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Correct Answers are located at the end of each chapter.

TRUE/FALSE - Write 'T' if the statement is true and 'F' if the statement is false.

1) The classification system most commonly used by biologists today contains five domains.
   - ◎ true
   - ◎ false

2) Climate change is primarily due to an imbalance in the chemical cycling of the element carbon.
   - ◎ true
   - ◎ false

3) The control group in an experiment receives all the same treatments as the experimental group(s), except for the one variable being tested.
   - ◎ true
   - ◎ false

4) The selective agents for natural selection can be either abiotic or biotic.
   - ◎ true
   - ◎ false

CHECK ALL THE APPLY. Choose all options that best completes the statement or answers the question.

5) Due to human activities, more carbon dioxide is being released into the atmosphere than is being removed. What happens to this extra carbon dioxide? Select all that apply.
   - A) Some of the carbon dioxide stays in the atmosphere which causes surface temperature to rise.
   - B) Approximately half of the extraneous carbon dioxide is being expelled into deep space.
   - C) Much of the extraneous carbon dioxide is dissolved into the oceans where it is causing acidification.
   - D) Trees and other plants have increased their rates of photosynthesis and are effectively removing most of the extraneous carbon dioxide.

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6) Select all the following that describe biodiversity in a particular ecosystem.
   A) is the total number of species in that ecosystem
   B) includes the variability of the individual genes
   C) impacts the function of the ecosystem in which the species live
   D) usually increases rapidly over time

MULTIPLE CHOICE - Choose the one alternative that best completes the statement or answers the question.

7) A university biology department wishes to hire a scientist to work on the relationships among the wolves, moose, trees, and physical features on an island. If you were charged with writing the job description, you should title the position
   A) population geneticist.
   B) molecular biologist.
   C) ecosystem ecologist.
   D) organismal physiologist.
   E) island zoologist.

8) Which of the following terms best describes a conceptual scheme in science that is strongly supported, has not yet been found incorrect, and is based on the results of many observations?
   A) a scientific model
   B) an experiment
   C) descriptive research
   D) a scientific theory or principle
   E) experimental results

9) Choose the correct order of classification from most inclusive to most exclusive.
   A) Domain-Kingdom-Phylum-Class-Order-Family-Genus-Species
   B) Kingdom-Domain-Class-Phylum-Order-Family-Genus-Species
   C) Kingdom-Domain-Class-Phylum-Order-Genus-Species-Family
   D) Kingdom-Class-Phylum-Domain-Genus-Order-Family-Species

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10) Which listing correctly indicates a sequence of increasing biological organization?
A) molecule, cell, organelle, atom
B) organelle, tissue, cell, molecule
C) organ, tissue, atom, molecule
D) atom, molecule, organelle, cell

11) Which of the below is NOT true regarding single-celled prokaryotes?
A) lack a membrane-bounded nucleus
B) are classified in the domains Bacteria and Archaea
C) are found in almost all habitats
D) contain organelles such as mitochondria

12) In the scientific method, what precedes the formation of the hypothesis?
A) a prediction
B) experimentation
C) analysis of results
D) observation

13) Which of the below is NOT a feature that living organisms are characterized by?
A) adapting to the environment
B) evolving over time
C) displaying homeostatic controls
D) requiring oxygen to survive

14) Which of the following domains contains prokaryotes that are known for living in extreme environments?
A) Archaea
B) Bacteria
C) Plantae
D) Fungi
E) Eukarya

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15) Which of the following concepts is NOT one of the basic theories of biology?

A) All organisms are composed of cells.
B) Life may arise through spontaneous generation.
C) New cells only come from preexisting cells.
D) The internal environment of an organism stays relatively constant.
E) All living things have a common ancestor and are adapted to a particular way of life.

16) All of the following are examples of maintaining homeostasis except:

A) A sensor detects CO_2 levels in the blood and triggers an increase or decrease in the rate of breathing.
B) A drop in body temperature triggers shivering which generates heat; an increase in body temperature triggers sweating which releases heat.
C) Feelings of hunger and then fullness affect the length of time between meals and quantity of food you eat, keeping your weight near a "set point."
D) A cancerous tumor continues to grow larger and then metastasizes, spreading to new areas of the body.
E) By opening and closing pores in their leaves, plants continuously exchange oxygen and carbon dioxide with the atmosphere.

17) The expected outcome of an experiment is known as

A) a scientific model.
B) an experiment.
C) a prediction.
D) a scientific theory or principle.
E) experimental results.

18) Which of the following organisms are ultimately dependent on the sun as a source of energy?

