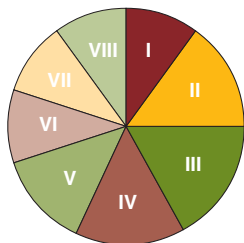


Biology and General Science (0030)

Test at a Glance

Test Name	Biology and General Science		
Test Code	0030		
Time	2 hours		
Number of Questions	120		
Format	Multiple-choice questions		
	Content Categories	Approximate Number of Questions	Approximate Percentage of Examination
	I. History, Philosophy, and Methodology of Science; Science, Technology, and Society	12	10%
	II. Molecular and Cellular Biology	18	15%
	III. Diversity of Life, Plants, and Animals	20	17%
	IV. Evolution and Classical Genetics	18	15%
	V. Ecology	16	13%
	VI. Chemistry	12	10%
	VII. Physics	12	10%
	VIII. Earth and Space Science	12	10%



About This Test

The Biology and General Science test is designed to measure the preparation of prospective teachers of secondary school biology and/or general science. About 60 percent of the test's 120 multiple-choice questions deal with biological science content. The remaining questions are divided among chemistry; physics; Earth and space science; and the history, philosophy, and methodology of science, as well as science, technology, and society.

Within these content areas, the test questions focus on the ability to identify fundamental scientific concepts and principles and to use them in the analysis and explanation of phenomena:

- recall of scientific terminology, principles, generalizations, classifications, and sequential processes
- application of principles and theories to familiar situations
- interpretation of laboratory and field experiences
- interrelationships among science, technology, and societal issues

Questions also focus on the ability to use the methods of inquiry, including identifying problems appropriate for scientific investigation and identifying processes used in scientific inquiry, such as formulating hypotheses, designing controlled experiments, analyzing and evaluating data, and making predictions.

Questions are designed to test mastery of factual subject matter and to evaluate examinees' knowledge of the techniques and processes associated with the teaching of the subject matter. This test may contain some questions that will not count toward your score.

Topics Covered

Representative descriptions of topics covered in each category are provided below.

I. History, Philosophy, and Methodology of Science; Science, Technology, and Society

- Nature of scientific knowledge, inquiry, and historical perspectives:
 - scientific methods
 - processes involved in scientific inquiry
 - process skills, facts, concepts, models, commonly shared scientific ideals, history and philosophy
 - contributions made by major historical figures and landmark events in the field of biology
 - safe preparation, storage, use, and disposal of laboratory and field materials
 - selection and use of appropriate laboratory equipment
- Science, technology, and society:
 - impact of science and technology on the environment and human affairs
 - human- and nature-induced hazards
 - issues and applications: production, storage, use, management, and disposal of consumer products and energy, and management of natural resources
 - social, political, ethical, and economic issues in biology and science
 - societal issues with health and medical advances

II. Molecular and Cellular Biology

- Chemical basis of life:
 - basic chemical structures
 - atoms, molecules, and chemical bonds
 - buffers
 - pH
 - biologically important molecules
 - thermodynamics and free energy
 - cellular bioenergetics
 - photosynthesis
 - respiration
 - enzymes
- Cell structure and function:
 - membranes, organelles, and subcellular components of prokaryotic and eukaryotic cells
 - cell cycle and cytokinesis
 - mitosis and meiosis

- Molecular basis of heredity:
 - structure and function of nucleic acids
 - DNA replication
 - protein synthesis
 - gene regulation
 - mutation and transposable elements
 - viruses
 - molecular basis of genetic diseases, e.g., cancer, sickle cell anemia, hemophilia
 - recombinant DNA and genetic engineering
 - genome mapping of humans and other organisms

III. Diversity of Life, Plants, and Animals

Diversity of life: such as classification schemes and characteristics and representatives of kingdoms or domains

