ETS PRAXIS

Measuring the Power of Learning.®

The *Praxis*® Study Companion

Biology: Content Knowledge

5235

www.ets.org/praxis

Welcome to *The Praxis® Study Companion*

Prepare to Show What You Know

You have been working to acquire the knowledge and skills you need for your teaching career. Now you are ready to demonstrate your abilities by taking a *Praxis®* test.

Using the *Praxis® Study Companion* is a smart way to prepare for the test so you can do your best on test day. This guide can help keep you on track and make the most efficient use of your study time.

The Study Companion contains practical information and helpful tools, including:

- An overview of the *Praxis* tests
- Specific information on the *Praxis* test you are taking
- A template study plan
- Study topics
- Practice questions and explanations of correct answers
- Test-taking tips and strategies
- Frequently asked questions
- Links to more detailed information

So where should you start? Begin by reviewing this guide in its entirety and note those sections that you need to revisit. Then you can create your own personalized study plan and schedule based on your individual needs and how much time you have before test day.

Keep in mind that study habits are individual. There are many different ways to successfully prepare for your test. Some people study better on their own, while others prefer a group dynamic. You may have more energy early in the day, but another test taker may concentrate better in the evening. So use this guide to develop the approach that works best for you.

Your teaching career begins with preparation. Good luck!

Know What to Expect

Which tests should I take?

Each state or agency that uses the *Praxis* tests sets its own requirements for which test or tests you must take for the teaching area you wish to pursue.

Before you register for a test, confirm your state or agency's testing requirements at www.ets.org/praxis/states.

How are the *Praxis* tests given?

Praxis tests are given on computer. Other formats are available for test takers approved for accommodations (see page 48).

What should I expect when taking the test on computer?

When taking the test on computer, you can expect to be asked to provide proper identification at the test center. Once admitted, you will be given the opportunity to learn how the computer interface works (how to answer questions, how to skip questions, how to go back to questions you skipped, etc.) before the testing time begins. Watch the What to Expect on Test Day video to see what the experience is like.

Where and when are the *Praxis* tests offered?

You can select the test center that is most convenient for you. The *Praxis* tests are administered through an international network of test centers, which includes Prometric® Testing Centers, some universities, and other locations throughout the world.

Testing schedules may differ, so see the *Praxis* web site for more detailed test registration information at www.ets.org/praxis/register.

Table of Contents

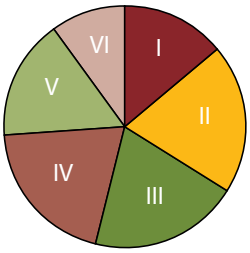
The Praxis® Study Companion guides you through the steps to success

1. Learn About Your Test

Learn about the specific test you will be taking

Biology: Content Knowledge (5235)

Test at a Glance	
Test Name	Biology: Content Knowledge
Test Code	5235
Time	2.5 hours
Number of Questions	150
Format	Selected-response questions
Test Delivery	Computer delivered



Content Categories		Approximate Number of Questions	Approximate Percentage of Examination
I.	History and Nature of Science	21	14%
II.	Molecular and Cellular Biology	30	20%
III.	Genetics and Evolution	30	20%
IV.	Diversity of Life and Organismal Biology	30	20%
V.	Ecology: Organisms and Environments	24	16%
VI.	Science, Technology, and Social Perspectives	15	10%

About This Test

The Biology: Content Knowledge test is designed to measure the knowledge and competencies necessary for a beginning teacher of secondary school Biology. Examinees have typically completed or nearly completed a bachelor's degree program with appropriate coursework in Biology and education.

The development of the test questions and the construction of the test reflect the National Science Education Standards (NSES) and the National Science Teacher Association (NSTA) standards and recognize that there are conceptual and procedural schemes that unify the various scientific disciplines. These fundamental concepts and processes (systems; models; constancy and change; equilibrium; form and function) are useful in understanding the natural world. Insofar as possible, then, the test questions will have the primary objective of evaluating the content areas by using questions that focus on conceptual understanding, critical thinking, and problem solving in science. The test content is developed and reviewed in collaboration with practicing high school Biology teachers, teacher-educators, and higher education content specialists to keep the test updated and representative of current standards.

The 150 selected-response questions include concepts, terms, phenomena, methods, applications, data analysis, and problem solving in Biology, and include an understanding of the impact of science and technology on the environment and human affairs. The topics are typically those covered in introductory college-level Biology courses, although some questions of a more advanced nature are included, because secondary-school teachers must understand the subject matter from a more advanced viewpoint than that presented to their students.

Examinees will not need to use calculators in taking this test.

This test may contain some questions that will not count toward your score.

Test Specifications

Test specifications describe the knowledge and skills measured by the test. Study topics to help you prepare to answer test questions can be found on page 35.

I. Nature of Science: Scientific Inquiry, Methodology, Techniques, and History

A. Processes Involved in Scientific Inquiry

1. Making observations
2. Formulating and testing hypotheses
3. Identifying experimental variables and controls
4. Conclusions: proof versus support
5. Scientific sources and communicating findings

B. Science Involves Many Disciplines

1. Chemical nature of biology
2. Calculations in biology (e.g., statistics, probability)
3. Physical laws and principles governing biological systems

C. Differences among Facts, Hypotheses, Theories, and Laws

1. Testable nature of hypotheses
2. Formulation of theories based on accumulated data
3. Durability of laws

D. Scientific Ideas Change over Time; Contributions Made by Major Historical Figures

1. Cell theory and germ theory (e.g., Hooke, Pasteur)
2. Heredity, evolution, and ecology (e.g., Mendel, Darwin)
3. Structure and nature of genetic material (e.g., Hershey and Chase, Franklin, Watson and Crick)
4. Classification of organisms (e.g., Linnaeus, Woese)

E. Appropriate Use of Scientific Measurement and Notation Systems

1. Precision versus accuracy
2. Metric and SI units
3. Unit conversions
4. Scientific notation and significant figures
5. Linear versus logarithmic scales (e.g., pH)

F. Read and Interpret Data Represented in Tables, Graphs, and Charts

1. Identify patterns and trends in data
2. Choose appropriate types of graphs or charts
3. Error analysis
4. Draw conclusions and make predictions

G. Construct and Use Scientific Models to Explain Complex Phenomena

1. Limitations of models
2. Select models for a given purpose
3. Physical (e.g., anatomical models), conceptual (e.g., fluid mosaic model), graphical and/or mathematical models (e.g., population growth or climate change models)

H. Procedures Involved in the Safe Preparation, Storage, Use, and Disposal of Laboratory and Field Materials

1. Molarity and percent solutions
2. Acid and base solutions
3. Flammable and/or caustic materials
4. Biological specimens and waste

I. Appropriate and Safe Use and Care of Laboratory Equipment

1. Optical equipment (e.g., microscopes, spectrophotometers, UV light sources)
2. Separation equipment (e.g., gel electrophoresis, chromatography, centrifuges)
3. Measurement, mixing, and heating equipment (e.g., balances, stirrers, burners)
4. Sterilization equipment (e.g., autoclave, ovens)

J. Safety and Emergency Procedures for Science Classrooms and Laboratories

1. Use of material safety data sheets (MSDS, or safety data sheets, SDS)
2. Use of personal safety equipment: (e.g., gloves, goggles, lab coats)
3. Use of laboratory safety equipment (e.g., fire extinguishers, eye wash stations, emergency showers)

II. Molecular and Cellular Biology

A. Chemical Structures and Properties of Biologically Important Molecules

1. Atomic structure
2. Organic versus inorganic molecules
3. Chemical bonding (e.g., hydrogen, covalent)
4. Molecular structure (e.g., water, oxygen)
5. Water properties (e.g., cohesion, high specific heat)
6. Macromolecules (e.g., carbohydrates, nucleic acids, proteins, lipids)

B. Biological Processes Are Dependent on Chemical Principles

1. Chemical and physical gradients (e.g., osmosis, diffusion, temperature)
2. Thermodynamics
3. Anabolic and catabolic reactions (e.g., hydrolysis)
4. Reduction-oxidation reactions

C. Structure and Function of Enzymes and Factors Influencing their Activity

1. Active site structure and substrate binding (e.g., induced fit, lock and key)
2. Reaction kinetics (e.g., effects of temperature, pH, and inhibitors)
3. Regulation (e.g., cooperative binding, feedback inhibition)

D. Biochemical Pathways and Energy Flow Within an Organism

1. Cellular locations of biochemical pathways
2. Photosynthesis (e.g., photosystems, electron transport, C_3 and C_4)
3. Cellular respiration (e.g., fermentation, Krebs (citric acid) cycle, electron transport chain)
4. Chemosynthesis (e.g., deep sea vent microorganisms)

E. Major Differences between Prokaryotes and Eukaryotes

1. Cell size
2. Membrane-bound organelles
3. Cell walls (e.g., peptidoglycan, cellulose)
4. Chromosome structure (e.g., circular versus linear)

F. Structure and Function of Cells and Organelles

1. Plant cells versus animal cells
2. Cell membranes
3. Membrane-bound organelles (e.g., nucleus, chloroplast) and ribosomes
4. Cytoskeleton

G. Cells Maintain their Internal Environment and Respond to External Signals

1. Selective permeability
2. Active and passive transport
3. Water movement (e.g., osmolarity, water potential)
4. Cell surface proteins and cell communication
5. Exocytosis and endocytosis
6. Hormone action and feedback

H. Cellular Division, the Cell Cycle, and How They Are Regulated

1. Cell cycle stages (G_1, S, G_2, M)
2. Mitosis and meiosis (e.g., stages, functions, results)
3. Cytokinesis (e.g., cleavage furrow, cell plate)
4. Cell cycle checkpoints

I. Structure and Function of Nucleic Acids

1. Sugar-phosphate backbone
2. DNA versus RNA
3. Complementary base pairing
4. Chromosome structure (e.g., nucleosomes, telomeres, linear versus circular)
5. DNA replication

J. Processes Involved in Protein Synthesis

1. RNA transcription
2. mRNA processing (e.g., polyadenylation, splicing)
3. Translation (e.g., ribosome structure, tRNA)

K. Regulation of Gene Expression

1. Promoters
2. Enhancers
3. Transcription factors
4. Operons
5. Environmental influences (e.g., epigenetics)

L. Cells May Undergo Differentiation and Specialization

1. Differential gene expression
2. Stem cells (e.g., sources, developmental potential)

M. Nature of Mutations

1. Causes of mutations (e.g., recombination, mutagens)
2. Types of mutations (e.g., point mutation, deletion, inversion, translocation)
3. Somatic versus germline mutations

N. Use of Basic Laboratory Techniques to Study Biological Processes

1. Gel electrophoresis
2. Microscopy
3. Spectrophotometry

O. Use and Applications of DNA Technologies and Genetic Engineering

1. DNA sequencing and polymerase chain reaction (PCR)
2. Genome sequencing projects (e.g., Human Genome Project)
3. Gene therapy
4. Cloning
5. Transgenic and genetically engineered cells

III. Genetics and Evolution

A. Mendel's Laws and Predicting the Probable Outcome of Given Genetic Crosses

1. Independent assortment
2. Law of segregation
3. Monohybrid and dihybrid crosses
4. Pedigree analysis

B. Non-Mendelian inheritance

1. Linkage (e.g., recombination mapping)
2. Sex-linked inheritance
3. Multiple alleles, codominance, and incomplete dominance
4. Polygenic inheritance, epistasis, and pleiotropy
5. Organelle inheritance (e.g., mitochondrial inheritance)

C. Chromosomal and Genetic Changes that Lead to Common Human Genetic Disorders

1. Changes in chromosome numbers (e.g., Down syndrome)
2. Changes in chromosome structure (e.g., deletion, inversion, duplication, translocation)
3. Common genetic disorders (e.g., Sickle-cell anemia, Tay-Sachs disease)

D. Sources of Genetic Variation

1. Mutation
2. Crossing-over
3. Genetic exchange (e.g., transduction, transformation, conjugation)
4. Sexual reproduction (e.g., independent assortment)

E. Mutations, Gene Flow, Genetic Drift, and Nonrandom Mating Affect the Gene Pool of a Population

1. Distribution and movement of alleles within populations
2. Distribution and movement of alleles between populations

F. Principles and Applications of Hardy-Weinberg Equilibrium

1. Conditions of HW equilibrium
2. Calculating allele frequencies using the HW equation

G. Mechanisms of Evolution

1. Natural and artificial selection
2. Sexual selection
3. Genetic drift (e.g., bottleneck, founder effect)
4. Coevolution
5. Adaptive radiation

H. Evidence that Supports Evolution

1. Molecular evidence (e.g., DNA sequence comparisons)
2. Structural and developmental evidence (e.g., homology, embryology)
3. Fossil record
4. Endosymbiosis
5. Convergent versus divergent evolution
6. Major evolutionary trends (e.g., cephalization, multicellularity)

I. Genetic Basis of Speciation

1. Reproductive isolation (e.g., prezygotic, postzygotic)
2. Types of speciation (e.g., allopatric, sympatric)

J. Models of Evolutionary Rates

1. Gradualism
2. Punctuated equilibrium

K. Scientific Explanations for the Origin of Life on Earth

1. Panspermia (e.g., asteroid seeding)
2. Abiotic synthesis of organic compounds (e.g., Miller-Urey experiment)
3. Biological influences on atmospheric composition (e.g., photosynthesis)
4. Development of self-replication (e.g., RNA world)

L. Factors that Lead to Extinction of Species

1. Lack of genetic diversity
2. Environmental pressures (e.g., climate and habitat change)
3. Human impacts
4. Interspecific competition

IV. Diversity of Life and Organismal Biology

A. Characteristics of Living Versus Nonliving Things

1. Cellular organization
2. Growth and reproduction
3. Regulation and responses to the environment
4. Obtain and use energy

B. Historical and Current Biological Classification Systems of Organisms

1. Kingdom system
2. Domain system

C. Defining Characteristics of Viruses, Bacteria, Protists, Fungi, Plants, and Animals

1. Structure (e.g., capsid, cell wall, organelles)
2. Organization (e.g., prokaryote, multicellular)
3. Modes of nutrition (e.g., heterotroph, autotroph)
4. Reproduction/replication (e.g., viral replication, binary fission, budding)

