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GRADUATE RECORD EXAMINATIONS®

Biology Test Practice Book

This practice book contains

- one actual, full-length GRE® Biology Test
- test-taking strategies

Become familiar with

- test structure and content
- test instructions and answering procedures

Compare your practice test results with the performance of those who took the test at a GRE administration.

This book is provided **FREE** with test registration by the Graduate Record Examinations Board.

www.ets.org/gre

Note to Test Takers: Keep this practice book until you receive your score report. This book contains important information about scoring.

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Purpose of the GRE Subject Tests

The GRE Subject Tests are designed to help graduate school admission committees and fellowship sponsors assess the qualifications of applicants in specific fields of study. The tests also provide you with an assessment of your own qualifications.

Scores on the tests are intended to indicate knowledge of the subject matter emphasized in many undergraduate programs as preparation for graduate study. Because past achievement is usually a good indicator of future performance, the scores are helpful in predicting success in graduate study. Because the tests are standardized, the test scores permit comparison of students from different institutions with different undergraduate programs. For some Subject Tests, subscores are provided in addition to the total score; these subscores indicate the strengths and weaknesses of your preparation, and they may help you plan future studies.

The GRE Board recommends that scores on the Subject Tests be considered in conjunction with other relevant information about applicants. Because numerous factors influence success in graduate school, reliance on a single measure to predict success is not advisable. Other indicators of competence typically include undergraduate transcripts showing courses taken and grades earned, letters of recommendation, and GRE General Test scores. For information about the appropriate use of GRE scores, see the *GRE Guide to the Use of Scores* at **ets.org/gre/stupubs**.

Development of the Subject Tests

Each new edition of a Subject Test is developed by a committee of examiners composed of professors in the subject who are on undergraduate and graduate faculties in different types of institutions and in different regions of the United States and Canada. In selecting members for each committee, the GRE Program seeks the advice of appropriate professional associations in the subject.

The content and scope of each test are specified and reviewed periodically by the committee of examiners. Test questions are written by committee members and by other university faculty members who are subject-matter specialists. All questions proposed for the test are reviewed and revised by the committee and subject-matter specialists at ETS. The tests are assembled in accordance with the content specifications developed by the committee to ensure adequate coverage of the various aspects of the field and, at the same time, to prevent overemphasis on any single topic. The entire test is then reviewed and approved by the committee.

Subject-matter and measurement specialists on the ETS staff assist the committee, providing information and advice about methods of test construction and helping to prepare the questions and assemble the test. In addition, each test question is reviewed to eliminate language, symbols, or content considered potentially offensive, inappropriate for major subgroups of the test-taking population, or likely to perpetuate any negative attitude that may be conveyed to these subgroups.

Because of the diversity of undergraduate curricula, it is not possible for a single test to cover all the material you may have studied. The examiners, therefore, select questions that test the basic knowledge and skills most important for successful graduate study in the particular field. The committee keeps the test up-to-date by regularly developing new editions and revising existing editions. In this way, the test content remains current. In addition, curriculum surveys are conducted periodically to ensure that the content of a test reflects what is currently being taught in the undergraduate curriculum.

After a new edition of a Subject Test is first administered, examinees' responses to each test question are analyzed in a variety of ways to determine whether each question functioned as expected. These analyses may reveal that a question is ambiguous, requires knowledge beyond the scope of the test, or is inappropriate for the total group or a particular subgroup of examinees taking the test. Such questions are not used in computing scores.

Following this analysis, the new test edition is equated to an existing test edition. In the equating process, statistical methods are used to assess the difficulty of the new test. Then scores are adjusted so that examinees who took a more difficult edition of the test are not penalized, and examinees who took an easier edition of the test do not have an advantage. Variations in the number of questions in the different editions of the test are also taken into account in this process.

Scores on the Subject Tests are reported as three-digit scaled scores with the third digit always zero. The maximum possible range for all Subject Test total scores is from 200 to 990. The actual range of scores for a particular Subject Test, however, may be smaller. For Subject Tests that report subscores, the maximum possible range is 20 to 99; however, the actual range of subscores for any test or test edition may be smaller than 20 to 99. Subject Test score interpretive information is provided in *Interpreting Your GRE Scores*, which you will receive with your GRE score report. This publication is also available at **ets.org/gre/stupubs**.

Content of the Biology Test

The GRE Biology examination is designed to evaluate the following abilities and background of the student.

- Knowledge of basic vocabulary and facts in several biological fields at the equivalent of an upper-level course.
- Conceptual understanding of ideas, relationships, and processes
- Understanding of basic scientific research, procedures, and tools
- Capacity to read, evaluate, and draw conclusions from unfamiliar laboratory and field studies
- Understanding of the connections among biological fields and between biological fields and allied sciences

The test contains about 200 five-choice questions, a number of which are grouped in sets toward the end of the test and are based on descriptions of laboratory and field situations, diagrams, or experimental results.

To cover the broad field of the biological sciences, the subject matter on which the students are tested is organized into three major areas: cellular and molecular biology; organismal biology; and ecology and evolution. Approximately equal weight is given to each of these three areas. In addition to the total score, a subscore in each of these subareas is reported.

The approximate distribution of questions by content category is shown below. However, subject areas indicated by Arabic numerals may not contain equal numbers of questions.

I. Cellular and Molecular Biology (33-34%)

Fundamentals of cellular biology, genetics, and molecular biology are addressed. Major topics in cellular structure and function include metabolic pathways and their regulation, membrane dynamics and cell surfaces, organelles, cytoskeleton, and cell cycle. Major areas in genetics and molecular biology include chromatin and chromosomal structure, genomic organization and maintenance, and the regulation of gene expression. The cellular basis of immunity and the mechanisms of antigen-antibody interactions are included. Distinctions between prokaryotic and eukaryotic cells are considered where appropriate. Attention is also given to experimental methodology.

A. Cellular Structure and Function (16-17%)

1. Biological compounds
   - Macromolecular structure and bonding
   - Abiotic origin of biological molecules
2. Enzyme activity, receptor binding, and regulation
3. Major metabolic pathways and regulation
   - Respiration, fermentation, and photosynthesis
   - Synthesis and degradation of macromolecules
   - Hormonal control and intracellular messengers
4. Membrane dynamics and cell surfaces
   - Transport, endocytosis, and exocytosis
   - Electrical potentials and transmitter substances
   - Mechanisms of cell recognition, cell junctions, and plasmodesmata
   - Cell wall and extracellular matrix
5. Organelles: structure, function, synthesis, and targeting
   - Nucleus, mitochondria, and plastids
   - Endoplasmic reticulum and ribosomes
   - Golgi apparatus and secretory vesicles
   - Lysosomes, peroxisomes, and vacuoles
6. Cytoskeleton, motility, and shape
   - Actin-based systems
   - Microtubule-based systems
   - Intermediate filaments
   - Bacterial flagella and movement
7. Cell cycle, growth, division, and regulation (including signal transduction)
8. Methods
   - Microscopy (e.g., electron, light, fluorescence)
   - Separation (e.g., centrifugation, gel filtration, PAGE, Fluorescence activated cell sorting (FACS))
   - Immunological (e.g., Western Blotting, immunohistochemistry, immunofluorescence)

B. Genetics and Molecular Biology (16-17%)

1. Genetic foundations
   - Mendelian inheritance
   - Pedigree analysis
   - Prokaryotic genetics (transformation, transduction, and conjugation)
   - Genetic mapping
2. Chromatin and chromosomes
   - Nucleosomes
   - Karyotypes
   - Chromosomal aberrations
   - Polytene chromosomes
3. Genome sequence organization
   - Introns and exons
   - Single-copy and repetitive DNA
   - Transposable elements
4. Genome maintenance
   - DNA replication
   - DNA mutation and repair
5. Gene expression and regulation in prokaryotes and eukaryotes: mechanisms
   - The operon
   - Promoters and enhancers
   - Transcription factors
   - RNA and protein synthesis
   - Processing and modifications of both RNA and protein

6. Gene expression and regulation: effects
   Control of normal development
   Cancer and oncogenes
7. Immunobiology
   Cellular basis of immunity
   Antibody diversity and synthesis
   Antigen-antibody interactions
8. Bacteriophages, animal viruses, and plant viruses
   Viral genomes, replication, and assembly
   Virus-host cell interactions
9. Recombinant DNA methodology
   Restriction endonucleases
   Blotting and hybridization
   Restriction fragment length polymorphisms
   DNA cloning, sequencing, and analysis
   Polymerase chain reaction

II. Organismal Biology (33-34%)

The structure, physiology, behavior, and development of plants and animals are addressed. Topics covered include nutrient procurement and processing, gas exchange, internal transport, regulation of fluids, control mechanisms and effectors, and reproduction in autotrophic and heterotrophic organisms. Examples of developmental phenomena range from fertilization through differentiation and morphogenesis. Perceptions and responses to environmental stimuli are examined as they pertain to both plants and animals. Major distinguishing characteristics and phylogenetic relationships of selected groups from the various kingdoms are also covered.

A. Animal Structure, Function, and Organization (10%)

1. Exchange with environment
   Nutrient, salt, and water exchange
   Gas exchange
   Energy
2. Internal transport and exchange (circulatory, gastrovascular, and digestive systems)
3. Support and movement
   Support systems (external, internal, and hydrostatic)
   Movement systems (flagellar, ciliary, and muscular)
4. Integration and control mechanisms
   Nervous and endocrine systems
5. Behavior (communication, orientation, learning, and instinct)
6. Metabolic rates (temperature, body size, and activity)

B. Animal Reproduction and Development (6%)

1. Reproductive structures
2. Meiosis, gametogenesis, and fertilization
3. Early development (e.g., polarity, cleavage, and gastrulation)
4. Developmental processes (e.g., induction, determination, differentiation, morphogenesis, and metamorphosis)
5. External control mechanisms (e.g., photoperiod)

C. Plant Structure, Function, and Organization, with Emphasis on Flowering Plants (7%)

1. Organs, tissue systems, and tissues
2. Water transport, including absorption and transpiration
3. Phloem transport and storage
4. Mineral nutrition
5. Plant energetics (e.g., respiration and photosynthesis)

D. Plant Reproduction, Growth, and Development, with Emphasis on Flowering Plants (5%)

1. Reproductive structures
2. Meiosis and sporogenesis
3. Gametogenesis and fertilization
4. Embryogeny and seed development
5. Meristems, growth, morphogenesis, and differentiation
6. Control mechanisms (e.g., hormones, photoperiod, and tropisms)

E. Diversity of Life (6%)

1. Archaea
   - Morphology, physiology, and identification
2. Bacteria (including cyanobacteria)
   - Morphology, physiology, pathology, and identification
3. Protista
   - Protozoa, other heterotrophic Protista (slime molds and Oomycota), and Autotrophic Protista
   - Major distinguishing characteristics
   - Phylogenetic relationships
   - Importance (e.g. eutrophication, disease)
4. Fungi
   - Distinctive features of major phyla (vegetative, asexual and sexual reproduction)
   - Generalized life cycles
   - Importance (e.g., decomposition, biodegradation, antibiotics, and pathogenicity)
   - Lichens
5. Animalia with emphasis on major phyla
   - Major distinguishing characteristics
   - Phylogenetic relationships
6. Plantae with emphasis on major phyla
   - Alternation of generations
   - Major distinguishing characteristics
   - Phylogenetic relationships

III. Ecology and Evolution (33-34%)

This section deals with the interactions of organisms and their environment, emphasizing biological principles at levels above the individual. Ecological and evolutionary topics are given equal weight. Ecological questions range from physiological adaptations to the functioning of ecosystems. Although principles are emphasized, some questions may consider applications to current environmental problems. Questions in evolution range from its genetic foundations through evolutionary processes to their consequences. Evolution is considered at the molecular, individual, population, and higher levels. Principles of ecology, genetics, and evolution are interrelated in many questions. Some questions may require quantitative skills, including the interpretation of simple mathematical models.

A. Ecology (16-17%)

1. Environment/organism interaction
   - Biogeographic patterns
   - Physiological ecology
   - Temporal patterns (e.g., seasonal fluctuations)
2. Behavioral ecology
   - Habitat selection
   - Mating systems
   - Social systems
   - Resource acquisition
3. Population Structure and Function
   - Population dynamics/regulation
   - Demography and life history strategies
4. Communities
   - Direct and indirect interspecific interactions
   - Community structure and diversity
   - Change and succession
5. Ecosystems
   - Productivity and energy flow
   - Chemical cycling

B. Evolution (16-17%)

1. Genetic variability
   - Origins (mutations, linkage, recombination, and chromosomal alterations)
   - Levels (e.g., polymorphism and heritability)
   - Spatial patterns (e.g., clines and ecotypes)
   - Hardy-Weinberg equilibrium
2. Evolutionary processes
   - Gene flow and genetic drift
   - Natural selection and its dynamics
   - Levels of selection (e.g., individual and group)
   - Trade-offs and genetic correlations

3. Evolutionary consequences
   - Fitness and adaptation
   - Speciation
   - Systematics and phylogeny
   - Convergence, divergence, and extinction
   - Coevolution
4. History of life
   - Origin of prokaryotic and eukaryotic cells
   - Fossil record
   - Paleontology and paleoecology

Preparing for a Subject Test

GRE Subject Test questions are designed to measure skills and knowledge gained over a long period of time. Although you might increase your scores to some extent through preparation a few weeks or months before you take the test, last minute cramming is unlikely to be of further help. The following information may be helpful.

- A general review of your college courses is probably the best preparation for the test. However, the test covers a broad range of subject matter, and no one is expected to be familiar with the content of every question.
- Use this practice book to become familiar with the types of questions in the GRE Biology Test, paying special attention to the directions. If you thoroughly understand the directions before you take the test, you will have more time during the test to focus on the questions themselves.

Test-Taking Strategies

The questions in the practice test in this book illustrate the types of multiple-choice questions in the test. When you take the actual test, you will mark your answers on a separate machine-scorable answer sheet. Total testing time is two hours and fifty minutes; there are no separately timed sections.

Following are some general test-taking strategies you may want to consider.

- Read the test directions carefully, and work as rapidly as you can without being careless. For each question, choose the best answer from the available options.
- All questions are of equal value; do not waste time pondering individual questions you find extremely difficult or unfamiliar.
- You may want to work through the test quite rapidly, first answering only the questions about which you feel confident, then going back and answering questions that require more thought, and concluding with the most difficult questions if there is time.
- If you decide to change an answer, make sure you completely erase it and fill in the oval corresponding to your desired answer.
- Questions for which you mark no answer or more than one answer are not counted in scoring.
- Your score will be determined by subtracting one-fourth the number of incorrect answers from the number of correct answers. If you have some knowledge of a question and are able to rule out one or more of the answer choices as incorrect, your chances of selecting the correct answer are improved, and answering such questions will likely improve your score. It is unlikely that pure guessing will raise your score; it may lower your score.
- Record all answers on your answer sheet. Answers recorded in your test book will not be counted.
- Do not wait until the last five minutes of a testing session to record answers on your answer sheet.

What Your Scores Mean

Your raw score, that is—the number of questions you answered correctly minus one-fourth of the number you answered incorrectly—is converted to the scaled score that is reported. This conversion ensures that a scaled score reported for any edition of a Subject Test is comparable to the same scaled score earned on any other edition of the same test. Thus, equal scaled scores on a particular Subject Test indicate essentially equal levels of performance regardless of the test edition taken. Test scores should be compared only with other scores on the same Subject Test. (For example, a 680 on the Computer Science Test is not equivalent to a 680 on the Mathematics Test.)

Before taking the test, you may find it useful to know approximately what raw scores would be required to obtain a certain scaled score. Several factors influence the conversion of your raw score to your scaled score, such as the difficulty of the test edition and the number of test questions included in the computation of your raw score. Based on recent editions of the Biology Test, the following table gives the range of raw scores associated with selected scaled scores for three different test editions. (Note that when the number of scored questions for a given test is greater than the range of possible scaled scores, it is likely that two or more raw scores will convert to the same scaled score.) The three test editions in the table that follows were selected to reflect varying degrees of difficulty. Examinees should note that future test editions may be somewhat more or less difficult than those test editions illustrated in the table.

Range of Raw Scores* Needed to Earn Selected Scaled Score on Three Biology Test Editions That Differ in Difficulty

Scaled Score	Raw Scores		
	Form A	Form B	Form C
800	128-130	124-125	120-121
700	101-103	95-97	92-94
600	74-76	67-69	64-66
500	47-49	39-41	37-39
Number of Questions Used to Compute Raw Score			
	199	198	200

*Raw Score = Number of correct answers minus one-fourth the number of incorrect answers, rounded to the nearest integer.