A) A night-blooming flower that is pollinated by night-flying bats.
B) An underground earthworm that avoids the sun.
C) A cave fish that feeds on plant debris.
D) All of the choices ARE ultimately dependent on the sun.
E) All of the choices are NOT ultimately dependent on the sun.

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19) A researcher is interested in determining the average length and weight of loblolly pine tree needles in the southeast United States. Will the data be obtained through observation or experimentation?
   A) observation
   B) experimentation
   C) Neither observation nor experimentation.
   D) Both observation and experimentation.

20) A doctor is testing the effectiveness of a new antibiotic. He gives the first group of patients a placebo, a second group receives antibiotic A, while the third group receives antibiotic B. Which of the groups is considered the control group?
   A) the group that received antibiotic A
   B) the group that received the placebo
   C) the group that received antibiotic B
   D) both groups receiving antibiotic A and B

21) An earlier classification system grouped organisms by whether they inhabited the air, land, or sea. More modern classification systems such as the three-domain system are divided into class-order-family-genus-species as described in this chapter. Which of the following is NOT an advantage of the more modern classification system over the older system?
   A) The modern classification system better represents the unity of life.
   B) The modern classification system reflects the evolutionary relationships between organisms.
   C) The modern classification system allows for the precise organization of a multitude of species.
   D) The more modern classification system groups organisms based on similarities related to their structure and evolution.
   E) The modern classification system is more intuitive than the older system.

22) A cell is to a tissue as an atom is to a
   A) molecule.
   B) subatomic particle.
   C) electron.
   D) population.

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23) You are interested in the effect of increased carbon dioxide versus normal air on the growth of corn plants as well as the effect of green light versus full sunlight on the growth of corn plants. Your plan is to set up your experiment inside a greenhouse where you can control the environment. Which of the following is NOT an aspect of the experiment that should be considered and controlled?

A) An increase in carbon dioxide should not result in a substantial decrease of other necessary gases.
B) All seedlings come from one uniform strain.
C) The intensity or brightness of the green light equals the intensity of the full sunlight.
D) All temperatures and available water remain the same for all plants.
E) Some plants should be given a fertilizer and others no fertilizer.

24) Tropical rain forests have many species that are found in great abundance. A study in the Brazilian rain forest found 487 tree species growing on a single hectare (2.5 acres). In the U.S. and Canada together, there are only 700 species of trees on millions of acres. In one park in a Peruvian rain forest, scientists have identified over 1,300 species of butterflies, while in all of Europe there are approximately 320 butterfly species. These findings suggest that

A) rain forests are biologically less diverse than other ecosystems on Earth.
B) the number of tree species and butterfly species are about the same throughout the ecosystems of the world.
C) rain forests are biologically more diverse than other ecosystems.
D) as many as 400 species a day are lost due to human activity.
E) rain forests do not have any type of value to humans.

25) Some members of Daphnia, a water flea, have a genetic mutation that causes them to prefer warmer environments. These members reproduce and pass these genetic changes to their offspring. The next generation will occupy warmer environments not previously occupied by this species. This is an example of

A) adaptation.
B) homeostasis.
C) irritability.
D) development

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26) Some biologists study the complex interactions of animals and plants in forests or prairies. Such ecology field research often produces slightly different results for different researchers. In contrast, ecology experiments that are run indoors with one organism in a terrarium usually produce results that are repeatable. What is the most likely explanation?

A) The scientific method is only useful in laboratory settings.
B) It is not possible to establish a control group outside of a laboratory.
C) It is easier to hold all but one variable constant in a laboratory.
D) Field research is only descriptive, and descriptive research is not strictly "science."
E) Fieldwork is inductive; lab work is deductive.

27) For five years, you wake up before the alarm is set to ring each morning. This leads you to conclude that all people have a built-in "alarm clock" capable of waking them up. From a science viewpoint, this conclusion

A) is science because it is based on real observations.
B) is science because it is predictive of what will happen tomorrow morning.
C) is scientifically valid because 5 years × 365 days is a large number of trials.
D) may not be valid because it generalizes about all people, and there may have been other variables that could awaken you without a built-in clock.
E) cannot be scientifically tested because it involves human behavior.

28) The manner in which a scientist intends to conduct an experiment is called

A) inductive reasoning.
B) the experimental design.
C) data collection and analysis.
D) the conclusion.

29) Arrange in order, the levels of ecological study from most inclusive to most exclusive:

A) biosphere, ecosystem, community, population, individual organism
B) ecosystem, biosphere, population, community, individual organism
C) individual organism, community, population, ecosystem, biosphere
D) individual organism, population, community, ecosystem, biosphere

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30) Which definition best describes a population?