- Plants:
 - evolution, including adaptation to land and major divisions
 - anatomy, including roots, stems, leaves, and reproductive structures
 - physiology, including C3 and C4 photosynthesis, hormones, photoperiods, water and nutrient uptake, and translocation
 - reproduction, including alternation of generations, fertilization and zygote formation, dispersal, germination, growth and differentiation, and vegetative propagation
- Animals:
 - evolution, including phylogeny and classification, and major phyla
 - life functions and associated structures, including digestion, circulation, respiration, excretion, nervous control, contractile systems and movement, support, integument, immunity, and the endocrine system
 - reproduction and development, including gametogenesis, fertilization, parthenogenesis, embryogenesis, growth and differentiation, metamorphosis, and aging
 - behavior, including taxes, instincts, learned behaviors, and communication

IV. Evolution and Classical Genetics

- Evolution: evidence, mechanisms, population genetics, speciation, phylogeny, origin of life, species extinction
- Classical genetics: Mendelian and non-Mendelian inheritance, probability, linkage, human genetic disorders, interaction between heredity and the environment

V. Ecology

- Populations: intraspecific competition, density factors, population growth, dispersion patterns, life-history patterns, social behavior
- Communities: niche, interspecific relationships, species diversity, succession
- Ecosystems: terrestrial ecosystems, aquatic ecosystems, biomes, energy flow, biogeochemical cycles, stability and disturbances, human impact, interrelationships among ecosystems

VI. Chemistry

- Matter: structure, states, phase changes, chemical and physical properties, kinetic molecular theory, nomenclature
- Reactions and equilibria: balancing equations and stoichiometry, reactions and chemical formulas, oxidation/reduction, acids/bases, kinetics and catalysis, solubility and solution behavior
- Laboratory methods and safety
- Environmental issues related to chemistry

VII. Physics

- Mechanics: straight line, projectile, circular, and periodic motion, Newton's laws of motion, friction, work, power, gravity, weight, mass, momentum, kinetic energy, potential energy, conservation of momentum, conservation of energy, fluids
- Energy: sources, transformations, heat
- Electricity and magnetism: charge, static electricity, Coulomb's law, current, resistance, Ohm's law, circuits, capacitance, magnetism, applications
- Optics and wave phenomena: electromagnetic spectrum, mirrors, lenses, sound, reflection, refraction, interference, diffraction
- Atomic and nuclear physics: atomic structure, radioactivity, half-life, fission and fusion
- Environmental issues related to physics

VIII. Earth and Space Science

- Geology: minerals, rocks, plate tectonics, earthquakes, Earth's interior, weathering, erosional and depositional processes, geological features on maps, historical geology (origin of Earth, relative and absolute time, major stratigraphic principles, paleontology)
- Oceanography: physical aspects, chemical aspects, geological aspects, biological aspects
- Meteorology: energy flows, water cycle, atmosphere, weather systems, climate
- Astronomy: origin of the universe, galaxies, solar system, properties of stars, Earth-Sun-Moon relationships, space exploration
- Environmental issues related to Earth and space science

Sample Test Questions

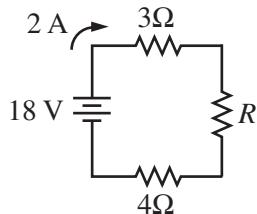
The sample questions that follow illustrate the types of questions in the test. They are not, however, representative of the entire scope of the test in either content or difficulty. Answers with explanations follow the questions.

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

- Observations from lakes in areas with granitic bedrock indicate that lakes are becoming depleted of living organisms. The primary cause is considered to be
 - nuclear waste
 - lowered water levels
 - acid rain
 - garbage dumping
 - oil spills
- Which of the following hypotheses is LEAST amenable to verification by experimentation?
 - The average size of eukaryotic genes is greater than the average size of prokaryotic genes.
 - Archaeopteryx* was the first flying organism.
 - Triploid watermelons exhibit defective meiosis and are therefore seedless.
 - The DNA that codes for the beta chain of hemoglobin has more introns than the DNA that codes for the alpha chain.
 - Humans and chimpanzees share some of the same genes.
- The phases of the Moon are mainly due to the
 - distance of the Moon from Earth
 - distance of the Moon from the Sun
 - rotation of Earth on its axis
 - angle of the Moon's orbit to that of Earth's orbit
 - position of Earth and the Moon relative to the Sun
- Which of the following factors help(s) to account for the fact that, in the United States, lands to the east of a mountain range receive less rain than lands to the west of the mountains receive?
 - Winds often blow from west to east.
 - An air mass cools as it goes over a mountain range.
 - The maximum amount of water vapor that can be in a sample of warm air is greater than that in a sample of cooler air.
 - II only
 - III only
 - I and II only
 - II and III only
 - I, II, and III
- The goal of a teaching unit is for students to recognize that species are replaced by other species as their environment changes. Which of the following is an appropriate learning experience?
 - Comparing plant types of a primary dune to those of a secondary dune
 - Characterizing the stages of embryo development of a chick
 - Observing phototropic movements by plants
 - Recording changes in heart rate of *Daphnia* at different temperatures
 - Comparing brain structure and function among higher vertebrates
- All of the atoms of sodium, whether or not in compounds, must have exactly eleven of which of the following?
 - Ions
 - Protons
 - Neutrons
 - Electrons
 - Photons

