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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 kingdoms of plants, fungi, and animals all evolved from protists.
   - ◎ true
   - ◎ false

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

2) Which of the following statement(s) regarding genes is/are true?
   - A) Genes are made up of DNA.
   - B) All cells in a multicellular organism contain the same set of genes.
   - C) Humans receive their DNA/genes from either their mother or their father but not both.
   - D) Variations in genes are the result of mutations.
   - E) All organisms such as roses, elephants and mushrooms have the same set of genes.

3) Which of the below statements regarding the classification of organisms in the domain Eukarya are true?
   - A) The four kingdoms of eukaryotes (Animals, Plants, Fungi and Protists) all descended from a common ancestor.
   - B) The kingdoms Animalia, Plantae, and Fungi all evolved from Protists.
   - C) Not all organisms in the kingdom Protista derived from a common ancestor.
   - D) The kingdoms Animalia, Plantae, and Protista all evolved from the kingdom Fungi.
   - E) The taxonomic level of**supergroup** was developed to divide each of the four kingdoms of eukaryotes.
   - F) The kingdom level of classification is below the level of supergoup.
   - G) In the future, the kingdom Protista will likely be removed as a level of classification within the domain Eukarya.

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

4) The kidney of a dolphin is considered an organ because it is composed of different
   A) cells.
   B) tissues.
   C) organs.
   D) molecules.
   E) organelles.

5) Which of the following correctly lists the levels of biological organization from most complex to simplest?
   A) cells, organs, tissues, organ systems, organism
   B) organism, organ system, organs, tissues, cells
   C) tissues, organs, organ systems, organism, cells
   D) cells, tissues, organs, organ systems, organism
   E) organ systems, tissues, cells, organism, organs

6) When populations of different types of organisms interact in a given area, they comprise a(n)
   A) ecosystem.
   B) population.
   C) community.
   D) biosphere.
   E) species.

7) Organisms that transform solar energy into chemical energy are called
   A) carnivores.
   B) consumers.
   C) decomposers.
   D) producers.
   E) transformers.

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8) Using their lateral line organ, fish can perceive and react to changes in water currents caused by prey and predators. This is an example of
   A) maintaining homeostasis.
   B) metabolism.
   C) response to the environment.
   D) energy regulation.
   E) organization.

9) Salmon are born in fresh water but migrate out to marine waters for most of their life. Eventually, they return to the place they were born to spawn. Because migrating between fresh water and saltwater affects the balance of water in their body, salmon have evolved an internal control system called osmoregulation that restores water balance by negative feedback. This is an example of which characteristic of life?
   A) adaptation
   B) reproduction and development
   C) response to the environment
   D) energy transformation
   E) maintaining homeostasis

10) Which of the following pairs of words is matched correctly?
   A) bladder - organ
   B) neuron - tissue
   C) osteocyte - molecule
   D) gene - atom
   E) heart - organ system

11) Many insects cannot see the color red, and as a result many insect-pollinated flowers are colors other than red (e.g., purple and yellow). Flower color would be considered a(n)
   A) method for maintaining homeostasis.
   B) way to maintain metabolism.
   C) adaptation.
   D) example of energy flow.
   E) example of nutrient cycling.

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12) Latonya is an avid gardener who spends a lot of time caring for the plants in her garden. To minimize damage from pests, Latonya uses a pesticide spray. After a few years of using the same pesticide spray, she notices that it has become less effective. This is most likely due to
A) evolution by natural selection.
B) not using enough pesticide spray.
C) the plants in the garden evolving.
D) the plants maintaining homeostasis.
E) something else in the environment.

13) All the chemical reactions that occur in a cell are collectively called
A) mitosis.
B) photosynthesis.
C) cellular respiration.
D) meiosis.
E) metabolism.

14) Is the following statement true or false? All single-celled organisms are prokaryotes.
A) true, because prokaryotes are the simplest cell form
B) true, because all eukaryotes are multicellular
C) false, because some eukaryotes are single-celled
D) false, because some prokaryotes are multicellular
E) false, because all single-celled organisms are eukaryotes

15) All honeycreeper species have a similar size and body shape but vary in beak shapes. This is an example of
A) ascent with new traits.
B) descent with modification.
C) taxonomic differentiation.
D) fixed traits.
E) modification of adaptations.

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16) Based on the evolutionary tree of the three domains, which of the following statements is true?