A) the members of similar organisms within a particular area
B) the interaction between the organisms and their environment
C) the region of Earth that contains living organisms
D) the interaction between various groups of organisms in a given environment
E) all of the females of a given species in a particular area

31) Which of the following features are NOT present at the ecosystem level?

A) chemical cycling through the food chain
B) energy flow that begins at the producer level
C) input of solar energy
D) complex interactions between a variety of populations
E) includes the entire region of the Earth's surface that is inhabited by living organisms

32) Organisms belonging to the same_____ would be the most closely related.

A) kingdom
B) phylum
C) family
D) class
E) order

33) What type of information does science provide for society?

A) information about the natural world
B) information about the supernatural world
C) information about religious beliefs
D) information about religious beliefs and the natural world

34) What is the best description of technology?

A) Technology is the application of scientific knowledge to the interests of humans.
B) Technology is the development of new tools.
C) Technology is the use of power to make human life easier.
D) Technology is the advancement of the functionality of computers.

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35) Climate change is primarily due to an imbalance in the chemical cycling of which element?

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

36) Which of the below statements is true regarding the control group in a controlled experiment?

A) Two or more variables are changed in the control group relative to the experimental group(s).
B) It receives all the same treatments as the experimental group(s) and serves to verify the results of the experimental group(s).
C) The control group is used to calibrate the instruments used in measuring the response variable(s).
D) It receives all the same treatments as the experimental group(s), except for the one variable being tested.

37) The selective agents for natural selection can be either abiotic or biotic.

A) Only biotic factors can serve as selective agents for natural selection.
B) Only abiotic factors can serve as selective agents for natural selection.
C) Selective agents for natural selection can be either biotic or abiotic.

SECTION BREAK. Answer all the part questions.

38) Living organisms on Earth share many common characteristics. Answer the following questions regarding the characteristics of all living things.

38.1) All living organisms are made up of cells.

◎ true
◎ false

38.2) Living things must have an outside source of nutrients and energy.

◎ true
◎ false

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38.3) Living things must have an outside source of
A) sunlight.
B) nutrients and energy.
C) oxygen.
D) carbon dioxide.

38.4) In multicellular organisms, tissues are comprised of many different types of cells.
◎ true
◎ false

38.5) In multicellular organisms, tissues are comprised of
A) similar types of cells.
B) many different types of cells.
C) at least two different cell types.
D) acellular materials like proteins.

38.6) Only multicellular organisms need to maintain homeostasis.
◎ true
◎ false

38.7) Which of the below statements is true regarding homeostasis in living things?
A) Only multicellular organisms need to maintain homeostasis.
B) Only single celled organisms need to maintain homeostasis.
C) All living things need to maintain homeostasis.
D) Photosynthetic organisms do not need to maintain homeostasis because they get their energy from the sun.

38.8) The ultimate source of energy for nearly all forms of life on Earth is water.
◎ true
◎ false

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38.9) The ultimate source of energy for nearly all forms of life on Earth is
A) water.
B) carbohydrate.
C) the sun.
D) ATP.

38.10) Which of the following are components of all living organisms?
A) organs
B) organ systems
C) tissues
D) cells

39) Living and nonliving entities share some characteristics. Answer the following questions about the living and nonliving components of an ecosystem.

39.1) All living things and nonliving materials are made of cells.
◎ true
◎ false

39.2) Which of the below statements correctly describes the things that are made up of cells.
A) All living things are made of cells.
B) All nonliving materials are made up of cells.
C) Some living things are made up of cells.
D) Some nonliving materials are made up of cells.
E) All living things and nonliving materials are made up of cells.

39.3) All living things and nonliving materials exhibit homeostatic controls.
◎ true
◎ false

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39.4) Which of the below exhibit homeostatic control mechanisms?

A) All living things
B) All nonliving materials
C) All living things and nonliving materials
D) Only some living things

39.5) All matter, whether alive or not, is comprised of atoms.

◎ true
◎ false

39.6) Which of the below statements best describes what things are comprised of atoms?

A) Only nonliving things are comprised of atoms.
B) Only living things are comprised of atoms.
C) Some living things are comprised of atoms but all nonliving materials are comprised of atoms.
D) All matter, whether alive or not, is comprised of atoms.

39.7) Both living and nonliving entities adapt to the environment.

◎ true
◎ false

39.8) Which of the below are entities that adapt to the environment?

A) Only living entities can adapt to the environment.
B) Only nonliving entities can adapt to the environment.
C) Both living and nonliving entities can adapt to the environment.
D) Only some living things can adapt to the environment.

