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SKU: 9780393680362-TEST-BANK

CHAPTER 1 | Cells: The Fundamental Units of Life

UNITY AND DIVERSITY OF CELLS

1.1.a Compare, with examples, some ways in which cells may vary in appearance and function.

1.1.b Outline, with examples, ways in which cells share a basic fundamental chemistry.

1.1.c Explain how the relationship between DNA, RNA, and protein—as laid out in the central dogma—makes the self-replication of living cells possible.

1.1.d Summarize how the processes of mutation and selection promote the gradual evolution of individuals best suited for survival in a wide range of habitats.

1.1.e Explain how differentiated cell types can vary widely in form and function despite having the same genome sequence.

CELLS UNDER THE MICROSCOPE

1.2.a List the three tenets of cell theory and explain their ramifications for the study of cell biology.

1.2.b Contrast light microscopy, super-resolution fluorescence light microscopy, and electron microscopy in terms of the cell components that can generally be distinguished using each.

1.2.c Compare how samples are prepared for light versus electron microscopy and explain how these preparations affect whether the technique can be used for viewing living cells or tissues.

THE PROKARYOTIC CELL

1.3.a Describe the structural differences between prokaryotes and eukaryotes.

1.3.b Analyze how eukaryotic cells and organisms rely on the function of prokaryotic cells and their descendants.

1.3.c Compare prokaryotes and eukaryotes in terms of their relative preponderance on Earth, their range of habitat, and their tendency toward multicellularity.

1.3.d Justify the division of prokaryotes into bacteria and archaea.

THE EUKARYOTIC CELL

1.4.a State the function of the nucleus and describe its structural features.

1.4.b Explain how the structure of the mitochondrion supports its function.

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1.4.c Outline the evolution of mitochondria and chloroplasts and cite the evidence for these origins.

1.4.d Explain how chloroplasts and mitochondria cooperate as plant cells convert light energy into chemical energy.

1.4.e Compare the function of lysosomes and peroxisomes.

1.4.f Compare the structure, location, and function of the endoplasmic reticulum and Golgi apparatus.

1.4.g Outline the role that transport vesicles play in endocytosis, exocytosis, and the movement of materials between one membrane-enclosed organelle and another.

1.4.h Relate the location of the cytosol with respect to the cell's membrane-enclosed organelles.

1.4.i List the three major filaments of the cytoskeleton and contrast the roles they have in animal cells.

1.4.j Outline the role the cytoskeleton has in plant cells.

1.4.k Describe the ancestral cell that likely engulfed the aerobic bacteria that gave rise to mitochondria and explain why this event is thought to have preceded the acquisition of chloroplasts.

MODEL ORGANISMS

1.5.a Review why scientists study model organisms.

1.5.b Compare E. coli, S. cerevisiae, and A. thaliana and list the types of discoveries made by studying each.

1.5.c Compare flies, worms, fish, and mice as model organisms and name a benefit of studying each.

1.5.d Review the benefits of studying cultured human cells.

1.5.e Assess the relationship between genome size and gene number.

1.5.f Explain the significance of homologous genes and proteins.

1.5.g Summarize the roles played by the nucleotide sequences contained in an organism's genome.

1.5.h Outline an experiment that would allow investigators to determine whether proteins from different eukaryotes are functionally interchangeable.

MULTIPLE CHOICE

1. Living systems are incredibly diverse in size, shape, environment, and behavior. It is estimated that there are between 10 million and 100 million different species. Despite this wide variety of organisms, it remains difficult to define what it means to say something is alive. Which of the following can be described as the smallest living unit?
   a. DNA
   b. cell
   c. organelle
   d. protein

   ANS: b DIF: Easy REF: 1.1 OBJ: 1.1.b Outline, with examples, ways in which cells share a basic fundamental chemistry. MSC: Understanding

2. The central dogma provides a framework for thinking about how genetic information is copied and used to produce structural and catalytic components of the cell. From the choices below, select the order of biochemical processes that best correlates with the tenets of the central dogma.
   a. replication, transcription, translation
   b. replication, translation, transcription
   c. translation, transcription, replication
   d. translation, replication, transcription

   ANS: A DIF: Easy REF: 1.1 OBJ: 1.1.c Explain how the relationship between DNA, RNA, and protein—as laid out in the central dogma—makes the self-replication of living cells possible. MSC: Understanding

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3. Proteins are important architectural and catalytic components within the cell, helping to determine its chemistry, its shape, and its ability to respond to changes in the environment. Remarkably, all of the different proteins in a cell are made from the same 20 _____. By linking them in different sequences, the cell can make protein molecules with different conformations and surface chemistries, and therefore different functions.
   a. nucleotides
   b. sugars
   c. amino acids
   d. fatty acids

   ANS: C DIF: Easy REF: 1.1 OBJ: 1.1.b Outline, with examples, ways in which cells share a basic fundamental chemistry. MSC: Remembering

4. Which statement is NOT true about mutations?
   a. A mutation is a change in the DNA that can generate offspring less fit for survival than their parents.
   b. A mutation can be a result of imperfect DNA duplication.
   c. A mutation is a result of sexual reproduction.
   d. A mutation is a change in the DNA that can generate offspring that are as fit for survival as their parents are.