A) All three domains have a common ancestor.
B) Domain Bacteria and domain Eukarya are more closely related to each other than to domain Archaea.
C) The Eukarya have remained the same throughout evolutionary time.
D) All three domains are equally related to one another.
E) The Eukarya are the common ancestor to the three domains.

17) Which of the following can be categorized as prokaryotic?

A) domain Eukarya
B) kingdom Plantae
C) kingdom Protista
D) domain Bacteria
E) kingdom Animalia

18) Is the following statement true or false? The Scots pine (*Pinus sylvestris*) and the black pine (*Pinus nigra*) belong to the same species.

A) true, because they both start with *Equus*
B) true, because they are both related to horses
C) false, because the specific epithet is different
D) false, because they have no similarities to each other
E) true, because they belong to the same genus

19) Which of the following correctly lists the classification categories from most to least inclusive?

A) kingdom, phylum, domain, class, order family, genus, species
B) domain, kingdom, phylum, class, order, family, genus, species
C) species, genus, family, class, order, domain, phylum, kingdom
D) species, genus, family, order, class, phylum, kingdom, domain
E) phylum, species, genus, kingdom, domain, order, class, family

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20) Phylum Mollusca is broken into subgroups which include both Cephalopoda (e.g., squid and octopus) and Bivalvia (e.g., clams and mussels). As a result, Cephalopoda and Bivalvia most likely belong to which classification category?

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

21) Which kingdom includes both unicellular and multicellular organisms?

A) Eukarya
B) Bacteria
C) Protista
D) Archaea
E) Plantae

22) Which of the following classification categories for humans is correct?

A) *Homo*: genus
B) *Pan*: species
C) Plantae: kingdom
D) *sapiens*: family
E) Archaea: domain

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23) Miguel keeps a red worm bin in his basement because the worms need cooler temperatures to survive. He feeds them about one pound of kitchen scraps each week. One summer the temperatures rose above the optimal temperature for the red worms (~ 85°F) and many in his colony died. However, the worms that survived continued to reproduce and within six months his colony was thriving again. The following summer, unusually warm temperatures once again resulted in the basement temperatures rising above 85°F. Surprisingly, Miguel noticed that only a small portion of the worm colony died. What is the best explanation for the higher survivorship rate?

A) After the first summer, a new species of worm evolved.
B) The worms sensed that the temperature was going to be hot in the future and altered their physiology.
C) The worms learned how to tolerate higher temperatures.
D) The worms that survived the first summer had a higher heat tolerance and passed this trait on to their offspring.
E) Temperature and worm survival are not related.

24) Which of the following levels of biological organization is correctly matched with an example?

A) a herd of llamas - community
B) a lobster - organ system
C) trees and fungi in a forest - organism
D) a coral reef with various fish and seagrasses - population
E) a tropical rain forest with rain, sunlight, trees, insects, and animals - ecosystem

25) Himari is studying birth and death rates of spotted seals in a portion of Shiretoko National Park. What level of organization is she studying?

A) population
B) community
C) ecosystem
D) biosphere
E) cells

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26) *Harposporium anguillulae*are carnivorous fungi that prey nematodes and eelworms. How should
*Harposporium anguillulae*be classified?
A) eukaryotic decomposer
B) prokaryotic consumer
C) bacterial decomposer
D) prokaryotic producer
E) eukaryotic consumer

27) Kai is studying the interaction between porcupines, pinion pine trees, and pine bark beetles in Rocky Mountain National Park. Over the course of his study, he observes the behaviors of 25 porcupines, records the location of 151 pinion pines, and traps 332 beetles. How many organisms does his study include?
A) 1
B) 3
C) 508
D) 151
E) There is not enough information to answer the question.

28) Which of the following levels of organization include the physical environment?
A) class
B) population
C) ecosystem
D) species
E) cells

29) Sofia is studying predator-prey interactions. One day she notices a caterpillar eating a leaf. Later the caterpillar is captured and eaten by a beetle. The next day, Sofia observes a bird eating the beetle. How many consumers has Sofia observed directly in this scenario?
A) 0
B) 1
C) 2
D) 3
E) 4

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30) Jawad is studying predator-prey interactions. One day he notices a mole eating a grub. Later that day, a hawk eats the mole. How many producers are there is this scenario?

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

31) Liyana is studying predator-prey interactions. One day she notices a fox eating a rabbit. Later that day, a mountain lion eats the fox. How many species are involved in her study?