D. Characteristics of the Major Animal Phyla

1. Body plans (e.g., radial versus bilateral symmetry)
2. Body cavities (e.g., coelomates, pseudocoelomates, acoelomates)
3. Modes of reproduction
4. Modes of temperature regulation (e.g., endotherm, ectotherm)

E. Organizational Hierarchy of Multicellular Organisms

1. Cells
2. Tissues
3. Organs
4. Organ systems

F. Anatomy and Physiology of Major Organ Systems in Animals

1. Cardiovascular and respiratory
2. Reproductive
3. Digestive and excretory
4. Nervous and endocrine
5. Immune

G. Maintenance of Homeostasis in Organisms

1. Role of structural components (e.g., kidney, hypothalamus)
2. Feedback mechanisms
3. Role of hormones (e.g., antidiuretic hormone (ADH), insulin)
4. Role of behaviors (e.g., diurnal, nocturnal, basking)

H. Reproduction, Development, and Growth in Animals

1. Gamete formation
2. Fertilization
3. Embryonic development
4. Growth, development, and aging

I. Characteristics of Major Plant Divisions

1. Vascular versus nonvascular plants
2. Flowering versus nonflowering plants
3. Monocot versus eudicot (dicot)

J. Structure and Function of Major Plant Tissues and Organs

1. Dermal
2. Vascular (i.e., xylem, phloem)
3. Ground (e.g., parenchyma, cortex)
4. Meristems
5. Flowers, stems, leaves, and roots

K. Plant Life Cycles and Reproductive Strategies

1. Alternation of generations (i.e., gametophyte, sporophyte)
2. Pollination strategies (e.g., wind, insect)
3. Seed dispersal

L. Plants Obtain and Transport Water and Inorganic Nutrients

1. Roots
2. Xylem transport
3. Control (e.g., stomata)

M. Plants Transport and Store Products of Photosynthesis

1. Products (e.g., simple and complex carbohydrates)
2. Phloem transport
3. Storage and support molecules (e.g., starch, cellulose)
4. Storage structures (e.g., plastids, vacuoles, tuber)

V. Ecology: Organisms and Environments

A. Hierarchical Structure of the Biosphere

1. Populations
2. Communities
3. Ecosystems
4. Biomes

B. Biotic and Abiotic Components of an Ecosystem Influence Population Size

1. Resource availability and abiotic factors (e.g., nutrients and temperature)
2. Habitat and niche
3. Competition and predation

C. Models of Population Growth

1. Exponential growth
2. Logistic growth (e.g., carrying capacity)

D. Relationship Between Reproductive Strategies and Mortality Rates

1. Sexual versus asexual reproduction
2. Parental investment
3. Number of offspring produced versus number that survive

E. Relationships Within and Between Species

1. Symbiosis (e.g., parasitism, commensalism, mutualism)
2. Predation
3. Competition and territoriality
4. Altruistic behaviors

F. Changes Occur During Ecological Succession

1. Primary versus secondary succession
2. Biomass, diversity, productivity, and habitat changes during succession

G. Types and Characteristics of Biomes

1. Aquatic (e.g., stream, estuary, coral reef)
2. Terrestrial (e.g., desert, grassland, tropical rain forest)

H. Energy Flow in the Environment

1. Trophic levels (e.g., pyramids of biomass, pyramids of energy)
2. Food webs

I. Biogeochemical Cycles

1. Water cycle
2. Carbon cycle
3. Nitrogen cycle
4. Phosphorus cycle

J. Effects of Natural Disturbances on Ecosystems

1. Temporal and spatial disturbances (e.g., climate, fire, disease)
2. Fragmentation of ecosystems
3. Natural ecosystem recovery

K. Humans Affect Ecological Systems and Biodiversity

1. Pollution (e.g., greenhouse gases, acid precipitation)
2. Habitat destruction (e.g., deforestation)
3. Introduced species (e.g., non-native, reintroduced)
4. Remediation (e.g., reforestation, mine reclamation)

L. Connections among Ecosystems on a Local and Global Scale

1. Natural flow of material between ecosystems
2. Transport of materials by humans
3. Movement of organisms (e.g., migration)

VI. Science, Technology, and Social Perspectives

A. Impact of Science and Technology on the Environment

1. Pollution and pollution mitigation (e.g., burning fossil fuels, green building, environmental cleanup)
2. Resource management (e.g., waste management, recycling, efficiency)
3. Conservation (e.g., habitat protection, habitat restoration, species protection)
4. Non-point sources of pollution (e.g., lawn fertilizers)

B. Impact of Human Activity and Natural Phenomena on Society

1. Consequences (e.g., economic, social)
2. Disaster management (e.g., hurricane relief and cleanup)
3. Global warming, sea levels, flooding
4. Epidemiology (e.g., malaria, influenza)
5. Agriculture and soil erosion
6. Estuary and wetland degradation
7. Water management
8. Production, use, and disposal of consumer products (e.g., plastics)

C. Societal Impacts Associated with the Management of Natural Resources

1. Habitat preservation (e.g., Endangered Species Act, National Parks)
2. Extraction of mineral and energy resources (e.g., mining, drilling)
3. Agriculture, forestry, wildlife, and fisheries practices
4. Renewable and/or sustainable use of resources

D. Ethical and Societal Issues Arising from the Use of Science and Technology

1. Ethical research concerns (e.g., stem cells, toxic chemicals)
2. Ethical use of technology (e.g., genetically modified organisms, cloning)
3. Societal concerns (e.g., security of genetic information, equal access to medical treatment)

2. Familiarize Yourself with Test Questions

Become comfortable with the types of questions you'll find on the Praxis *tests*

The *Praxis* assessments include a variety of question types: constructed response (for which you write a response of your own); selected response, for which you select one or more answers from a list of choices or make another kind of selection (e.g., by clicking on a sentence in a text or by clicking on part of a graphic); and numeric entry, for which you enter a numeric value in an answer field. You may be familiar with these question formats from taking other standardized tests. If not, familiarize yourself with them so you don't spend time during the test figuring out how to answer them.

Understanding Computer-Delivered Questions

Questions on computer-delivered tests are interactive in the sense that you answer by selecting an option or entering text on the screen. If you see a format you are not familiar with, read the directions carefully. The directions always give clear instructions on how you are expected to respond.

For most questions, you respond by clicking an oval to select a single answer from a list of answer choices.

However, interactive question types may also ask you to respond by:

- **Clicking more than one oval** to select answers from a list of answers.
- **Typing in an entry box.** When the answer is a number, you may be asked to enter a numerical answer. Some questions may have more than one place to enter a response.
- **Clicking check boxes.** You may be asked to click check boxes instead of an oval when more than one choice within a set of answers can be selected.
- **Clicking parts of a graphic.** In some questions, you will select your answers by clicking on a location (or locations) on a graphic such as a map or chart, as opposed to choosing your answer from a list.
- **Clicking on sentences.** In questions with reading passages, you may be asked to choose your answers by clicking on a sentence (or sentences) within the reading passage.
- **Dragging and dropping answer choices into targets on the screen.** You may be asked to select answers from a list of choices and drag your answers to the appropriate location in a table, paragraph of text or graphic.
- **Selecting answer choices from a drop-down menu.** You may be asked to choose answers by selecting choices from a drop-down menu (e.g., to complete a sentence).

Remember that with every question you will get clear instructions.

Perhaps the best way to understand computer-delivered questions is to view the Computer-delivered Testing Demonstration on the Praxis web site to learn how a computer-delivered test works and see examples of some types of questions you may encounter.

Understanding Selected-Response Questions

Many selected-response questions begin with the phrase "which of the following." Take a look at this example:

Which of the following is a flavor made from beans?

(A) Strawberry

(B) Cherry

(C) Vanilla

(D) Mint

How would you answer this question?

All of the answer choices are flavors. Your job is to decide which of the flavors is the one made from beans.

Try following these steps to select the correct answer.

1) **Limit your answer to the choices given.** You may know that chocolate and coffee are also flavors made from beans, but they are not listed. Rather than thinking of other possible answers, focus only on the choices given ("which of the following").

2) **Eliminate incorrect answers.** You may know that strawberry and cherry flavors are made from fruit and that mint flavor is made from a plant. That leaves vanilla as the only possible answer.

3) **Verify your answer.** You can substitute "vanilla" for the phrase "which of the following" and turn the question into this statement: "Vanilla is a flavor made from beans." This will help you be sure that your answer is correct. If you're still uncertain, try substituting the other choices to see if they make sense. You may want to use this technique as you answer selected-response questions on the practice tests.

Try a more challenging example

The vanilla bean question is pretty straightforward, but you'll find that more challenging questions have a similar structure. For example:

Entries in outlines are generally arranged according to which of the following relationships of ideas?

(A) Literal and inferential

(B) Concrete and abstract

(C) Linear and recursive

(D) Main and subordinate

You'll notice that this example also contains the phrase "which of the following." This phrase helps you determine that your answer will be a "relationship of ideas" from the choices provided. You are supposed to find the choice that describes how entries, or ideas, in outlines are related.

Sometimes it helps to put the question in your own words. Here, you could paraphrase the question in this way: "How are outlines usually organized?" Since the ideas in outlines usually appear as main ideas and subordinate ideas, the answer is (D).

QUICK TIP: Don't be intimidated by words you may not understand. It might be easy to be thrown by words like "recursive" or "inferential." Read carefully to understand the question and look for an answer that fits. An outline is something you are probably familiar with and expect to teach to your students. So slow down, and use what you know.

Watch out for selected-response questions containing "NOT," "LEAST," and "EXCEPT"

This type of question asks you to select the choice that does not fit. You must be very careful because it is easy to forget that you are selecting the negative. This question type is used in situations in which there are several good solutions or ways to approach something, but also a clearly wrong way.

How to approach questions about graphs, tables, or reading passages

When answering questions about graphs, tables, or reading passages, provide only the information that the questions ask for. In the case of a map or graph, you might want to read the questions first, and then look at the map or graph. In the case of a long reading passage, you might want to go ahead and read the passage first, noting places you think are important, and then answer the questions. Again, the important thing is to be sure you answer the questions as they refer to the material presented. So read the questions carefully.

How to approach unfamiliar formats

New question formats are developed from time to time to find new ways of assessing knowledge. Tests may include audio and video components, such as a movie clip or animation, instead of a map or reading passage. Other tests may allow you to zoom in on details in a graphic or picture.

Tests may also include interactive questions. These questions take advantage of technology to assess knowledge and skills in ways that standard selected-response questions cannot. If you see a format you are not familiar with, **read the directions carefully**. The directions always give clear instructions on how you are expected to respond.

QUICK TIP: Don't make the questions more difficult than they are. Don't read for hidden meanings or tricks. There are no trick questions on *Praxis* tests. They are intended to be serious, straightforward tests of your knowledge.

Understanding Constructed-Response Questions

Constructed-response questions require you to demonstrate your knowledge in a subject area by creating your own response to particular topics. Essays and short-answer questions are types of constructed-response questions.

For example, an essay question might present you with a topic and ask you to discuss the extent to which you agree or disagree with the opinion stated. You must support your position with specific reasons and examples from your own experience, observations, or reading.

Take a look at a few sample essay topics:

- "Celebrities have a tremendous influence on the young, and for that reason, they have a responsibility to act as role models."
- "We are constantly bombarded by advertisements—on television and radio, in newspapers and magazines, on highway signs, and the sides of buses. They have become too pervasive. It's time to put limits on advertising."
- "Advances in computer technology have made the classroom unnecessary, since students and teachers are able to communicate with one another from computer terminals at home or at work."

Keep these things in mind when you respond to a constructed-response question

1) **Answer the question accurately.** Analyze what each part of the question is asking you to do. If the question asks you to describe or discuss, you should provide more than just a list.

2) **Answer the question completely.** If a question asks you to do three distinct things in your response, you should cover all three things for the best score. Otherwise, no matter how well you write, you will not be awarded full credit.

3) **Answer the question that is asked.** Do not change the question or challenge the basis of the question. You will receive no credit or a low score if you answer another question or if you state, for example, that there is no possible answer.

4) **Give a thorough and detailed response.** You must demonstrate that you have a thorough understanding of the subject matter. However, your response should be straightforward and not filled with unnecessary information.

5) **Reread your response.** Check that you have written what you thought you wrote. Be sure not to leave sentences unfinished or omit clarifying information.

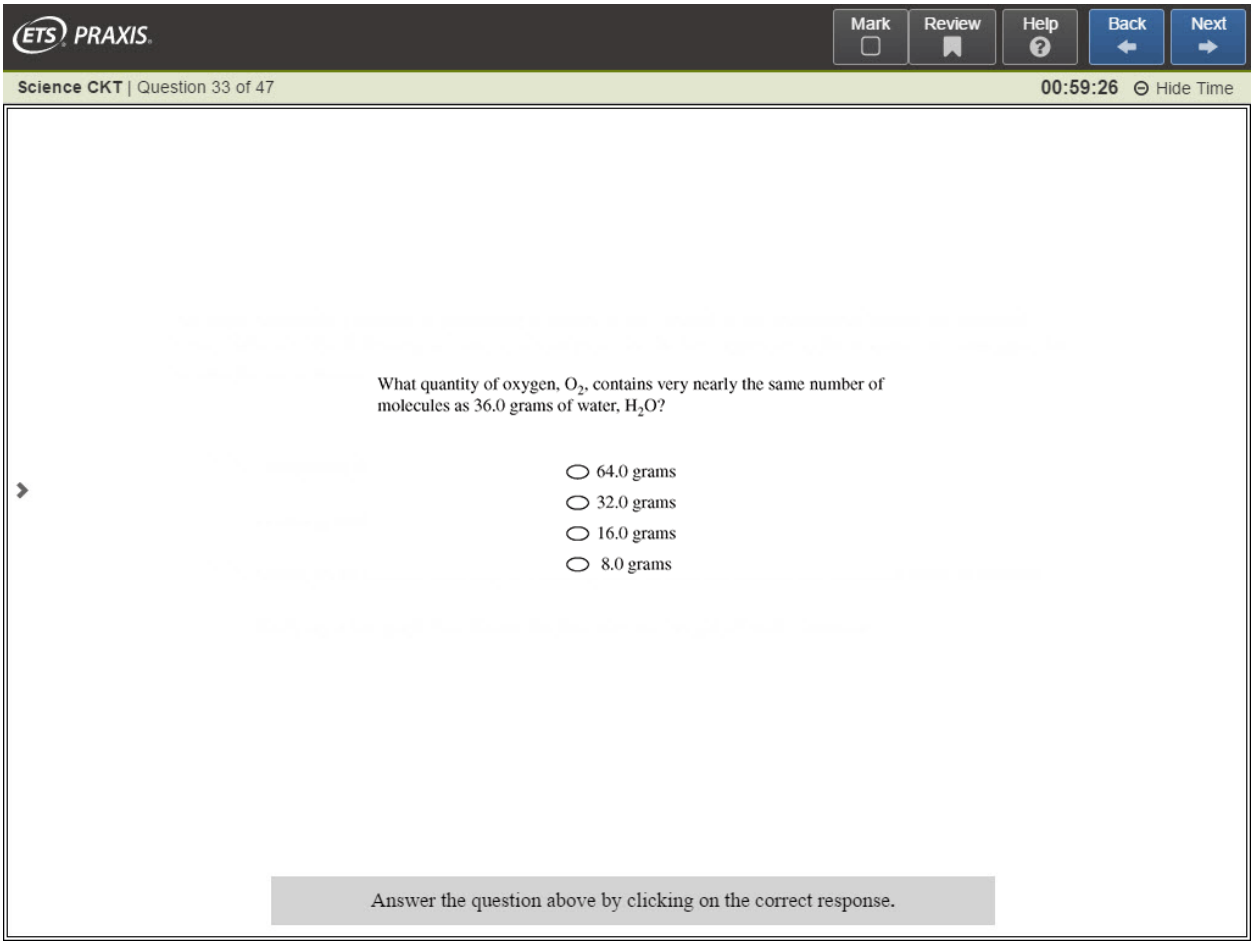
QUICK TIP: You may find that it helps to take notes on scratch paper so that you don't miss any details. Then you'll be sure to have all the information you need to answer the question.