For a particular test edition, there are many ways to earn the same raw score. For example, on the edition listed above as "Form A," a raw score of 101 through 103 would earn a scaled score of 700. Below are a few of the possible ways in which a scaled score of 700 could be earned on the edition:

Examples of Ways to Earn a Scaled Score of 700 on the Edition Labeled as "Form A"

Raw Score	Questions Answered Correctly	Questions Answered Incorrectly	Questions Not Answered	Number of Questions Used to Compute Raw Score
101	101	0	98	199
101	111	39	49	199
101	120	78	1	199
103	103	0	96	199
103	112	37	50	199
103	122	75	2	199

Practice Test

To become familiar with how the administration will be conducted at the test center, first remove the answer sheet (pages 69 and 70). Then go to the back cover of the test book (page 64) and follow the instructions for completing the identification areas of the answer sheet. When you are ready to begin the test, note the time and begin marking your answers on the answer sheet.

FORM GR0624

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GRADUATE RECORD EXAMINATIONS®

BIOLOGY TEST

Do not break the seal
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THIS TEST BOOK MUST NOT BE TAKEN FROM THE ROOM.

NO TEST MATERIAL ON THIS PAGE

BIOLOGY TEST

Time—170 minutes

200 Questions

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

1. In the formation of the secondary structure of a protein, which of the following are most responsible for holding an alpha-helix region in its helical form?

   (A) Ionic bonds
   (B) Hydrogen bonds
   (C) Disulfide bonds
   (D) Hydrophobic interactions
   (E) van der Waals interactions

2. Why do erythrocytes swell and burst when placed in water?

   (A) Since water concentration is higher outside the cell, water moves inward by passive diffusion.
   (B) Since hemoglobin concentration is higher inside the cell, hemoglobin moves outward by exocytosis.
   (C) Since potassium ions are more concentrated inside the cells, potassium ions move outward by osmosis.
   (D) Erythrocytes pump water inward by active transport to balance osmotic gradients.
   (E) Water is a universal solvent and simply dissolves the erythrocyte membranes.

3. The addition of α-amanitin, a known inhibitor of DNA-dependent mRNA synthesis, to growing cells will most likely cause protein synthesis to

   (A) stop immediately
   (B) stop as mRNA becomes depleted
   (C) stop as thymidine becomes depleted
   (D) stop as the ribosomes become inactivated
   (E) be unaffected

4. An infectious agent that appears to have no nucleic acid is a

   (A) bacterium
   (B) bacteriophage
   (C) viroid
   (D) virus
   (E) prion

5. Separation of molecules according to size can be achieved by which of the following?

   (A) Gel-filtration chromatography
   (B) Ion-exchange chromatography
   (C) Affinity chromatography
   (D) Isoelectric focusing
   (E) X-ray diffraction

6. Which of the following is true of the movement of cilia and flagella in eukaryotes?

   (A) It produces ATP.
   (B) It is the result of a rotating motion.
   (C) It is identical to that of bacterial flagella.
   (D) It is driven by a proton gradient.
   (E) It results from one microtubule pair sliding along a neighboring microtubule pair.

7. Which of the following is true of the polymerase chain reaction?

   (A) It enables a small amount of DNA to be amplified.
   (B) It involves the addition of a poly-A sequence to mRNA.
   (C) It cuts DNA into numerous small fragments for analysis.
   (D) It separates DNA fragments according to size.
   (E) It requires RNA in order to proceed.

8. Which of the following pathways is most likely taken by newly synthesized histones?

   (A) Rough endoplasmic reticulum → Golgi complex → secretory vesicle
   (B) Rough endoplasmic reticulum → Golgi complex → nucleus
   (C) Rough endoplasmic reticulum → smooth endoplasmic reticulum → nucleus
   (D) Cytoplasm → nucleus
   (E) Cytoplasm → rough endoplasmic reticulum → Golgi complex → nucleus

GO ON TO THE NEXT PAGE.

9. How many different types of gametes could be produced by an individual with the arbitrary genotype of *AAbbCCDdEe* ?

   (A) Two
   (B) Four
   (C) Six
   (D) Eight
   (E) More than eight

10. During cytokinesis in an animal cell, a constricting ring pinches the dividing cell into the two daughter cells. This contractile ring is formed by which of the following structures?

   (A) Centrioles
   (B) Microtubules
   (C) Microfilaments
   (D) Z discs
   (E) The spindle apparatus

11. If an organic acid accumulates in a plant cell in sufficient quantities to affect the cell's pH significantly, then the acid will probably be stored in the

   (A) cytosol
   (B) vacuole
   (C) nucleus
   (D) mitochondria
   (E) chloroplasts

12. Which of the following information can be gained from determining the primary structure of an enzymatically active protein?

   (A) The amino acids in the active site can be positively identified.
   (B) The molecular weight of the protein can be accurately established.
   (C) The temperature at which thermal inactivation will occur can be accurately established.
   (D) An estimate of K_m can be calculated.
   (E) An estimate of V_{max} can be calculated.

13. Which of the following is correct concerning the K_m of an enzyme?

   (A) It depends on the dissociation constant for the product of the reaction.
   (B) It defines the V_{max} of the enzyme-catalyzed reaction.
   (C) It is a measure of the number of substrate molecules converted to product in a specific unit of time.
   (D) It is the substrate concentration at which the velocity of the reaction is equal to 1/2 V_{max}.
   (E) It is measured in units of moles per minute.

14. Which of the following types of enzymes are usually subjected to direct feedback inhibition by an intracellular metabolite?

   (A) Enzymes catalyzing the last step in a catabolic pathway
   (B) Enzymes catalyzing the last step in a biosynthetic pathway
   (C) Enzymes catalyzing the first step in a biosynthetic pathway
   (D) Enzymes localized in the extracellular matrix
   (E) Enzymes localized in lysosomes

15. Which of the following cellular structures serve similar functions in plants and animals, respectively?

	Plants	Animals
(A)	Tight junctions	Gap junctions
(B)	Desmosomes	Gap junctions
(C)	Plasmodesmata	Gap junctions
(D)	Plasmodesmata	Desmosomes
(E)	Plasmodesmata	Tight junctions

16. Increased calcium influx across the membranes of presynaptic neurons has which of the following effects on synaptic transmission?

   (A) Increased release of neurotransmitter
   (B) Increase in voltage-dependent potassium efflux
   (C) Decreased release of neurotransmitter
   (D) Decrease in voltage-dependent potassium efflux
   (E) Closure of the acetylcholine-gated channel

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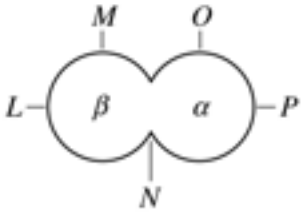

17. The tubulin heterodimer depicted above is located within a protofilament of an intact microtubule. To which site is the α portion of its neighboring heterodimer (within the same protofilament) attached?

(A) *L*
(B) *M*
(C) *N*
(D) *O*
(E) *P*

18. During meiosis, homologous chromosomes pair up along their lengths. The most plausible explanation for the karyotype structure shown above is that

(A) portions of non-homologous chromosomes have been translocated
(B) one of the two homologous chromosomes has suffered a deletion
(C) one of the two homologous chromosomes has undergone an inversion
(D) the homologous chromosomes have each suffered a gene duplication
(E) one of a pair of homologous chromosomes has been lost via nondisjunction

19. Which of the following best explains how the activity of an enzyme is regulated by an allosteric inhibitor?

(A) Direct competition between the binding of the inhibitor and the binding of a substrate to the active site
(B) Induction of a conformational change in the enzyme by the inhibitor, which affects enzyme activity
(C) Irreversible binding of the inhibitor to the enzyme, which affects enzyme activity
(D) Inhibition of the transcription of the gene encoding the enzyme by the inhibitor
(E) Denaturation of the protein induced by binding of the inhibitor

20. A species of plant is discovered in which individual plants produce either white or purple flowers. True breeding plants that have short stems with white flowers are crossed with true breeding plants that have tall stems and purple flowers. The resulting offspring all have tall stems with purple flowers. When one of these tall, purple-flowered offspring is crossed with a short, white-flowered plant, plants with the following characteristics were obtained in equal proportions.

White flowers on tall stems
Purple flowers on tall stems
White flowers on short stems
Purple flowers on short stems

Given the information above, which of the following is most likely true?

(A) The white-flower allele and the tall-stem allele occur at the same locus.
(B) The genes for flower color and stem length are closely linked.
(C) Extensive crossing-over between the purple-flower allele and the white-flower allele has occurred.
(D) The genes for flower color and stem length are not linked.
(E) Independent assortment does not occur in this species of plant.

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21. An X-linked recessive gene produces red-green color blindness in humans. A woman with normal color vision whose father was color-blind marries a color-blind man. What is the probability that their son will be color-blind?

(A) 0
(B) 1/4
(C) 1/2
(D) 3/4
(E) 1/1

22. Which of the following is NOT a correct statement about the process of meiosis?

(A) Meiosis I separates chromosomes; meiosis II separates chromatids.
(B) Synapsis and crossing-over occur during meiosis I.
(C) Kinetochores are responsible for aligning chromatids during meiosis I.
(D) Karyokinesis occurs before cytokinesis.
(E) Segregation of unlinked alleles occurs during meiosis.

23. Endoplasmic reticulum (ER) is the site of all of the following EXCEPT

(A) drug detoxification by means of mixed-function oxidases
(B) synthesis of proteins that are secreted from the cell
(C) N-linked glycosylation of newly formed polypeptides
(D) Ca^{2+} storage in muscle tissues
(E) hydrolytic activities carried out by acid hydrolases

24. Exons of a gene are defined as

(A) the untranslated regions of the corresponding mRNA
(B) regions in the corresponding mRNA that are involved in initiation of transcription
(C) regions that are not transcribed by RNA polymerase
(D) regions that are excised from the corresponding protein after it is synthesized
(E) regions that remain in the corresponding mRNA after splicing

25. In nerves, vesicles can move the length of an axon at a rate that far exceeds that which would be predicted for simple diffusion. Which of the following models best explains vesicular movement in these cells?

(A) Depolymerization of actin microfilaments attached to vesicles pulls the vesicles toward the site of depolymerization.
(B) Vesicles are propelled by fluid movement generated by changes in osmotic potential within the cells.
(C) Vesicles are moved by alternate contraction and relaxation of actin-myosin "muscle" complexes.
(D) Vesicles, by virtue of their net negative charge, are attracted to positively charged regions of the cell.
(E) Vesicles are attached to the protein kinesin, which slides along microtubules by an ATP-dependent process.

26. Additions or deletions of bases in the nucleotide sequence of a structural gene most often result in

(A) an altered sequence of amino acids in the protein that the gene encodes
(B) insertion of a new intron into the coding sequence of the gene
(C) decreased histone binding
(D) decreased excision repair
(E) increased levels of mRNA production

27. Radioactive cytosine was added to an actively growing culture of *E. coli* bacteria. Which of the following would be the result if a cell replicated once in the presence of this radioactive base?

(A) One of the daughter cells, but not the other, would have radioactive DNA.
(B) Neither of the two daughter cells would have radioactive DNA.
(C) Both daughter cells would have radioactive DNA.
(D) Radioactive cytosine would pair with nonradioactive adenine during DNA replication.
(E) DNA replication would not occur, because two radioactive bases are required for proper pairing.

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28. Which of the following is an anticodon?

(A) The part of a DNA molecule that codes for chain termination
(B) A 3-nucleotide sequence of an mRNA molecule
(C) A specific part of a tRNA molecule
(D) A nucleotide triplet of an rRNA molecule
(E) The portion of a ribosomal subunit that interacts with aminoacyl-tRNA synthetase

29. *Drosophila* lines with large, sometimes multiple, inversions in one or more chromosomes are often used in maintaining laboratory stocks because of which of the following reasons?

(A) Inversions maximize the process of chromosome pairing within and near the inversion.
(B) Inversions in the male inhibit fertilization of non-inversion-containing females.
(C) Inversion heterozygotes produce a greater number of viable offspring.
(D) Inversion heterozygotes usually yield inviable gametes or zygotes when crossing-over occurs within the inversion.
(E) Inversion heterozygotes produce a greater number of recombinant offspring.

30. Chimeric mice can be generated by injecting a cell from an early embryo into a blastocyst of another genotype. The fact that the single injected cell can contribute to many tissues of the chimeric mouse has led to the conclusion that cells of the early embryo are

(A) differentiated
(B) motile
(C) transformed
(D) transduced
(E) totipotent

31. In *Drosophila*, regions of polytene chromosomes show puffs at different times in development. Studies with labeled compounds have indicated that the localization to the puffs of tritiated

(A) thymidine indicates that DNA is being synthesized
(B) thymidine indicates that RNA is being synthesized
(C) leucine indicates that new proteins are being synthesized
(D) uridine indicates that DNA is being synthesized
(E) uridine indicates that RNA is being synthesized

32. In *Drosophila*, a homeotic mutation would be the most likely explanation for which of the following?

(A) A decrease in the number of parasegments
(B) A leg developing where an antenna would normally be located
(C) Forked and dense body bristles instead of straight and sparse ones
(D) A significantly shorter life span
(E) An increase in wing length

33. Humoral immunity is characterized by all of the following EXCEPT

(A) a memory response
(B) antigen-antibody interaction
(C) the synthesis of immunoglobulins
(D) the production of plasma cells
(E) the production of cytotoxic T cells

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34. The immune system in mammals can rapidly respond to foreign molecules because of the enormous variety of B lymphocytes, each with different cell-surface antibodies that can bind specific antigens. Which of the following best explains the principal mechanism by which the diversity of lymphocytes arises?

(A) During the development of B lymphocytes, rearrangements of the DNA coding for the various domains of the antibody molecule occur.
(B) During the development of B lymphocytes, different introns are spliced out of antibody mRNA's.
(C) mRNA's for all 10^{15} types of antibodies are produced by each B lymphocyte; however, only one type of mRNA gets translated.
(D) All 10^{15} types of antibodies are produced by each B lymphocyte; specific proteases degrade all but one type.
(E) Different B lymphocytes carry different transcription activators, so that only one specific mRNA (and therefore, antibody) is produced by each lymphocyte.

35. Hybridization between mature mRNA and DNA can identify introns in eukaryotic genes. When mature mRNA produced by the insulin gene is hybridized with denatured chromosomal DNA, which of the following will most likely be observed?

(A) No hybridization would occur under any conditions.
(B) Hybridization of mRNA would occur with random sections of chromosomal DNA.
(C) Hybridization of mRNA with DNA would occur in a continuous stretch that is equal to the length of the mRNA.
(D) Hybridization of mRNA with DNA would occur but with many single-stranded loops of DNA.
(E) Hybridization of mRNA with DNA would occur but with many single-stranded loops of mRNA.

36. In adult mammals, the primary site for the final stage of differentiation of T lymphocytes is the

(A) spleen
(B) bone marrow
(C) bursa of Fabricius
(D) thymus
(E) liver

37. In the DNA sequence 5′ CGA TCG GCT 3′, which of the following is considered a transition-type mutation?

(A) 5′ CGA CCG GCT 3′
(B) 5′ CGA TGG CT 3′
(C) 5′ CGA TCG CCT 3′
(D) 5′ CGA TCG GCA 3′
(E) 5′ CGA UCG GCU 3′

38. Artificially acquired passive immunity involves

(A) vaccination with attenuated virus or bacteria
(B) the transfer of antibodies, as from a mother to her fetus
(C) the production of a cellular immune response or antibodies
(D) antibody formation as a result of exposure to antigens in the environment
(E) injection of preformed antibodies such as immunoglobulin

39. Which of the following is true concerning animal retroviruses?

(A) They must replicate during the S phase of the cell cycle.
(B) They require an RNA-dependent DNA polymerase.
(C) They are nonenveloped viruses.
(D) The virions have double-stranded RNA genomes.
(E) Replication of their genome occurs entirely within the host nucleus.

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40. In *Escherichia coli*, the synthesis of tryptophan is controlled by the tryptophan operon that is repressed in the presence of excessive tryptophan. When a mutant strain that has lost the regulatory gene of the tryptophan operon is placed in a medium that contains all nutrients the cells need to grow except tryptophan, which of the following will occur?

(A) The cells will continue to grow even though excess tryptophan is synthesized.
(B) The cells will grow until excessive tryptophan arrests the expression of the operon.
(C) The cells will not grow until enough tryptophan has been synthesized to activate the corepressor.
(D) The cells will never grow unless tryptophan is added to the medium.
(E) The cells will not grow even when tryptophan is added to the medium.