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

32) Mateo is studying interactions between black bears and grizzly bears in Banff National Park.What level of organization is he studying?

A) population
B) community
C) ecosystem
D) biosphere
E) cells

33) Which of the following is true about ecosystems?

A) nutrients are never recycled
B) producers are a food source for decomposers but not consumers
C) solar energy is required for photosynthesis
D) energy continually cycles through an ecosystem
E) chemicals constantly flow into and out of an ecosystem

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34) The food web in a prairie ecosystem includes grasshoppers which feed on grasses. When the grasshoppers die, their dead bodies are broken down with the help of fungi. List in order the producer, decomposer, and consumer in this system.

A) grasshoppers, fungi, grass
B) grass, grasshoppers, fungi
C) fungi, grasshoppers, grass
D) grass, fungi, grasshoppers
E) fungi, grass, grasshoppers

35) Male amphibians, including frogs and toads, have been plagued by feminization, deformity, behavioral abnormalities and sterility. Biologists from the University of Florida investigated whether reproductive problems among populations of cane toads (*Bufo marinus*) are caused by poisons from chemicals associated with agriculture. The biologists collected local adult cane toads from more than 20 different locations. Toads were collected from areas close to agriculture, both large-scale and small-scale farms, as well as from suburbs that are nonagricultural areas. Which of the following statements would be the best hypothesis for this study?

A) All amphibian populations are facing problems due to agricultural chemicals.
B) Toxins are capable of causing diseases and deformities within many different amphibian populations.
C) Toads collected from suburbs have more deformities compared to toads collected from agricultural areas.
D) Agricultural chemicals can cause deformities and feminization amongst cane toads.
E) More male toads from the large-scale agricultural areas will show signs of feminization as compared to male toads from small-scale agricultural areas.

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36) Male amphibians, including frogs and toads, have been plagued by feminization, deformity, behavioral abnormalities and sterility. Biologists from the University of Florida investigated whether reproductive problems among populations of cane toads (*Bufo marinus*) are caused by poisons from chemicals associated with agriculture. The biologists collected local adult cane toads from more than 20 different locations. Toads were collected from areas close to agriculture, both large-scale and small-scale farms, as well as from suburbs that are non-agricultural areas. Based on this study, what is the control group?

A) male toads collected from the suburbs
B) male toads collected from areas near large-scale farms
C) male toads collected from small-scale farms
D) male toads collected from all the different sites
E) female toads that were not collected

37) Male amphibians, including frogs and toads, have been plagued by feminization, deformity, behavioral abnormalities and sterility. Biologists from the University of Florida investigated whether reproductive problems among populations of cane toads (*Bufo marinus*) are caused by poisons from chemicals associated with agriculture. The biologists collected local adult cane toads from more than 20 different locations. Toads were collected from areas close to agriculture, both large-scale and small-scale farms, as well as from suburbs that are non-agricultural areas. Based on this study, what is/are the test group(s)?

A) male toads collected from the suburbs
B) male toads collected from areas near large-scale and small-scale farms
C) female toads collected from all the different sites
D) male toads collected from all the different sites
E) male and female toads collected from areas near large-scale and small-scale farms

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38) Male amphibians, including frogs and toads, have been plagued by feminization, deformity, behavioral abnormalities and sterility. Biologists from the University of Florida investigated whether reproductive problems among populations of cane toads (*Bufo marinus*) are caused by poisons from chemicals associated with agriculture. The biologists collected local adult cane toads from more than 20 different locations. Toads were collected from areas close to agriculture, both large-scale and small-scale farms, as well as from suburbs that are non-agricultural areas. In this study, what is the genus of the study animal?

A) *Bufo marinus*
B) cane toad
C) amphibian
D) *Bufo*
E) *marinus*

39) Male amphibians, including frogs and toads, have been plagued by feminization, deformity, behavioral abnormalities and sterility. Biologists from the University of Florida investigated whether reproductive problems among populations of cane toads (*Bufo marinus*) are caused by poisons from chemicals associated with agriculture. The biologists collected local adult cane toads from more than 20 different locations. Toads were collected from areas close to agriculture, both large-scale and small-scale farms, as well as from suburbs that are non-agricultural areas. Data collected by the biologists suggested a strong correlation between feminization of male toads and agricultural chemicals. Is it accurate to state that the scientists had supported their *theory* that agricultural chemicals cause deformities?