3. Practice with Sample Test Questions

Answer practice questions and find explanations for correct answers

Computer Delivery

This test is available via computer delivery. To illustrate what the computer-delivered test looks like, the following sample question shows an actual screen used in a computer-delivered test. For the purposes of this guide, sample questions are provided as they would appear in a paper-delivered test.



Sample Test Questions

The sample questions that follow illustrate the kinds of questions on the test. They are not, however, representative of the entire scope of the test in either content or difficulty. Answers with explanations follow the questions.

Directions: Each of the questions or incomplete statements below is followed by four suggested answers or completions. Select the one that is best in each case.

EFFECT OF TEMPERATURE ON SEEDLING CO_2 PRODUCTION

Seedling Group	Incubation Conditions
1	In a refrigerator (5°C)
2	At room temperature (22°C)
3	In a 35°C water bath
4	In a 45°C water bath

1. A group of students are setting up an experiment to determine how temperature affects the rate of CO_2 production in germinating seedlings. The students place twelve similar sprouting corn seedlings in individual test tubes. Each seedling sits on top of a cotton ball over 15 mL of a blue solution of bromothymol blue. The test tubes are sealed to trap CO_2 emitted from the seedlings; the bromothymol blue is expected to turn from blue to green to yellow as the CO_2 reacts with the solution. The students divide the test tubes into four groups of three and incubate the groups in a closed and darkened refrigerator or in a well-lit classroom under the conditions shown in the table above. Which of the following is a significant flaw in the experimental design?
   (A) The students should test CO_2 emission at more temperatures.
   (B) The experiment includes more than one independent variable.
   (C) Too many seedlings are placed in each experimental group.
   (D) The data obtained are qualitative rather than quantitative.

2. Organisms in which of the following phyla have a true coelom?
   (A) Platyhelminthes
   (B) Porifera
   (C) Annelida
   (D) Nematoda

3. A child with type AB blood inherits an I^A allele from one parent and an I^B allele from the other. The child will carry both A and B glycoproteins on the surface of all red blood cells. This pattern of expression is referred to as
   (A) codominance
   (B) epistasis
   (C) polygenic
   (D) linkage

4. Two trees of the same species growing close together will use the same resources, such as light, water, and nutrients. If any of these resources becomes limiting, then each tree will receive less of it than if the trees were growing farther apart. This scenario is an example of which of the following?
   (A) Parasitism
   (B) Commensalism
   (C) Natural selection
   (D) Intraspecific competition

5. Which of the following best explains why people can digest starch but cannot digest cellulose even though both molecules are composed of glucose monomers?
   (A) The bonds linking the monomers of starch differ in shape from the bonds linking the monomers of cellulose.
   (B) Molecules of starch are much smaller than molecules of cellulose.
   (C) Starch is an intracellular molecule, while cellulose is an extracellular molecule.
   (D) Starch is hydrated by water, but cellulose is not.

6. To ensure that hatchling sea turtles orient to the sea rather than inland, which of the following is the most environmentally sound practice around sea turtle nest sites?

   (A) Digging troughs in the sand from the nests to the sea

   (B) Minimizing artificial lighting in the area

   (C) Scattering preferred turtle foods between the nests and the sea

   (D) Building low fences on the sand dunes

7. Which of the following best explains why lignin is important to the evolutionary success of land plants?

   (A) Lignin provides structural support, allowing plants to grow tall.

   (B) Lignin stimulates spore formation, leading to gametogenesis.

   (C) Lignin supplies the developing embryo with essential nutrients, enabling its growth.

   (D) Lignin supplements the absorption of light by chlorophyll, increasing photosynthetic output.

8. A certain autosomal recessive trait is expressed in 1% of a population. Assuming that the population is in Hardy-Weinberg equilibrium, what percent of the population are carriers but do not express the trait?

   (A) 10%

   (B) 18%

   (C) 27%

   (D) 50%

9. Recently, seasonal dead zones in low-oxygen waters have been occurring annually in the Gulf of Mexico near the mouth of the Mississippi River. The dead zones result from the rapid growth of photosynthetic phytoplankton (algal blooms) and their subsequent decay by oxygen-depleting microbes in the water column. Which of the following factors most likely triggers the algal blooms and the associated dead zones?

   (A) A decrease in the light level in surface waters as day length starts to shorten after the summer solstice

   (B) Increased predation by marine larvae and other zooplankton during the summer months

   (C) A summer influx of nutrients derived from chemical fertilizers that are high in nitrogen and phosphorus

   (D) Decreased competition from other marine phytoplankton during the summer months

10. Which TWO of the following statements describe typical structural differences between prokaryotic cells and eukaryotic cells?

    (A) The plasma membrane of a prokaryotic cell lacks phospholipids, while that of a eukaryotic cell contains phospholipids.

    (B) The ribosomes of a prokaryotic cell each have only one subunit, while those of a eukaryotic cell each have two subunits.

    (C) The volume of a prokaryotic cell is smaller than that of a eukaryotic cell.

    (D) The chromosome of a prokaryotic cell is circular, while the chromosomes of a eukaryotic cell are linear.

11. Which of the following is a property that is shared by Zika fever, West Nile fever, and malaria?

    (A) The diseases are caused by viruses.

    (B) The diseases occur only in individuals who visit or live in tropical countries.

    (C) The pathogens that cause the diseases have developed resistance to antibiotics.

    (D) The pathogens that cause the diseases are primarily transmitted by the bite of an infected mosquito.

12. Which of the following statements best explains why Mendel's principle of segregation was deemed a law?

    (A) Mendel's work with pea plants and his conclusions have been described in many sources.

    (B) The patterns of trait inheritance observed in pea plants were repeatedly demonstrated in other eukaryotes.

    (C) Chromosomes were found to contain the genetic information for traits.

    (D) The discovery of the structure of DNA supported Mendel's observations and laws.

13. A healthy man and woman are worried about having children because they are both carriers of sickle-cell disease. If the couple have a biological child, what is the chance that the child will inherit sickle-cell disease?

    (A) 100%

    (B) 75%

    (C) 50%

    (D) 25%

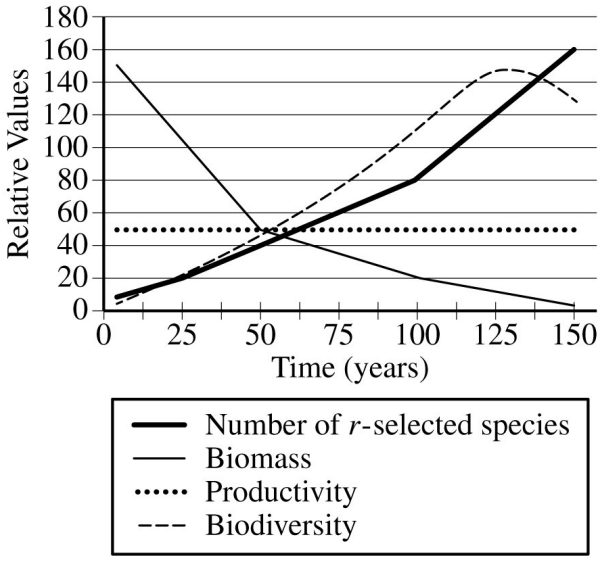
14. Which of the following is the direct energy source that allows ATP synthase to produce ATP in mitochondria?

    (A) NADH diffusing from the mitochondrial intermembrane space to the matrix

    (B) The reduction of NAD^+ during the conversion of pyruvate to acetyl-CoA

    (C) H^+ ions flowing down a gradient across the mitochondrial inner membrane

    (D) The energy of electrons passing along the electron transport chain



15. For a particular terrestrial habitat, the change during ecological succession for each of four different variables is represented in the graph above. Assuming that no additional disturbances occur, the change over time for which variable is most likely correct?

    (A) Number of *r*-selected species

    (B) Biomass

    (C) Productivity

    (D) Biodiversity

16. A small population of birds is blown to an isolated island by a hurricane and establishes a colony. The gene pool of the newly established population of birds is likely to reflect the effects of which of the following?

    (A) Directed mutation

    (B) Genetic drift

    (C) Adaptive radiation

    (D) Disruptive selection

17. Water and minerals that reach the xylem in the center of a plant root must first

    (A) move through neighboring phloem vessels

    (B) cross open stomata in the root epidermis

    (C) cross the endodermis of the root cortex

    (D) pass through the pith of the root cap

18. During which phase of the cell cycle does the quantity of DNA in a eukaryotic cell typically double?

    (A) G_1

    (B) G_2

    (C) M

    (D) S

19. Students are conducting a plant pigment separation exercise that requires them to use a closed chromatography chamber with a small amount of acetone in the bottom of the chamber. Safety warnings for acetone include the statement that it is an eye and skin irritant and has flammable vapors. Of the following, which safety precaution should the students take while conducting the exercise?

    (A) Putting on fire-retardant gloves to carry the chamber to a fume hood if the acetone catches fire

    (B) Placing the chamber in a closed, darkened cabinet for the duration of the pigment separation

    (C) Wearing leather gloves and covering the nose and mouth with a particle mask

    (D) Wearing goggles and nitrile-type gloves and keeping all acetone containers closed

20. Which of the following changes in a gamete is most likely to lead to a heritable change in a protein?

    (A) Deleting two nucleotides from the middle of an intron

    (B) Deleting two nucleotides immediately upstream of a gene promoter

    (C) Inserting two nucleotides in the genome at the beginning of a codon

    (D) Adding two nucleotides to the poly(A) tail of an mRNA

5′ GTA _ _ _ AA 3′

3′ CAT G C A TT 5′

21. The segment of DNA shown above has undergone a mutation in which three nucleotides have been deleted as indicated. Repair enzymes would be expected to replace the deleted nucleotides with which of the following sequences of nucleotides?

    (A) 5′ CGT 3′

    (B) 5′ GCA 3′

    (C) 5′ CTG 3′

    (D) 5′ GTA 3′

22. A gas phase is generally absent from which of the following biogeochemical cycles?

    (A) Water

    (B) Carbon

    (C) Sulfur

    (D) Phosphorus

23. Members of which of the following groups are most likely to be surrounded by a protein coat?

    (A) Viruses

    (B) Bacteria

    (C) Eukaryotes

    (D) Archaea

24. Crop rotation is the successive planting of different crops on the same land in sequential seasons. Which of the following statements summarizes the most likely benefits of this practice?

    (A) It allows the farmer to plant the crops with the greatest demand in the marketplace.

    (B) It increases crop yields and soil fertility and minimizes pathogen infection and pest infestation.

    (C) It allows the hybridization of successive crops and the development of newer varieties of crop plants.

    (D) It decreases the need for diverse harvesting equipment and minimizes production costs.

25. Convergent evolution is best exemplified by which of the following?

    (A) The pectoral fins of fish and the front legs of cats

    (B) The presence of a notochord in all chordate embryos

    (C) The wings of an insect and the wings of a bird

    (D) The leaves of an oak tree and the spines of a cactus

Second Base

First Base	U	C	A	G	Third Base
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	Stop	Stop	A
	Leu	Ser	Stop	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

26. Based on the codon table shown, which of the following is the template DNA sequence for the mRNA codon that specifies tryptophan (Trp) ?

    (A) 5′ CCA 3′

    (B) 5′ ACC 3′

    (C) 5′ CAC 3′

    (D) 5′ CAT 3′

$$2\ H_2O_2 \rightarrow 2\ H_2O\ +\ O_2$$

27. A student wants to investigate how the rate of the enzyme-catalyzed reaction shown above changes over time. The student sets up four replicate tubes that contain identical amounts of hydrogen peroxide (H_2O_2) and the enzyme catalase. The total amount of oxygen produced in each tube is measured and recorded every minute for a period of 40 minutes, and the data are averaged for each time point. Which of the following types of figure should be used to most effectively present the data?

    (A) A histogram

    (B) A pie chart

    (C) A line graph

    (D) A table

28. Which of the following best explains why drinking breast milk is beneficial to a human infant?

    (A) Breast milk contains vitamins that repair mutations originating in the sperm or egg.

    (B) Breast milk contains maternal antibodies that protect against gastrointestinal pathogens.

    (C) Breast milk contains maternal vaccines that destroy common childhood pathogens.

    (D) Breast milk contains red blood cells with adult hemoglobin that are beneficial to the infant's developing brain.