7. The Galápagos finches studied by Darwin are a good example of
- (A) inheritance of acquired characteristics
 - (B) nonselection
 - (C) adaptive radiation
 - (D) speciation by polyploidy
 - (E) convergent evolution
8. The presence of which of the following is useful in separating ferns and mosses into different taxonomic categories?
- (A) Chlorophyll
 - (B) Vascular tissue
 - (C) Nuclei
 - (D) Chloroplasts
 - (E) Flagellated sperm
9. Toxic materials are often found in high concentrations in the tissues of organisms at the top of food pyramids because these materials are first
- (A) degraded in plants
 - (B) metabolized by plants
 - (C) excreted as wastes by animals
 - (D) accumulated in the cells of autotrophs and herbivores
 - (E) absorbed from the abiotic environment by carnivores
10. If a DNA template has the base sequence 5' -TAG- 3', the corresponding base sequence of an mRNA transcript would be
- (A) 5' -ATC- 3'
 - (B) 5' -CTA- 3'
 - (C) 5' -AUC- 3'
 - (D) 5' -CUA- 3'
 - (E) 5' -GTC- 3'
11. Which of the following structures is present in the roots of vascular plants but NOT in stems?
- (A) Cambium
 - (B) Pericycle
 - (C) Xylem
 - (D) Cortex
 - (E) Apical meristem
12. A certain autosomal recessive trait is expressed in 1 percent 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%
 - (E) 99%
13. Which of the following cellular processes normally produces ATP from glucose in the absence of oxygen?
- (A) Krebs cycle
 - (B) Glycolysis
 - (C) Chemiosmosis
 - (D) Calvin cycle
 - (E) Oxidative phosphorylation
14. Which of the following mechanisms can best account for the higher concentrations of mineral nutrients in the root cells of vascular plants than in the surrounding soil environment?
- (A) Osmosis
 - (B) Diffusion
 - (C) Facilitated diffusion
 - (D) Active transport
 - (E) Guttation

15. A person touches a hot object and immediately moves her finger away from it. Which of the following structures is the first to receive an impulse triggered by the stimulus?
- (A) Synapse
 - (B) Ventral root ganglion
 - (C) Motor neuron
 - (D) Sensory neuron
 - (E) Schwann cell
16. Males of a certain species of small mammal have been observed to have either fluffy tails or furless tails. Those with the fluffy tails have been observed to attract significantly more mates than those with furless tails. The phenomenon described is an example of
- (A) disruptive dimorphism
 - (B) disruptive selection
 - (C) sexual dimorphism
 - (D) sexual selection
 - (E) Mendelian genetics



17. In the circuit shown above, an 18 V battery is connected to three resistors in series. As a result, a current of 2 A flows through the circuit. The value of the resistor labeled R is
- (A) 1Ω
 - (B) 2Ω
 - (C) 3Ω
 - (D) 4Ω
 - (E) 5Ω

18. Of the following, which is most responsible for creating the surface currents of Earth's oceans?
- (A) Density variations of the seawater
 - (B) Heat that escapes from Earth's mantle layer
 - (C) The prevailing winds of Earth's atmosphere
 - (D) The oxygen content of Earth's atmosphere
 - (E) The gravitational pull of other planets

Directions: The group of questions below consists of five lettered headings followed by two numbered words. For each numbered word, select the one heading that is most closely related to it. Each heading may be used once, more than once, or not at all.