41. Which of the following is LEAST likely to cause a proto-oncogene to become an oncogene?

(A) A gene is incorporated into a retroviral genome.
(B) A gene is expressed at an inappropriate time.
(C) A gene is moved close to an enhancer, causing excess product to be made.
(D) A gene is truncated, yielding a protein with modified activity.
(E) A gene is moved into centromeric heterochromatin, silencing its transcription.

42. The physiological role of restriction endonucleases is to

(A) allow the *in vitro* construction of recombinant DNA molecules
(B) methylate host DNA
(C) remove RNA primer during DNA synthesis
(D) allow mapping of gene location
(E) cleave foreign DNA molecules that enter the cell

Type I: slow, oxidative, red
Type II A: fast, oxidative, red
Type II B: fast, glycolytic, white

43. The muscle cells listed above will most likely fatigue in what order, from first to last?

First ⟶		Last
(A) Type I	Type II A	Type II B
(B) Type I	Type II B	Type II A
(C) Type II A	Type I	Type II B
(D) Type II B	Type II A	Type I

(E) All three types will fatigue at the same rate.

44. Members of which of the following terrestrial groups have the most water-permeable body covering?

(A) Insecta
(B) Reptilia
(C) Aves
(D) Arachnida
(E) Amphibia

45. Which of the following is found in mammals during male gamete formation?

(A) Two successive centrosome duplications during meiosis
(B) Accumulation of yolk during gamete formation
(C) Generation of a polar body during meiosis I
(D) Formation of four functional gametes from a primary germ cell
(E) Temporary arrest of meiosis at the metaphase I stage

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46. During the evolution of life on Earth, the photosynthetic organisms initially responsible for raising atmospheric oxygen concentrations from less than 1 percent to about 20 percent were

(A) cyanobacteria
(B) archaea
(C) diatoms
(D) flowering plants
(E) mosses

47. Which of the following statements about circadian rhythms is correct?

(A) They are expressed during cell division only.
(B) They occur only in mammals.
(C) They are not found in humans.
(D) They are generated exogenously.
(E) They have a periodicity of about 24 hours.

48. The receptive surface for pollen on an angiosperm flower is the

(A) anther
(B) corolla
(C) ovary
(D) style
(E) stigma

49. Immediately after fertilization in animals, the first structural and biochemical changes in the egg are initiated by

(A) new gene transcription
(B) the release of Ca^{2+} from internal reservoirs
(C) the initiation of DNA synthesis
(D) a lowering of cytosolic pH
(E) a sudden drop in ATP levels

50. Chickadees were given an opportunity to store seeds in 72 possible storage sites consisting of holes drilled in small trees that had been placed in an aviary. Typically, the seeds were placed in only 4 or 5 storage sites. The chickadees were then removed from the aviary, the seeds removed from the storage sites, and each hole covered. A day later, the chickadees were returned to the aviary and they spent nearly 5 times as long pulling at the covers on storage sites than at the covers on sites where they had not stored food. This experiment indicates that chickadees

(A) use auditory cues to find stored food
(B) have a spatial memory that enables them to locate storage sites
(C) have a propensity to inspect and pull at the covers wherever they are located
(D) cannot find a storage site if they cannot see the food in it
(E) rely on the visual cues provided by the opening to a storage site to locate stored food

51. Bird species *X* stores seeds in a large number of separate caches in the summer and then locates the caches in the winter. Compared with a bird species that does <u>not</u> store seeds, species *X* can be expected to have a proportionately larger

(A) cerebellum
(B) hippocampus
(C) optic lobe
(D) hypothalamus
(E) medulla

52. Functionally, Hensen's node is to a chick embryo as the

(A) animal pole is to a frog embryo
(B) blastopore dorsal lip is to a frog embryo
(C) ectoderm is to a bird embryo
(D) vegetal pole is to a frog embryo
(E) anterior pole cells are to a *Drosophila* embryo

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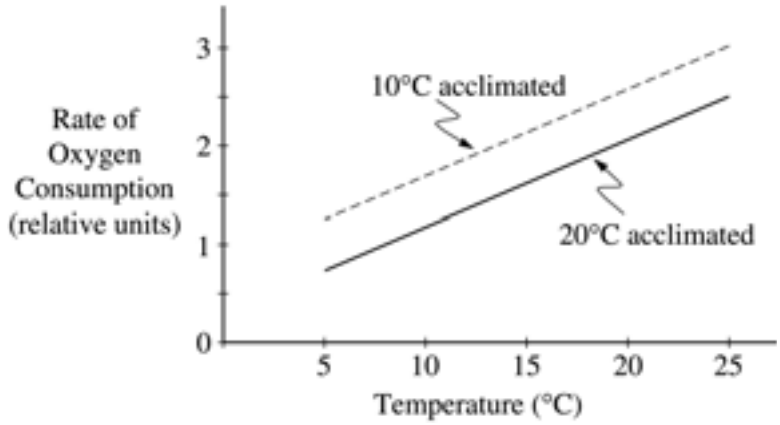
53. The oxygen consumption of marine crabs acclimated to either 10°C or 20°C was measured at environmental temperatures of 5°C to 25°C to produce the following graph.



Which of the following can be correctly concluded from the information in the graph?

(A) Acclimation temperature does not affect the rate of oxygen consumption.
(B) Crabs have higher rates of oxygen consumption when measured at 10°C than when measured at 20°C.
(C) Oxygen consumption is higher in the 10°C-acclimated crabs than in the 20°C-acclimated crabs at each test temperature.
(D) Acclimation to a high temperature induces a high rate of oxygen consumption at all test temperatures.
(E) This pattern of acclimation produces complete metabolic compensation.

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54. The outermost tissue of a tree trunk that is 6 feet in diameter would most likely be

(A) epidermis
(B) cork
(C) cortex
(D) phloem
(E) xylem

55. Which of the following is the tissue that is most important in plant survival during droughts and why?

(A) Vascular tissue, because the phloem keeps the plant supplied with water
(B) Vascular tissue, because the xylem can store considerable amounts of water
(C) Ground tissue, because water can be stored in the sclerenchyma for use during droughts
(D) Ground tissue, because the parenchymal tissue provides hormonal cues to stop water loss
(E) Epidermal tissue, because it is covered with a waxy cuticle and includes drought-responsive stomata

56. Which of the following cells or tissues are characteristically found in the roots, but <u>not</u> the stems, of angiosperms?

(A) Parenchyma and collenchyma
(B) Epidermis and cork
(C) Pericycle and endodermis
(D) Vessel elements and tracheids
(E) Sieve tube members and companion cells

Species	Stomata·mm^{-2} on Leaves	
	Upper Epidermis	Lower Epidermis
Encelia farinosa	248	355
Haworthia attenuata	15	25
Bursera latiflora	0	272
Scilla violaceae	3	35
Agave deserti	40	32

57. The data above were collected from plants growing in the desert of southwest Arizona. Which species probably undergoes the most evaporative cooling in this environment?

(A) *Encelia farinosa*
(B) *Haworthia attenuata*
(C) *Bursera latiflora*
(D) *Scilla violaceae*
(E) *Agave deserti*

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58. A piece of prospective belly epidermis of a newt neurula-stage embryo is grafted to the prospective mouth region of a frog neurula, replacing the frog epidermal tissue at that spot. The grafted embryo continues to develop and forms a newt mouth and teeth at the position of the graft. This result is consistent with which of the following?

(A) Newt tissue develops autonomously according to its original fate, despite its new location in the frog embryo.
(B) Newt tissue dedifferentiates whenever it is grafted.
(C) Tissues of the frog neurula induce the newt tissue to express frog-specific genes that it would not normally express.
(D) The mouths and teeth of frogs and newts are the same in type.
(E) The frog tissues of the neurula induce the newt tissue to form mouthparts.

59. Some chemoautotrophic bacteria living around deep-sea vents obtain their energy by converting

(A) alcohols to aldehydes
(B) hydrogen sulfide to elemental sulfur
(C) carbon dioxide and hydrogen to methane
(D) iron oxides to iron
(E) nitrogen to ammonia

60. The ability of a desert rodent's kidneys to form highly concentrated urine is largely attributable to

(A) a high glomerular filtration rate
(B) the production of a very salty ultrafiltrate in the glomerulus
(C) the ability of cells lining the proximal convoluted tubule to absorb water
(D) long loops of Henle that pass through tissues of increasing salt concentrations
(E) distal convoluted tubules that are impermeable to water

61. In a plant growing vigorously under normal conditions without water stress, in which tissue would you expect to find the lowest (most negative) water potential?

(A) Root epidermal cell
(B) Root cortical parenchyma
(C) Root endodermis
(D) Stem xylem
(E) Leaf mesophyll parenchyma

62. In organisms with closed circulatory systems, fluid leaves the blood of capillary networks at the arterial end and returns to blood at the venous end for which of the following reasons?

(A) Osmotic pressure increases prior to dehydration.
(B) Osmotic pressure difference dominates at the arterial end; hydrostatic pressure difference dominates at the venous end.
(C) Hydrostatic pressure difference dominates at the arterial end; osmotic pressure difference dominates at the venous end.
(D) Hydrostatic pressure drops during diastole.
(E) Hydrostatic pressure difference dominates at both the arterial and the venous ends.

63. Which of the following mineral nutrients is directly involved in light absorption during photosynthesis?

(A) Zn^{2+}
(B) Mn^{2+}
(C) Cu^{2+}
(D) Mg^{2+}
(E) Ca^{2+}

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64. Most of the dry mass of a plant is derived from

(A) minerals from the soil
(B) carbon from the soil
(C) carbon from the atmosphere
(D) oxygen from the atmosphere
(E) oxygen from soil water

65. Chlorophylls *a* and *b* are two pigments primarily responsible for the capture and processing of solar energy in the light reactions of photosynthesis. Which of the following best explains why having both chlorophyll *a* and *b* benefits a plant more than having one?

(A) Chlorophylls *a* and *b* have slightly different absorption spectra; this expands the range of wavelengths of light that can be captured for photosynthesis.
(B) Chlorophyll *a* is primarily involved in electron transfer; chlorophyll *b* is mainly involved in the capture of light energy.
(C) Chlorophyll *a* captures all the solar energy; chlorophyll *b* serves to protect chlorophyll *a* from overexcitation.
(D) Chlorophyll *b* captures all the solar energy; since chlorophyll *a* is a precursor to chlorophyll *b*, a pool of chlorophyll *a* must be maintained.
(E) Chlorophyll *a* resides in the thylakoid membranes and captures light energy there; chlorophyll *b* is soluble in the chloroplast stroma and captures light energy there.

66. The Calvin cycle, the "dark reactions" or carbon fixation reactions of photosynthesis, cannot occur at night in a living plant. Which of the following best describes why this is true?

(A) The stomata are incapable of opening at night, thus CO_2 cannot enter the leaf.
(B) The reactions of the Calvin cycle are dependent on light reactions for high-energy compounds.
(C) Several enzymes necessary for Calvin cycle activity have been degraded during the day and must be replaced.
(D) Light is required to transport the water necessary for the cycle.
(E) Cooler temperatures at night slow enzyme activity and rates of substrate diffusion.

67. If the egg cell of a megagametophyte of a flowering plant has a marker gene designated as *X* and the sperm cell of a compatible pollen grain has a marker gene designated as *Y*, which of the following represents the endosperm that will result from fertilization in most flowering plants?

(A) *XX*
(B) *YY*
(C) *XY*
(D) *XXY*
(E) *YYX*

68. Ca^{2+} is important in skeletal muscle contraction because it

(A) activates the myosin ATPase by binding to it
(B) binds to troponin to remove a constant inhibition of cross-bridge attachment
(C) prevents the formation of bonds between the myosin cross bridges and the actin filament
(D) is required to detach the myosin head from the actin filament
(E) causes muscle relaxation at intracellular concentrations of Ca^{2+} higher than 10^{-6}M

69. Which of the following structures present in the embryos of higher plants develops into the primary root of the seedling?

(A) Epicotyl
(B) Hypocotyl
(C) Cotyledon
(D) Radicle
(E) Endosperm

70. Which of the following statements about the motility of *Paramecium* is true?

(A) *Paramecium* employs a pseudopod.
(B) *Paramecium* has no structures for motility.
(C) *Paramecium* uses a single flagellum.
(D) *Paramecium* uses a pair of flagella.
(E) *Paramecium* uses cilia.

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71. In the cellular slime molds, the aggregation of myxamoebas is initiated by

(A) low light intensities
(B) high pH
(C) uptake of chloride ion
(D) secretion of cyclic AMP
(E) elevated temperature

72. A unicellular eukaryote that contains chlorophyll *a* (but no chlorophyll *b*), that functions as one of the major photosynthetic autotrophs in open-ocean ecosystems, and that has cell walls that contain silica is a

(A) red alga
(B) green alga
(C) dinoflagellate
(D) euglenoid
(E) diatom

73. Dikaryotic hyphae are a kind of fungal tissue that

(A) contain two chromosomes
(B) form after plasmogamy and before karyogamy
(C) are only a short stage of the life cycle of the Basidiomycota
(D) are not found in the Ascomycota
(E) are formed by the fusion of two nuclei

74. Saprophytic fungi obtain their nutrition by

(A) taking food into their gastrovascular cavity, and then digesting and absorbing it
(B) making food by chemosynthesis
(C) secreting digestive enzymes into the environment and then absorbing the digestive products
(D) using their amoeboid cells in phagocytosis
(E) forming a parasitic relationship with soil bacteria

75. An animal with a coelom, jointed appendages, and metameric segmentation would be classified in the phylum

(A) Mollusca
(B) Cnidaria
(C) Platyhelminthes
(D) Arthropoda
(E) Chordata

76. Which of the following animal phyla is diploblastic, that is, exhibits only two embryonic germ layers?

(A) Rotifera
(B) Mollusca
(C) Nematoda
(D) Platyhelminthes
(E) Cnidaria

77. Which of the following describes members of both the Bryophyta and the Pteridophyta?

(A) The absence of true roots
(B) The absence of swimming sperm
(C) The absence of meristematic growth
(D) The presence of chlorophyll
(E) The dominance of the haploid phase of the life cycle

78. In sporophytes of some mosses, a ring of peristome teeth regulates

(A) sperm release
(B) spore dispersal
(C) spore germination
(D) asexual reproduction
(E) rhizoid production

79. Which of the following characterizes dicotyledonous plants?

(A) Their flowers always have superior ovaries.
(B) Their seeds usually contain two embryos.
(C) Their stems have scattered vascular bundles.
(D) Their leaves usually have parallel veins.
(E) Their flowers usually have parts in multiples of four or five.

80. All of the following allow hermaphroditic animal species to avoid inbreeding EXCEPT

(A) functioning as only one sex during mating
(B) releasing eggs and sperm simultaneously
(C) being protandrous
(D) being protogynous
(E) changing sex

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81. All of the following occur during the cleavage stage of animal development EXCEPT

(A) an increase in the nuclear-to-cytoplasmic ratio of the cells
(B) an increase in the number of blastomeres
(C) an increase in the mass of the embryo
(D) an increase in the surface-to-volume ratio of the cells
(E) rapid cell divisions

82. Plants that utilize photosynthesis via the C_4 pathway differ from those that use the C_3 pathway in that at higher temperatures the C_4 plants

(A) are less productive per unit area of leaf
(B) are more productive per unit area of leaf
(C) can tolerate lower light conditions better
(D) carry on high levels of photorespiration
(E) use much more water for transpiration per unit of photosynthesis

83. A lateral root forms on the primary root of a typical herbaceous dicot by

(A) continued growth of a root hair on an epidermal cell
(B) lateral outgrowth of xylem
(C) lateral outgrowth from the root apical meristem
(D) activation of a lateral bud at a node on the surface of the root
(E) activation of an area in the pericycle to form an apical meristem

84. The leaves of grasses can continue to elongate following mowing or grazing due to actively growing tissue at the base of the leaf blades and sheaths called

(A) apical meristems
(B) lateral cambium
(C) intercalary meristems
(D) axillary buds
(E) interfascicular parenchyma

85. The amount of energy entering a food chain depends on the

(A) direction of energy flow in the system
(B) efficiency of energy recycling in the system
(C) biomass of carnivores and their efficiency in locating and capturing animal prey
(D) biomass of heterotrophs and their efficiency in transforming plant tissue into animal tissue
(E) biomass of autotrophs and their efficiency in transforming solar energy into chemical energy

86. Two plant species co-occur in a prairie. Species *X* always occurs near species *Y*. However, species *Y* often occurs in isolation from species *X* and produces more seeds when alone than when growing next to species *X*. Which of the following interactions between species *X* and *Y* could generate this pattern?