29. Which of the following is (are) required when performing a polymerase chain reaction (PCR) on a DNA sample?

    (A) Reverse transcriptase

    (B) A vacuum chamber

    (C) Primers complementary to certain portions of the DNA

    (D) DNA ligase

30. Which of the following is the most likely benefit of periodic natural wildfires in some forest ecosystems?

    (A) The fires remove dead and decaying plant matter, reducing the risk of more intense and destructive fires.

    (B) The fires leach nutrients from the soil, preventing the germination of plants that might compete with native species.

    (C) The fires drive off herbivores whose plant-based diets reduce the amount of vegetation.

    (D) The fires dry out the soil and decrease the chance of flooding after heavy rains.

31. Which of the following disorders will most likely result from X chromosome aneuploidy in women?

    (A) Cystic fibrosis

    (B) Hemophilia

    (C) Turner syndrome

    (D) Tay-Sachs disease

32. The western prairie fringed orchid is an endangered plant found in only a small number of populations, most of which have relatively few members, in the midwestern United States and south central Canada. The orchid grows primarily in wet, unplowed tallgrass prairies and meadows and is dependent on hawkmoths for pollination. Much of its original habitat is extremely fertile and has been converted to cropland. Which TWO of the following practices in areas where the orchid remains are most likely to help protect it from extinction?

    (A) Using herbicides on croplands to rid the area of invasive species of plants

    (B) Decreasing the use of broad-spectrum pesticides that remove insects from croplands

    (C) Educating landowners to recognize the orchid and the ecological value of the habitat in which it thrives

    (D) Constructing large fences around the croplands to separate them from the surrounding patches of prairie

33. In vertebrate embryos, which of the following developmental processes most directly results in the formation of the three primary germ layers?

    (A) Neurulation

    (B) Blastula formation

    (C) Cleavage

    (D) Gastrulation

34. Which of the following pairs of scientists pioneered the ecological discipline known as island biogeography?

(A) Robert MacArthur and E. O. Wilson

(B) James Watson and Francis Crick

(C) Matthias Schleiden and Theodor Schwann

(D) Alfred Hershey and Martha Chase

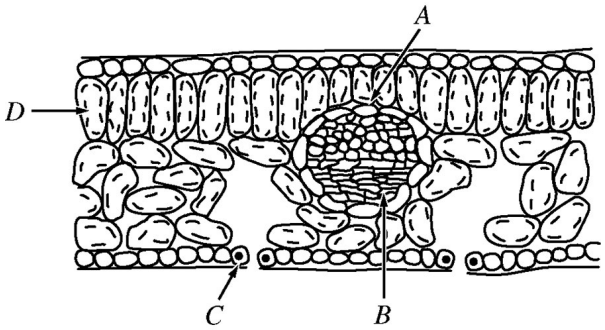
35. Which of the following is most likely to increase the rate of diffusion of an uncharged solute across the plasma membrane of a cell?

(A) Decreasing the number of different solutes in the solution that bathes the cells

(B) Increasing the concentration gradient of the solute across the membrane

(C) Increasing the ratio of phospholipids to proteins in the membrane

(D) Decreasing the membrane potential across the membrane



36. A cross section of a leaf is represented in the figure above. Which of the labeled structures regulates the rate of evaporation from the leaf?

(A) *A*

(B) *B*

(C) *C*

(D) *D*

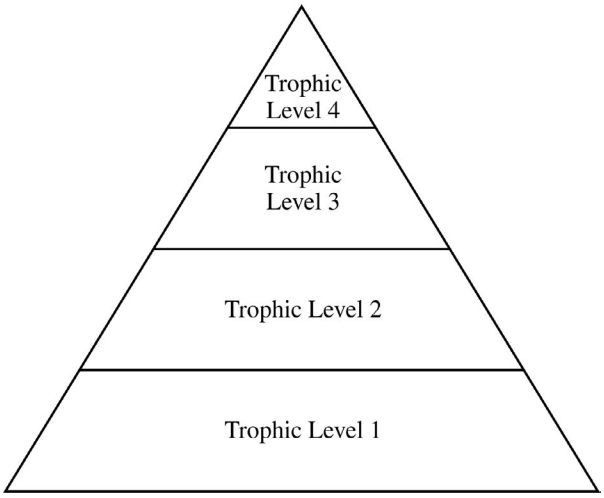
37. A gradual drop in the water level of a large lake divided it into three smaller lakes. The division separated a single population of fish into three smaller, isolated populations. After many generations it was determined that the three populations of fish had become three separate species. Which of the following is most likely correct about the three species?

(A) There are differences in the nucleotide sequences of certain gene alleles among the species.

(B) There are differences in the amino acid specified by each codon among the species.

(C) There are differences in the type of cleavage that produces the first blastomeres among the species.

(D) There are differences in the composition of ribosomes among the species.



38. Energy pyramids, such as the one shown above, depict available energy at each trophic level of an ecosystem. An energy pyramid is wide at the base and narrow at the apex primarily because of principles associated with the

(A) law of conservation of mass

(B) second law of thermodynamics

(C) theory of evolution through natural selection

(D) processes of ecological succession

Answers to Sample Questions

1. The correct answer is (B). An experiment should test only one independent variable at a time. If more than one such variable is changed, it is impossible to know which changed variable is responsible for observed results. In the experiment described, two variables, temperature and light, differ between group 1 and groups 2, 3, and 4. The refrigerator that is used for group 1 seedlings is unlit, but the other three groups of seedlings are kept in a well-lit classroom. Each of the four groups is incubated at a different temperature.

2. The correct answer is (C). Organisms in the phylum Annelida (segmented worms) have a true coelom, a body cavity that is lined by mesoderm-derived tissue and from which internal organs are suspended. The phylum Annelida includes earthworms but consists primarily of marine and freshwater species.

3. The correct answer is (A). Simultaneous expression of both alleles of a gene is referred to as codominance. In this instance, the surface phenotype of the red blood cells includes both A and B glycoproteins, encoded by the I^A allele and I^B allele, respectively.

4. The correct answer is (D). Competition between any organisms of the same species for limited resources is referred to as intraspecific competition. The limited resources can be anything necessary for survival and reproduction, including light, water, nutrients, shelter, and mates.

5. The correct answer is (A). In both starch and cellulose, the glucose monomers are linked by glycosidic bonds, but the shape of the bonds differs between the two macromolecules. The ring structure of glucose differs in the two macromolecules such that the glycosidic bonds in starch are α1-4 linkages, while those in cellulose are β1-4 linkages. This difference in glycosidic bond shape means that starch is a helical molecule, while cellulose is linear. People have enzymes that recognize and can catalyze the hydrolysis of α1-4 glycosidic bonds but do not have enzymes that recognize β1-4 glycosidic bonds.

6. The correct answer is (B). Hatchling sea turtles orient to the sea largely by moving toward light reflected from the water's surface. Observation and experimentation have demonstrated that in the presence of extra illumination, the hatchlings orient to the area of brightest light. Therefore, artificial lighting should be minimized in areas where turtles nest to avoid confusing the hatchlings as they find their way from their nests to the sea.

7. The correct answer is (A). Lignin, a complex organic polymer, fills in the spaces between other cell wall components such as cellulose and pectin and provides rigid structural support to vascular plants. This support allows the plants to grow taller than would be possible in the absence of such support. Because lignin is hydrophobic, it is also particularly well suited to preventing the leakage of water from the xylem vessels out into the cell walls of the surrounding cells.

8. The correct answer is (B). The Hardy-Weinberg equation states: $p^2 + 2pq + q^2 = 1$, where a gene has only two alleles, and p equals the frequency in the population of the dominant allele, and q equals the frequency of the recessive allele. If the recessive allele is expressed in 1% of the population, this means that $q^2 = 0.01$, and the frequency of the recessive allele (q) in the population is 0.1. If $q = 0.1$, then $p = 1 - 0.1 = 0.9$, and the frequency of the dominant allele (p) in the population is 0.9. Therefore, $2pq = (2)(0.9)(0.1) = 0.18$, and 18% of the population are carriers of the trait.

9. The correct answer is (C). A summer influx of chemical fertilizers most likely triggers the seasonal algal blooms and associated dead zones. Because the majority of crop growth occurs in warmer weather, the use of chemical fertilizers that are high in nitrogen and phosphorus also increases at this time of the year. With every rainfall, the fertilizers are washed off the fields into local waterways that drain into the Mississippi River and are carried toward the Gulf of Mexico. The fertilizer accumulation at the mouth of the river promotes the growth of algae that in turn depletes the water of oxygen. Organisms cannot survive in the hypoxic waters, and terrestrial organisms that depend on the river-dwelling organisms are also negatively affected.

10. The correct answers are (C) and (D). With a couple of rare exceptions, prokaryotic cells are smaller than eukaryotic cells. Additionally, a prokaryotic cell typically has a single circular chromosome, while a eukaryotic cell has linear chromosomes that, in somatic cells, are usually present in pairs.

11. The correct answer is (D). Zika fever, West Nile fever, and malaria are primarily transmitted by the bite of a virus-infected mosquito. Although Zika virus and West Nile virus can be transmitted from a mother to a fetus through the placenta, and West Nile virus can be transmitted through breast-feeding, these modes of transmission are far less common than is transmission through the bite of an infected mosquito.

12. The correct answer is (B). Mendel proposed his principle of segregation after observing the phenotypes of the progeny produced when he crossed pea plants that differed with respect to a variety of traits such as flower color or pea shape. He proposed that cells contain pairs (alleles) of every hereditary unit or factor (gene). His principle of segregation stated that during gamete production, the members of a pair of factors separate (segregate) randomly such that a gamete receives only one copy of every factor. At fertilization, the number of copies of each factor in the zygote is restored to two. Mendel's principle of segregation was deemed a law because the random separation of allele pairs was repeatedly and consistently observed when the genetics of many other organisms were studied by other scientists.

13. The correct answer is (D). If the parents are both carriers of sickle-cell disease, they must be heterozygous at the gene locus that confers the disease (*Ss*). There is a 50% chance for each parent to produce a gamete that contains the recessive disease-causing allele and thus a 25% chance that both the sperm and the egg it fertilizes will contain copies of the recessive disease-causing allele and produce a zygote with two recessive alleles (*ss*).

14. The correct answer is (C). The direct source of energy that allows ATP synthase to produce ATP in mitochondria is the flow of H^+ ions (protons) down a gradient from the intermembrane space to the mitochondrial matrix by passing through a channel in each of the inner membrane-embedded ATP synthase enzymes. As electrons pass through a series of redox reactions along the electron transport chain, protons are pumped into the intermembrane space. This pumping of protons establishes an electrochemical gradient composed of both a concentration gradient and an electrical charge gradient across the inner mitochondrial membrane and thus acts as a source of energy for ATP production.

15. The correct answer is (D). The variable that shows the most likely pattern of change during the 150-year period of ecological succession in a terrestrial habitat is biodiversity. Biodiversity typically increases during succession as habitats change and then typically levels off or possibly declines in the mature community.

16. The correct answer is (B). If a small population of birds is isolated from a larger population, the gene pool of the small population is likely to reflect the effects of genetic drift. The genetic variation and thus the allele frequencies for this small population are likely to be more restricted than those of the larger parent population.

17. The correct answer is (C). Water that is taken up by a root must cross the endodermis of the root cortex to reach the xylem vessels. Water taken up by roots does not enter the phloem, the root epidermis lacks stomata, and the root cap lacks pith.

18. The correct answer is (D). The quantity of DNA in a eukaryotic cell typically doubles during the S phase of the cell cycle when DNA is replicated. At the end of the S phase, each chromosome is composed of two identical chromatids that will separate during cell division.

19. The correct answer is (D). Because acetone is an eye and skin irritant, students should wear goggles and nitrile-type gloves to protect their eyes and hands, respectively. Keeping all containers that contain acetone closed will minimize fumes and thus decrease eye and skin exposure as well as the chance of accidentally igniting acetone vapors.

20. The correct answer is (C). The insertion of two nucleotides at the beginning of a codon will cause a frameshift mutation to a gene such that all amino acids encoded downstream of the insertion will be different from those in the usual wild-type version of the protein. If this gamete contributes to the formation of a zygote, all cells of the resulting organism will contain the identical mutation.

21. The correct answer is (A). The three nucleotides that should replace the deleted ones must be complementary to the nucleotides in the intact strand. Thus, the nucleotides are, from 5′ to 3′, C G T.

22. The correct answer is (D). A gas phase is generally absent from the phosphorus cycle. The largest reservoir of phosphorus is in sedimentary rocks of marine origin. Most phosphorus cycles among rocks, soil, water, and living organisms.

23. The correct answer is (A). All viruses are surrounded by a capsid that is composed entirely of proteins. Some viruses that infect animal cells have an additional layer, an envelope that is acquired from the cell membrane, around the capsid.

24. The correct answer is (B). The main benefits to crop rotation are increasing crop yields and minimizing pathogen infection and pest infestation. Some crops return nutrients such as nitrogen to the soil that other crops deplete, some crops have deep roots while others have shallow roots, and some crops help to minimize the growth of weeds. When a crop is planted that is not a host for a pathogen or insect pest that affected a previous crop, the number of such organisms in the agricultural area will decrease over time.

25. The correct answer is (C). Convergent evolution is the process by which organisms in different evolutionary lineages evolve similar adaptations. The presence of wings in both insects and birds evolved independently because wings provide an advantage to these organisms in their environments.

26. The correct answer is (A). Based on the codon table shown, the mRNA codon that specifies tryptophan is 5′ UGG 3′. The template DNA sequence must be complementary to and run in an antiparallel orientation to the mRNA codon, so the template DNA sequence is 3′ ACC 5′, which is more commonly written as 5′ CCA 3′.

27. The correct answer is (C). A line graph in which the *x*-axis represents time and the *y*-axis represents the amount of oxygen released is best used to represent the data. Data points should be graphed for each time point at which oxygen production is measured. Then all the data points should be connected by a line, and the shape of that line can be evaluated.

28. The correct answer is (B). Breast milk contains maternal antibodies and some immune cells that can help protect a human infant whose own immune system is very immature at birth. The majority of the antibodies in breast milk are of the IgA isotype that particularly protects mucosal surfaces such as the gastrointestinal tract.