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40) Dr. James isolated Staphylococcus aureus, a type of bacteria, from the leg wound of a ten-year-old male. They suspected these bacteria would grow better at body temperature than room temperature (72°F), but thought that they should collect data to support his thinking. Dr. James introduced the same number of Staphylococcus bacteria into each of six test tubes containing the same type and amount of nutrient broth. Three test tubes were incubated at 98.6°F (Group 1), while three test tubes (Group 2) sat at 72°F. After 24 hours, Dr. James compared the turbidity (indicative of growth) of all six tubes and rated each on a scale of 0 - 4. 0 indicates no turbidity (no growth), while 4 indicates high turbidity (high growth). The following data were collected:

Test Tube	Temperature °F	Turbidity
Group 1:		
1	**98.6**	**+4**
2	**98.6**	**+4**
3	**98.6**	**+3**
Group 2:		
4	**72**	**0**
5	**72**	**+1**
6	**72**	**0**

40.1) After reading the scenario, write the hypothesis that was being tested in Dr. James's experiment.

40.2) Would you consider this to be a controlled experiment?

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40.3) Evaluate the data presented here to reach a conclusion. Would you reject or accept the null hypothesis?

40.4) The dependent (responding) variable in this experiment is
A) the temperature.
B) growth of bacteria, as indicated by the turbidity in the test tubes.
C) the time that the test tubes were allowed to sit.
D) amount of initial inoculum, or number of bacteria introduced into each test tube.

40.5) The independent (experimental) variable is
A) temperature.
B) growth of bacteria.
C) incubation period.
D) amount of initial inoculum.

40.6) To ensure a controlled experiment, all of the following conditions (variables) should be identical in Group 1 and Group 2:
A) type of bacteria, temperature, and incubation period
B) temperature and amount of initial inoculum (bacteria used)
C) type of bacteria, incubation period, amount of bacteria used
D) degree of turbidity, incubation period, and amount of bacteria

40.7) Choose which of the the following statements is a hypothesis for an experiment.
A) Based on the data collected during an experiment, *S. aureus* grows better at body temperature than room temperature.
B) Based on observation, it is predicted that *S. aureus* will grow better at body temperature than at room temperature.
C) *S. aureus*grew equally well at room temperature and at body temperature.
D) Based on the data collected during the experiment, it is confirmed that *S. aureus* grew better at room temperature.

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40.8) Dr. James performed another experiment. Instead of inoculating the test tubes with *Staphylococcus*, they used the bacterium, *Streptococcus*. They found that *Streptococcus* grew better at body temperature than at room temperature. This is a replicate of the first experiment.

A) True
B) False

40.9) How would Dr. James perform a replication of his experiment?

A) They should repeat the experiment exactly as before but instead of inoculating the test tubes with *Staphylococcus,* they should use the bacterium *Streptococcus.*
B) Thee should repeat the experiment exactly as before but add a Group 3 that is incubated at 103 °F.
C) They should isolate *Staphylococcus aureus* again from the same ten-year-old male and use it to repeat the experiment exactly as before.

40.10) Dr. James considers the bacteria grown at body temperature to be the control group and room temperature the experimental group. Do you agree with this reasoning?

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Answer Key

Test name: Chapter 01

1) FALSE
2) TRUE
3) TRUE
4) TRUE
5) [A, C]
6) [A, B, C]
7) C
8) D
9) A
10) D
11) D
12) D
13) D
14) A
15) B
16) D
17) C
18) D
19) A
20) B
21) E
22) A
23) E
24) C
25) A
26) C
27) D
28) B
29) A
30) A
31) E
32) C
33) A
34) A
35) B
36) D
37) C

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38) Section Break
38.1) TRUE
38.2) TRUE
38.3) B
38.4) FALSE
38.5) A
38.6) FALSE
38.7) C
38.8) FALSE
38.9) C
38.10) D
39) Section Break
39.1) FALSE
39.2) A
39.3) FALSE
39.4) A
39.5) TRUE
39.6) D
39.7) FALSE
39.8) A
40) Section Break
40.1) Short Answer
40.2) Short Answer
40.3) Short Answer
40.4) B
40.5) A
40.6) C
40.7) B
40.8) B
40.9) C
40.10) Short Answer

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1 INTRODUCTION

CHAPTER 1 Biology: The Study of Life

The text opens with a description of the characteristics of life, followed by a discussion of the human species' integration into the highly diverse biosphere. Taxonomic classification, the system by which all organisms are categorized, is discussed. The steps of the scientific method are outlined. A scientific experiment is described in detail. Section 1.4, Science, and the Challenges Facing Society, includes new, topical sections on emerging diseases and ecosystems threatened with extinction.