(A) Competition, in which *Y* is superior to *X* in accumulating resources
(B) Mutualism, in which both *X* and *Y* benefit by exchanging resources
(C) Parasitism, in which *X* benefits from resources produced by *Y* and reduces the growth of *Y* by doing so
(D) Commensalism, in which *X* benefits from resources produced by *Y* but does not affect the growth of *Y* by doing so
(E) Amensalism, in which *X* gains no benefit from *Y* but reduces the growth of *Y*

87. In the endosymbiont hypothesis for the origin of eukaryotic cells, which of the following is proposed as the role of cyanobacteria?

(A) They become the chlorophyll of plant cells.
(B) They are the ancestor of mitochondria.
(C) They are the ancestor of the chloroplasts.
(D) They lose their DNA and become the vacuoles of plant cells.
(E) They lose their photosynthetic pigments and become the nuclei of eukaryotes.

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88. The process of speciation can be prevented by

(A) genetic differentiation
(B) geographical barriers
(C) inhibition of gene exchange
(D) gene flow
(E) behavioral barriers

89. Small body size often allows animals to exploit desert habitats because it

(A) decreases the ratio of surface area to volume and hence the tendency to lose water
(B) promotes heat gain
(C) enhances thermal inertia
(D) enables exploitation of favorable microhabitats
(E) enables prolonged reliance on internal water stores

90. All of the following are strategies used by potential prey to avoid predation EXCEPT

(A) mimetic coloration
(B) erratic flight
(C) cryptic coloration
(D) lekking
(E) alarm signals

91. The amount of genotypic variation in a natural population can be increased by all of the following EXCEPT

(A) mutation
(B) recombination
(C) immigration
(D) hybridization
(E) inbreeding

92. The graph above illustrates a simplified description of the effect of disturbance on species diversity. Which of the following best explains the graph?

(A) Productivity is enhanced at intermediate levels of disturbance.
(B) Stabilizing selection occurs at intermediate levels of disturbance.
(C) The interaction of physical factors and biological competition increases diversity at intermediate levels of disturbance.
(D) Directional selection is enhanced by increased disturbance.
(E) Food chains are disrupted at high and low levels of disturbance.

93. Plants having C_4 metabolism are common in all of the following regions EXCEPT

(A) taiga
(B) warm deserts
(C) tropical grasslands
(D) tropical agricultural areas
(E) deserts with limited trace elements

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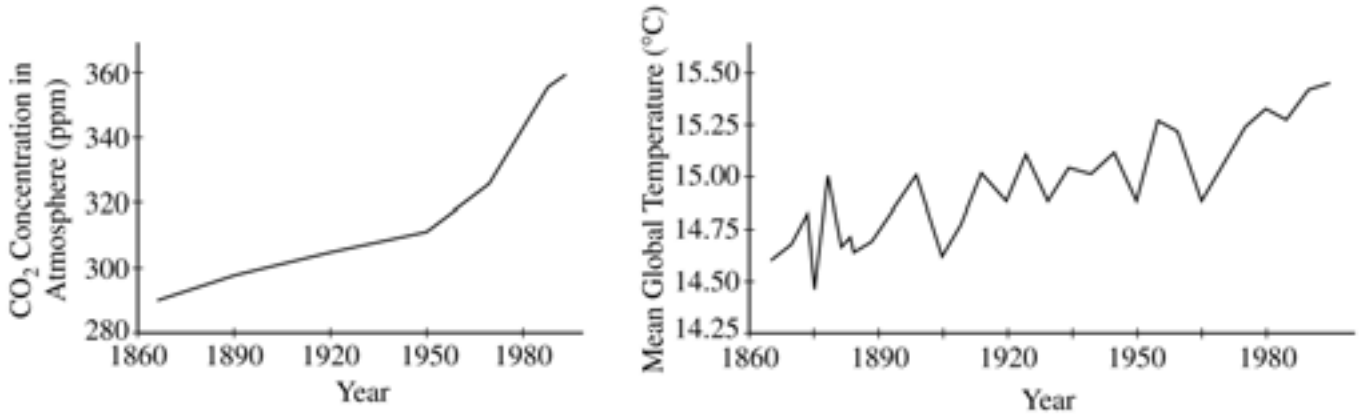

94. The graphs above show that the relationship between atmospheric CO_2 and mean global temperature is

(A) a positive correlation
(B) an inverse relationship
(C) a cause-and-effect relationship
(D) evidence of an impending ice age
(E) no relationship at all

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95. Which of the following is NOT a hypothesis explaining the advantage of group living?

(A) Vigilance effect
(B) Dilution effect
(C) Group foraging
(D) Group defense
(E) Parasite avoidance

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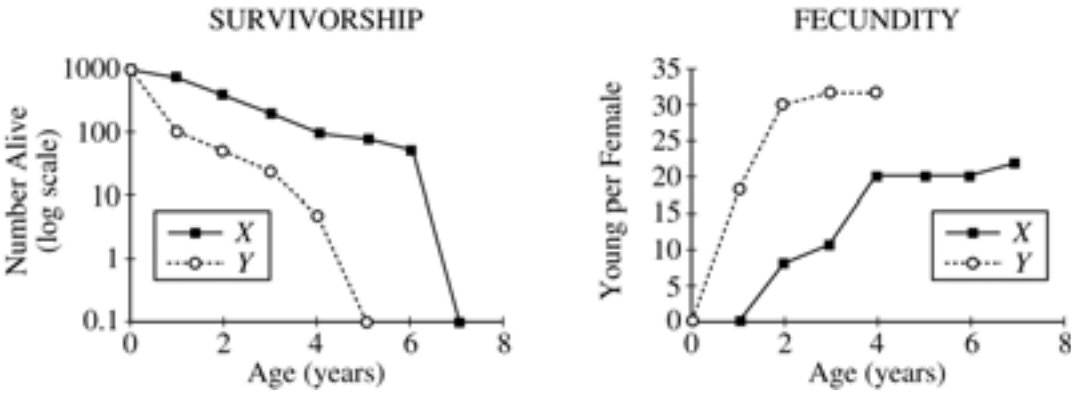

96. The graphs above show the survivorship and fecundity curves for two congeneric species, *X* and *Y*, that are found in different habitats. Of the two species, *Y* is more likely to

(A) come from a disturbed habitat in early succession
(B) have a longer generation time
(C) have a lower fecundity
(D) have a longer life span
(E) have low dispersal ability

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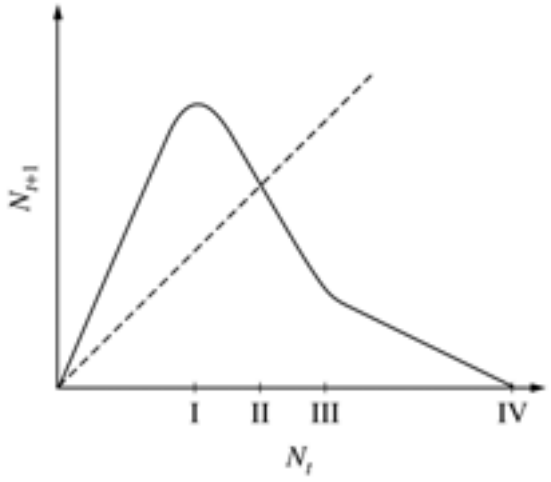
97. If average family size for the human population could be immediately reduced to two children per couple, the population would

(A) remain constant
(B) begin an immediate decline
(C) continue to increase for 20 to 40 years
(D) continue to increase indefinitely
(E) crash within 5 years



98. The figure above illustrates the relationship between population density in the present generation (N_t) and population density in the next generation (N_{t+1}). The dashed reference line has a slope of 1. Which of the following represents equilibrium density of this population?

(A) I
(B) II
(C) III
(D) IV
(E) There is no equilibrium.

99. Reproductive value (V_x) calculated from population life-table data provides a measure of the

(A) contribution of an individual of age x to the future growth of the population relative to a newborn's contribution
(B) average number of offspring produced by a female during age interval x
(C) proportion of available resources allocated to reproduction in individuals in population x
(D) probability of offspring surviving to age class x
(E) intrinsic growth rate of the population

100. Life-history characteristics associated with *K*-selected organisms include

(A) rapid reproductive rates, short generation times, and large body size
(B) repeated reproduction, few progeny, and large body size
(C) inhabiting early successional state communities, rapid maturation rates, and numerous large offspring
(D) inhabiting climax communities, many small offspring, and short life span
(E) poor competitive ability, rapid maturation rates, and short life span

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$$\frac{dN}{dt} = rN\left(\frac{K - N}{K}\right)$$

101. The logistic equation above is used to describe the rate of change of a population, N, with time, t, where r is the intrinsic rate of increase and K is the carrying capacity. Which of the following statements is true for this equation?

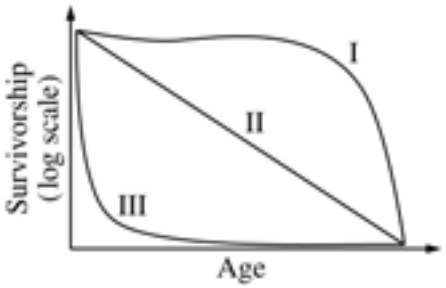
(A) For a given population, r is variable.
(B) For a given environment, K is variable.
(C) As N approaches K, dN/dt approaches 0.
(D) As N approaches K, dN/dt approaches K.
(E) As N approaches K, dN/dt approaches r.

102. Which of the following biomes is characterized by a wet, mild winter and a warm, dry summer?

(A) Taiga
(B) Tundra
(C) Chaparral
(D) Tropical rain forest
(E) Temperate deciduous forest

103. If a species is a keystone predator, then its removal from a community should

(A) decrease population size of the predator's preferred prey
(B) decrease species diversity in the prey community
(C) decrease productivity of the predator's preferred prey
(D) increase species diversity in the prey community
(E) increase the number of trophic levels



104. The diagram above depicts three general types of survivorship curves. Only the form of the curve is important, not its absolute scale. Which of the following statements is LEAST likely to be true?

(A) Nearly constant mortality results in a Type II curve.
(B) A fish that lays vast numbers of eggs exhibits a Type III curve.
(C) Mortality that is initially low, then increases rapidly during old age, results in a Type I curve.
(D) Currently, human populations in the United States and Europe generally exhibit a Type I curve.
(E) A species with high juvenile mortality and high adult survivorship results in a Type I curve.

105. All of the following may be considered as sites for secondary succession EXCEPT

(A) an abandoned agricultural field
(B) a bare rock shelf on a mountainside
(C) a forest gap resulting from a tree fall
(D) a hurricane-damaged forest
(E) a flooded valley

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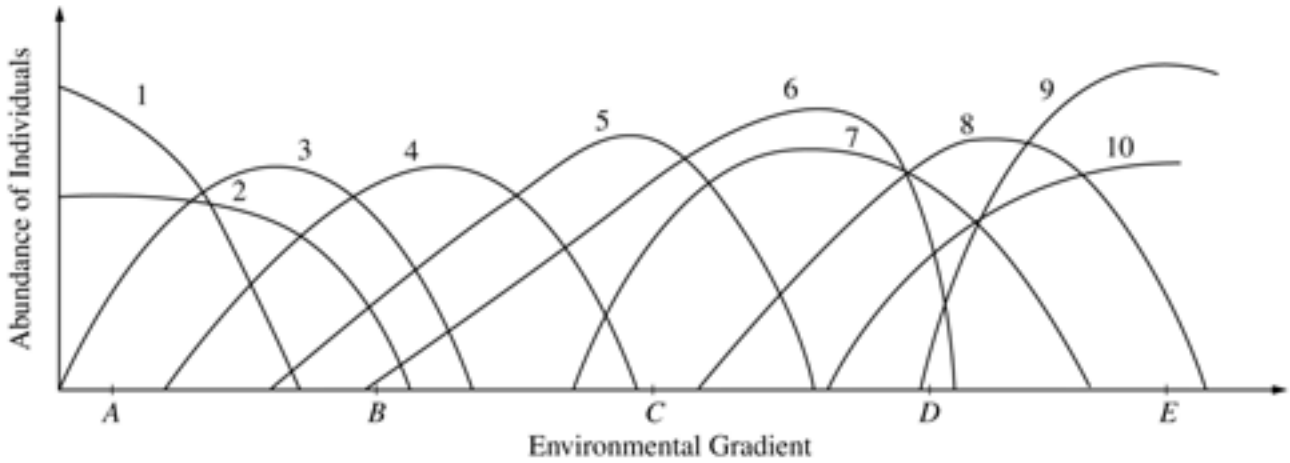

106. The figure above shows the distribution of 10 plant species that grow along a regular environmental gradient, such as depth of the water table in a river valley. All other environmental factors are similar. This figure demonstrates that

(A) species richness increases along the gradient from *A* to *E*
(B) species richness decreases along the gradient from *A* to *E*
(C) discrete communities are formed at sites *D* and *E*
(D) discrete communities are formed at sites *A*, *C*, and *D*
(E) no discrete communities are formed along the gradient

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107. Acid rain damage depends on the buffering capacity of the soils in a given region. Damage has been greatest where the soil layer is

(A) thin and contains little calcium and magnesium
(B) thin and contains abundant calcium and magnesium
(C) thin and contains abundant calcium but little magnesium
(D) thick and contains abundant calcium and magnesium
(E) thick and contains little calcium and magnesium

108. Nitrogen is a major environmental pollutant of groundwater in many parts of the world. What is the major cause of this nitrogen accumulation in groundwater?

(A) Excessive use of nitrogen fertilizers
(B) Destruction of nitrifying bacteria, which results in soil nitrogen remaining as NH_4^+
(C) Excess soil moisture, which causes ammonification or denitrification
(D) Presence of sandy-textured soil
(E) Lack of moisture in the topsoil, which attracts nitrogen to the subsurface and groundwater

109. The phosphoglucomutase (*Pgm*) locus in California populations of Nuttall's white-crowned sparrow has allelic frequencies of 0.8 and 0.2, respectively, for the alleles *Pgm-A* and *Pgm-B*. What is the probability that two heterozygous individuals will mate, given that *Pgm* is in Hardy-Weinberg equilibrium?

(A) 0.01
(B) 0.10
(C) 0.16
(D) 0.32
(E) 0.60

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	GENOTYPES			
	RR	*Rr*	*rr*	*Total*
Initial frequency	p^2	$2pq$	q^2	$p^2 + 2pq + q^2$
Adaptive value	1	1	$1 - s$	
Frequency after selection	p^2	$2pq$	$q^2(1 - s)$	$1 - sq^2$
Relative genotype frequency after one generation of selection	$\frac{p^2}{(1 - sq^2)}$	$\frac{2pq}{(1 - sq^2)}$	$\frac{q^2(1 - s)}{(1 - sq^2)}$	1

110. For a trait controlled by a single-locus, two-allele system with complete dominance, p is the gene frequency of *R*, the dominant allele, q is the gene frequency of *r*, the recessive allele, and s is the selection coefficient against the recessive homozygote. The table above indicates the effects of natural selection on genotype frequencies over one generation.

After one generation of such selection, the relative frequency of the recessive allele, *r*, will be equal to

(A) $\frac{1}{2}(2pq) + q^2(1 - s)$

(B) $\frac{\frac{1}{2}(2pq) + q^2(1 - s)}{(1 - sq^2)}$

(C) $\frac{q^2(1 - s)}{(1 - sq^2)}$

(D) $\frac{\frac{1}{2}(2pq) + p^2}{(1 - sq^2)}$

(E) $\frac{1}{2}(2pq) + q^2$

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111. Sewall Wright's metaphor of evolution on an adaptive landscape describes a population as occupying a field of genotypes graded by contours delimiting gene combinations of equal fitness. The evolutionary mechanism most likely to move a population consistently "uphill" toward adaptive peaks on this landscape is

(A) chance
(B) directed mutation
(C) natural selection
(D) gene flow between populations
(E) genotypic recombination

112. When exposed to a cold environment for several weeks, many small mammals dramatically increase their capacity for heat production primarily by means of

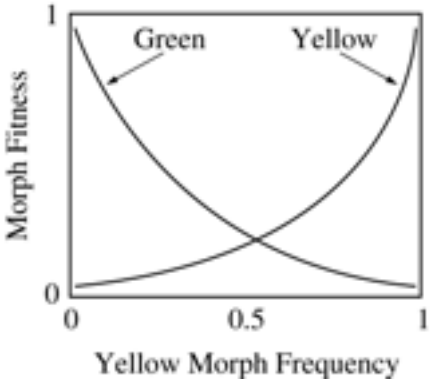
(A) decreased insulation
(B) increased insulation
(C) increased renal function
(D) shivering thermogenesis
(E) nonshivering thermogenesis

113. Plant species *A* has a diploid number of 12, while species *B* has a diploid number of 16. Which of the following would be the diploid number of an allotetraploid derived from a hybrid between these two species?