29. The correct answer is (C). Primers are required for PCR. During PCR, an increase in the incubation temperature melts the DNA (separates the two strands). As the temperature is then reduced, primers added to the reaction mixture anneal to complementary sequences at each end of the desired region of amplification. DNA polymerase enzymes in the reaction mixture start to add nucleotides (dNMPs) that are complementary to the single-stranded DNA by extending from the 3′ end of each primer. By alternately heating the DNA to separate the strands and reducing the temperature to allow primer annealing and DNA polymerase extension, many copies of DNA complementary to the region between the primers are synthesized.

30. The correct answer is (A). Typically, periodic natural wildfires are of relatively low intensity. They remove dead and decaying plant matter, including dead trees, leaf litter and pine needles, and shrubs. Without periodic wildfires, the material accumulates so that when a fire eventually does occur, it is much greater in intensity and size and potentially very destructive to living organisms.

31. The correct answer is (C). Turner syndrome, a relatively rare disorder, results when a woman has only one normal X chromosome. The second X chromosome is either missing (an example of aneuploidy) or is structurally altered.

32. The correct answers are (B) and (C). Two practices that are most likely to help protect the western prairie fringed orchid from extinction are decreasing the use of broad-spectrum pesticides and educating landowners to recognize the orchid and appreciate the ecological value of its habitat. These orchids are dependent on hawkmoths for pollination; broad-spectrum pesticides have negative effects on both larval and adult hawkmoths as well as on other insects that occupy distinct niches in the local ecosystem. Most of the tallgrass prairie land in the United States has been converted to agricultural use, so not only are plants such as the western prairie fringed orchid that require such land for growth endangered but other species indigenous to the prairie are as well.

33. The correct answer is (D). During embryogenesis, after formation of the hollow ball of cells called the blastula, one end of the embryo folds in and expands to gradually fill the space in the blastula. This process is referred to as gastrulation and results in the formation of the three primary germ layers: the endoderm, the mesoderm, and the ectoderm.

34. The correct answer is (A). In the 1960s Robert MacArthur and E. O. Wilson developed the ecological discipline of island biogeography, where an island is defined as a landmass that is surrounded by water or any terrestrial area that is surrounded by land that cannot support the species living in the surrounded area. The model identified the key determinants of species diversity on such an island. The model states that the two factors that primarily determine the biodiversity of an island are the rate at which new species immigrate to the island and the rate at which species on the island become extinct. Two factors that additionally affect immigration and extinction rates for an island surrounded by water are the island's size and its distance from the mainland.

35. The correct answer is (B). Increasing the concentration gradient (concentration difference) of an uncharged solute across the membrane of a cell will most likely increase the rate of diffusion of the solute across the membrane of the cell. As the number of molecules of the solute increases on one side of the membrane with respect to the other side, there is a greater probability that a molecule of the solute on the side of higher concentration will cross the membrane to the side of lower concentration.

36. The correct answer is (C). Arrow *C* points to a guard cell, pairs of which regulate the size of each stomatal opening and thus regulate water and gas exchange with the environment.

37. The correct answer is (A). If a large population is broken into three separate, smaller populations that become distinct species, the nucleotide sequences of certain gene alleles found in the parent population are now likely to differ among the three species.

38. The correct answer is (B). The second law of thermodynamics states that every transfer or transformation of energy increases the entropy of the universe. Only a portion (approximately 10%) of the chemical energy in each trophic level is available for transfer to organisms at the next trophic level because much of the energy in each trophic level is dissipated as heat.

4. Determine Your Strategy for Success

Set clear goals and deadlines so your test preparation is focused and efficient

Effective *Praxis* test preparation doesn't just happen. You'll want to set clear goals and deadlines for yourself along the way. Otherwise, you may not feel ready and confident on test day.

1) Learn what the test covers.

You may have heard that there are several different versions of the same test. It's true. You may take one version of the test and your friend may take a different version a few months later. Each test has different questions covering the same subject area, but both versions of the test measure the same skills and content knowledge.

You'll find specific information on the test you're taking on page 5, which outlines the content categories that the test measures and what percentage of the test covers each topic. Visit www.ets.org/praxis/testprep for information on other *Praxis* tests.

2) Assess how well you know the content.

Research shows that test takers tend to overestimate their preparedness—this is why some test takers assume they did well and then find out they did not pass.

The *Praxis* tests are demanding enough to require serious review of likely content, and the longer you've been away from the content, the more preparation you will most likely need. If it has been longer than a few months since you've studied your content area, make a concerted effort to prepare.

3) Collect study materials.

Gathering and organizing your materials for review are critical steps in preparing for the *Praxis* tests. Consider the following reference sources as you plan your study:

- Did you take a course in which the content area was covered? If yes, do you still have your books or your notes?
- Does your local library have a high school-level textbook in this area? Does your college library have a good introductory college-level textbook in this area?

Practice materials are available for purchase for many *Praxis* tests at www.ets.org/praxis/testprep. Test preparation materials include sample questions and answers with explanations.

4) Plan and organize your time.

You can begin to plan and organize your time while you are still collecting materials. Allow yourself plenty of review time to avoid cramming new material at the end. Here are a few tips:

- Choose a test date far enough in the future to leave you plenty of preparation time. Test dates can be found at www.ets.org/praxis/register/dates_centers.
- Work backward from that date to figure out how much time you will need for review.
- Set a realistic schedule—and stick to it.

5) Practice explaining the key concepts.

Praxis tests with constructed-response questions assess your ability to explain material effectively. As a teacher, you'll need to be able to explain concepts and processes to students in a clear, understandable way. What are the major concepts you will be required to teach? Can you explain them in your own words accurately, completely, and clearly? Practice explaining these concepts to test your ability to effectively explain what you know.

6) Understand how questions will be scored.

Scoring information can be found on page 51.

7) Develop a study plan.

A study plan provides a road map to prepare for the *Praxis* tests. It can help you understand what skills and knowledge are covered on the test and where to focus your attention. Use the study plan template on page 33 to organize your efforts.

And most important—get started!

Would a Study Group Work for You?

Using this guide as part of a study group

People who have a lot of studying to do sometimes find it helpful to form a study group with others who are working toward the same goal. Study groups give members opportunities to ask questions and get detailed answers. In a group, some members usually have a better understanding of certain topics, while others in the group may be better at other topics. As members take turns explaining concepts to one another, everyone builds self-confidence.

If the group encounters a question that none of the members can answer well, the group can go to a teacher or other expert and get answers efficiently. Because study groups schedule regular meetings, members study in a more disciplined fashion. They also gain emotional support. The group should be large enough so that multiple people can contribute different kinds of knowledge, but small enough so that it stays focused. Often, three to six members is a good size.

Here are some ways to use this guide as part of a study group:

- **Plan the group's study program.** Parts of the study plan template, beginning on page 31 can help to structure your group's study program. By filling out the first five columns and sharing the worksheets, everyone will learn more about your group's mix of abilities and about the resources, such as textbooks, that members can share with the group. In the sixth column ("Dates I will study the content"), you can create an overall schedule for your group's study program.
- **Plan individual group sessions.** At the end of each session, the group should decide what specific topics will be covered at the next meeting and who will present each topic. Use the topic headings and subheadings in the Test at a Glance table on page 5 to select topics, and then select practice questions, beginning on page 16.
- **Prepare your presentation for the group.** When it's your turn to present, prepare something that is more than a lecture. Write two or three original questions to pose to the group. Practicing writing actual questions can help you better understand the topics covered on the test as well as the types of questions you will encounter on the test. It will also give other members of the group extra practice at answering questions.

- **Take a practice test together.** The idea of a practice test is to simulate an actual administration of the test, so scheduling a test session with the group will add to the realism and may also help boost everyone's confidence. Remember, complete the practice test using only the time that will be allotted for that test on your administration day.
- **Learn from the results of the practice test.** Review the results of the practice test, including the number of questions answered correctly in each content category. For tests that contain constructed-response questions, look at the Sample Test Questions section, which also contain sample responses to those questions and shows how they were scored. Then try to follow the same guidelines that the test scorers use.
- **Be as critical as you can.** You're not doing your study partner(s) any favors by letting them get away with an answer that does not cover all parts of the question adequately.
- **Be specific.** Write comments that are as detailed as the comments about the sample responses. Indicate where and how your study partner(s) are doing an inadequate job of answering the question. Writing notes in the margins of the answer sheet may also help.
- **Be supportive.** Include comments that point out what your study partner(s) got right.

Then plan one or more study sessions based on aspects of the questions on which group members performed poorly. For example, each group member might be responsible for rewriting one paragraph of a response in which someone else did an inadequate job.

Whether you decide to study alone or with a group, remember that the best way to prepare is to have an organized plan. The plan should set goals based on specific topics and skills that you need to learn, and it should commit you to a realistic set of deadlines for meeting those goals. Then you need to discipline yourself to stick with your plan and accomplish your goals on schedule.

5. Develop Your Study Plan

Develop a personalized study plan and schedule

Planning your study time is important because it will help ensure that you review all content areas covered on the test. Use the sample study plan below as a guide. It shows a plan for the *Core Academic Skills for Educators: Reading* test. Following that is a study plan template that you can fill out to create your own plan. Use the "Learn about Your Test" and "Test Specifications" information beginning on page 5 to help complete it.

Use this worksheet to:
1. **Define Content Areas:** List the most important content areas for your test as defined in chapter 1.
2. **Determine Strengths and Weaknesses:** Identify your strengths and weaknesses in each content area.
3. **Identify Resources:** Identify the books, courses, and other resources you plan to use for each content area.
4. **Study:** Create and commit to a schedule that provides for regular study periods.

Praxis Test Name (Test Code): Core Academic Skills for Educators: Reading (5712)
Test Date: 9/15/17

Content covered	Description of content	How well do I know the content? (scale 1–5)	What resources do I have/need for the content?	Where can I find the resources I need?	Dates I will study the content	Date completed
Key Ideas and Details						
Close reading	Draw inferences and implications from the directly stated content of a reading selection	3	Middle school English textbook	College library, middle school teacher	7/15/17	7/15/17
Determining Ideas	Identify summaries or paraphrases of the main idea or primary purpose of a reading selection	3	Middle school English textbook	College library, middle school teacher	7/17/17	7/17/17
Determining Ideas	Identify summaries or paraphrases of the supporting ideas and specific details in a reading selection	3	Middle and high school English textbook	College library, middle and high school teachers	7/20/17	7/21/17
Craft, Structure, and Language Skills						
Interpreting tone	Determine the author's attitude toward material discussed in a reading selection	4	Middle and high school English textbook	College library, middle and high school teachers	7/25/17	7/26/17
Analysis of structure	Identify key transition words and phrases in a reading selection and how they are used	3	Middle and high school English textbook, dictionary	College library, middle and high school teachers	7/25/17	7/27/17
Analysis of structure	Identify how a reading selection is organized in terms of cause/effect, compare/contrast, problem/solution, etc.	5	High school textbook, college course notes	College library, course notes, high school teacher, college professor	8/1/17	8/1/17
Author's purpose	Determine the role that an idea, reference, or piece of information plays in an author's discussion or argument	5	High school textbook, college course notes	College library, course notes, high school teacher, college professor	8/1/17	8/1/17

(continued on next page)

Content covered	Description of content	How well do I know the content? (scale 1–5)	What resources do I have/need for the content?	Where can I find the resources I need?	Dates I will study the content	Date completed
Language in different contexts	Determine whether information presented in a reading selection is presented as fact or opinion	4	High school textbook, college course notes	College library, course notes, high school teacher, college professor	8/1/17	8/1/17
Contextual meaning	Identify the meanings of words as they are used in the context of a reading selection	2	High school textbook, college course notes	College library, course notes, high school teacher, college professor	8/1/17	8/1/17
Figurative Language	Understand figurative language and nuances in word meanings	2	High school textbook, college course notes	College library, course notes, high school teacher, college professor	8/8/17	8/8/17
Vocabulary range	Understand a range of words and phrases sufficient for reading at the college and career readiness level	2	High school textbook, college course notes	College library, course notes, high school teacher, college professor	8/15/17	8/17/17
Integration of Knowledge and Ideas						
Diverse media and formats	Analyze content presented in diverse media and formats, including visually and quantitatively, as well as in words	2	High school textbook, college course notes	College library, course notes, high school teacher, college professor	8/22/17	8/24/17
Evaluation of arguments	Identify the relationship among ideas presented in a reading selection	4	High school textbook, college course notes	College library, course notes, high school teacher, college professor	8/24/17	8/24/17
Evaluation of arguments	Determine whether evidence strengthens, weakens, or is relevant to the arguments in a reading selection	3	High school textbook, college course notes	College library, course notes, high school teacher, college professor	8/27/17	8/27/17
Evaluation of arguments	Determine the logical assumptions upon which an argument or conclusion is based	5	High school textbook, college course notes	College library, course notes, high school teacher, college professor	8/28/17	8/30/17
Evaluation of arguments	Draw conclusions from material presented in a reading selection	5	High school textbook, college course notes	College library, course notes, high school teacher, college professor	8/30/17	8/31/17
Comparison of texts	Recognize or predict ideas or situations that are extensions of or similar to what has been presented in a reading selection	4	High school textbook, college course notes	College library, course notes, high school teacher, college professor	9/3/17	9/4/17
Comparison of texts	Apply ideas presented in a reading selection to other situations	2	High school textbook, college course notes	College library, course notes, high school teacher, college professor	9/5/17	9/6/17

My Study Plan

Use this worksheet to:

1. **Define Content Areas:** List the most important content areas for your test as defined in chapter 1.
2. **Determine Strengths and Weaknesses:** Identify your strengths and weaknesses in each content area.
3. **Identify Resources:** Identify the books, courses, and other resources you plan to use for each content area.
4. **Study:** Create and commit to a schedule that provides for regular study periods.

Praxis Test Name (Test Code): _____

Test Date: _____

Content covered	Description of content	How well do I know the content? (scale 1–5)	What resources do I have/need for this content?	Where can I find the resources I need?	Dates I will study this content	Date completed

(continued on next page)

Content covered	Description of content	How well do I know the content? (scale 1–5)	What resources do I have/need for the content?	Where can I find the resources I need?	Dates I will study the content	Date completed

6. Review Study Topics

Detailed study topics with questions for discussion

Using the Study Topics That Follow

The Biology: Content Knowledge test is designed to measure the knowledge and skills necessary for a beginning teacher.