Questions 19–20

These questions relate to matching specific substances with their group of compounds.

- (A) Protein
 - (B) Carbohydrate
 - (C) Fatty acid
 - (D) Nucleic acid
 - (E) Steroid
19. Cholesterol
20. Glycogen

Directions: Each group of questions below concerns a laboratory or experimental situation. In each case, first study the description of the situation. Then choose the one best answer to each question following it.

Questions 21–23

Mass of empty test tube	17 grams
Molar mass of iron	55.8 grams
Molar mass of sulfur	32 grams

A student in a laboratory is given 7 grams of pure iron filings and 4 grams of pure powdered sulfur. The two elements are thoroughly mixed together on a sheet of paper. Then the mixture of iron and sulfur is put into an empty test tube and heated. A red glow spreads throughout the tube and the appearance of the contents is changed.

21. Which of the following is the best method for separating the iron from the mixture on the paper?
- (A) Lifting out the iron filings by using a magnifying glass and tweezers
 - (B) Adding water and filtering
 - (C) Adding water and evaporating to dryness
 - (D) Heating the mixture
 - (E) Passing a magnet just above the mixture

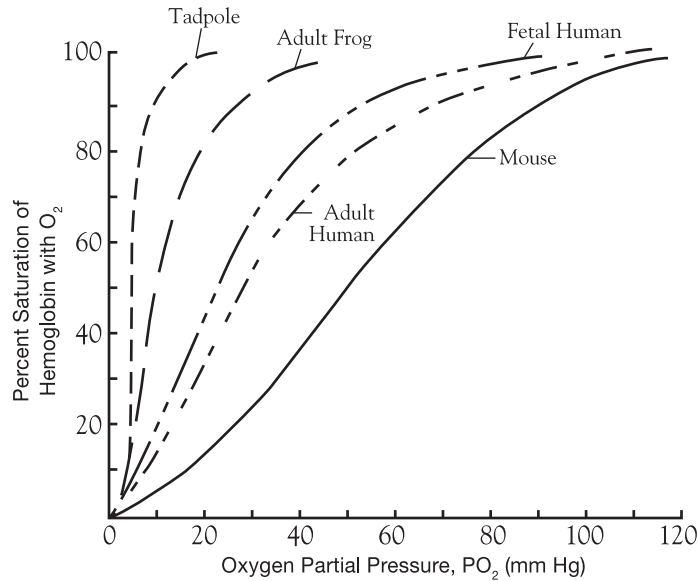
22. After cooling, the test tube and its contents are weighed. If it is assumed that no gases from the air or surroundings were incorporated into the contents, the mass of the test tube and its contents should be approximately

- (A) 6 grams
- (B) 17 grams
- (C) 27 grams
- (D) 28 grams
- (E) 29 grams

23. If the contents of the test tube are removed and mixed with carbon disulfide, none of the solid dissolves. Pure solid sulfur is soluble in carbon disulfide. Conclusions supported by all of the information given include which of the following?

- I. A chemical change occurred when the mixture was heated.
 - II. The sulfur has completely reacted.
 - III. Iron is not soluble in carbon disulfide.
- (A) I only
 - (B) III only
 - (C) I and II only
 - (D) I and III only
 - (E) I, II, and III

Questions 24–25 refer to the graph below, which depicts the oxygen-dissociation curves of the hemoglobin of various organisms.



24. Which of the animals shows the greatest rate of change in oxygen uptake between 80 and 120 millimeters of mercury?
- (A) Tadpole
 - (B) Adult frog
 - (C) Fetal human
 - (D) Adult human
 - (E) Mouse
25. Of the following, the last organism to succumb in an oxygen-deprived environment would probably be the
- (A) tadpole
 - (B) adult frog
 - (C) fetal human
 - (D) adult human
 - (E) mouse

Answers

1. Rain combines with various types of air pollution, forming acid rain. Lakes formed in limestone bedrock can neutralize the acidity of the rain, but lakes with granitic bedrock have limited capacity to neutralize the acid rain. The increasing acidity of these lakes has had a negative impact on the organisms normally inhabiting these lakes. Thus, C is the correct answer.