(A) 14
(B) 28
(C) 40
(D) 44
(E) 56

114. If two parents that are heterozygous (*Aa*) at a single locus give rise to offspring that are 25 percent *AA*, 50 percent *Aa*, and 25 percent *aa*, then all of the following are true EXCEPT:

(A) The parents are diploid organisms.
(B) The *a* allele is recessive lethal.
(C) The alleles assort independently.
(D) The gametes combine at random.
(E) The probability that a given gamete will receive allele *A* is one-half.



115. In a certain species of lizard, there are two color morphs associated with a single locus (*Y*) having two alleles (*Y*, *y*): yellow (*yy*) and green (*YY*, *Yy*). The fitness of the morphs is frequency-dependent, as indicated in the graph above. If the frequency of the yellow morph in a population is 0.70 and individuals are randomly mating, then the expected equilibrium population due to natural selection is

(A) monomorphic for yellow morphs
(B) monomorphic for green morphs
(C) polymorphic with a stable ratio of about 1:1 of yellow to green morphs
(D) polymorphic with oscillating frequencies of yellow and green morphs
(E) polymorphic, but always with a higher frequency of yellow morphs than green morphs

116. The fitness of a genotype is higher when it is rare in a population than when it is common. Which of the following types of selection is most likely operating?

(A) Density-independent selection
(B) Frequency-dependent selection
(C) Directional selection
(D) Stabilizing selection
(E) Disruptive selection

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117. The mating system in which a female defends a large, multipurpose territory within which several males defend smaller, exclusive territories is known as

(A) polygynandry
(B) resource defense polygyny
(C) resource defense polyandry
(D) resource defense promiscuity
(E) harem defense polygyny

118. One theory of the evolution of cooperation in animals states that under conditions of low resource availability, some members of a population are willing to sacrifice their own efforts to reproduce to ensure that the population as a whole will not exhaust all its resources and go extinct. Which level of selection is described in this model?

(A) Directional selection
(B) Individual selection
(C) Disruptive selection
(D) Stabilizing selection
(E) Group selection

119. Charles Darwin discussed all of the following EXCEPT:

(A) Natural selection tends to remove those organisms that are poorly adapted to their environments.
(B) Individuals in a population compete with one another for limited resources.
(C) Gene mutations are the source of variation for evolution.
(D) Organisms tend to produce more offspring than can survive in each generation.
(E) Individuals within species exhibit variability in form and function.

120. When numbers of organisms and amounts of living material in successively higher trophic levels are compared, the values usually take the form of a pyramid, with the largest numbers and greatest biomass in the producer trophic level. However, in some marine ecosystems, the consumer trophic levels contain significantly greater amounts of living material than does the primary-producer trophic level. The best explanation for this is which of the following?

(A) The main primary producers in marine ecosystems are microscopic algae with extremely high rates of population turnover.
(B) Most consumers in marine ecosystems are filter feeders that must maintain large basketlike structures for extracting food from the water.
(C) The increased availability of solar radiation in marine ecosystems means that fewer primary producers are required to support marine food chains.
(D) Marine zooplankton often produce large extensions of their bodies in order to increase buoyancy.
(E) The largest consumers in marine ecosystems, the baleen whales, are essentially filter feeders.

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121. Two populations of sunflowers, *A* and *B*, differ in the heritability of the oil content in their seeds; H^2 equals 0.40 in population *A*, while H^2 equals 0.70 in population *B*. Which of the following statements about these sunflower populations is correct?

(A) Population *A*'s seeds have a lower oil content than those of *B*.
(B) The variability in seed oil content is higher in population *B* than in *A*.
(C) Population *A* grows in a more diverse and unstable environment than does *B*.
(D) Proportionately more phenotypic variation is environmental variation in population *A* than in *B*.
(E) Population *B* has more genetic variation for seed oil content than does *A*.

122. From an evolutionary point of view, plant tendrils derived from leaves and those derived from stems are examples of

(A) analogous structures resulting from convergence only
(B) homologous structures resulting from convergence only
(C) analogous structures resulting from divergence only
(D) homologous structures resulting from divergence only
(E) both analogous and homologous structures resulting from divergence

123. Which of the following is characteristic of allopatric speciation?

(A) Large populations
(B) Asexually reproducing populations
(C) Geographic isolation
(D) Isolation through adaptation of alleles
(E) The sudden appearance of new species

1 *Tyrannosaurus* (dinosaur)
2. Lobe-finned fishes
3. Great apes
4. *Eohippus* (horse)
5. Trilobites

124. Which of the following represents the proper sequence, from the earliest in the fossil record to the latest, of the animals listed above?

(A) 1, 2, 5, 4, 3
(B) 2, 5, 1, 3, 4
(C) 2, 5, 1, 4, 3
(D) 5, 1, 2, 3, 4
(E) 5, 2, 1, 4, 3

125. Invasion of the land by vascular plants most likely began in which of the following periods?

(A) Precambrian
(B) Silurian
(C) Pennsylvanian
(D) Cretaceous
(E) Jurassic

GO ON TO THE NEXT PAGE.

Directions: Each group of questions below consists of five lettered headings followed by a list of numbered words, phrases, or sentences. For each numbered word, phrase or sentence, select the one heading that is most closely related to it and fill in completely the corresponding space on the answer sheet. One heading may be used once, more than once, or not at all in each group.

Questions 126-129

(A) Gross primary production
(B) Net primary production
(C) Decomposition
(D) Secondary production
(E) Assimilation

126. Gross energy intake by animals minus egested energy losses

127. Stored energy left in plants after respiration

128. Total amount of energy fixed by autotrophs

129. Total energy present at the consumer level

Questions 130-132 refer to the following.

(A) Myelin
(B) Dendrite
(C) Axon
(D) Efferent neuron
(E) Synapse

130. Increases the speed of nerve impulse propagation

131. Transmits nerve impulses from the cell body

132. Is a functional contact between neurons

Questions 133-135 refer to the following.

(A) Clathrin
(B) Mannose 6-phosphate
(C) Dolichol phosphate
(D) Signal sequence
(E) Tubulin

133. Targets lysosomal hydrolases to lysosomes

134. Targets proteins to the endoplasmic reticulum

135. Stabilizes regions of the plasma membrane where coated pits are formed

Questions 136-138

(A) Stabilizing selection
(B) Group selection
(C) Directional selection
(D) Disruptive selection
(E) Kin selection

136. Intermediate-sized sparrows have higher survival during a storm than those of extreme sizes.

137. Rats with either a high or a low level of testosterone have higher survival than those with an intermediate level.

138. Over a 50-year period, the melanic (dark) form of a moth increases from less than 1% to more than 95% of the population because melanic moths experience less predation from birds than do non-melanic moths.

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Questions 139-141 refer to the following enzymes.

(A) Pyruvate dehydrogenase
(B) Ribulose bisphosphate carboxylase (rubisco)
(C) Phosphofructokinase
(D) F_1ATPase
(E) Aldolase

139. Enzyme involved in carbon fixation by chloroplasts

140. Enzyme that catalyzes a major regulation point of glycolysis

141. Enzyme complex responsible for catalyzing the reaction that is the transition between glycolysis and the citric acid (Krebs) cycle

Questions 142-144 refer to the following cell types from the vascular tissue of a plant.

(A) Vessel members
(B) Tracheids
(C) Fibers
(D) Sieve-tube members
(E) Pith ray cells

142. The most primitive vascular plant cells that conduct water and provide support

143. Cells that primarily provide rapid transport of water in angiosperms

144. Cells that transport photosynthate

Questions 145-147 refer to the following.

(A) Leucine zipper motif
(B) Zinc finger motif
(C) Transcription factor IID
(D) Upstream control element
(E) Enhancer element

145. Binds to the TATA box and assists in mediating multiple rounds of transcription by RNA polymerase II

146. DNA sequence required for gene transcription that extends approximately 100 nucleotide pairs in front of the RNA start site

147. Stimulates RNA transcription from either an upstream or downstream position

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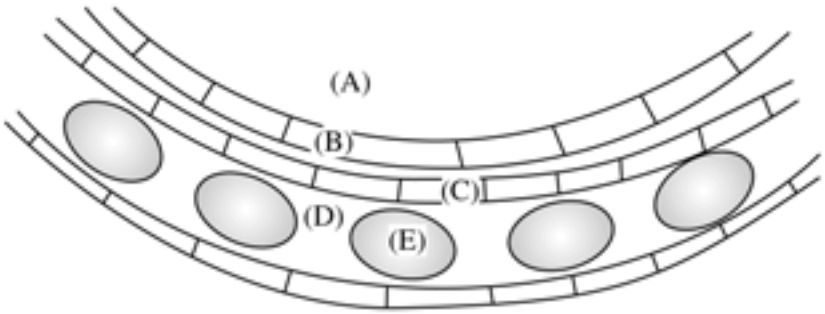
Questions 148-150 refer to the diagram below of a capillary net around an alveolus.



(A) Alveolar space
(B) Alveolar wall
(C) Capillary wall
(D) Plasma
(E) Erythrocyte

148. Prior to equilibrium, the highest partial pressure of oxygen occurs at this site.

149. Carbon monoxide causes respiratory failure by outcompeting oxygen at this site.

150. Hemoglobin is located primarily at this site.

Questions 151-153

(A) Tethys
(B) Pangea
(C) Gondwana
(D) Laurasia
(E) Archean

151. Precursor to the northern group of continents

152. Precursor to Africa, South America, Australia, Antarctica, and India

153. The supercontinent that began to break up during the Triassic

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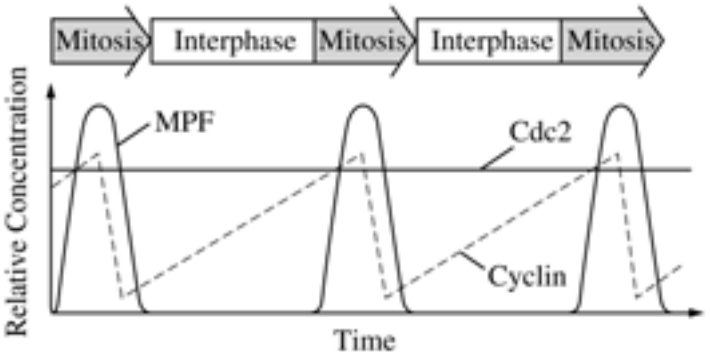
Directions: Each group of questions below concerns a laboratory or an experimental situation. In each case, first study the description of the situation. Then choose the one best answer to each question and fill in completely the corresponding space on the answer sheet.

Questions 154-155

M-phase-promoting factor (MPF) triggers mitosis by activating other proteins that function in cell division. Active MPF consists of two associated proteins, cyclin and Cdc2. The Cdc2 component of active MPF is a protein kinase. The relative concentrations of active MPF, Cdc2, and cyclin were monitored during the cell cycle and are depicted in the figure below.



154. During the cell cycle, active MPF decreases at the end of mitosis. This can be best explained by the

(A) increase in Cdc2 during mitosis
(B) increase in cyclin during mitosis
(C) decrease in cyclin during mitosis
(D) decrease in Cdc2 during mitosis
(E) decrease in inactive MPF during mitosis

155. If MPF activates a series of enzymes, one of which inactivates MPF, it is likely that one of the enzymes activated by MPF

(A) degrades cyclin only
(B) degrades Cdc2 only
(C) degrades cyclin and Cdc2
(D) stimulates cyclin
(E) stimulates Cdc2

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Questions 156-157 refer to the following experiment.

The marine coenocytic green alga *Caulerpa* grows in a unidirectional pattern. Photosynthetic fronds are produced on its upper surface and anchoring rhizoids on the lower surface (Figure I). When the same organism was inverted, new rhizoids were then initiated on the newly formed lower surface, while fronds were initiated on the newly formed upper surface (Figure II).

Secondary fronds can be initiated from the margins of the primary fronds. In another experiment, it was found that if the secondary fronds are initiated after the plant has been inverted, they will grow upward, even if the frond from which they are growing is oriented downward (Figure III).

Figure I

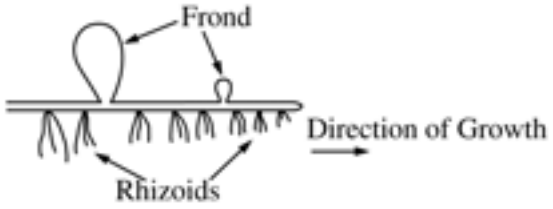

Figure II

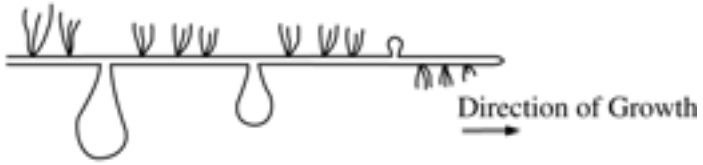

Figure III

156. Which of the following conclusions is best indicated by the additional experiment in Figure III ?

(A) Cellular gravity sensors are likely not responsible for the establishment of polarity.
(B) Tip growth always occurs perpendicular to the pull of gravity.
(C) Newly formed cytoplasm is fully differentiated and cannot respond to altered orientation.
(D) The change in polarity is expressed only in newly formed cytoplasm.
(E) Coenocytic organisms do not display cellular differentiation.

157. Which of the following procedures would best test whether the induction of polarity is regulated at the transcriptional level?

(A) Expose plants to a protein synthesis inhibitor, then invert.
(B) Invert plants, then expose to a protein synthesis inhibitor.
(C) Expose plants to an RNA synthesis inhibitor, then invert.
(D) Invert plants, then expose to an RNA synthesis inhibitor.
(E) Expose plants to a DNA synthesis inhibitor, then invert.

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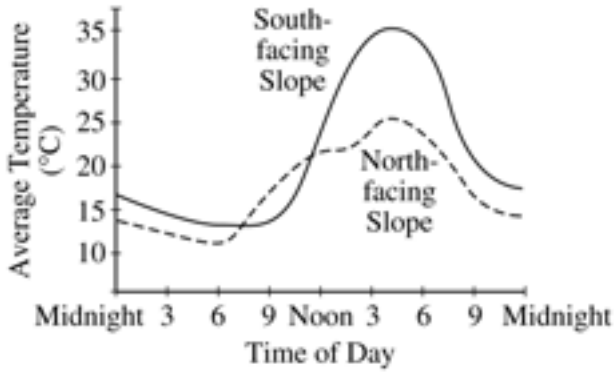
Questions 158-159

The average daily temperature change on an exposed south-facing slope and a north-facing slope for a late summer day in the Northern Hemisphere are shown below.

DAILY TEMPERATURE CHANGE ON SOUTH-FACING AND NORTH-FACING SLOPES



158. Compared with a south-facing slope, the climatic conditions on a north-facing slope favor the formation of a vegetation community best adapted to

(A) colder temperatures and wetter environments
(B) colder temperatures and drier environments
(C) hotter temperatures and similar moisture environments
(D) hotter temperatures and wetter environments
(E) hotter temperatures and drier environments

159. The difference in the maximum average daily temperature between the south-facing slope and the north-facing slope is approximately

(A) 0°C
(B) 5°C
(C) 10°C
(D) 25°C
(E) 35°C

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Questions 160-163

In experiments to determine possible metabolic side effects of a new industrial by-product X941, the rate of respiratory oxygen consumption by isolated mitochondria was assayed. The mitochondria were maintained in a solution containing high concentrations of dissolved oxygen and inorganic phosphate.

Figure 1 shows the results of a control experiment. Pyruvic acid, the principal metabolic precursor for the citric acid cycle, was added to isolated mitochondria, followed a short time later by the addition of ADP. Figure 2 illustrates the effect of adding X941 instead of ADP.