A) yes, the data collected during the study strongly supports their theory
B) no, the data did not show a link between the feminization of male toads and agricultural chemicals
C) no, the scientists were testing a hypothesis which is not the same things as a theory
D) yes, this was a controlled study
E) no, this was a controlled study

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40) Which of the following statements is correctly matched to the step of the scientific method?
A) Biologists suggest that 2-3 cups of coffee per day can decrease death rates among women. (Theory)
B) Adina set up mist nets to catch bats flying over a small stream. Each bat that was caught was weighed and sexed. (Observation)
C) Yente watched butterflies feeding in a large field of wildflowers. She noticed that more butterflies approached the yellow and purple flowers than the red flowers. (Hypothesis)
D) A researcher reported that red-foot tortoises preferred red-colored fruits and vegetables to those that were green or white. (Prediction)
E) For a research project on test scores, Jayden divides students into two groups: the first group sleeps 8 hours a night, the second group sleeps 6 hours a night (Experimental design)

41) Usain, an aspiring scientist in a biology class, wanted to conduct a study on the effects of cigarette smoke on the web-building ability of spiders. Which of the following statements is an incorrect use of terms pertaining to the scientific method?
A) Usain wanted to see if his *hypothesis* was true that cigarette smoke will influence web-building in spiders.
B) Usain made the *observation* that spiders weave webs.
C) As a *control*, Usain had a group of spiders that were never exposed to cigarette smoke.
D) Usain examined the webs from both the control group and the test group and the *data* were recorded in a table.
E) At the end of his experiment, Usain *theorized* that there was no significant difference in the ability to weave a web under conditions of cigarette smoke compared to spiders that were not exposed.

42) Scientists were studying if white-nosed syndrome is responsible for the deaths of millions of American bats. Scientists hypothesized that white-nose syndrome, caused by the fungus *Pseudogymnoascus destructans*, makes bats die by increasing the amount of energy they use during winter hibernation. What would be the *best* control group for this study?
A) non-infected male and female bats hibernating in Europe
B) non-infected male and female bats hibernating in America
C) infected male bats hibernating in America
D) infected male and female bats hibernating in America
E) infected juvenile female bats hibernating in Europe

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43) Scientists were studying if white-nosed syndrome is responsible for the deaths of millions of American bats. Scientists hypothesized that white-nose syndrome, caused by the fungus *Pseudogymnoascus destructans*, makes bats die by increasing the amount of energy they use during winter hibernation. What would the test group be in this experiment?

A) non-infected male and female bats hibernating in Europe
B) non-infected male and female bats hibernating in America
C) infected male bats hibernating in America
D) infected male and female bats hibernating in America
E) infected juvenile female bats hibernating in Europe

44) Which of the following statement(s) is not a true statement with respect to scientific theory?

A) Theories are accepted explanations for how the world works.
B) The theory of evolution is considered the unifying concept in biology.
C) Theories can help scientists generate new testable hypotheses.
D) Theories are supported by many observations and experiments.
E) All scientific theories are considered scientific principles or laws.

45) Which of the following is an inaccurate statement about extinction?

A) Many extinctions are associated with climate change.
B) It is estimated that presently we are losing hundreds of species every year due to human activities.
C) It is estimated that as much as 27% of all species, including most primates, birds, and amphibians, may be in danger of extinction before the end of the century.
D) Extinction is the death of a species or a larger taxonomic group.
E) Scientists are not currently alarmed by the current rate of extinction which is unlikely to rival rates seen during the last 5 mass extinctions.

46) Which of the following statements inaccurately describes biodiversity?

A) Biodiversity is the total number and relative abundance of species, the variability of their genes, and the different ecosystems in which they live.
B) The biodiversity of our planet has been estimated to be around 8.7 million species.
C) The impact of human activities on biodiversity loss is one of the most significant bioethical issues that we face today.
D) So far, approximately 6 million species have been identified and named.
E) Biologists are alarmed about the current rate of extinction.

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47) Living organisms must constantly take in energy in order to power functions necessary to remain alive. All of the chemical reactions that involve energy conversions within a cell are called
A) evolution.
B) respiration.
C) photosynthesis.
D) metabolism.
E) homeostasis.

48) For metabolic processes to occur within their cells, all living organisms need to maintain homeostasis which means they need
A) to maintain the correct internal temperature, moisture level, and acidity as well as other factors.
B) to rely on the external conditions in the environment to maintain their body temperature.
C) minute to minute and day to day fluctuations in body temperature, moisture level and acidity.
D) to eat other organisms for energy and nutrition.
E) to constantly evolve as the environment changes around them.