This chapter is intended to help you organize your preparation for the test and to give you a clear indication of the depth and breadth of the knowledge required for success on the test.

Virtually all accredited programs address the topics covered by the test; however, you are not expected to be an expert on all aspects of the topics that follow.

You are likely to find that the topics below are covered by most introductory textbooks. Consult materials and resources, including lecture and laboratory notes, from all your coursework. You should be able to match up specific topics and subtopics with what you have covered in your courses.

Try not to be overwhelmed by the volume and scope of content knowledge in this guide. Although a specific term may not seem familiar as you see it here, you might find you can understand it when applied to a real-life situation. Many of the items on the actual test will provide you with a context to apply to these topics or terms.

Discussion Areas

Interspersed throughout the study topics are discussion areas, presented as open-ended questions or statements. These discussion areas are intended to help test your knowledge of fundamental concepts and your ability to apply those concepts to situations in the classroom or the real world. Most of the areas require you to combine several pieces of knowledge to formulate an integrated understanding and response. If you spend time on these areas, you will gain increased understanding and facility with the subject matter covered on the test. You may want to discuss these areas and your answers with a teacher or mentor.

Note that this study companion *does **not** provide answers for the discussion area questions*, but thinking about the answers to them will help improve your understanding of fundamental concepts and will probably help you answer a broad range of questions on the test.

Study Topics

An overview of the areas covered on the test, along with their subareas, follows.

I. Nature of Science: Scientific Inquiry, Methodology, Techniques, and History

A. Processes Involved in Scientific Inquiry

1. Making observations
2. Formulating and testing hypotheses
3. Identifying experimental variables and controls
4. Conclusions: proof versus support
5. Scientific sources and communicating findings

B. Science Involves Many Disciplines

1. Chemical nature of biology
2. Calculations in biology (e.g., statistics, probability)
3. Physical laws and principles governing biological systems

C. Differences among Facts, Hypotheses, Theories, and Laws

1. Testable nature of hypotheses
2. Formulation of theories based on accumulated data
3. Durability of laws

D. Scientific Ideas Change over Time; Contributions Made by Major Historical Figures

1. Cell theory and germ theory (e.g., Hooke, Pasteur)
2. Heredity, evolution, and ecology (e.g., Mendel, Darwin)
3. Structure and nature of genetic material (e.g., Hershey and Chase, Franklin, Watson and Crick)
4. Classification of organisms (e.g., Linnaeus, Woese)

E. Appropriate Use of Scientific Measurement and Notation Systems

1. Precision versus accuracy
2. Metric and SI units
3. Unit conversions
4. Scientific notation and significant figures
5. Linear versus logarithmic scales (e.g., pH)

F. Read and Interpret Data Represented in Tables, Graphs, and Charts

1. Identify patterns and trends in data
2. Choose appropriate types of graphs or charts
3. Error analysis
4. Draw conclusions and make predictions

G. Construct and Use Scientific Models to Explain Complex Phenomena

1. Limitations of models
2. Select models for a given purpose
3. Physical (e.g., anatomical models), conceptual (e.g., fluid mosaic model), graphical and/or mathematical models (e.g., population growth or climate change models)

H. Procedures Involved in the Safe Preparation, Storage, Use, and Disposal of Laboratory and Field Materials

1. Molarity and percent solutions
2. Acid and base solutions
3. Flammable and/or caustic materials
4. Biological specimens and waste

I. Appropriate and Safe Use and Care of Laboratory Equipment

1. Optical equipment (e.g., microscopes, spectrophotometers, UV light sources)
2. Separation equipment (e.g., gel electrophoresis, chromatography, centrifuges)
3. Measurement, mixing, and heating equipment (e.g., balances, stirrers, burners)
4. Sterilization equipment (e.g., autoclave, ovens)

J. Safety and Emergency Procedures for Science Classrooms and Laboratories

1. Use of material safety data sheets (MSDS, or safety data sheets, SDS)
2. Use of personal safety equipment: (e.g., gloves, goggles, lab coats)
3. Use of laboratory safety equipment (e.g., fire extinguishers, eye wash stations, emergency showers)

Discussion areas

- Vegetable crops growing on a commercial farm are damaged by an unknown disease or pest with a 70 to 90 percent mortality rate. The farmer claims that he has not changed his procedures for watering and fertilizer application. Formulate a hypothesis about the causative agent, given the observations above. What type of experiments should be used to help support or falsify the hypothesis?
- Carl Woese based his phylogenetic classification on analyses of what macromolecule? As a result of Woese's analyses, how was the tree of life revised from that based on morphological similarities?
- What is the most effective way to compare information obtained from television, a newspaper article, a web site, and a scientific journal for accuracy? For understandability? For use in the classroom setting?
- A scientist studying nutrient requirements for a particular type of bacteria inoculates three flasks of culture medium with an equal number of bacteria. Extra glucose is added to one of the flasks, and extra lactose is added to another. The number of bacteria per mL is determined every two hours for a period of 12 hours. What type of graph is best used to represent the data?
- Describe how to prepare 1 L of an 0.85% NaCl solution. If the solution is to be used to culture live cells, is it important to include a buffer in the solution? Explain.

II. Molecular and Cellular Biology

A. Chemical Structures and Properties of Biologically Important Molecules

1. Atomic structure
2. Organic versus inorganic molecules
3. Chemical bonding (e.g., hydrogen, covalent)
4. Molecular structure (e.g., water, oxygen)
5. Water properties (e.g., cohesion, high specific heat)
6. Macromolecules (e.g., carbohydrates, nucleic acids, proteins, lipids)

B. Biological Processes Are Dependent on Chemical Principles

1. Chemical and physical gradients (e.g., osmosis, diffusion, temperature)
2. Thermodynamics
3. Anabolic and catabolic reactions (e.g., hydrolysis)
4. Reduction-oxidation reactions

C. Structure and Function of Enzymes and Factors Influencing their Activity

1. Active site structure and substrate binding (e.g., induced fit, lock and key)
2. Reaction kinetics (e.g., effects of temperature, pH, and inhibitors)
3. Regulation (e.g., cooperative binding, feedback inhibition)

D. Biochemical Pathways and Energy Flow Within an Organism

1. Cellular locations of biochemical pathways
2. Photosynthesis (e.g., photosystems, electron transport, C_3 and C_4)
3. Cellular respiration (e.g., fermentation, Krebs (citric acid) cycle, electron transport chain)
4. Chemosynthesis (e.g., deep sea vent microorganisms)

E. Major Differences between Prokaryotes and Eukaryotes

1. Cell size
2. Membrane-bound organelles
3. Cell walls (e.g., peptidoglycan, cellulose)
4. Chromosome structure (e.g., circular versus linear)

F. Structure and Function of Cells and Organelles

1. Plant cells versus animal cells
2. Cell membranes
3. Membrane-bound organelles (e.g., nucleus, chloroplast) and ribosomes
4. Cytoskeleton

G. Cells Maintain their Internal Environment and Respond to External Signals

1. Selective permeability
2. Active and passive transport
3. Water movement (e.g., osmolarity, water potential)
4. Cell surface proteins and cell communication
5. Exocytosis and endocytosis
6. Hormone action and feedback

H. Cellular Division, the Cell Cycle, and How They Are Regulated

1. Cell cycle stages (G_1, S, G_2, M)
2. Mitosis and meiosis (e.g., stages, functions, results)
3. Cytokinesis (e.g., cleavage furrow, cell plate)
4. Cell cycle checkpoints

I. Structure and Function of Nucleic Acids

1. Sugar-phosphate backbone
2. DNA versus RNA
3. Complementary base pairing
4. Chromosome structure (e.g., nucleosomes, telomeres, linear versus circular)
5. DNA replication

J. Processes Involved in Protein Synthesis

1. RNA transcription
2. mRNA processing (e.g., polyadenylation, splicing)
3. Translation (e.g., ribosome structure, tRNA)

K. Regulation of Gene Expression

1. Promoters
2. Enhancers
3. Transcription factors
4. Operons
5. Environmental influences (e.g., epigenetics)

L. Cells May Undergo Differentiation and Specialization

1. Differential gene expression
2. Stem cells (e.g., sources, developmental potential)

M. Nature of Mutations

1. Causes of mutations (e.g., recombination, mutagens)
2. Types of mutations (e.g., point mutation, deletion, inversion, translocation)
3. Somatic versus germline mutations

N. Use of Basic Laboratory Techniques to Study Biological Processes

1. Gel electrophoresis
2. Microscopy
3. Spectrophotometry

O. Use and Applications of DNA Technologies and Genetic Engineering

1. DNA sequencing and polymerase chain reaction (PCR)
2. Genome sequencing projects (e.g., Human Genome Project)
3. Gene therapy
4. Cloning
5. Transgenic and genetically engineered cells

Discussion areas

- What are the four most abundant elements in the human body?
- What are functional groups? How do the differing charges of functional groups influence the behavior of the functional groups, the structure of molecules bearing the functional groups, and the interactions of the molecules with water?
- Why are fats insoluble in water?
- Describe the structural and functional differences between starch and cellulose.
- What factors influence the rate at which an ion diffuses across a cell membrane?
- How is ATP involved in the transfer of usable energy between molecules?
- How do temperature, pH, and competitive or noncompetitive inhibitors influence enzyme activity?

- What are the sources of CO_2, O_2, and water used by a plant in photosynthesis or cellular respiration? Through what structures and by what processes do these molecules enter and exit a plant?
- State some similarities and differences between aerobic and anaerobic respiration.
- Explain the benefit, at the cellular level, of producing ATP aerobically. After strenuous activity, one may feel a burning sensation in some muscles. What is responsible for the sensation?
- How does the consumption of too many carbohydrates lead to an increase in body fat?
- Compare the structure of chromosomes in eukaryotes, bacteria, and archaea.
- What structures are likely to be found in a plant cell but not in an animal cell?
- What structures are likely to be found in an animal cell but not in a bacterium?
- What organelles are likely to be present in greater abundance in a cell that is secreting a large amount of protein (e.g., an antibody-secreting plasma cell) than in a cell secreting very little protein (e.g., a skin cell)?
- Describe the difference between active and passive transport. Compare simple diffusion, osmosis, and facilitated diffusion.
- If an individual is stranded in a lifeboat on an ocean, why is drinking seawater more harmful to the individual than drinking no water at all?
- Compare mitosis and meiosis: the stages, genetic makeup of daughter cells, unique features.
- Name the three cell cycle checkpoints. What criteria must be met at each of the checkpoints for a cell to progress through the cell cycle?
- In addition to killing many types of cancer cells, why does chemotherapy treatment cause side effects such as anemia, gastrointestinal distress, and hair loss?
- Compare the structure of DNA and RNA: number of strands, flexibility, molecular composition.
- If a fragment of DNA has the sequence 5' ACTCGGTAC 3', what is the sequence of the complementary strand from 5' to 3' ?
- During DNA synthesis at a replication fork, why is one new strand of DNA synthesized in a continuous fashion and the other new strand synthesized in a discontinuous fashion?
- What is the signal for the start site of RNA transcription? for the approximate end site of transcription?
- What is the signal for the start site of translation? for the end site of translation?
- What is an operon? The *lac* operon is considered to be inducibly expressed. Explain how this operon is regulated.
- What causes human liver cells to be structurally and functionally different from human muscle cells?
- In what types of cells must a mutation be found for the mutation to be passed on to offspring? Mutations in what types of cells are not inherited by offspring?
- What types of molecules are typically separated by gel electrophoresis? Where are the largest molecules in a sample typically found with respect to the wells in which the samples are loaded onto the gel?
- What type of microscope is typically used to examine live, anaesthetized fruit flies? What type of microscope is typically used to examine thin sections of cells?
- What are the roles of plasmids and restriction endonucleases in DNA cloning?
- How are viruses used in gene therapy?

III. Genetics and Evolution

A. Mendel's Laws and Predicting the Probable Outcome of Given Genetic Crosses

1. Independent assortment
2. Law of segregation
3. Monohybrid and dihybrid crosses
4. Pedigree analysis

B. Non-Mendelian inheritance

1. Linkage (e.g., recombination mapping)
2. Sex-linked inheritance
3. Multiple alleles, codominance, and incomplete dominance
4. Polygenic inheritance, epistasis, and pleiotropy
5. Organelle inheritance (e.g., mitochondrial inheritance)

C. Chromosomal and Genetic Changes that Lead to Common Human Genetic Disorders

1. Changes in chromosome numbers (e.g., Down syndrome)
2. Changes in chromosome structure (e.g., deletion, inversion, duplication, translocation)
3. Common genetic disorders (e.g., Sickle-cell anemia, Tay-Sachs disease)

D. Sources of Genetic Variation

1. Mutation
2. Crossing-over
3. Genetic exchange (e.g., transduction, transformation, conjugation)
4. Sexual reproduction (e.g., independent assortment)

E. Mutations, Gene Flow, Genetic Drift, and Nonrandom Mating Affect the Gene Pool of a Population

1. Distribution and movement of alleles within populations
2. Distribution and movement of alleles between populations

F. Principles and Applications of Hardy-Weinberg Equilibrium

1. Conditions of HW equilibrium
2. Calculating allele frequencies using the HW equation

G. Mechanisms of Evolution

1. Natural and artificial selection
2. Sexual selection
3. Genetic drift (e.g., bottleneck, founder effect)
4. Coevolution
5. Adaptive radiation

H. Evidence that Supports Evolution

1. Molecular evidence (e.g., DNA sequence comparisons)
2. Structural and developmental evidence (e.g., homology, embryology)
3. Fossil record
4. Endosymbiosis
5. Convergent versus divergent evolution
6. Major evolutionary trends (e.g., cephalization, multicellularity)

I. Genetic Basis of Speciation

1. Reproductive isolation (e.g., prezygotic, postzygotic)
2. Types of speciation (e.g., allopatric, sympatric)

J. Models of Evolutionary Rates

1. Gradualism
2. Punctuated equilibrium

K. Scientific Explanations for the Origin of Life on Earth

1. Panspermia (e.g., asteroid seeding)
2. Abiotic synthesis of organic compounds (e.g., Miller-Urey experiment)
3. Biological influences on atmospheric composition (e.g., photosynthesis)
4. Development of self-replication (e.g., RNA world)

L. Factors that Lead to Extinction of Species

1. Lack of genetic diversity
2. Environmental pressures (e.g., climate and habitat change)
3. Human impacts
4. Interspecific competition

Discussion areas

- In pea plants, the allele for purple flowers (*W*) is dominant to the allele for white flowers (*w*). To determine whether a plant with purple flowers is homozygous or heterozygous with respect to flower color, the plant should be crossed with another pea plant with what genotype and phenotype with respect to flower color?
- A wild-type fruit fly that is heterozygous for both the black body (*b*) and vestigial wings (*vg*) genes is mated with a fly that exhibits both of these recessive mutations. Of 500 progeny produced, the phenotypic distribution is:
  199 wild-type body/wild-type eyes;
  42 wild-type body/vestigial wings;
  48 black body/wild-type wings;
  211 black body/vestigial wings.
  Are the *b* and *vg* genes most likely on the same or different chromosomes? Explain.
- Name a genetic disorder that is most commonly caused by fusion of a gamete with a normal chromosome number with another gamete that contains two copies of a particular chromosome. What is the most likely cause of the abnormal chromosome number in the gamete?
- Describe the relationship between DNA mutation, skin cancer, and prolonged exposure to the sun.
- A particular genetic trait is inherited in an autosomal recessive fashion. If one out of every 400 individuals has the trait, what percent of the population are expected to be carriers of the trait?
- A particular population exhibits variation in certain traits. For natural selection to act on the variations, what two requirements must be met by the variations?
- As a result of habitat fragmentation, a small population of leopards becomes isolated from the larger original population. As time progresses, are allele frequencies and genetic variation expected to differ between the original population and the isolated population? If so, describe how and why they will differ.
- What structural and functional characteristics of mitochondria and chloroplasts provide evidence to support the theory of endosymbiosis?
- Horses and donkeys can mate and produce viable offspring, but horses and donkeys are considered to be separate species. Explain why this is so.
- What organic compounds were produced in the Miller-Urey experiment? How did the design of the experiment support the hypothesis that organic compounds are likely to have arisen from abiotic materials present in the atmosphere of early Earth?