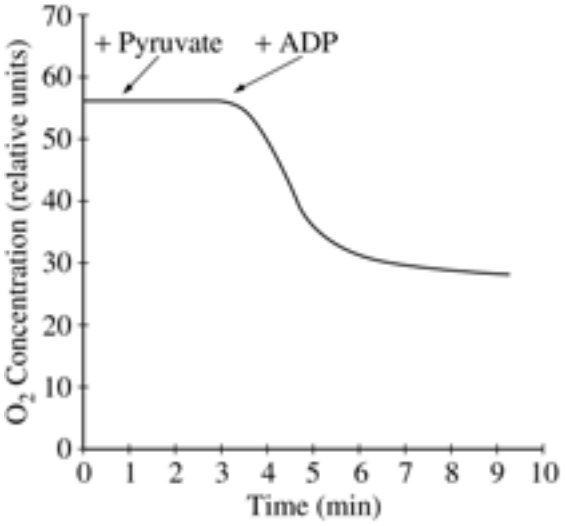

Figure 1

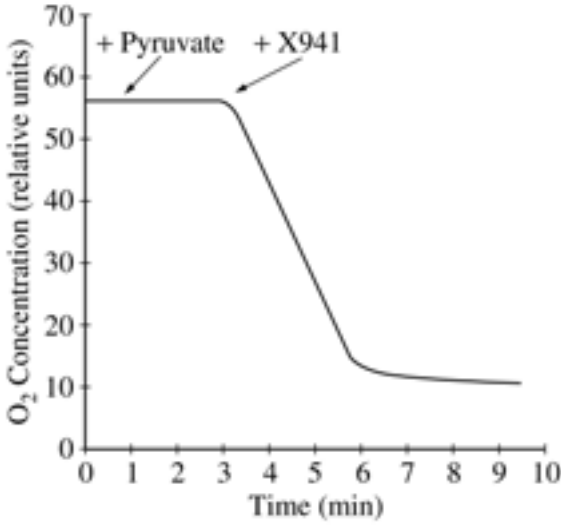

Figure 2

160. Which of the following best explains why O_2 concentration does not decrease until after the addition of ADP, as shown in Figure 1 ?

(A) The proton gradient that drives electron transport can be produced only by phosphorylation of ADP.
(B) A complete turn of the citric acid cycle requires several ADP's directly.
(C) ADP is a substrate, along with pyruvate, for pyruvate dehydrogenase.
(D) ADP is an allosteric activator of cytochrome oxidase, which is unable to transfer electrons to O_2 without ADP.
(E) The proton gradient produced by pyruvate metabolism quickly inhibits electron transport; the inhibition is released by ATP synthesis.

161. Which of the following is the most likely reason that O_2 consumption stops a short time after the addition of ADP, as shown in Figure 1 ?

(A) The O_2 concentration has fallen to zero.
(B) Most of the ADP has been phosphorylated.
(C) The mitochondria have burst from excess ATP.
(D) The pyruvate dehydrogenase activity has been destroyed.
(E) The electron transport system has been denatured.

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162. In Figure 2, the addition of X941 results in the nearly complete depletion of the O_2 in the assay mixture. A further test showed that this depletion occurred even when inorganic phosphate was omitted from the assay. The most likely explanation for the effect of X941 is that X941

(A) allows O_2 to leak out of the mitochondria
(B) is a precursor to the synthesis of ADP
(C) uncouples ADP phosphorylation from electron transport
(D) serves as an alternative electron acceptor in the system
(E) serves as an allosteric activator of pyruvate dehydrogenase

163. If X941 is an ionophore, which of the following best describes its mode of action?

(A) It rearranges the mitochondrial membrane, thus allowing O_2 to pick up electrons of higher energy.
(B) It allows O_2 to diffuse through the inner mitochondrial membrane more quickly.
(C) It sequesters ions that are known to inhibit the transfer of electrons to O_2.
(D) It allows protons to diffuse through the inner mitochondrial membrane, thus dissipating the proton gradient.
(E) It acts as an electron donor, thus providing the electron transport system with a large number of electrons to reduce O_2.

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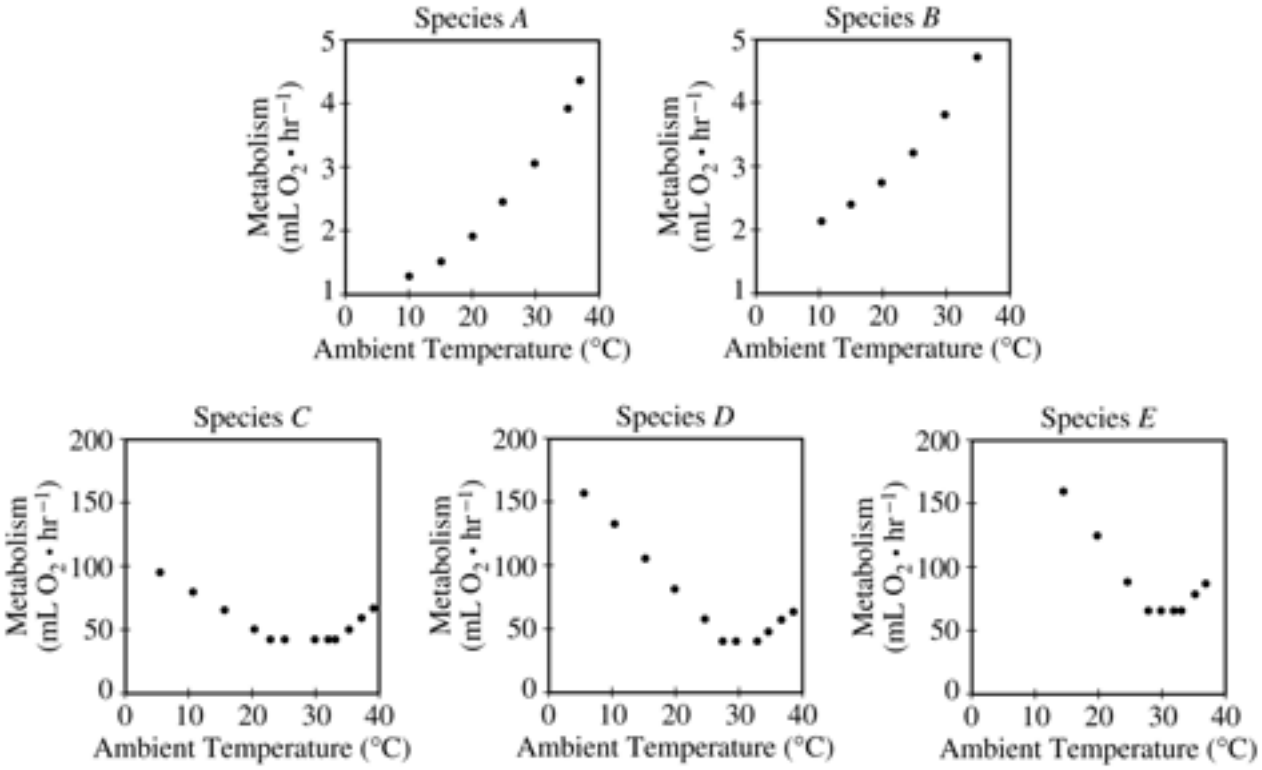
Questions 164-167

Graphs showing the metabolic response of five different species of animals at various ambient temperature exposures are shown below. The average body mass of each of the species is 25 grams. All measurements were made using respirometers in the lab with the animals at rest and postabsorptive.



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164. Of the species studied, which is best insulated?

(A) Species *A*
(B) Species *B*
(C) Species *C*
(D) Species *D*
(E) Species *E*

165. Of the species studied, which has the highest basal metabolic rate?

(A) Species *A*
(B) Species *B*
(C) Species *C*
(D) Species *D*
(E) Species *E*

166. Which of the following can be concluded for species *C*, *D*, and *E*?

(A) Metabolic costs increase with increased body mass.
(B) Metabolic expenditures decrease below the lower critical temperature.
(C) The lowest metabolic costs are in the thermoneutral zone.
(D) The lowest metabolic costs are attained at an ambient temperature of 20°C.
(E) The animals require no energy input in the thermoneutral zone.

167. Which of the following pairs of species are ectotherms?

(A) Species *A* and *B*
(B) Species *A* and *C*
(C) Species *B* and *D*
(D) Species *B* and *E*
(E) Species *C* and *D*

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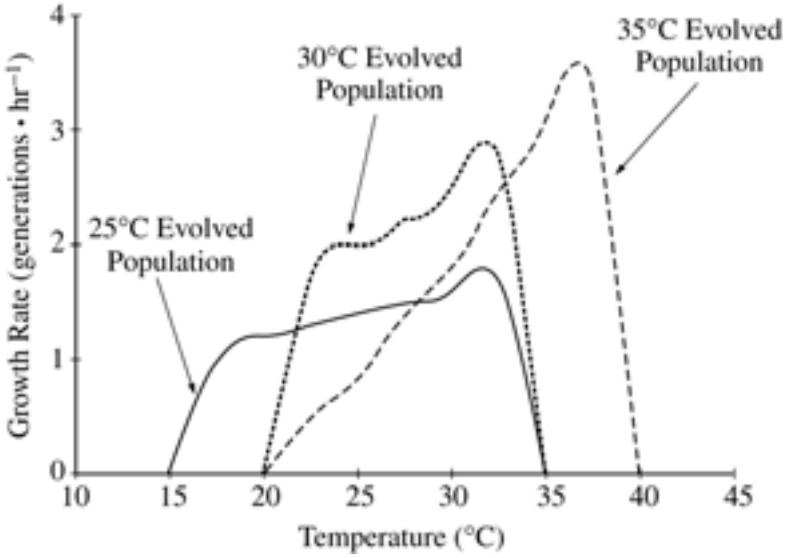
Questions 168-171

The graph below shows the growth rates of populations of bacteria that have evolved for many generations at different culture temperatures (25°C, 30°C, and 35°C). Each population grows over only a limited range of temperatures (its thermal niche), which are bounded by its critical thermal limits. Within this range, growth rate increases with temperature up to a maximal value and then declines rapidly with increasing temperature. Growth rates are known to be the major determinant of fitness for these bacteria.

EVOLUTIONARY ADAPTATION TO TEMPERATURE



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168. Which of the following is true concerning the thermal dependence of growth rate between 25°C and 30°C in these populations?

(A) Thermal dependence is greatest in the population evolved at 25°C.
(B) Thermal dependence is greatest in the population evolved at 30°C.
(C) Thermal dependence is greatest in the population evolved at 35°C.
(D) Growth rates of all populations are equally thermally dependent over this temperature range.
(E) Growth rates of all populations are thermally independent over this temperature range.

169. Which population has the highest fitness at 25°C ?

(A) The population evolved at 25°C.
(B) The population evolved at 30°C.
(C) The population evolved at 35°C.
(D) All populations are equally fit at this temperature.
(E) It cannot be determined from the information given.

170. Which of the following can be correctly concluded from this experiment?

(A) The temperature range of the thermal niche remains constant at different evolutionary temperatures, even though critical thermal limits may change.
(B) Critical thermal limits remain constant during evolution at different temperatures.
(C) The same maximal growth rate is attained in all three populations, but it is attained at different temperatures.
(D) Maximal growth rate is not always attained at the temperature at which a population evolved.
(E) No evolutionary changes have occurred in these populations.

171. If all three populations were mixed together and placed at 37°C, which of the following would be most likely to happen?

(A) Only the population evolved at 25°C would die and become extinct.
(B) Only the population evolved at 35°C would survive and reproduce.
(C) All the bacteria would die and the populations would become extinct.
(D) All populations would grow, and transfer of genes would create one common population.
(E) It cannot be determined from the information given.

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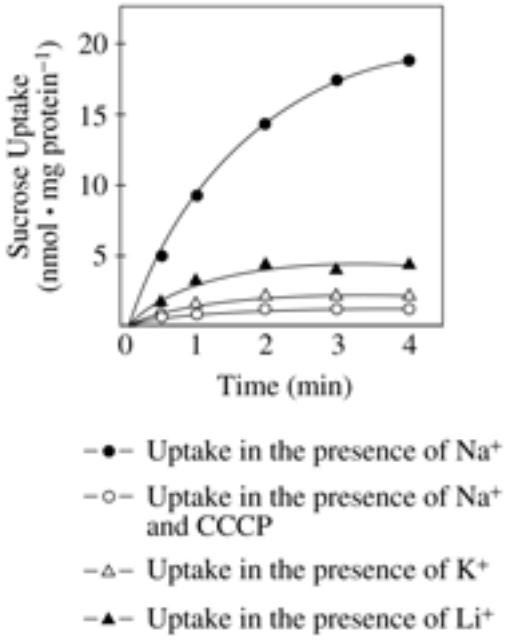
Questions 172-174 refer to the following experiment.

The graph below contains data obtained in an experiment designed to elucidate the mechanism of sucrose uptake by the marine bacterium *Vibrio alginolyticus*. Sucrose uptake was determined by incubating washed cells in [^{14}C]-sucrose for short periods of time, harvesting, rewashing the cells, and measuring the sucrose present. Uptake was measured in the presence of Na^+, Na^+ plus CCCP (an inhibitor of proton gradient formation), K^+, and Li^+.



172. Based on the data, which of the following statements best describes the uptake of sucrose by these cells?

(A) Sucrose crosses the membrane by simple diffusion.
(B) Sucrose is transported by a carrier-mediated system.
(C) Sucrose transport is not dependent on Na^+.
(D) Sucrose transport occurs by only one mechanism.
(E) Sucrose is not transported into the cell under most conditions.

173. The primary reason for testing the effects of CCCP is to determine whether

(A) the effect of Li^+ is dependent on Na^+
(B) a proton gradient is required for sucrose transport
(C) Na^+ transport occurs alone
(D) nonsaturable transport occurs
(E) K^+ can substitute for Na^+ in sucrose transport

174. Which of the following is the best explanation for the effects of Li^+ and K^+ on the uptake of sucrose?

(A) These ions bind to sucrose and block its entry into the cell.
(B) These ions decrease the net Na^+ available in the cells for cotransport.
(C) These ions uncouple the respiratory process that generates energy for the uptake of sucrose.
(D) These ions are not transported rapidly by the Na^+/sucrose cotransporter system.
(E) These ions are allosteric effectors of the sucrose transporter system.

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Questions 175-177

The concept of species diversity has two components: evenness and richness. Evenness is based on the relative abundance of species. Richness is based on the total number of species present. Diversity indices combine a measure of richness and evenness. The Simpson index (C) is calculated from the following equation.

$$C = \sum_i (n_i / N)^2$$

where

n_i = importance value for each species

N = total importance values

Below are data collected in two terrestrial plant communities that represent part of a successional chronosequence. In this case, importance values were measured as percent cover.

EARLY-SUCCESSIONAL COMMUNITY

Species	Percent Cover
A	83
B	5
C	9
D	2
E	1

LATE-SUCCESSIONAL COMMUNITY

Species	Percent Cover
F	24
G	20
H	18
I	23
J	15

175. The Simpson index value for the late-successional community is

(A) 1.00
(B) 0.410
(C) 0.205
(D) 0.0410
(E) 0.0205

176. The data indicate that, relative to the early-successional community, the late-successional community has which of the following characteristics?

	Species Richness	Evenness
(A)	Higher	Higher
(B)	Higher	Lower
(C)	Same	Lower
(D)	Same	Higher
(E)	Lower	Lower

177. Experimental removal of species *B* and *C* in the early-successional community resulted in a slower subsequent colonization and establishment of species *F* and *G*. This result suggests that the primary mechanism by which *F* and *G* replace *B* and *C* during succession is

(A) inhibition
(B) facilitation
(C) competitive displacement
(D) allelopathy
(E) facultative mutualism

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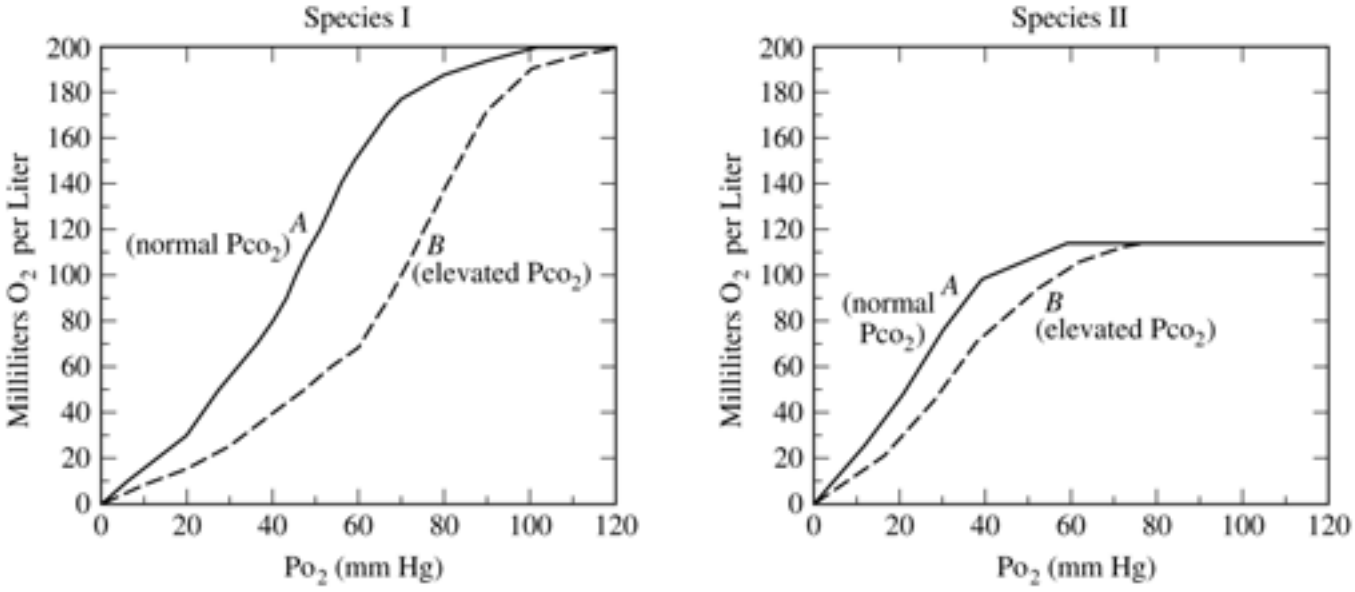
Questions 178-181 refer to the following experiment.