   ANS: C DIF: Easy REF: 1.1 OBJ: 1.1.d Summarize how the processes of mutation and selection promote the gradual evolution of individuals best suited for survival in a wide range of habitats. MSC: Analyzing

5. Changes in DNA sequence from one generation to the next may result in offspring that are altered in fitness compared with their parents. The process of change and selection over the course of many generations is the basis of
   a. mutation.
   b. evolution.
   c. heredity.
   d. reproduction.

   ANS: B DIF: Easy REF: 1.1 OBJ: 1.1.d Summarize how the processes of mutation and selection promote the gradual evolution of individuals best suited for survival in a wide range of habitats. MSC: Understanding

6. Select the option that BEST finishes the following statement: Evolution is a process
   a. that can be understood based on the principles of mutation and selection.
   b. that results from repeated cycles of adaptation over billions of years.
   c. by which all present-day cells arose from 4–5 different ancestral cells.
   d. that requires hundreds of thousands of years.

   ANS: A DIF: Moderate REF: 1.1 OBJ: 1.1.d Summarize how the processes of mutation and selection promote the gradual evolution of individuals best suited for survival in a wide range of habitats. MSC: Analyzing

7. Select the option that correctly finishes the following statement: A cell's genome
   a. is defined as all the genes being used to make protein.
   b. contains all of a cell's DNA.
   c. constantly changes, depending upon the cell's environment.
   d. is altered during embryonic development.

   ANS: B DIF: Easy REF: 1.1 OBJ: 1.1.b Outline, with examples, ways in which cells share a basic fundamental chemistry. MSC: Remembering

8. Which statement is NOT true about the events/conclusions from studies during the mid-1800s surrounding the discovery of cells?
   a. Cells came to be known as the smallest universal building block of living organisms.
   b. Scientists came to the conclusion that new cells can form spontaneously from the remnants of ruptured cells.
   c. Light microscopy was essential in demonstrating the commonalities between plant and animal tissues.
   d. New cells arise from the growth and division of previously existing cells.

   ANS: B DIF: Easy REF: 1.2 OBJ: 1.2.a List the three tenets of cell theory and explain their ramifications for the study of cell biology. MSC: Remembering

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9. What unit of length would you generally use to measure a typical plant or animal cell?
   a. centimeters
   b. nanometers
   c. millimeters
   d. micrometers

   ANS: D DIF: Easy REF: 1.1 OBJ: 1.1.a Compare, with examples, some ways in which cells may vary in appearance and function. | 1.2.a List the three tenets of cell theory and explain their ramifications for the study of cell biology. MSC: Remembering

10. Cell biologists employ targeted fluorescent dyes or modified fluorescent proteins in both standard fluorescence microscopy and confocal microscopy to observe specific details in the cell. Even though fluorescence permits better visualization, the resolving power is essentially the same as that of a standard light microscope because the resolving power of a fluorescent microscope is still limited by the _____ of visible light.
   a. absorption
   b. intensity
   c. filtering
   d. wavelength

   ANS: D DIF: Moderate REF: 1.2 OBJ: 1.2.b Contrast light microscopy, super-resolution fluorescence light microscopy, and electron microscopy in terms of the cell components that can generally be distinguished using each. MSC: Understanding

11. What is the smallest distance two points can be separated and still resolved using light microscopy?
   a. 20 nm
   b. 0.2 µm
   c. 2 µm
   d. 200 µm

   ANS: B DIF: Moderate REF: 1.2 OBJ: 1.2.b Contrast light microscopy, super-resolution fluorescence light microscopy, and electron microscopy in terms of the cell components that can generally be distinguished using each. MSC: Understanding

12. Prokaryotic cells do not possess
   a. a nucleus.
   b. replication machinery.
   c. ribosomes.
   d. membrane bilayers.

   ANS: A DIF: Easy REF: 1.3 OBJ: 1.3.a Describe the structural differences between prokaryotes and eukaryotes. MSC: Remembering

13. Which three characteristics best support the rapid evolution of prokaryotic populations?
   a. microscopic, motile, anaerobic
   b. aerobic, motile, rapid growth
   c. no organelles, cell wall, can exchange DNA
   d. large population, rapid growth, can exchange DNA

   ANS: D DIF: Easy REF: 1.3 OBJ: 1.3.c Compare prokaryotes and eukaryotes in terms of their relative preponderance on Earth, their range of habitat, and their tendency toward multicellularity. MSC: Analyzing

