diagram.

Scientists used embryology, morphology, paleontology, and molecular biology to create the phylogenetic tree below.



56. Which of the following is the LEAST closely related according to the phylogenetic tree?

- (A) *B. physalus* and *B. brydei*
- (B) *B. boreales* and *B. brydei*
- (C) *B. musculus* and *B. brydei*
- (D) *B. musculus* and *Eschrichtius robustus*

57. Which of the sources of evolutionary evidence would be the most reliable of those listed?

- (A) Embryology
- (B) Morphology
- (C) Paleontology
- (D) Molecular biology

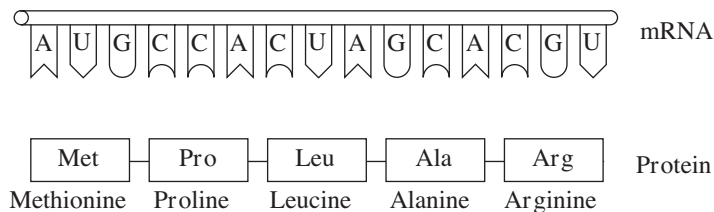
58. The brain of the frog is destroyed. A piece of acid-soaked paper is applied to the frog's skin. Every time the piece of paper is placed on its skin, one leg moves upward. Which of the following conclusions is best supported by the experiment?

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

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Questions 59–60 refer to the figure and chart below.

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



Formation of a Protein

59. Which of the following DNA strands is the template strand that led to the amino acid sequence shown above?
- (A) 3'-ATGCGACCAGCACGT-5'
 (B) 3'-AUGCCACUAGCAGCU-5'
 (C) 3'-TACGGTGATCGTGCA-5'
 (D) 3'-UACGGUGAUCGUGCA-5'
60. Immediately after the translation of methionine, a chemical is added which deletes all remaining uracil nucleotides in the mRNA. 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

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. At what level does natural selection operate: the individual or the group? This is a central question in the field of sociobiology. In 1962, V. C. Wynne Edwards put forth his revolutionary group selection thesis, which states that animals avoid overexploitation of their habitats, especially with regard to food supply. In his theory, they accomplish this by altruistic restraint on the part of individuals who reduce their reproduction, or refrain altogether, to avoid overpopulation. Thus altruism is favored by natural selection.

For example, small birds of the species *Parus major* typically produce nine or ten eggs per clutch, although they have been observed to produce as many as thirteen eggs per clutch. Data show that a clutch size larger than nine or ten actually produces fewer surviving offspring. See Figure 1; the vertical axis gives the percent occurrence of each brood size, and the numbers labeling the dots indicate the number of known survivors per nest.

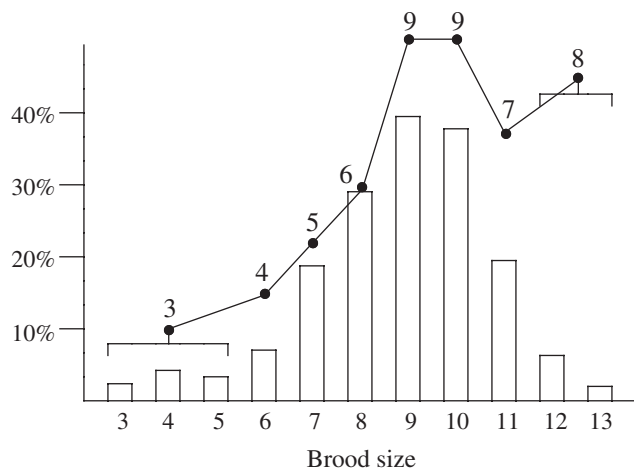


Figure 1

Additional evidence for the group-selection theory is that there appears to be a relationship between reproductive success of individuals and the density of the population. When density is low, mortality is likewise low and

reproductive rate high. At high numbers resources are more scarce, and it is more difficult to stay alive and to reproduce, so mortality is high and reproductivity low. Figure 2 shows the number of surviving offspring per mating pair plotted against the number of breeding adults present (the graph covers several years).