The two graphs above indicate the relationship between oxygen content and oxygen partial pressure (Po_2) in samples of blood taken from two species of vertebrates (species I and species II). Each sample was subjected to two levels of carbon dioxide pressure (Pco_2): curve *A* represents the values measured at normal Pco_2 and curve *B* represents the values measured at elevated Pco_2. The blood passing through the lungs of these species normally has a Po_2 of 100 millimeters of mercury and the venous blood leaving the tissues has a Po_2 of 40 millimeters of mercury.

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178. When curve *A* for species I is compared to curve *A* for species II, it can be predicted that the O_2 concentration of the blood will be

(A) higher in the lung for species I than for species II
(B) lower in the lung for species I than for species II
(C) higher in species I at all pressures
(D) lower in species I at all pressures
(E) the same in both species at all pressures

179. If deoxygenated blood samples were exposed to increasing Po_2, the first sample to become saturated with O_2 would be from which of the following?

(A) Species I at normal Pco_2
(B) Species I at elevated Pco_2
(C) Species II at normal Pco_2
(D) Species II at elevated Pco_2
(E) There are no differences.

180. Which of the following statements best describes the effect of increased carbon dioxide pressure in the blood of the two species?

(A) It affects oxygen affinity and oxygen-carrying capacity in one species only.
(B) It increases the oxygen affinity but has no effect on oxygen-carrying capacity in either species.
(C) It reduces the oxygen affinity and the oxygen-carrying capacity in both species.
(D) It reduces oxygen affinity but has no effect on oxygen-carrying capacity in either species.
(E) It has no effect on either oxygen affinity or oxygen-carrying capacity in either species.

181. If the Pco_2 of arterial blood is equivalent to that used to obtain curve *A* and if venous Pco_2 corresponds to that used to obtain curve *B*, how much oxygen will be released from a liter of blood as it passes through the tissues in species I ?

(A) 20 mL
(B) 40 mL
(C) 120 mL
(D) 160 mL
(E) 200 mL

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Questions 182-185 refer to the following model as an example of adaptive radiation and species diversification.

One of the classical examples of evolution occurs on the Galápagos Islands with Darwin's finches. The islands have always been separate from the South American mainland and vary in size and elevation. The lowlands are covered with thorn scrub, while higher elevations (found only on the larger islands) are covered with moist, dense forests. All the organisms living on these islands are descendants of species that have emigrated there, primarily from South America. In studying the finch populations, researchers have identified fourteen species, none of which are found on the mainland.

182. The initial colonizing population of finches most likely exhibited which of the following?

(A) Hybridization with bird species already existing on the islands
(B) High rates of interbreeding with mainland populations
(C) Increased rates of mutation to fill habitats
(D) A novel behavior not seen in mainland populations
(E) A smaller gene pool than that of the mainland populations

183. As opposed to the mainland, on the islands the initial colonists (finches) had the opportunity to evolve in new directions primarily because there

(A) was an absence of interspecific competition
(B) was mixing of the gene pool
(C) was a higher mutation rate
(D) was higher predation pressure
(E) were higher levels of inbreeding

184. Initially, one species of finch may have settled on two different islands, maintained this separation over hundreds of years, and eventually followed divergent adaptive pathways. If these now two separate species should migrate onto a new island, they could maintain their individual species identities on this island in all the following ways EXCEPT if one species

(A) hybridizes successfully with the other species
(B) lives in the forests and the other in the scrubland
(C) carries out different stages of its life cycle at different times than the other species
(D) fails to produce viable young after mating with the other species
(E) is not attracted to the other species for mating

185. Although the initial finch species on the islands may have all been seed eaters, which of the following processes minimized competition as the population expanded?

(A) Selection for niche diversification
(B) Development of more efficient attack behavior
(C) Further emigration when carrying capacity was reached
(D) Genetic drift
(E) Postzygotic mating factors

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Questions 186-188

Lymphocytes extracted from the rat kangaroo, *Potorous tridactylus*, were grown in culture for karyotype analysis. To obtain chromosome spreads, such as that illustrated below, lymphocytes were incubated in the antimitotic drug colchicine for 30 minutes before fixation and staining. The chromosomes depicted below are representative of the karyotype found in all of the cells of the culture.

186. Which of the following correctly describes the chromosome number in this rat kangaroo cell?

(A) The haploid chromosome number is 12.
(B) The haploid chromosome number is 24.
(C) The diploid chromosome number is 12.
(D) The diploid chromosome number is 24.
(E) The triploid chromosome number is 24.

187. During anaphase, how many kinetochores would be expected in a normal rat kangaroo lymphocyte?

(A) 12
(B) 18
(C) 24
(D) 36
(E) 48

188. During S phase, DNA synthesis originates at specific sequences in the chromosomal DNA. How many sites for initiation of DNA synthesis would be expected among the chromosomes within the rat kangaroo karyotype during S phase?

(A) Fewer than 12
(B) 12
(C) Between 12 and 24
(D) 24
(E) More than 24

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Questions 189-192

Protein X is a protein kinase encoded by mRNA X and is normally present in extracts of whole cleavage-stage frog embryos. Protein I, encoded by mRNA I, is an inactive mutant form of protein X and blocks the function of protein X present in the same cell by competing for binding. The results shown in the table below were obtained in a series of experiments in which all four cells in four-cell-stage embryos were injected as shown and allowed to develop to the early larval stage. Control embryos were pierced by a needle, but no material was injected. The larvae were scored for the presence or absence of eyes in the normal dorsal body axis and for the presence of eyes in the ventrally located secondary body axis that formed as a result of some of the treatments.

Material Injected	Injection Location	Dorsal Body Axis with Eyes	Ventral Body Axis with Eyes
Control	Dorsal	100%	0%
mRNA X	Dorsal	0%	0%
mRNA I	Dorsal	100%	0%
Control	Ventral	100%	0%
mRNA X	Ventral	100%	0%
mRNA I	Ventral	100%	100%

GO ON TO THE NEXT PAGE.

189. The results suggest that protein X has which of the following effects on formation of normal head structures?

(A) Weak inhibition
(B) Weak stimulation
(C) Strong inhibition
(D) Strong stimulation
(E) The effect cannot be evaluated from these data.

190. The data indicate that in at least some cells in the frog embryos, translation effectively occurs for

(A) mRNA X but not mRNA I
(B) mRNA I but not mRNA X
(C) neither mRNA X nor mRNA I
(D) both mRNA X and mRNA I
(E) most types of mRNA molecules

191. If translation of mRNA X occurs during cleavage, the results suggest that protein X would most likely be detectable at which location in untreated late-cleavage-stage frog embryos?

(A) Primarily in the dorsal cells of the embryos
(B) Primarily in the equatorial cells of the embryos
(C) Primarily in the ventral cells of the embryos
(D) In all of the cells of the embryos
(E) In few, if any, of the cells of the embryos

192. In Mangold and Spemann's experiments pieces of dorsal lip tissue transplanted to the ventral surface of amphibian embryos induced the formation of a secondary body axis. Their results can be reconciled with the results shown above by assuming which of the following about the cells of the dorsal lip of the blastopore (Spemann's primary inducer) ?

(A) They secrete protein X into the extracellular matrix of the embryo.
(B) They destroy protein X in the extracellular matrix of the embryo.
(C) They contain relatively high concentrations of protein X.
(D) They stimulate protein X synthesis or increase activity of protein X in neighboring cells in the embryo.
(E) They inhibit protein X synthesis or decrease activity of protein X in neighboring cells in the embryo.

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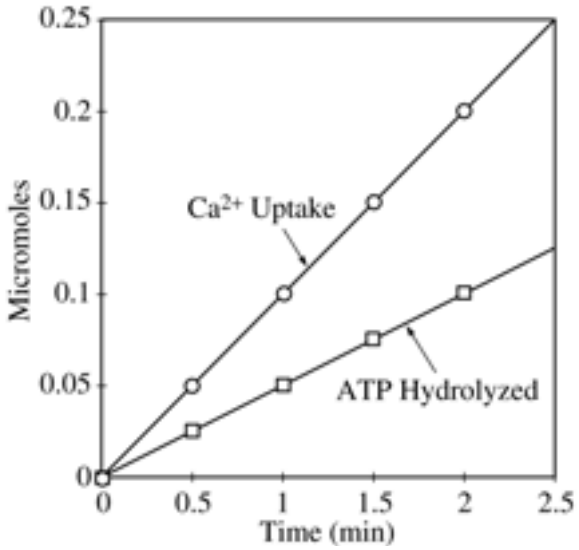
Questions 193-195

In muscle cells, Ca^{2+} is actively transported into the sarcoplasmic reticulum. The membranes of the sarcoplasmic reticulum can be isolated in the form of microsomes. Each microsome contains several hundred molecules of an enzyme that uses ATP as an energy source to drive the inward transport of calcium ions that are added externally. In one experiment, the results shown below were obtained.



Experimental conditions:

1.0	ml of 0.1 M KCl containing:
5	mM $MgCl_2$
5	mM ATP
0.1	mM $CaCl_2$
0.1	mg protein (ATPase)

193. What is the rate of ATP hydrolysis, expressed as micromoles of ATP hydrolyzed per milligram of protein per minute?

(A) 2
(B) 1
(C) 0.5
(D) 0.25
(E) 0.1

194. What is the ratio of calcium pumped per ATP hydrolyzed?

(A) 1:4
(B) 1:2
(C) 1:1
(D) 2:1
(E) 4:1

195. The specific activity for the ATPase enzyme is expressed in units of

(A) mole ATPase·sec^{-1}
(B) mole ATP·sec^{-1}·mg $protein^{-1}$
(C) mole ADP·sec^{-1}
(D) mole ADP·sec^{-1}·mg $protein^{-1}$
(E) mole ADP·sec^{-1}·mole $ATPase^{-1}$

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Questions 196-198

A species of long-day plant (LDP) and a species of short-day plant (SDP), each having a critical photoperiod of 10 hours, were placed in growth chambers that provided identical environmental conditions, except for the length of the photoperiod. Individuals from each species were treated as indicated in the following table for a period of many weeks.

		24-hour Cycle	
Treatment	Plant Species	Hours of Light	Hours of Darkness
1	LDP	8	16
2	LDP	16	8
3	SDP	8	16
4	SDP	16	8

A second experiment was conducted under identical conditions, except that halfway through the dark period the lights were switched on for one minute and then switched off.

196. In the initial experiment, for which of the following treatments would the plants be expected to flower?

(A) 1 and 2
(B) 1 and 3
(C) 1 and 4
(D) 2 and 3
(E) 2 and 4

197. In the second experiment, for which of the following treatments would the plants be expected to flower?

(A) 1 and 2
(B) 1 and 3
(C) 1 and 4
(D) 2 and 3
(E) 2 and 4

198. Which of the following wavelengths of light would be the most effective in interrupting the dark period in the second experiment?

(A) 460 nm (blue)
(B) 520 nm (green)
(C) 580 nm (yellow)
(D) 660 nm (red)
(E) 730 nm (far-red)

GO ON TO THE NEXT PAGE.

Questions 199-200

The mussel *Mytilus edulis* thrives in saline habitats, in both the highly salty seawater of tidal zones and the less salty estuaries. This results in two kinds of populations: one adapted to the higher salt concentrations of the tidal zone, and one adapted to the lower salt concentrations of the estuary. It has been found that the more salt-tolerant populations have high frequencies of an allele that produces an enzyme involved in maintaining osmotic equilibrium. Conversely, estuarine mussels having the same enzyme seem to be disfavored and have a much higher death rate than mussels without the allele. Adult estuarine populations do have lower frequencies of this allele. Each spring, large numbers of larvae from the salty habitats pour into the estuaries.

199. The invasion of the seawater larvae would be expected to facilitate change in the genetic structure of the estuarine population by a process called

(A) directional selection
(B) genetic drift
(C) gene flow
(D) disruptive selection
(E) nonrandom mating

200. THIS ITEM WAS NOT SCORED.

If you finish before time is called, you may check your work on this test.

NO TEST MATERIAL ON THIS PAGE

I

NOTE: To ensure prompt processing of test results, it is important that you fill in the blanks exactly as directed.

SUBJECT TEST

A. Print and sign your full name in this box:

PRINT: _____
(LAST) (FIRST) (MIDDLE)

SIGN: _____

Copy this code in box 6 on your answer sheet. Then fill in the corresponding ovals exactly as shown.

6. TITLE CODE				
2	4	1	5	5
0	0	0	0	0
1	1	●	1	1
●	2	2	2	2
3	3	3	3	3
4	●	4	4	4
5	5	5	●	●
6	6	6	6	6
7	7	7	7	7
8	8	8	8	8
9	9	9	9	9

Copy the Test Name and Form Code in box 7 on your answer sheet.

TEST NAME Biology

FORM CODE GR0624

GRADUATE RECORD EXAMINATIONS SUBJECT TEST

B. The Subject Tests are intended to measure your achievement in a specialized field of study. Most of the questions are concerned with subject matter that is probably familiar to you, but some of the questions may refer to areas that you have not studied.

Your score will be determined by subtracting one-fourth the number of incorrect answers from the number of correct answers. Questions for which you mark no answer or more than one answer are not counted in scoring. If you have some knowledge of a question and are able to rule out one or more of the answer choices as incorrect, your chances of selecting the correct answer are improved, and answering such questions will likely improve your score. It is unlikely that pure guessing will raise your score; it may lower your score.

You are advised to use your time effectively and to work as rapidly as you can without losing accuracy. Do not spend too much time on questions that are too difficult for you. Go on to the other questions and come back to the difficult ones later if you can.

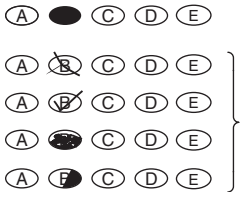
YOU MUST INDICATE ALL YOUR ANSWERS ON THE SEPARATE ANSWER SHEET. No credit will be given for anything written in this examination book, but you may write in the book as much as you wish to work out your answers. After you have decided on your response to a question, fill in the corresponding oval on the answer sheet. BE SURE THAT EACH MARK IS DARK AND COMPLETELY FILLS THE OVAL. Mark only one answer to each question. No credit will be given for multiple answers. Erase all stray marks. If you change an answer, be sure that all previous marks are erased completely. Incomplete erasures may be read as intended answers. Do not be concerned that the answer sheet provides spaces for more answers than there are questions in the test.

Example:

What city is the capital of France?

(A) Rome
(B) Paris
(C) London
(D) Cairo
(E) Oslo

Sample Answer



DO NOT OPEN YOUR TEST BOOK UNTIL YOU ARE TOLD TO DO SO.

Educational Testing Service

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Princeton, New Jersey 08541

Scoring Your Subject Test

Biology Test scores are reported on a 200 to 990 score scale in ten-point increments. The actual range of scores is smaller, and it varies from edition to edition because different editions are not of precisely the same difficulty. However, this variation in score range is usually small and should be taken into account mainly when comparing two very high scores. In general, differences between scores at the 99th percentile should be ignored. **The score conversion table on page 67 shows the score range for this edition of the test only.**

Subscores are reported as two-digit scaled scores. The maximum possible range of Subject Test subscores is 20 to 99. Like total scores, the actual range of subscores for any test or test edition may be smaller than 20 to 99.