Learning Outcomes

1.1 The Characteristics of Life

1. Distinguish among the levels of biological organization.
2. Identify the basic characteristics of life.

1.2 Evolution and the Classification of Life

1. Explain the relationship between the process of natural selection and evolutionary change.
2. Distinguish among the three domains of life.

1.3 The Process of Science

1. Identify the components of the scientific method.
2. Distinguish between a theory and a hypothesis.
3. Analyze a scientific experiment and identify the hypothesis, experiment, control groups, and conclusions.

1.4 Science and the Challenges Facing Society

1. Distinguish between science and technology.
2. Summarize the major challenges facing science and society.

Chapter Outline

1.1 The Characteristics of Life

A. Life Is Organized
   1. Organization of living systems begins with **atoms,** which combine to form small **molecules.**
   2. The **cell** is the basic structural and functional unit of all living organisms.
      a. Some cells are independent organisms, such as **single-celled** bacteria.
      b. **Multicellular** organisms are made up of many cells that work together.

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3. Different cells combine to make up **tissues** (e.g., nerve tissue).
4. Tissues combine to make up an **organ** (e.g., the brain).
5. Specific organs work together as an **organ system** (e.g., the brain, spinal cord, etc.).
6. Multicellular organisms (each an "individual" within a particular species) contain organ systems.
7. A species in a particular area (e.g., elephants and trees in Africa) constitutes a **population.**
8. Interacting populations in a particular area comprise a **community.**
9. A community plus its physical environment is an **ecosystem.**
10. The biosphere is comprised of regions of the Earth's crust, waters, and atmosphere inhabited by organisms.
11. Each level of organization is more complex than the level preceding it.
12. Each level of organization has *emergent properties* due to interactions between the parts making up the whole; all emergent properties follow the laws of physics and chemistry.

B. Life Requires Materials and Energy
1. Maintaining organization and conducting life-sustaining processes requires an outside source of **energy,** which is defined as the capacity to do "work."
2. **Metabolism** is all the chemical reactions that occur in a cell.
3. The ultimate source of energy for nearly all life on Earth is the sun; plants and certain other organisms convert solar energy into chemical energy by the process of **photosynthesis.**

C. Living Organisms Maintain Homeostasis
1. All organisms must maintain a state of biological balance or **homeostasis.**
2. Temperature, moisture level, pH, and so on must be maintained within the tolerance range of the organism.
3. In order to maintain homeostasis, body systems monitor internal conditions and adjust when needed.
4. Organisms have intricate feedback and control mechanisms to maintain homeostatic balance.

D. Living Organisms Respond
1. Living organisms interact with the environment and with other living organisms.
2. Response often results in movement of the organism (e.g., a plant bending toward the sun to capture solar energy, a turtle withdrawing into its shell for safety, etc.).
3. Responses help ensure the survival of the organism and allow the organism to carry out its biological activities.
4. The collective responses of an organism constitute the behavior of the organism.

E. Living Organisms Reproduce and Develop
1. **Reproduction** is the ability of every organism to give rise to another organism like itself.
2. Bacteria, protozoans, and other unicellular organisms can reproduce asexually by splitting in two (binary fission).
3. Multicellular organisms often reproduce sexually, uniting sperm and egg, each from a different individual, resulting in an immature individual that develops into an adult.
4. The instructions for an organism's organization and development are encoded in **genes.**
5. Genes are comprised of long molecules of **DNA (deoxyribonucleic acid);** DNA is the genetic code in all living organisms.
6. Genes are passed on from generation to generation. Methods to ensure genetic variability include a random combination of sperm and egg and **mutations.**

F. Living Organisms Have Adaptations
1. **Adaptations** are modifications that make organisms better able to function in an environment.
2. **Evolution** includes the way in which populations change over the course of generations to become more suited to their environments.

1.2 Evolution and the Classification of Life

A. Evolution: The Core Concept of Biology
1. **Natural selection** is the process by which species become modified over time.

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2. In natural selection, members of a species may inherit a genetic change that makes them better suited to a particular environment.
3. These members would be more likely to produce higher numbers of surviving offspring.