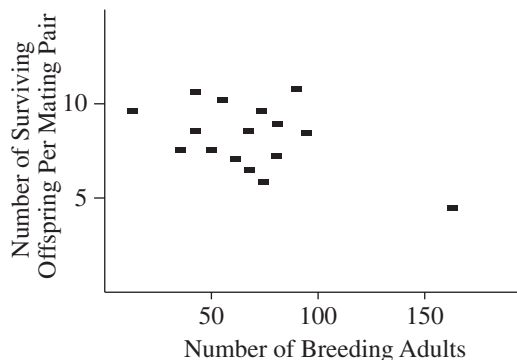


Figure 2

- (a) **Describe** the carrying capacity in a population, and whether or not a brood size can have a carrying capacity. **Justify** your choice.
- (b) This study involved observing birds in their natural habitat. **Identify** the independent variable in this brood size vs. percent survival study. **Describe** what makes an observational study different from a study inside a lab environment.
- (c) **Describe** the brood size(s) in which 100% of the offspring survive. **Identify** which brood size has the highest percent of mortality.
- (d) Over many more years the number of breeding adults was measured, and it was found that over a long time the number of breeding adults averaged around 100. **Describe** how this would change the information in Figure 1. **Justify** your answer.

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2. Diabetes mellitus type 2 (T2DM) is a metabolic disorder characterized by insulin resistance on the part of the body's tissues. Onset is usually much later in life and highly associated with obesity. A recent study evaluated the relative dysfunction of mitochondria of individuals who were lean, obese, and diabetic (type 2). Muscle biopsies were taken both prior to and after a twenty-week exercise program. The mitochondrial mass was measured by cardiolipin, the citric acid cycle was measured by citrate synthase, and electron transport chain activity was measured by NADH oxidase levels. The results are shown below in the table.

Table 1. Mean (upper rows) and standard error (lower rows) measurements for markers of ETC activity, in relative units normalized to creatine kinase activity.

	Cardiolipin		Citrate synthase		NADH oxidase	
Mean	Before	After	Before	After	Before	After
Lean ($n = 10$)	70	109	2.4	3.2	0.45	0.63
Obese ($n = 9$)	72	83	3.7	5.2	0.16	0.29
T2DM ($n = 11$)	58	86	3.3	5.1	0.15	0.28
Std Error	Before	After	Before	After	Before	After
Lean ($n = 10$)	6.1	5.2	0.2	0.4	0.1	0.12
Obese ($n = 9$)	7.9	4.8	0.3	0.5	0.05	0.1
T2DM ($n = 11$)	6.5	7.3	0.2	0.5	0.04	0.08

- (a) **Explain** how the citric acid cycle and the electron transport chain are related and how they are affected by exercise.
- (b) **Construct** a graph of the data indicating citric acid cycle activity. Be sure to use error bars.
- (c) **Identify** which group did not show an increase in cardiolipin after exercise was done. **Justify** your choice with data.
- (d) If another measure of the citric acid cycle were added in a future experiment, **explain** what results you would expect.
3. Maternal inheritance is one pattern of inheritance which does not follow the rules of Mendelian genetics. It is an example of uniparental inheritance in which all progeny have the genotype and phenotype of the female parent.

Maternal inheritance can be demonstrated in the haploid fungus *Neurospora* by crossing the fungi in such a way that one parent contributes the bulk of the cytoplasm to the progeny. This cytoplasm-contributing parent is called the female parent, even though no true sexual reproduction occurs. The inheritance patterns of a mutant strain of *Neurospora* called poky have been studied using such crosses. Poky differs from the wild-type in that it is slow-growing and has abnormal quantities of cytochromes.

Investigators suspected that the poky mutation was carried in the mitochondria, instead of in the nuclear genome. The following experiments were designed to test this hypothesis.

Step 1: Mitochondria were extracted from poky *Neurospora* mutants.

Step 2: An ultrafine needle and syringe was used to inject these mitochondria into wild-type *Neurospora* cells.

Step 3: These recipient cells were cultured for several generations, and the phenotypes were examined.

Results: The poky phenotype was observed in some of the cultured fungi.