IV. Diversity of Life and Organismal Biology

A. Characteristics of Living Versus Nonliving Things

1. Cellular organization
2. Growth and reproduction
3. Regulation and responses to the environment
4. Obtain and use energy

B. Historical and Current Biological Classification Systems of Organisms

1. Kingdom system
2. Domain system

C. Defining Characteristics of Viruses, Bacteria, Protists, Fungi, Plants, and Animals

1. Structure (e.g., capsid, cell wall, organelles)
2. Organization (e.g., prokaryote, multicellular)
3. Modes of nutrition (e.g., heterotroph, autotroph)
4. Reproduction/replication (e.g., viral replication, binary fission, budding)

D. Characteristics of the Major Animal Phyla

1. Body plans (e.g., radial versus bilateral symmetry)
2. Body cavities (e.g., coelomates, pseudocoelomates, acoelomates)
3. Modes of reproduction
4. Modes of temperature regulation (e.g., endotherm, ectotherm)

E. Organizational Hierarchy of Multicellular Organisms

1. Cells
2. Tissues
3. Organs
4. Organ systems

F. Anatomy and Physiology of Major Organ Systems in Animals

1. Cardiovascular and respiratory
2. Reproductive
3. Digestive and excretory
4. Nervous and endocrine
5. Immune

G. Maintenance of Homeostasis in Organisms

1. Role of structural components (e.g., kidney, hypothalamus)
2. Feedback mechanisms
3. Role of hormones (e.g., antidiuretic hormone (ADH), insulin)
4. Role of behaviors (e.g., diurnal, nocturnal, basking)

H. Reproduction, Development, and Growth in Animals

1. Gamete formation
2. Fertilization
3. Embryonic development
4. Growth, development, and aging

I. Characteristics of Major Plant Divisions

1. Vascular versus nonvascular plants
2. Flowering versus nonflowering plants
3. Monocot versus eudicot (dicot)

J. Structure and Function of Major Plant Tissues and Organs

1. Dermal
2. Vascular (i.e., xylem, phloem)
3. Ground (e.g., parenchyma, cortex)
4. Meristems
5. Flowers, stems, leaves, and roots

K. Plant Life Cycles and Reproductive Strategies

1. Alternation of generations (i.e., gametophyte, sporophyte)
2. Pollination strategies (e.g., wind, insect)
3. Seed dispersal

L. Plants Obtain and Transport Water and Inorganic Nutrients

1. Roots
2. Xylem transport
3. Control (e.g., stomata)

M. Plants Transport and Store Products of Photosynthesis

1. Products (e.g., simple and complex carbohydrates)
2. Phloem transport
3. Storage and support molecules (e.g., starch, cellulose)
4. Storage structures (e.g., plastids, vacuoles, tuber)

Discussion areas

- A rock is found with patches of an unfamiliar orange-colored flakey material on the surface. What possible features of the orange-colored material would indicate that the material is alive?
- Describe the characteristics of mushrooms that distinguish them as fungi rather than viruses, bacteria, protists, plants, or animals.
- Give an example of an animal with radial symmetry and one with bilateral symmetry. Is cephalization likely to be a feature of either one of these forms of symmetry? If so, of which?
- Describe the features of body cavities by which triploblastic animals can be distinguished as coelomates, pseudocoelomates, or acoelomates. Give an example of an animal that is a coelomate, one that is a pseudocoelomate, and one that is an acoelomate.
- Trace the flow of a drop of blood from the right atrium of the heart as the blood passes through the heart, the lungs, and one complete circuit of the human circulatory system.
- Describe the two ways in which ventilation in birds is particularly efficient in comparison to ventilation in most mammals.
- Describe the digestion of proteins in the human digestive system, specifically the enzymes involved, the location of the cells that produce the enzymes, and the organs in which the digestion occurs.

- Describe how B lymphocytes and cytotoxic T lymphocytes respond to a viral infection in a human.
- Name two ways by which the integument (skin) plays a role in thermoregulation in humans.
- Name four features of monocots that can frequently (although not always) be used to distinguish monocots from eudicots.
- What materials are transported in the xylem? What materials are transported in the phloem? In which direction does material flow in each type of vessel?
- In what root tissue are new root cells produced? Name four important functions of plant roots.
- Under what circumstance are stomata typically closed? Describe the mechanism by which ion flow and osmosis regulate the opening and closing of guard cells.

V. Ecology: Organisms and Environments

A. Hierarchical Structure of the Biosphere

1. Populations
2. Communities
3. Ecosystems
4. Biomes

B. Biotic and Abiotic Components of an Ecosystem Influence Population Size

1. Resource availability and abiotic factors (e.g., nutrients and temperature)
2. Habitat and niche
3. Competition and predation

C. Models of Population Growth

1. Exponential growth
2. Logistic growth (e.g., carrying capacity)

D. Relationship Between Reproductive Strategies and Mortality Rates

1. Sexual versus asexual reproduction
2. Parental investment
3. Number of offspring produced versus number that survive

E. Relationships Within and Between Species

1. Symbiosis (e.g., parasitism, commensalism, mutualism)
2. Predation
3. Competition and territoriality
4. Altruistic behaviors

F. Changes Occur During Ecological Succession

1. Primary versus secondary succession
2. Biomass, diversity, productivity, and habitat changes during succession

G. Types and Characteristics of Biomes

1. Aquatic (e.g., stream, estuary, coral reef)
2. Terrestrial (e.g., desert, grassland, tropical rain forest)

H. Energy Flow in the Environment

1. Trophic levels (e.g., pyramids of biomass, pyramids of energy)
2. Food webs

I. Biogeochemical Cycles

1. Water cycle
2. Carbon cycle
3. Nitrogen cycle
4. Phosphorus cycle

J. Effects of Natural Disturbances on Ecosystems

1. Temporal and spatial disturbances (e.g., climate, fire, disease)
2. Fragmentation of ecosystems
3. Natural ecosystem recovery

K. Humans Affect Ecological Systems and Biodiversity

1. Pollution (e.g., greenhouse gases, acid precipitation)
2. Habitat destruction (e.g., deforestation)
3. Introduced species (e.g., non-native, reintroduced)
4. Remediation (e.g., reforestation, mine reclamation)

L. Connections among Ecosystems on a Local and Global Scale

1. Natural flow of material between ecosystems
2. Transport of materials by humans
3. Movement of organisms (e.g., migration)

Discussion areas

- Distinguish between a population of organisms and a community of organisms.
- Name the two most common limiting factors to primary production in aquatic ecosystems.
- Draw the predicted growth curve for a population introduced into a new environment in which resources are initally unlimited. How will the shape of the curve change as the population reaches carrying capacity? What factors might determine the carrying capacity?
- Prairie dogs typically live in large colonies and dig extensive underground systems of burrows. If a predator approaches a colony, a prairie dog who spots the predator will sound a loud alarm that alerts the other members of the colony, most of whom will dive into the burrows and hide. The prairie dog that sounds the alarm is however drawing attention to itself and may be attacked by the predator. Explain why this behavior is often considered to be an example of altruism in animals.
- Compare primary and secondary succession: Is soil initially present in the environments where each type of succession occurs? What are the first organisms that typically colonize the environment where each type of succession occurs?
- Why is the density of water important to freshwater pond ecosystems in temperate regions?
- Why is the air temperature along the coast generally higher than the air temperature of inland areas in the same regions? How does this influence the types of organisms present in each region?
- A large percent of the mice in a particular population are infected by a virus that is usually fatal. What is the relationship between the virus and the mice? How will the viral infection most likely ultimately affect other members of the ecosystem such as grasses and owls?
- The major reservoir of carbon in the biosphere is one that turns over very slowly; what is it?
- What is the major natural route by which nitrogen enters an ecosystem?
- What are the major biotic and abiotic processes that drive the water cycle?
- What types of natural disturbances are most likely to lead to primary ecological succession? What kind of natural disturbances are most likely to lead to secondary succession? In the immediate aftermath of a disturbance, what will be the most likely effect on biodiversity of the region?
- What is meant by acid precipitation, and how is it harmful? How do human activities contribute to acid precipitation?
- Name some of the most likely reasons for the increased number of emerging infectious diseases affecting humans in recent years.

VI. Science, Technology, and Social Perspectives

A. Impact of Science and Technology on the Environment

1. Pollution and pollution mitigation (e.g., burning fossil fuels, green building, environmental cleanup)
2. Resource management (e.g., waste management, recycling, efficiency)
3. Conservation (e.g., habitat protection, habitat restoration, species protection)
4. Non-point sources of pollution (e.g., lawn fertilizers)

B. Impact of Human Activity and Natural Phenomena on Society

1. Consequences (e.g., economic, social)
2. Disaster management (e.g., hurricane relief and cleanup)
3. Global warming, sea levels, flooding
4. Epidemiology (e.g., malaria, influenza)
5. Agriculture and soil erosion
6. Estuary and wetland degradation
7. Water management
8. Production, use, and disposal of consumer products (e.g., plastics)

C. Societal Impacts Associated with the Management of Natural Resources

1. Habitat preservation (e.g., Endangered Species Act, National Parks)
2. Extraction of mineral and energy resources (e.g., mining, drilling)
3. Agriculture, forestry, wildlife, and fisheries practices
4. Renewable and/or sustainable use of resources

D. Ethical and Societal Issues Arising from the Use of Science and Technology

1. Ethical research concerns (e.g., stem cells, toxic chemicals)
2. Ethical use of technology (e.g., genetically modified organisms, cloning)
3. Societal concerns (e.g., security of genetic information, equal access to medical treatment)

Discussion areas

- How do lawn and agricultural fertilizers get into the natural water system? Why are the fertilizers harmful to many aquatic and semi-aquatic organisms or to any organisms that depend on the water supply?
- Why do many infectious diseases spread rapidly through "temporary" settlements established after an area is devastated by war or by a natural disaster? Name a disease transmitted by aerosol spray of a sneeze, a disease transmitted through drinking water, and a disease transmitted by an insect or arthropod vector.
- What is the relationship between the materials of which many plastics are produced and nonrenewable resources?
- A significant threat to marine turtles is incidental capture, injury, or death as a result of commercial fishing practices. What procedure has been implemented to protect marine turtles that are caught in nets, and what government agencies have been involved in implementing the turtle protection?
- What are some potentially beneficial uses of embryonic stem cells? Why do some people object to the use of these cells in research and development?

7. Review Smart Tips for Success

Follow test-taking tips developed by experts

Learn from the experts. Take advantage of the following answers to questions you may have and practical tips to help you navigate the *Praxis* test and make the best use of your time.

Should I guess?

Yes. Your score is based on the number of questions you answer correctly, with no penalty or subtraction for an incorrect answer. When you don't know the answer to a question, try to eliminate any obviously wrong answers and then guess at the correct one. Try to pace yourself so that you have enough time to carefully consider every question.

Can I answer the questions in any order?

You can answer the questions in order or skip questions and come back to them later. If you skip a question, you can also mark it so that you can remember to return and answer it later. Remember that questions left unanswered are treated the same as questions answered incorrectly, so it is to your advantage to answer every question.

Are there trick questions on the test?

No. There are no hidden meanings or trick questions. All of the questions on the test ask about subject matter knowledge in a straightforward manner.

Are there answer patterns on the test?

No. You might have heard this myth: the answers on tests follow patterns. Another myth is that there will never be more than two questions in a row with the correct answer in the same position among the choices. Neither myth is true. Select the answer you think is correct based on your knowledge of the subject.

Can I write on the scratch paper I am given?

Yes. You can work out problems on the scratch paper, make notes to yourself, or write anything at all. Your scratch paper will be destroyed after you are finished with it, so use it in any way that is helpful to you. But make sure to select or enter your answers on the computer.

Smart Tips for Taking the Test

1. **Skip the questions you find extremely difficult.** Rather than trying to answer these on your first pass through the test, you may want to leave them blank and mark them so that you can return to them later. Pay attention to the time as you answer the rest of the questions on the test, and try to finish with 10 or 15 minutes remaining so that you can go back over the questions you left blank. Even if you don't know the answer the second time you read the questions, see if you can narrow down the possible answers, and then guess. Your score is based on the number of right answers, so it is to your advantage to answer every question.