B. Organizing Diversity

1. **Taxonomy** is the discipline of identifying and grouping organisms according to certain rules.
2. **Systematics** is the study of the evolutionary relationships between organisms.
3. Taxonomic classification changes as more is learned about living organisms, including the evolutionary relationships between species.
4. From smaller (least inclusive) categories to larger (more inclusive), the sequence of classification categories includes **species, genus, family, order, class, phylum, kingdom, supergroup,** and **domain.**
5. The species within one genus share many specific characteristics and are the most closely related, while species in the same kingdom share only general characteristics with one another.
6. Biochemical evidence suggests there are three domains: domain **Bacteria,** domain **Archaea,** and domain **Eukarya.**
7. The domains Bacteria and Archaea contain **prokaryotes;** organisms in the domain Eukarya are **eukaryotes** that have a membrane-bound nucleus.
8. The prokaryotes are structurally simple but are metabolically complex.
9. Archaea can live in water devoid of oxygen and are able to survive harsh environmental conditions (temperatures, salinity, pH).
10. Bacteria are adapted to live almost anywhere (water, soil, atmosphere, in/on the human body, etc.).
11. The domains Archaea and Bacteria are not yet categorized into kingdoms.
12. Eukarya contains four kingdoms: Protista, Fungi, Plantae, and Animalia.
13. **Protists** (kingdom Protista) range from single-celled forms to multicellular forms.
14. **Plants** (kingdom Plantae) are multicellular photosynthetic organisms.
15. **Fungi** (kingdom Fungi) are molds and mushrooms.
16. **Animals** (kingdom Animalia) are multicellular organisms that ingest and process their food.
17. **Supergroup** has been developed to explain evolutionary relationships. There are currently six supergroups for the domain Eukarya.
18. **Binomial nomenclature** refers to a two-part scientific name: the genus (first word, capitalized) and the specific epithet of a species (second word, not capitalized).
19. Scientific names are based on Latin and are used universally by biologists.

1.3 The Process of Science

1. Biology is the scientific study of life, and it consists of many disciplines.
2. The scientific process differs from other ways of learning in that science follows the **scientific method,** which is characterized by observation, development of a hypothesis, experimentation, data collection, and forming a conclusion.

A. Observation

1. Scientists believe nature is orderly and measurable, and that natural laws (e.g., gravity) do not change with time.
2. Natural events, called **phenomena,** can therefore be understood from **observation.**
3. Scientists also use the knowledge and experiences of other scientists to expand their understanding of phenomena.

B. Hypothesis

1. **Inductive reasoning** allows a person to combine isolated facts into a cohesive whole.
2. Alexander Fleming reasoned that the mold *Penicillium* produces an antibacterial compound based on his observation of a bacteria-free area associated with a mold-contaminated area of his petri dish.
3. A scientist uses inductive reasoning to develop a possible explanation (a **hypothesis**) for a natural event; the scientist presents the hypothesis as an actual statement.

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4. Scientists only consider hypotheses that can be tested (i.e., moral and religious beliefs may not be testable by the scientific method).

C. Predictions and Experiments
   1. Testing a hypothesis involves either conducting an **experiment,** which relies on a prediction of the experimental results, or making further observations.
   2. **Deductive reasoning** involves "if, then" logic to make a **prediction** based on knowledge of the factors in the experiment.
   3. An **experimental design** is the manner in which an experiment is conducted.
   4. An experiment should include a **control group,** which goes through all the steps of an experiment but lacks (or is not exposed to) the factor being tested, and an experimental group (tested with the independent variable).
   5. Scientists may use a model (a representation of an actual object) in their experiments.
   6. Results are based on the examination of the responding variable (dependent variable) obtained from the use of the model.

D. Presenting and Analyzing the Data
   1. **Data** are the results of an experiment and are observable and objective rather than subjective.
   2. Data are often displayed in a graph or table.
   3. Results usually include a **standard deviation,** which is a statistical analysis that is a measure of how much the data in the experiment varies.
   4. Many studies rely on statistical data which, among other things, determines the probability of error in the experiment.
   5. Statistical significance means the experimental results were not due to chance or some factor other than the experimental (independent) variable.
   6. Scientists report their findings in scientific journals so that their methodology and data are available to other scientists.
   7. The experiments and observations must be repeatable, or the research is suspect.

E. Scientific Theory
   1. The ultimate goal is to understand the natural world in scientific **theories,** which are concepts that join well-supported, related hypotheses, and are supported by a broad range of observations, experiments, and data.
   2. Some basic theories of biology are:
      a. Cell: All organisms are composed of cells.
      b. Homeostasis: The internal environment of an organism stays relatively constant.
      c. Evolution: All living organisms have a common ancestor.
   3. A **principle** or a **law** is a theory that is generally accepted by most scientists.

G. An Example of the Scientific Method
   1. A controlled study ensures that the outcome is due to the experimental (independent) variable, the factor being tested.
   2. The Experiment
      a. Hypothesis: Newly discovered antibiotic B is a better treatment for ulcers than antibiotic A, which is in current use.
      b. Prediction: Patients with ulcers who are matched by sex, age, weight, and other illnesses and treated with a placebo (no treatment), antibiotic A, or antibiotic B will show statistically significant responses to their treatments, which will indicate that antibiotic B is a better treatment.
      c. Control group: Ulcer patients receive only a placebo.
      d. Test groups: Ulcer patients receive either antibiotic A or antibiotic B.
      e. All other variables are equal.
      f. Results: After endoscopy, antibiotic B proved to be more effective. Thus, the hypothesis is supported.