2. Choices A, C, D, and E all involve experimentation in the areas of cell biology and molecular biology. There are well-documented methods for conducting these kinds of experiments. Even if choice B were a correct statement (there were flying insects before *Archaeopteryx*), it is very unlikely that choice B could be verified by experimentation since there is no way to rule out the possibility that flying organisms evolved before *Archaeopteryx* and did not leave fossil evidence. B, therefore, is the best answer.

3. The Moon does not emit its own light but reflects light received from the Sun. It is the position of Earth and Moon relative to the Sun that determines the phase of the Moon. The half of the Moon that faces the Sun is always lighted, and the phases that are seen from Earth are determined by how much of the lighted half is visible. E is the correct answer.

4. The Earth's surface is covered by belts of air currents, which largely determine the movement of weather. In the United States, the westerlies are prevalent from the latitudes 30°N to 60°N; thus, statement I is correct and important in the determination of where rain falls. Statement II is also correct. As the air mass cools, it releases most of its water, resulting in rain on the windward (western) side of the mountain. As air masses travel from west to east, therefore, the land to the east of the mountain range will receive less rain than those lands to the west. Statement III is also true and relevant. As the cooled air passes over the mountain range, it will lose the water vapor as raindrops because cooler air has a lower maximum possible water vapor content. The factors, therefore, that help account for lands to the east of a mountain range receiving less rain than those to the west of a mountain range are statements I, II, and III. E is the correct answer.

5. As the environment changes, species change. The species that are dominant at any given time are normally those species most adapted to particular environmental conditions. Because B, C, D, and E have nothing to do with species replacing other species, these would not be appropriate choices. With respect to choice A, comparing plant types of both primary and secondary sand dunes should enable students to see ecological succession in action and would be an appropriate learning experience for a unit on species replacing other species as their environment changes. Thus, A is the correct answer.

6. Atoms differ from one another in their number of protons, neutrons, and electrons. It is the number of protons that defines the element of an atom. Sodium atoms always contain eleven protons; thus, choice B is the correct answer.

7. Adaptive radiation is defined as the evolution of several different species from one ancestor, each species filling a distinct ecological niche. The Galápagos finches are one of the best examples of this. Thirteen different species arose from a single ancestral type, believed to have been a ground-feeding finch. Thus, C is the correct answer.

8. The presence or absence of chlorophyll, nuclei, and chloroplasts cannot be used to separate ferns and mosses into different taxonomic categories, as these characteristics are common to all organisms in the kingdom Plantae. Flagellated sperm are characteristic of plants that rely on water for fertilization. Both mosses and ferns have flagellated sperm. Mosses are members of the Bryophyta and ferns of the Pterophyta. The bryophytes lack specialized tissue (vascular tissue) to carry water and nutrients, namely, the xylem and phloem, whereas the pterophytes contain these specialized tissues. Choice B, therefore, is the correct answer.

9. When organisms are taking in water and nutrients, they may accumulate toxic compounds in their tissues. The organisms cannot break these compounds down or excrete them. When these organisms are eaten, biological magnification takes place because the biomass at each trophic level is being produced from a much larger biomass at a lower trophic level. When autotrophs and herbivores accumulate the toxic nonfood materials in their cells and are in turn eaten by omnivores and carnivores, the toxic chemicals will then accumulate in the latter. D, therefore, is the correct answer.

10. The correct answer is D. The sequence of bases in an mRNA molecule is determined by antiparallel hybridization between A, T, C, and G of the template DNA and U, A, G, and C of the mRNA molecule, respectively.

11. The correct answer is B. In plant roots, the vascular tissue is located in the center of the root and is surrounded by a layer of endoderm cells. The pericycle is a layer of cells on the inner side of the endoderm in plant roots. Root branching is initiated in the pericycle.