The worksheet on page 66 lists the correct answers to the questions. Columns are provided for you to mark whether you chose the correct (C) answer or an incorrect (I) answer to each question. Draw a line across any question you omitted, because it is not counted in the scoring. At the bottom of the page, enter the total number correct and the total number incorrect. Divide the total incorrect by 4 and subtract the resulting number from the total correct. Then round the result to the nearest whole number. This will give you your raw total score. Use the total score conversion table to find the scaled total score that corresponds to your raw total score.

Example: Suppose you chose the correct answers to 105 questions and incorrect answers to 41. Dividing 41 by 4 yields 10.3. Subtracting 10.3 from 105 equals 94.7, which is rounded to 95. The raw score of 95 corresponds to a scaled score of 670.

The subscore columns in the worksheet can be similarly used to tally your correct and incorrect responses to the questions that contribute to each subscore. We suggest that you circle the "•" if you chose the correct answer, and put a minus sign beside the "•" for an incorrect answer. Space is provided at the bottom right of the worksheet to calculate and enter your three raw subscores. The subscore conversion table will show you the scaled subscores that correspond to your raw subscores.

Worksheet for the Biology Test, Form GR0624 Only
Answer Key and Percentages* of Examinees Answering Each Question Correctly

QUESTION		P+	RESPONSE		SUBSCORE		
Number	Answer		C	I	1	2	3
1	B	70			•		
2	A	84			•		
3	B	70			•		
4	E	67			•		
5	A	82			•		
6	E	59			•		
7	A	78			•		
8	D	10			•		
9	B	65			•		
10	C	45			•		
11	B	74			•		
12	B	47			•		
13	D	41			•		
14	C	58			•		
15	C	63			•		
16	A	49			•		
17	A	18			•		
18	A	28			•		
19	B	68			•		
20	D	68			•		
21	C	78			•		
22	C	26			•		
23	E	29			•		
24	E	70			•		
25	E	34			•		
26	A	92			•		
27	C	63			•		
28	C	56			•		
29	D	11			•		
30	E	63			•		
31	E	23			•		
32	B	33			•		
33	E	29			•		
34	A	32			•		
35	D	44			•		
36	D	56			•		
37	A	28			•		
38	E	45			•		
39	B	34			•		
40	A	60			•		
41	E	39			•		
42	E	49			•		
43	D	57				•	
44	E	89				•	
45	D	77				•	
46	A	76				•	
47	E	71				•	
48	E	58				•	
49	B	44				•	
50	B	91				•	
51	B	37				•	
52	B	13				•	
53	C	83				•	
54	B	32				•	
55	E	61				•	
56	C	35				•	
57	A	69				•	
58	E	55				•	
59	B	67				•	
60	D	44				•	
61	E	34				•	
62	C	34				•	
63	D	43				•	
64	C	54				•	
65	A	80				•	
66	B	72				•	
67	D	46				•	
68	B	46				•	
69	D	24				•	
70	E	64				•	

QUESTION		P+	RESPONSE		SUBSCORE		
Number	Answer		C	I	1	2	3
71	D	27				•	
72	E	57				•	
73	B	13				•	
74	C	57				•	
75	D	82				•	
76	E	35				•	
77	D	21				•	
78	B	38				•	
79	E	53				•	
80	B	68				•	
81	C	38				•	
82	B	50				•	
83	E	19				•	
84	C	26				•	
85	E	88					•
86	C	85					•
87	C	64					•
88	D	58					•
89	D	31					•
90	D	70					•
91	E	95					•
92	C	49					•
93	A	59					•
94	A	85					•
95	E	65					•
96	A	61					•
97	C	27					•
98	B	60					•
99	A	15					•
100	B	55					•
101	C	64					•
102	C	43					•
103	B	47					•
104	E	70					•
105	B	76					•
106	E	65					•
107	A	62					•
108	A	74					•
109	B	21					•
110	B	35					•
111	C	59					•
112	E	26					•
113	B	40					•
114	B	69					•
115	A	15					•
116	B	54					•
117	C	54					•
118	E	67					•
119	C	67					•
120	A	59					•
121	D	26					•
122	A	31					•
123	C	66					•
124	E	72					•
125	B	12					•
126	E	28					•
127	B	63					•
128	A	80					•
129	D	45					•
130	A	84				•	
131	C	72				•	
132	E	82				•	
133	B	13			•		
134	D	37			•		
135	A	38			•		
136	A	76					•
137	D	65					•
138	C	76					•
139	B	71			•		
140	C	44			•		

QUESTION		P+	RESPONSE		SUBSCORE		
Number	Answer		C	I	1	2	3
141	A	69			•		
142	B	33				•	
143	A	23				•	
144	D	29				•	
145	C	47			•		
146	D	55			•		
147	E	50			•		
148	A	57				•	
149	E	48				•	
150	E	80				•	
151	D	38					•
152	C	44					•
153	B	78					•
154	C	73			•		
155	A	66			•		
156	D	47				•	
157	C	42			•		
158	A	53					•
159	C	91					•
160	E	11			•		
161	B	74			•		
162	C	24			•		
163	D	12			•		
164	C	49				•	
165	E	54				•	
166	C	68				•	
167	A	83				•	
168	C	51					•
169	B	79					•
170	D	79					•
171	B	83					•
172	B	66			•		
173	B	72			•		
174	D	33			•		
175	C	19					•
176	D	61					•
177	B	35					•
178	A	56				•	
179	C	49				•	
180	D	34				•	
181	D	14				•	
182	E	65					•
183	A	65					•
184	A	84					•
185	A	76					•
186	C	63			•		
187	C	48			•		
188	E	30			•		
189	C	37				•	
190	D	28				•	
191	C	30				•	
192	E	21				•	
193	C	56			•		
194	D	64			•		
195	D	12			•		
196	D	57				•	
197	A	18				•	
198	D	24				•	
199	C	57					•
200	**						

Total Correct (**C**) _____

Total Incorrect (**I**) _____

Total Score:

C – **I**/4 = _____

Scaled Score (SS) = _____

Subscores

1) **C** – **I**/4 = _____ SS = _____

2) **C** – **I**/4 = _____ SS = _____

3) **C** – **I**/4 = _____ SS = _____

* The P+ column indicates the percent of BIOLOGY Test examinees who answered each question correctly; it is based on a sample of December 2006 examinees selected to represent all BIOLOGY Test examinees tested between July 1, 2004, and June 30, 2007.

** Item 200 was not scored when this form of the test was originally administered.

Score Conversions and Percents Below* for GRE Biology Test, Form GR0624 Only

TOTAL SCORE					
Raw Score	Scaled Score	%	Raw Score	Scaled Score	%
180-199	990	99	85-87	640	47
177-179	980	99	82-84	630	43
174-176	970	99	80-81	620	40
172-173	960	99	77-79	610	37
169-171	950	99	74-76	600	34
166-168	940	99			
164-165	930	99	71-73	590	31
161-163	920	99	69-70	580	28
158-160	910	99	66-68	570	26
155-157	900	98	63-65	560	23
			61-62	550	21
153-154	890	98	58-60	540	19
150-152	880	97	55-57	530	16
147-149	870	96	52-54	520	14
145-146	860	96	50-51	510	12
142-144	850	95	47-49	500	10
139-141	840	94			
136-138	830	92	44-46	490	9
134-135	820	90	42-43	480	7
131-133	810	89	39-41	470	6
128-130	800	88	36-38	460	5
			33-35	450	4
126-127	790	86	31-32	440	3
123-125	780	84	28-30	430	2
120-122	770	82	25-27	420	2
117-119	760	79	23-24	410	1
115-116	750	77	20-22	400	1
112-114	740	75			
109-111	730	72	17-19	390	1
107-108	720	69	14-16	380	1
104-106	710	67	12-13	370	1
101-103	700	64	9-11	360	1
			6-8	350	1
99-100	690	61	4-5	340	1
96-98	680	58	1-3	330	1
93-95	670	56	0	320	1
90-92	660	53			
88-89	650	49			

*Percent scoring below the scaled score is based on the performance of 12,405 examinees who took the BIOLOGY Test between July 1, 2004, and June 30, 2007. This percent below information was used for score reports during the 2008-09 testing year.

Score Conversions for GRE Biology Test Subscores Form GR0624 Only

SUBSCORES							
Raw Scores			Scaled Score	Raw Scores			Scaled Score
Sub 1	Sub 2	Sub 3		Sub 1	Sub 2	Sub 3	
63-67	60-67		99	27	27	32	64
62	59		98	26	26	31	63
61	58		97	25	25	30	62
60	57		96	24	24	28-29	61
59	56	65	95	23		27	60
58	55	64	94				
57	54	63	93	22	23	26	59
56	53	62	92	21	22	25	58
55	52	61	91	20	21	24	57
54	51	60	90	19	20	23	56
				18	19	22	55
53	50	59	89	17	18	21	54
52	49	58	88	16	17	20	53
50-51		57	87	15	16	19	52
49	48	56	86	14	15	18	51
48	47	54-55	85	13	14	16-17	50
47	46	53	84				
46	45	52	83	12	13	15	49
45	44	51	82	11	12	14	48
44	43	50	81	10		13	47
43	42	49	80	8-9	11	12	46
				7	10	11	45
42	41	48	79	6	9	10	44
41	40	47	78	5	8	9	43
40	39	46	77	4	7	8	42
39	38	45	76	3	6	7	41
38	37	44	75	2	5	6	40
37		43	74				
36	36	41-42	73	1	4	5	39
35	35	40	72	0	3	3-4	38
34	34	39	71		2	2	37
33	33	38	70		1	1	36
					0	0	35
32	32	37	69				
31	31	36	68				
30	30	35	67				
29	29	34	66				
28	28	33	65				

Evaluating Your Performance

Now that you have scored your test, you may wish to compare your performance with the performance of others who took this test. Both the worksheet on page 66 and the tables on page 67 use performance data from GRE Biology Test examinees.

The data in the worksheet on page 66 are based on the performance of a sample of the examinees who took this test in December 2006. This sample was selected to represent the total population of GRE Biology Test examinees tested between July 2004 and June 2007. The numbers in the column labeled "P+" on the worksheet indicate the percentages of examinees in this sample who answered each question correctly. You may use these numbers as a guide for evaluating your performance on each test question.

The first table on page 67 contains, for each scaled score, the percentage of examinees tested between July 2004 and June 2007 who received lower scores. Interpretive data based on the scores earned by examinees tested in this three-year period will be used by admissions officers in the 2008-09 testing year. These percentages appear in the score conversion table in a column to the right of the scaled scores. For example, in the percentage column opposite the scaled score of 670 is the number 56. This means that 56 percent of the GRE Biology Test examinees tested between July 2004 and June 2007 scored lower than 670. To compare yourself with this population, look at the percentage next to the scaled score you earned on the practice test.

Your three subscores show your relative strengths or weaknesses in the three subfield areas of the GRE Biology Test. The raw subscores are scaled in such a way that they are related to the total scores on the test. On the average, a person who has a comprehensive background in the field can expect to have subscores equal to about one-tenth of his or her total score. Thus, if you have a total score of 600, and your undergraduate program placed equal emphasis on the three areas of Biology represented by the subscores, you would expect to have a scaled subscore of about 60 in each area. If, however, your subscores differ by more than a few points, you may take this as an indication that your lower score shows weakness, and you may wish to concentrate your review efforts on topics in that area.

It is important to realize that the conditions under which you tested yourself were not exactly the same as those you will encounter at a test center. It is impossible to predict how different test-taking conditions will affect test performance, and this is only one factor that may account for differences between your practice test scores and your actual test scores. By comparing your performance on this practice test with the performance of other GRE Biology Test examinees, however, you will be able to determine your strengths and weaknesses and can then plan a program of study to prepare yourself for taking the GRE Biology Test under standard conditions.

DO NOT USE INK

Use only a pencil with soft, black lead (No. 2 or HB) to complete this answer sheet.
Be sure to fill in completely the space that corresponds to your answer choice.
Completely erase any errors or stray marks.

GRADUATE RECORD EXAMINATIONS® - ETS GRE - SUBJECT TEST

SIDE 1

1. NAME Enter your last name, first name initial (given name), and middle initial if you have one. Omit spaces, apostrophes, Jr., II., etc.

Last Name only (Family Name or Surname) - First 15 Letters

First Name Initial | Middle Initial

BE SURE EACH MARK IS DARK AND COMPLETELY FILLS THE INTENDED SPACE AS ILLUSTRATED HERE: ●

YOU MAY FIND MORE RESPONSE SPACES THAN YOU NEED. IF SO, PLEASE LEAVE THEM BLANK.

Item responses continued on reverse side.

2.

YOUR NAME: (Print) Last Name (Family or Surname) First Name (Given) M.I.

MAILING ADDRESS: (Print) P.O. Box or Street Address

City State or Province

Country Zip or Postal Code

CENTER: City State or Province

Country Center Number Room Number

SIGNATURE:

3. DATE OF BIRTH

Month: ○ Jan. ○ Feb. ○ Mar. ○ April ○ May ○ June ○ July ○ Aug. ○ Sept. ○ Oct. ○ Nov. ○ Dec.

Day | Year

4. SOCIAL SECURITY NUMBER (U.S.A. only)

5. REGISTRATION NUMBER (from your admission ticket)

6. TITLE CODE (on back cover of your test book)

7. TEST NAME (on back cover of your test book)

FORM CODE (on back cover of your test book)

8. TEST BOOK SERIAL NUMBER (number in upper right corner of front cover of your test book)

SHADED AREA FOR ETS USE ONLY

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1 2 3 4

SIDE 2

SUBJECT TEST

COMPLETE THE CERTIFICATION STATEMENT, THEN TURN ANSWER SHEET OVER TO SIDE 1.

CERTIFICATION STATEMENT

Please write the following statement below, DO NOT PRINT.
"I certify that I am the person whose name appears on this answer sheet. I also agree not to disclose the contents of the test I am taking today to anyone."
Sign and date where indicated.

SIGNATURE: _____ **DATE:** ___/___/___
Month Day Year

BE SURE EACH MARK IS DARK AND COMPLETELY FILLS THE INTENDED SPACE AS ILLUSTRATED HERE: ● .
YOU MAY FIND MORE RESPONSE SPACES THAN YOU NEED. IF SO, PLEASE LEAVE THEM BLANK.

115 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	147 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	179 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	211 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
116 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	148 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	180 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	212 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
117 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	149 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	181 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	213 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
118 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	150 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	182 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	214 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
119 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	151 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	183 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	215 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
120 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	152 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	184 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	216 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
121 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	153 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	185 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	217 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
122 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	154 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	186 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	218 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
123 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	155 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	187 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	219 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
124 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	156 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	188 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	220 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
125 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	157 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	189 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	221 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
126 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	158 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	190 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	222 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
127 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	159 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	191 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	223 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
128 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	160 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	192 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	224 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
129 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	161 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	193 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	225 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
130 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	162 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	194 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	226 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
131 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	163 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	195 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	227 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
132 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	164 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	196 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	228 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
133 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	165 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	197 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	229 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
134 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	166 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	198 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	230 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
135 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	167 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	199 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	231 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
136 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	168 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	200 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	232 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
137 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	169 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	201 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	233 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
138 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	170 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	202 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	234 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
139 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	171 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	203 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	235 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
140 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	172 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	204 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	236 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
141 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	173 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	205 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	237 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
142 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	174 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	206 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	238 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
143 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	175 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	207 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	239 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
144 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	176 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	208 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	240 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
145 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	177 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	209 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	241 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ
146 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	178 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	210 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ	242 Ⓐ Ⓑ Ⓒ Ⓓ Ⓔ

TR	TW	TFS	TCS	1R	1W	1FS	1CS	2R	2W	2FS	2CS
FOR ETS USE ONLY				3R	3W	3FS	3CS	4R	4W	4FS	4CS
				5R	5W	5FS	5CS	6R	6W	6FS	6CS

IF YOU DO NOT WANT THIS ANSWER SHEET TO BE SCORED

If you want to cancel your scores from this test administration, complete A and B below. You will not receive scores for this test. No record of this test or the cancellation will be sent to the recipients you indicated, and there will be no scores for this test on your GRE file.

To cancel your scores from this test administration, you must:

A. Fill in both ovals here . . . ◯ – ◯ B. sign your full name here: _____

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