1.4 Science and the Challenges Facing Society

Science differs from technology in that **technology** is the application of scientific knowledge to

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the interests of humans and scientific investigation.

A. Climate Change
    1. Climate change refers to changes in the normal cycles of the Earth's climate that may be attributed to human activity.
    2. Normally carbon is cycled within an ecosystem; however, due to human activities, more carbon is being released into the atmosphere than being removed.
    3. The increased amount of carbon dioxide and other gases is causing **global warming** due to the greenhouse effect, which is causing significant changes to Earth's ecosystems.

B. Biodiversity and Habitat Loss
    1. **Biodiversity** is the total number and relative abundance of species, the variability of their genes, and their ecosystems.
    2. **Extinction** is the death of a species or larger group; it is estimated that we are losing hundreds of species every year.
    3. Two biologically diverse ecosystems—tropical rain forests and coral reefs—are severely threatened by the human population.
    4. Destruction of healthy ecosystems has unintended effects including loss of food, medicine, raw materials, and extinction of organisms.
    5. The continued existence of the human species is dependent on the preservation of ecosystems and the biosphere.

C. Emerging Diseases
    1. H5N1 and H7N9, SARS, Ebola, and COVID-19 have been in the news as new or emerging diseases.
    2. Increased exposure to insect or animal populations or changes in human behaviors and use of technologies may have resulted in these new diseases.
    3. Globalization results in the transport of diseases otherwise restricted to isolated communities.

Lecture Enrichment Ideas

Experience Base: *(As teachers, we make assumptions about the common experiences shared with our students and thus the meaningfulness of the vocabulary we use. Questions that solicit student feedback establish if those experiences are adequate and the concepts are being understood. Students who relate their experiences and understanding in turn help classmates learn the concepts.)* Lecturers new to a college or university may wish to confer with veteran teachers about the state's high school biology and other science requirements, and the proportion of students likely to come from farm or urban backgrounds. Most high school biology textbooks address the basic properties of life and the five-kingdom system. Only the 1998 texts onward mention domains. Most entering college undergraduates do not have genuine experience with open-ended and purposeful science research.

1. Ask the students to think about how they may use the scientific method in everyday life.

2. Give the students a list of items, both organisms and objects. Ask the students which items are living and why. Have them go through the characteristics of living organisms to determine their answers.

3. Discuss some current events that relate to how human populations are disrupting ecosystems. Perhaps have students look in newspapers to find relevant articles, or discuss some major events: Chernobyl, the BP oil spill in the Gulf of Mexico, or even clearing land for housing or commercial developments.

4. Provide pictures of organisms and have students group them based on taxonomic classification.

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5. People from all backgrounds and educational levels make distinctions between living and nonliving organisms. Even if they have not read the material in the text, students can be led through a commonsense discussion of "what is life?" List the common traits of living organisms: growth, reproduction, response to the environment, metabolism, and so on. Ask whether any one of these aspects alone distinguishes a living organism from a nonliving substance. Is it necessary, for example, that every individual within a species be able to reproduce? Select specific species from various kingdoms and describe some of the responses and some of the adaptations those species have. Discuss how those responses and adaptations allow those species to survive in their environment.

6. Scientists are attempting to confirm whether there is or ever has been life on Mars. What phenomena should they look for? What is required for us to know for sure that there is or was life on Mars?

7. Read job descriptions for biologists (e.g., biochemist, anatomist, population ecologist, etc.) available from current journals and newspapers and ask students what level of biological organization the scientist studies.

8. List organisms with which students should be familiar. Ask students to place the organisms into the correct kingdom based on their known characteristics. List unfamiliar organisms and their characteristics; ask students to determine the kingdom to which they belong.

9. Discuss the evolutionary relatedness of mammals. Ask students to consider Australian marsupials that fit into the various niches filled by other mammals in other parts of the world. Note how marsupials are more closely related to one another but have diversified to fill many niches.

10. Discuss the theory that proposes that all life is a result of the development from unicellular ancestors with the same basic chemical structures and metabolism.

11. Discuss how organisms diversify due to the effects of mutation and selection by the environment.

12. Caution students not to confuse the terms "name," "identify," and "classify." "Classify" only involves grouping. Only a specialist who describes and publishes a new species "names" the species. In most cases, we are merely "identifying" organisms that are already known to science, originally "named" by taxonomists and "classified" by systematists.