49) The process of_____ leads to organisms that are_____ that environment.
A) natural selection; adapted to
B) adaption; evolved for
C) homeostasis; suited to
D) natural selection; perfect for
E) adaptation; only found in

50) In general, evolutionary processes lead to organisms that
A) are perfect.
B) function well in a given environment.
C) can only survive in that one environment.
D) have a single adaptive trait.
E) become extinct.

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51) In science, a theory
A) is tested by an experiment.
B) is more narrow in scope than a hypothesis.
C) encompasses many hypotheses.
D) cannot be tested.
E) is held to be an absolutely correct answer to a question.

52) The purpose of a control group in an experiment is
A) to prove the hypothesis.
B) for comparison to the experimental group.
C) for comparison to the results of other experiments.
D) to prove the prediction.
E) to control the dependent variable.

53) Which answer choice lists the steps of the scientific method in the correct order?
A) observation, hypothesis, prediction, experiment, conclusion
B) hypothesis, observation, experiment, conclusion, predictions
C) conclusion, hypothesis, observation, experiment, predictions
D) observation, experiment, hypothesis, conclusion, prediction
E) prediction, conclusion, hypothesis, experiment, observation

54) The scientific method
A) begins with the hypothesis.
B) ends with the predictions.
C) begins with observations.
D) ends after the experiment.
E) does not require a hypothesis.

55) Which of the following is not an example of an emerging disease?
A) SARS
B) COVID-19
C) avian influenza
D) cancer
E) MERS

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56) Technology
A) is separate from science.
B) has no role in helping us understand the natural world.
C) is the application of scientific knowledge to human interests.
D) will ultimately solve all critical challenges faced by science.
E) is the same thing as science.

57) Which of the following is considered the unifying concept of biology because it explains almost every aspect of life, including the diversity of life on this planet?
A) evolution
B) structure and function of cells
C) homeostasis
D) heredity
E) metabolism

58) Which of the following is the best explanation of how the goal of science differs from the goal of technology?
A) The goal of science is to answer questions and increase knowledge while the goal of technology is to utilize science to find solutions to practical problems.
B) The goal of science is to solve critical challenges while the goal of technology is to reap large profits.
C) The goal of science is to establish a collection of absolute facts while the goal of technology is to increase knowledge about how the world works.
D) The goal of science is to use data to support a particular point of view while the goal of technology is to answer questions and increase general knowledge of how the world works.
E) The goal of science is to create devices that help us understand how the world works while the goal of technology is to market those devices to the general public.

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Answer Key

Test name: Chapter 01

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

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38) D
39) C
40) E
41) E
42) B
43) D
44) E
45) E
46) D
47) D
48) A
49) A
50) B
51) C
52) B
53) A
54) C
55) D
56) C
57) A
58) A

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Mader: Essentials of Biology, 2026 Release
Instructor's Manual

Chapter 1 Biology: The Science of Life

Learning Outcomes

1.1 The Characteristics of Life

1. Explain the basic characteristics that are common to all living organisms.

2. Distinguish between the levels of biological organization.

3. Summarize how the terms *homeostasis, metabolism,* and *adaptation* relate to all living organisms.

4. Contrast chemical cycling and energy flow within an ecosystem.

1.2 Evolution: The Core Concept of Biology

1. Define the term *evolution*.

2. Explain the process of natural selection and its relationship to evolutionary processes.

3. Summarize the general characteristics of the domains and major kingdoms of life.

1.3 Science: A Way of Knowing

1. Identify the steps of the scientific method.

2. Describe the basic requirements for a controlled experiment.

3. Distinguish between a theory and a hypothesis.

1.4 Challenges Facing Science

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1. Distinguish between science and technology.

2. Summarize some of the major challenges currently facing science.

Extended Lecture Outline

1.1 The Characteristics of Life

Living organisms are organized from the cell as the basic unit of life to tissues, organs, and organ systems. Organisms are further organized through populations, communities, ecosystems, and the biosphere. Species are defined as interbreeding individuals that produce viable and fertile offspring.

Life Requires Materials and Energy

All life needs the input of energy beginning with the capture of solar energy by photosynthetic organisms (producers) such as plants. Energy is the capacity to do work, which is necessary to maintain organization. Metabolism refers to all chemical reactions that occur in a cell, and photosynthesis refers to the transformation of solar energy to chemical energy in nutrient molecules. Energy flows from the sun to photosynthetic organisms and then to other members of a food chain as they feed. As energy is transferred from one organism to the next, some energy is lost as heat. Death and decomposition enable inorganic nutrients to be reused by producers.