2. **Keep track of the time.** The onscreen clock will tell you how much time you have left. You will probably have plenty of time to answer all of the questions, but if you find yourself becoming bogged down, you might decide to move on and come back to any unanswered questions later.

3. **Read all of the possible answers before selecting one.** For questions that require you to select more than one answer, or to make another kind of selection, consider the most likely answers given what the question is asking. Then reread the question to be sure the answer(s) you have given really answer the question. Remember, a question that contains a phrase such as "Which of the following does NOT …" is asking for the one answer that is NOT a correct statement or conclusion.

4. **Check your answers.** If you have extra time left over at the end of the test, look over each question and make sure that you have answered it as you intended. Many test takers make careless mistakes that they could have corrected if they had checked their answers.

5. **Don't worry about your score when you are taking the test.** No one is expected to answer all of the questions correctly. Your score on this test is not analogous to your score on the *GRE*® or other tests. It doesn't matter on the *Praxis* tests whether you score very high or barely pass. If you meet the minimum passing scores for your state and you meet the state's other requirements for obtaining a teaching license, you will receive a license. In other words, what matters is meeting the minimum passing score. You can find passing scores for all states that use the *Praxis* tests at http://www.ets.org/s/praxis/pdf/passing_scores.pdf or on the web site of the state for which you are seeking certification/licensure.

6. **Use your energy to take the test, not to get frustrated by it.** Getting frustrated only increases stress and decreases the likelihood that you will do your best. Highly qualified educators and test development professionals, all with backgrounds in teaching, worked diligently to make the test a fair and valid measure of your knowledge and skills. Your state painstakingly reviewed the test before adopting it as a licensure requirement. The best thing to do is concentrate on answering the questions.

8. Check on Testing Accommodations

See if you qualify for accommodations to take the Praxis *test*

What if English is not my primary language?

Praxis tests are given only in English. If your primary language is not English (PLNE), you may be eligible for extended testing time. For more details, visit www.ets.org/praxis/register/plne_accommodations/.

What if I have a disability or other health-related need?

The following accommodations are available for *Praxis* test takers who meet the Americans with Disabilities Act (ADA) Amendments Act disability requirements:

- Extended testing time
- Additional rest breaks
- Separate testing room
- Writer/recorder of answers
- Test reader
- Sign language interpreter for spoken directions only
- Perkins Brailler
- Braille slate and stylus
- Printed copy of spoken directions
- Oral interpreter
- Audio test
- Braille test
- Large print test book
- Large print answer sheet
- Listening section omitted

For more information on these accommodations, visit www.ets.org/praxis/register/disabilities.

Note: Test takers who have health-related needs requiring them to bring equipment, beverages, or snacks into the testing room or to take extra or extended breaks must request these accommodations by following the procedures described in the *Bulletin Supplement for Test Takers with Disabilities or Health-Related Needs* (PDF), which can be found at https://www.ets.org/s/praxis/pdf/bulletin_supplement_test_takers_with_disabilities_health_needs.pdf

You can find additional information on available resources for test takers with disabilities or health-related needs at www.ets.org/disabilities.

9. Do Your Best on Test Day

Get ready for test day so you will be calm and confident

You followed your study plan. You prepared for the test. Now it's time to prepare for test day.

Plan to end your review a day or two before the actual test date so you avoid cramming. Take a dry run to the test center so you're sure of the route, traffic conditions, and parking. Most of all, you want to eliminate any unexpected factors that could distract you from your ultimate goal—passing the *Praxis* test!

On the day of the test, you should:

- be well rested
- wear comfortable clothes and dress in layers
- eat before you take the test
- bring an acceptable and valid photo identification with you
- bring an approved calculator only if one is specifically permitted for the test you are taking (see Calculator Use, at http://www.ets.org/praxis/test_day/policies/calculators)
- be prepared to stand in line to check in or to wait while other test takers check in

You can't control the testing situation, but you can control yourself. Stay calm. The supervisors are well trained and make every effort to provide uniform testing conditions, but don't let it bother you if the test doesn't start exactly on time. You will have the allotted amount of time once it does start.

You can think of preparing for this test as training for an athletic event. Once you've trained, prepared, and rested, give it everything you've got.

What items am I restricted from bringing into the test center?

You cannot bring into the test center personal items such as:

- handbags, knapsacks, or briefcases
- water bottles or canned or bottled beverages
- study materials, books, or notes
- pens, pencils, scrap paper, or calculators, unless specifically permitted for the test you are taking (see Calculator Use, at http://www.ets.org/praxis/test_day/policies/calculators)
- any electronic, photographic, recording, or listening devices

Personal items are not allowed in the testing room and will not be available to you during the test or during breaks. You may also be asked to empty your pockets. At some centers, you will be assigned a space to store your belongings, such as handbags and study materials. Some centers do not have secure storage space available, so please plan accordingly.

Test centers assume no responsibility for your personal items.

If you have health-related needs requiring you to bring equipment, beverages or snacks into the testing room or to take extra or extended breaks, you need to request accommodations in advance. Procedures for requesting accommodations are described in the Bulletin Supplement for Test Takers with Disabilities or Health-related Needs (PDF).

Note: All cell phones, smart phones (e.g., Android® devices, iPhones®, etc.), and other electronic, photographic, recording, or listening devices are strictly prohibited from the test center. If you are seen with such a device, you will be dismissed from the test, your test scores will be canceled, and you will forfeit your test fees. If you are seen *using* such a device, the device will be confiscated and inspected. For more information on what you can bring to the test center, visit www.ets.org/praxis/test_day/bring.

Are You Ready?

Complete this checklist to determine whether you are ready to take your test.

- ❒ Do you know the testing requirements for the license or certification you are seeking in the state(s) where you plan to teach?
- ❒ Have you followed all of the test registration procedures?
- ❒ Do you know the topics that will be covered in each test you plan to take?
- ❒ Have you reviewed any textbooks, class notes, and course readings that relate to the topics covered?
- ❒ Do you know how long the test will take and the number of questions it contains?
- ❒ Have you considered how you will pace your work?
- ❒ Are you familiar with the types of questions for your test?
- ❒ Are you familiar with the recommended test-taking strategies?
- ❒ Have you practiced by working through the practice questions in this study companion or in a study guide or practice test?
- ❒ If constructed-response questions are part of your test, do you understand the scoring criteria for these questions?
- ❒ If you are repeating a *Praxis* test, have you analyzed your previous score report to determine areas where additional study and test preparation could be useful?

If you answered "yes" to the questions above, your preparation has paid off. Now take the *Praxis* test, do your best, pass it—and begin your teaching career!

10. Understand Your Scores

Understand how tests are scored and how to interpret your test scores

Of course, passing the *Praxis* test is important to you so you need to understand what your scores mean and what your state requirements are.

What are the score requirements for my state?

States, institutions, and associations that require the tests set their own passing scores. Visit www.ets.org/praxis/states for the most up-to-date information.

If I move to another state, will my new state accept my scores?

The *Praxis* tests are part of a national testing program, meaning that they are required in many states for licensure. The advantage of a national program is that if you move to another state that also requires *Praxis* tests, you can transfer your scores. Each state has specific test requirements and passing scores, which you can find at www.ets.org/praxis/states.

How do I know whether I passed the test?

Your score report will include information on passing scores for the states you identified as recipients of your test results. If you test in a state with automatic score reporting, you will also receive passing score information for that state.

A list of states and their passing scores for each test are available online at www.ets.org/praxis/states.

What your *Praxis* scores mean

You received your score report. Now what does it mean? It's important to interpret your score report correctly and to know what to do if you have questions about your scores.

Visit http://www.ets.org/s/praxis/pdf/sample_score_report.pdf to see a sample score report.
To access *Understanding Your Praxis Scores*, a document that provides additional information on how to read your score report, visit www.ets.org/praxis/scores/understand.

Put your scores in perspective

Your score report indicates:

- Your score and whether you passed
- The range of possible scores
- The raw points available in each content category
- The range of the middle 50 percent of scores on the test

If you have taken the same *Praxis* test or other *Praxis* tests over the last 10 years, your score report also lists the highest score you earned on each test taken.

Content category scores and score interpretation

Questions on the *Praxis* tests are categorized by content. To help you in future study or in preparing to retake the test, your score report shows how many raw points you earned in each content category. Compare your "raw points earned" with the maximum points you could have earned ("raw points available"). The greater the difference, the greater the opportunity to improve your score by further study.

Score scale changes

ETS updates *Praxis* tests on a regular basis to ensure they accurately measure the knowledge and skills that are required for licensure. When tests are updated, the meaning of the score scale may change, so requirements may vary between the new and previous versions. All scores for previous, discontinued tests are valid and reportable for 10 years, provided that your state or licensing agency still accepts them.

These resources may also help you interpret your scores:

- *Understanding Your Praxis Scores* (PDF), found at www.ets.org/praxis/scores/understand
- *The Praxis Passing Scores* (PDF), found at www.ets.org/praxis/scores/understand
- State requirements, found at www.ets.org/praxis/states

Appendix: Other Questions You May Have

Here is some supplemental information that can give you a better understanding of the *Praxis* tests.

What do the *Praxis* tests measure?

The *Praxis* tests measure the specific knowledge and skills that beginning teachers need. The tests do not measure an individual's disposition toward teaching or potential for success, nor do they measure your actual teaching ability. The assessments are designed to be comprehensive and inclusive but are limited to what can be covered in a finite number of questions and question types. Teaching requires many complex skills that are typically measured in other ways, including classroom observation, video recordings, and portfolios.

Ranging from Agriculture to World Languages, there are more than 80 *Praxis* tests, which contain selected-response questions or constructed-response questions, or a combination of both.

Who takes the tests and why?

Some colleges and universities use the *Praxis* Core Academic Skills for Educators tests (Reading, Writing, and Mathematics) to evaluate individuals for entry into teacher education programs. The assessments are generally taken early in your college career. Many states also require Core Academic Skills test scores as part of their teacher licensing process.

Individuals entering the teaching profession take the *Praxis* content and pedagogy tests as part of the teacher licensing and certification process required by many states. In addition, some professional associations and organizations require the *Praxis* Subject Assessments for professional licensing.

Do all states require these tests?

The *Praxis* tests are currently required for teacher licensure in approximately 40 states and United States territories. These tests are also used by several professional licensing agencies and by several hundred colleges and universities. Teacher candidates can test in one state and submit their scores in any other state that requires *Praxis* testing for licensure. You can find details at www.ets.org/praxis/states.

What is licensure/certification?

Licensure in any area—medicine, law, architecture, accounting, cosmetology—is an assurance to the public that the person holding the license possesses sufficient knowledge and skills to perform important occupational activities safely and effectively. In the case of teacher licensing, a license tells the public that the individual has met predefined competency standards for beginning teaching practice.

Because a license makes such a serious claim about its holder, licensure tests are usually quite demanding. In some fields, licensure tests have more than one part and last for more than one day. Candidates for licensure in all fields plan intensive study as part of their professional preparation. Some join study groups, others study alone. But preparing to take a licensure test is, in all cases, a professional activity. Because a licensure exam surveys a broad body of knowledge, preparing for a licensure exam takes planning, discipline, and sustained effort.

Why does my state require the *Praxis* tests?

Your state chose the *Praxis* tests because they assess the breadth and depth of content—called the "domain"—that your state wants its teachers to possess before they begin to teach. The level of content knowledge, reflected in the passing score, is based on recommendations of panels of teachers and teacher educators in

each subject area. The state licensing agency and, in some states, the state legislature ratify the passing scores that have been recommended by panels of teachers.

How were the tests developed?

ETS consulted with practicing teachers and teacher educators around the country during every step of the *Praxis* test development process. First, ETS asked them what knowledge and skills a beginning teacher needs to be effective. Their responses were then ranked in order of importance and reviewed by hundreds of teachers.

After the results were analyzed and consensus was reached, guidelines, or specifications, for the selected-response and constructed-response tests were developed by teachers and teacher educators. Following these guidelines, teachers and professional test developers created test questions that met content requirements and ETS Standards for Quality and Fairness.*

When your state adopted the research-based *Praxis* tests, local panels of teachers and teacher educators evaluated each question for its relevance to beginning teachers in your state. During this "validity study," the panel also provided a passing-score recommendation based on how many of the test questions a beginning teacher in your state would be able to answer correctly. Your state's licensing agency determined the final passing-score requirement.

ETS follows well-established industry procedures and standards designed to ensure that the tests measure what they are intended to measure. When you pass the *Praxis* tests your state requires, you are proving that you have the knowledge and skills you need to begin your teaching career.

How are the tests updated to ensure the content remains current?

Praxis tests are reviewed regularly. During the first phase of review, ETS conducts an analysis of relevant state and association standards and of the current test content. State licensure titles and the results of relevant job analyses are also considered. Revised test questions are then produced following the standard test development methodology. National advisory committees may also be convened to review and revise existing test specifications and to evaluate test forms for alignment with the specifications.

How long will it take to receive my scores?

Scores for tests that do not include constructed-response questions are available on screen immediately after the test. Scores for tests that contain constructed-response questions or essays aren't available immediately after the test because of the scoring process involved. Official score reports are available to you and your designated score recipients approximately two to three weeks after the test date for tests delivered continuously, or two to three weeks after the testing window closes for other tests. See the test dates and deadlines calendar at www.ets.org/praxis/register/dates_centers for exact score reporting dates.

Can I access my scores on the web?

All test takers can access their test scores via My *Praxis* Account free of charge for one year from the posting date. This online access replaces the mailing of a paper score report.

The process is easy—simply log into My *Praxis* Account at www.ets.org/praxis and click on your score report. If you do not already have a *Praxis* account, you must create one to view your scores.

Note: You must create a *Praxis* account to access your scores, even if you registered by mail or phone.

*ETS Standards for Quality and Fairness (2014, Princeton, N.J.) are consistent with the Standards for Educational and Psychological Testing, industry standards issued jointly by the American Educational Research Association, the American Psychological Association, and the National Council on Measurement in Education (2014, Washington, D.C.).

Your teaching career is worth preparing for, so start today!

Let the *Praxis*® *Study Companion* guide you.

To search for the *Praxis* test prep resources
that meet your specific needs, visit:

www.ets.org/praxis/testprep

To purchase official test prep made by the creators
of the *Praxis* tests, visit the ETS Store:

www.ets.org/praxis/store

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