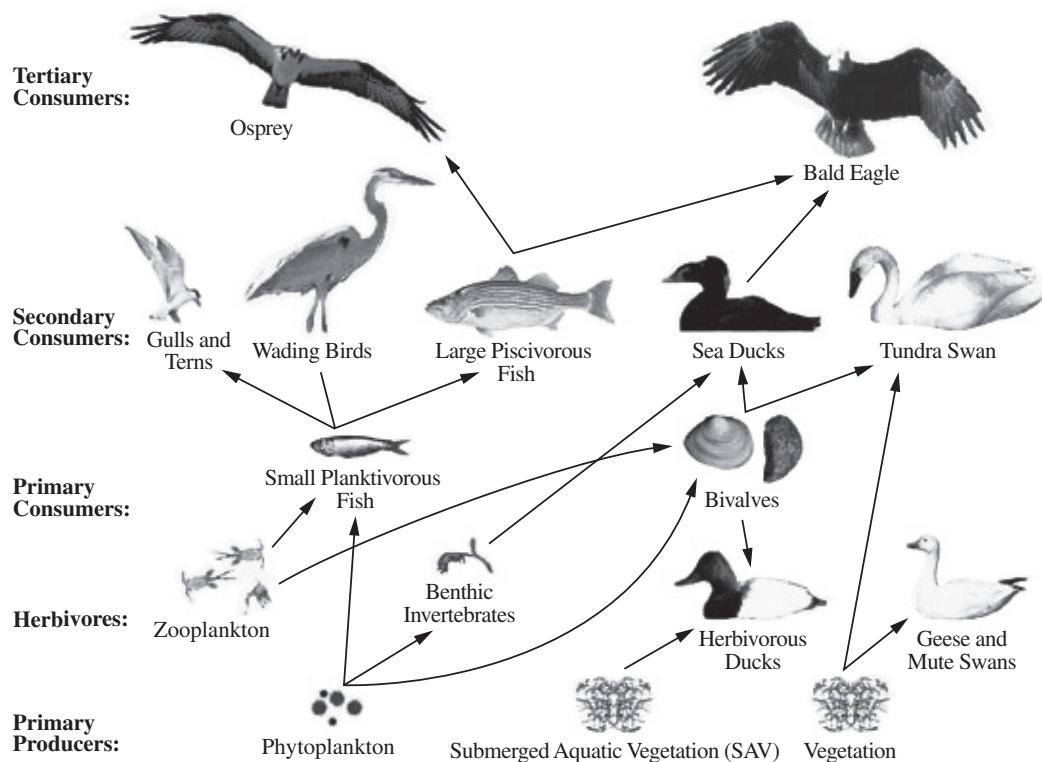
- (a) In mitochondrial inheritance the offspring have the genotype and phenotype of the mother. Under Mendelian inheritance it is possible for the offspring to have a different genotype but the same phenotype as the mother. **Describe** how this is possible.
- (b) **Explain** what important control(s) the scientists should do to account for the procedure in Step 2.
- (c) If the nuclear DNA was injected into the wild-type *Neurospora* cells instead of the mitochondria, **identify** whether the resulting fungi would have the poky phenotype.
- (d) **Justify** your prediction.

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4. A diverse flock of finches that can eat many sizes of seeds lives on a small island in Polynesia, which recently experienced a drought. Trees producing robust, medium-sized seeds died out in large numbers, but more resilient trees that produced both small and large-sized seeds are thriving. The finches can shelter in the trees or in burrows underground. The island is home to several tree species that do not produce edible seeds and small rodents that also eat the seeds.
- (a) Finches are incapable of digging burrows, yet approximately 25% of the finches found on the island live in underground dwellings. **Describe** the source of the finch dwellings.
- (b) **Describe** the relationship between the finches and rodents on the island.
- (c) Protein HITB8 is found to be present in high levels in medium-sized beak finches and less so in other finch types. **Predict** what will happen to the frequency of this protein product in the finch population after two generations if the drought continues.
- (d) **Justify** your answer to (c).

5.

Chesapeake Bay Waterbird Food Web



- (a) **Describe** the importance of being the sole occupant of a niche in an ecosystem.
- (b) **Describe** the impact of an invasive species that competes with phytoplankton and zooplankton.
- (c) **Identify** the number of species with no natural predator on this food web.
- (d) **Explain** why toxins are more of a concern for tertiary consumers than they are for primary consumers.

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6. A teacher observes squirrels frequently crossing the road and wants to determine if squirrels prefer one side of the road to the other. At 4:00 P.M. for three non-consecutive days the teacher counts the number of squirrels on each side. The north side has predominantly pine trees, while the south side has mostly red maple trees.

Table 1

	North Side	South Side
Monday	21	15
Wednesday	18	18
Friday	22	14
Average		

- (a) **Identify** the null hypothesis of this experiment.
- (b) **Complete** the table with the average data and values necessary to test the hypothesis. (All white empty blanks should be filled.)

	O	E	O-E	(O-E) ²	(O-E) ² /E
North Side					
South Side					
				$\chi^2 =$	

- (c) Use statistics to **determine** whether the null hypothesis should be rejected.
- (d) **Explain** how the results of the experiment support the theory that animal behavior changes as their environment changes.

STOP

END OF EXAM