13. Ask students to design an experiment following the scientific method in which they test a weight-loss drug. Ensure that the experiments have the proper controls and are conducted logically and realistically, the data (made up by the instructor for the sake of this experiment) are interpreted correctly, and a proper conclusion is drawn.

14. Ask students for examples of the scientific method in their everyday lives, such as preparing dinner, determining how to dress for the day's weather or activities, finding their way around a strange area, or dealing with a malfunctioning car.

15. Have students search a week's newspapers for examples of using the scientific method in the news—such as testing consumer goods or reports on medical research—and discuss them in class. Then show students a tabloid newspaper making fabulous claims and discuss why it does not fulfill scientific standards.

16. Discuss the difference between scientific observations of the natural world and superstitions such as those associated with Friday the thirteenth and black cats. Scientific examination of examples involving water dousing, spontaneous human combustion, crop circles, and other modern misbeliefs are given in the *Skeptic* and *Skeptical Inquirer* magazines.

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17. Discuss why it is possible to prove a hypothesis or theory false but not to prove it absolutely true. (This Karl Popper concept of "falsifiability" has limited usage in science and is not applicable in all areas of biology. However, deep discussion of this concept is best left to upper-level philosophy of science courses where the students will have had some actual direct experiences with genuine research.)

18. Ask students if they believe the world is spherical. Have them cite evidence to support their belief. However, unless they have flown in a supersonic jet, they have no direct observational evidence to prove that the Earth is in fact spherical. Emphasize the point that even though they have no direct, personal evidence that fits the spherical Earth model, science frequently relies on *reasoning* and *models* as well as observational data.

Critical Thinking

Question 1. Assume that you found an object that you think might be alive. What would be several things you would need to observe about this object to determine if it was, in fact, alive?

Answer: You could subject the object to environmental stimuli (heat, pH changes, physical pressure, etc.) to see if it responded to any of those stimuli. The object should have a number of physical characteristics (adaptations) that allow it to survive in a particular environment. The object would have a metabolism. At the biochemical level, the object would have DNA and certain molecules in common with all known life on Earth. The object may or may not be able to reproduce: It could be a sterile individual of a species or it could be a sexually reproducing organism, in which case a "mate" would be needed!

Question 2. Arguments about teaching evolution in the public school classroom continually attract public attention as elected school boards (in certain states) meet to approve new science teaching curricula. Issues raised in the public sector (not from scientists) include arguments about evolution being "just a theory," giving religious creationism "equal time," and replacing the definition of science as the study of natural phenomena with science as a logical construct. Why do scientists reject these arguments?

Answer: Although school boards must vote on policy, scientists do not "vote" on science. The nature of "theory" in this context means considerably more than the street vernacular "it's just a theory." Science does not provide "equal time" to nonscience explanations that do not lend themselves to observation, experimentation, and the development of new research. And, although many academic fields are based on "logic" (most notably mathematics), science is defined and uniquely tethered to concepts that are in agreement with the workings of the natural world. "Supernatural" explanations simply do not allow a researcher to formulate tests and expand understanding of the "natural world."

Question 3. Ecology experiments can be separated into two general categories. Some ecologists prefer to bring an organism into the laboratory and isolate it in a chamber where they can keep the setup simple and where they determine all the environmental conditions. Other ecologists prefer to study organisms in the wild and attempt to determine why they occur in certain natural habitats. Using terms for scientific methodology, explain the benefits of both systems.

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Answer: The natural environment is so complex that only simple lab settings can eliminate complex factors and show how an organism responds to just one variable. A controlled chamber allows the scientist to set up a control group that lacks just the experimental variable. On the other hand, a natural environment is closer to what the organism actually encounters. There may be many factors in a natural environment that are major and important influences on an organism but which a researcher has not considered in a controlled lab setting experiment. While two "equal" field sites can be used, one as a treatment and one as a control, the ecologist cannot be certain that another uncontrolled factor in nature is not involved or that chance variation is not a contributing factor. Ecologists often integrate the results of both types of research to formulate their conclusions.

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UNIT I THE CELL

Because the cell is the basic unit of life, cell structure, function, and metabolism are major concepts necessary to understand life. Cellular metabolism is simplified, and cellular processes are described in preparation for an understanding of genetic control, the origin of the cell, and adaptation to the environment.

2 Basic Chemistry
3 The Chemistry of Organic Molecules
4 Cell Structure and Function
5 Membrane Structure and Function
6 Metabolism: Energy and Enzymes
7 Photosynthesis
8 Cellular Respiration

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