12. The correct answer is B. The Hardy-Weinberg equation states $p^2 + 2pq + q^2 = 1$, where p = the frequency of the dominant allele of a gene and q = the frequency of the recessive allele of a gene. If a recessive trait is expressed in 1% of the population ($q^2 = 0.01$), the frequency of the allele in the population is 0.1 (square root of 0.01). If the frequency of the recessive allele = 0.1, then the frequency of the dominant allele must be 0.9 ($1 - 0.1 = 0.9$). Therefore, $2pq = (2)(0.9)(0.1) = 0.18$.

13. The correct answer is B. In the absence of oxygen, glycolysis can still occur, and it produces a net yield of 2 ATP per molecule of glucose. Neither oxidative phosphorylation, chemiosmosis, nor the Krebs cycle function in the absence of oxygen. The Calvin cycle normally uses ATP.

14. The correct answer is D. Energy is required to move minerals up their concentration gradient. In both osmosis and diffusion, substances move down a gradient. Guttation occurs when hydrostatic pressure builds up in roots (typically at night when transpiration rates are low) and forces water up through the xylem.

15. The correct answer is D. This question describes a motor reflex loop between a thermosensory neuron and a motor neuron. Most reflex loops involve an impulse being initiated in a sensory neuron and then passing either directly from a sensory neuron to a motor neuron or from the sensory neuron to an interneuron and then from the interneuron to a motor neuron.

16. The correct answer is D. Mate selection based on a physical feature defines sexual selection.

17. Three resistors in series have a total resistance (R_{eq}) that is equal to the sum of their individual resistances, so that $R_{eq} = 3\Omega + R + 4\Omega = 7\Omega + R$. According to Ohm's law, the current and the voltage in the circuit are related as follows:

$$18 \text{ V} = (2 \text{ A}) \cdot (R_{eq}),$$

which simplifies to

$$9\Omega = R_{eq} = 7\Omega + R$$

or

$$R = 2\Omega.$$

B is the correct answer.

18. The winds of Earth's atmosphere are the primary force that creates the surface currents of the oceans. Density variations in seawater help establish different layers of seawater and vertical mixing. The oxygen content of the atmosphere does not directly affect the ocean currents. The gravitational pull of other planets has a negligible effect on Earth's oceans. C is the correct answer.

19. Cholesterol, which is found in the cell membranes of animals, is a steroid, choice E.

20. Glycogen is one of the primary food-storage substances of most animals and fungi. It is a carbohydrate, choice B.

21. Although the separation could be accomplished as described in choice A, it would be tedious and clearly not the best method among the choices given. Choices B and C both describe good methods for separating mixtures, provided one or more of the components dissolve in water; iron and sulfur are essentially insoluble in water. Since mixtures can be separated into their component parts only by using methods that involve physical changes, "heating the mixture," choice D, will not separate out the iron and sulfur; in fact, it will cause them to combine. "Passing a magnet just above the mixture," choice E, makes use of the property of magnetism that only the iron has. This property is made use of in recycling plants to separate iron and steel from nonmagnetic material such as paper. Thus, a magnet will collect the iron from the iron-sulfur mixture; choice E is the correct answer.

22. The law of conservation of mass states that the mass of the reactants must be equal to the mass of the products in a reaction. When 7 grams of iron filings is heated with 4 grams of sulfur, and it is assumed that no atmospheric gases are involved, then approximately 11 grams of product should be formed. As the mass of the test tube is 17 grams, the total mass should be the sum of 11 grams and 17 grams. Thus choice D, "28 grams," is the correct answer.

23. The solid that results after heating does not dissolve in carbon disulfide, a known solvent of sulfur; thus, the sulfur must be in a combined form. The information given only relates to sulfur, so no conclusions can be made regarding the iron. The conclusions that can be drawn are I, "A chemical change occurred when the mixture was heated," and II, "The sulfur has completely reacted." The correct answer, therefore, is choice C, "I and II only."

24. The greatest rate of change in oxygen uptake between 80 and 120 millimeters of mercury is seen in the mouse, where the saturation of hemoglobin with oxygen goes from approximately 80 percent to 100 percent. E, therefore, is the correct answer.

25. In an oxygen-deprived environment, the tadpole would probably be the last organism to succumb because its hemoglobin remains saturated with O_2 at lower oxygen partial pressures than does the hemoglobin of the other organisms shown. A, therefore, is the correct answer.



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