Living Organisms Maintain an Internal Environment

Living organisms need to keep themselves stable in temperature, moisture level, acidity, and other factors that are critical to maintaining life. The maintenance of internal conditions within certain boundaries is called homeostasis.

Living Organisms Respond

All living organisms respond in some fashion to their environment.

Living Organisms Reproduce and Develop

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All living organisms produce offspring, passing on genes (located on DNA) that control how the offspring develops. This process is called reproduction.

Living Organisms Have Adaptations

Living organisms have adaptations that enable them to survive in certain environments. Evolution is the process by which species become adapted to their environments.

1.2 Evolution: The Core Concept of Biology

All organisms share the same basic characteristics, suggesting that they share a common ancestor—the first cell or cells. Changes in a population occur over time and passing on those changes to the next generation takes place when evolution occurs.

Natural Selection and Evolutionary Processes

Natural selection, proposed by Charles Darwin and Alfred Russel Wallace, is the mechanism by which evolution occurs. Adaptations that result in greater reproductive success appear more frequently in a population as evolution takes place. Through evolution (common descent with modification), one species can be the common ancestor to multiple species, each of which has adaptations suited to a specific environment.

The overuse of antibiotics serves as a selective agent for bacteria resistant to the antibiotics, leading to an increased number of bacteria that are resistant and a greater number of infections that cannot be treated with once-effective antibiotics.

Organizing the Diversity of Life

Taxonomy involves identifying and classifying organisms, and systematics involves determining the evolutionary relationship between organisms.

Classification includes species, genus, family, order, class, phylum, kingdom, supergroup, and domain from the least inclusive to the most inclusive. Three domains exist based on biochemical evidence; they are Bacteria, Archaea, and Eukarya. Bacteria and Archaea contain prokaryotes. Eukarya contains four

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kingdoms, protists, fungi, plants, and animals. Protists are very diverse, and supergroups are used to describe evolutionary relationships between protists and the other three kingdoms. Organisms are identified using scientifically based binomial names.

1.3 Science: A Way of Knowing

The scientific method is typically used to study the natural world.

Start with an Observation

Observation, the first step in the scientific method, includes an individual's observations, as well as observations of other scientists found in scientific literature. Instrumentation extends a scientist's ability to observe.

Develop a Hypothesis

Hypotheses are often proposed and conclusions are often provided using inductive reasoning. A hypothesis is based on existing knowledge and is more than just a guess. A useful hypothesis is one that is testable.

Make a Prediction and Perform Experiments

Experimental design includes an experimental variable and a control group. Models are often used. Data collected is often mathematical.

Develop a Conclusion

Based on the experimental data, conclusions can be drawn as to whether the hypothesis was supported or not. Experiments must be repeatable.

Scientific Theory

Scientific theories explain how the natural world works.

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An Example of a Controlled Study

Experimental design and data are presented for an investigation of the effectiveness of two different antibiotics used to treat ulcers. In experimental systems, there are often test groups and control groups.

Publishing the Results

Scientific studies are published in scientific journals through a process of rigorous review; this makes studies available to the entire scientific community.

1.4 Challenges Facing Science

Scientific knowledge is important for making informed decisions about the use of technology.

Climate Change

Human activities have affected climate change—changes to the normal cycle of the Earth's climate. Increased burning of fossil fuels and forest destruction have led to increased carbon dioxide in the atmosphere and global warming, creating one the foremost challenges of our time.

Biodiversity and Habitat Loss

Humans modify ecosystems for their own purposes, which may lead to the extinction, or death, of many species or a larger taxonomic group. Many unintended effects, such as flooding problems or the loss of the next miracle drug, are associated with the destruction of healthy ecosystems, such as tropical rainforests and coral reefs.

Emerging and Reemerging Diseases

Changes in human behavior and use of technology can lead to emerging diseases, such as avian and swine flu, and increased cases of known diseases, such as Ebola. Increased global travel has been a contributor to the spread of SARS-CoV-2 and the emerging COVID19 pandemic.

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Lecture Enrichment Topics

1.1 The Characteristics of Life

1. Choose an ecosystem, such as the campus or students' backyards, and have students list some ways living organisms interact with their physical environment. How do students interact with their physical environment? For example, food chains and food webs unify the diversity of life, which is described later.
2. Ask students for some ways that humans maintain homeostasis. For example, how do they maintain homeostasis of fluid or temperature when they are exercising and perspiring, or when they walk outside in cold weather without wearing a coat?

1.2 Evolution: The Core Concept of Biology

1. To reinforce the need for scientific names, present the following common names for the snake, *Bothrops asper*: Belize—yellow-jaw tommygoff; Guatemala and Honduras—barba amarilla; Mexico—cola blanca, palancaloca, tephocho; Venezuela—macagua, tigra.

1.3 Science: A Way of Knowing

In presenting the scientific method, present students with different fields of biology. Do scientists in the different fields use the same techniques or different techniques to conduct their investigations?

1. In presenting the parts of the scientific method, give an ongoing example of how people use the scientific method in everyday life. One example may be the use of premium versus regular gasoline. Students can propose conditions that should remain constant, as well as the type of mathematical data that could be collected and analyzed.
2. Propose a "study" as follows: A report on the television states that a 12-year study of a new dog food will allow your dog to live longer if fed to the dog throughout its life. Ask students what questions they might have about the report in order to discern its validity.
3. Explain the importance of objectivity (one reason mathematical data is so important) in experimental design. Using the example in #2 above, categorize the following statements about the example into objective statements versus

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subjective statements. Have the students include reasons why they categorized each statement as objective or subjective.

- "The dogs that ate the new dog food seemed to have shinier coats."
- "78% of the control dogs did not eat all of their food within the time allotted."
- "Most of the experimental dogs needed fewer teeth cleanings."
- "Half of the experimental dogs were more playful after eight years of using the new dog food."
- "The new dog food probably tasted better as the experimental dogs ate their food in less time."

4. Present when Charles Darwin proposed the evolution theory (1859); when Schleiden and Schwann proposed the cell theory (1838); and when Mendel (1866), and Watson and Crick (1953) proposed the gene theory. Emphasize the length of time and number of studies that must have occurred during this time that support these theories.
5. Discuss the scientific definition of *theory* versus the everyday use of the word *theory*. Presenting a dictionary's definition should include both aspects. Explain why saying "It's *just* a theory" may not be appropriate with regard to scientific theories. (See also #4).

1.4 Challenges Facing Science

1. Ask for a list of biology-related concerns currently in the news (cloning, stem cell research, habitat loss due to development or other human activities, species newly classified as threatened or endangered). Students could bring in headlines or articles from newspapers. Point out that at the end of this course, students should be better able to decide their positions on these issues.

Critical Thinking Questions

1. Discuss the difference in meaning between the terms "supported" and "proven." Why is the term "supported" used with regard to hypotheses? For example, "A hypothesis is supported by experimental data."

Ans: The term "proven" indicates a greater degree of certainty with no indication

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suggested for further search of information. The term “supported” indicates that with the current knowledge, the hypothesis appears to be true, but further experimentation may indicate otherwise.

2. Regarding the example of a controlled study in the text using winter wheat and pea plants as fertilizer, what specific aspects of environmental conditions would be included as conditions that were kept constant?

Ans: Answers will vary but may include:

- amount and type of nutrients in soil before addition of nitrogen fertilizer or pea plants
- amount of water the plants received
- amount of sunlight the plants received
- the temperatures throughout the test period
- the size of the pots
- pH of soil

Essay Questions

1. Give an example of how behavior contributes to homeostasis.

Ans: (Students may be able to come up with some of their own examples.) Animals such as lizards need to regulate their body temperature by moving about their environment. If they are cold, they move to a sunny area; if hot, they move to a shaded area. A plant may grow its leaves to follow the position of the sun to maintain a certain rate of photosynthesis.

2. Explain why scientific binomial names are important.

Ans: People often have many different common names for living organisms, varying between geographical areas or languages. Scientists need a name for each species that does not change no matter what language is spoken or what geographical area is being considered. Each known species has an assigned scientific binomial name that is accepted by all scientists.

3. Describe the importance of using models in experimental design.

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Ans: Models, or modeling, can be used instead of the actual subject. This can be important in forecasting the impact of human activity on ecosystems. Also, animals can be used as models when testing chemicals or processes being developed for humans.

4. Which model organism are best for:

a) Field investigations?

b) Lab investigations?

Consider the size, reproductive habit, and the life cycle of the organisms.

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