14. The world of prokaryotes is divided into two domains (bacteria and archaea), each as different from each other as from eukaryotes. Select the observable characteristic that BEST separates archaea from bacteria.
   a. can metabolize inorganic substances
   b. are found in extremely harsh environments
   c. thrive in anaerobic conditions
   d. are photosynthetic organisms

   ANS: B DIF: Easy REF: 1.3 OBJ: 1.3.d Justify the division of prokaryotes into bacteria and archaea. MSC: Remembering

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15. The _____ _____ is made up of two concentric membranes and is continuous with the membrane of the endoplasmic reticulum.
    a. plasma membrane
    b. Golgi network
    c. mitochondrial membrane
    d. nuclear envelope

    ANS: D DIF: Easy REF: 1.4 OBJ: 1.4.a State the function of the nucleus and describe its structural features. MSC: Remembering

16. The nucleus, an organelle found in eukaryotic cells, confines the _____, keeping them separated from other components of the cell.
    a. lysosomes
    b. chromosomes
    c. peroxisomes
    d. ribosomes

    ANS: B DIF: Easy REF: 1.4 OBJ: 1.4.a State the function of the nucleus and describe its structural features. MSC: Remembering

17. Which of the following organelles has both an outer and an inner membrane?
    a. endoplasmic reticulum
    b. mitochondrion
    c. lysosome
    d. peroxisome

    ANS: B DIF: Easy REF: 1.4 OBJ: 1.4.b Express how the structure of the mitochondrion supports its function. MSC: Remembering

18. Mitochondria perform cellular respiration, a process that uses oxygen, generates carbon dioxide, and produces chemical energy for the cell. Which answer below indicates a correct pairing of the material "burned" and the form of energy produced during cellular respiration?
    a. fat, ADP
    b. sugar, fat
    c. sugar, ATP
    d. fat, protein

    ANS: C DIF: Easy REF: 1.4 OBJ: 1.4.d Explain how chloroplasts and mitochondria cooperate as plant cells convert light energy into chemical energy. MSC: Understanding

19. Mitochondria contain their own genome, are able to duplicate, and actually divide on a different time line from the rest of the cell. Nevertheless, mitochondria cannot function for long when isolated from the cell because they are
    a. viruses.
    b. parasites.
    c. endosymbionts.
    d. anaerobes.

    ANS: C DIF: Easy REF: 1.4 OBJ: 1.4.b Explain how the structure of the mitochondrion supports its function. MSC: Remembering

20. The mitochondrial proteins found in the inner membrane are involved in the conversion of ADP to ATP, a source of energy for the cell. This process consumes which of the following substances?
    a. oxygen
    b. nitrogen
    c. sulfur
    d. carbon dioxide

    ANS: A DIF: Easy REF: 1.4 OBJ: 1.4.b Explain how the structure of the mitochondrion supports its function.| 1.4.d Explain how chloroplasts and mitochondria cooperate as plant cells convert light energy into chemical energy. MSC: Remembering

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21. Chloroplasts are complex organelles present in all photosynthesizing eukaryotes. Three different membranes create chemically different environments inside the chloroplast. Precisely where are chlorophyll molecules localized in the chloroplast?
    a. in the first, outer membrane
    b. in the space between the first and second membranes
    c. in the second, inner membrane
    d. in the third, innermost membrane

    ANS: D DIF: Easy REF: 1.4 OBJ: 1.4.d Explain how chloroplasts and mitochondria cooperate as plant cells convert light energy into chemical energy. MSC: Remembering

22. Photosynthesis enables plants to capture the energy from sunlight. In this essential process, plants incorporate the carbon from CO_2 into high-energy _____ molecules, which the plant cell mitochondria use to produce ATP.
    a. fat
    b. sugar
    c. protein
    d. fiber

    ANS: B DIF: Easy REF: 1.4 OBJ: 1.4.d Explain how chloroplasts and mitochondria cooperate as plant cells convert light energy into chemical energy. MSC: Remembering

23. Which of the following choices BEST describes the role of the lysosome?
    a. transport of material to the Golgi apparatus
    b. clean-up, recycling, and disposal of macromolecules
    c. sorting of transport vesicles
    d. the storage of excess macromolecules

    ANS: B DIF: Easy REF: 1.4 OBJ: 1.4.e Compare the function of lysosomes and peroxisomes. MSC: Remembering

24. The cell constantly exchanges materials by bringing nutrients in from the external environment and shuttling unwanted by-products back out. Which term describes the process by which external materials are captured inside transport vesicles and brought into the cell?
    a. degradation
    b. exocytosis
    c. phagocytosis
    d. endocytosis

    ANS: D DIF: Easy REF: 1.4 OBJ: 1.4.g Outline the role that transport vesicles play in endocytosis, exocytosis, and the movement of materials between one membrane-enclosed organelle and another. MSC: Remembering

25. Eukaryotic cells are able to trigger the release of material from secretory vesicles to the extracellular space using a process called exocytosis. An example of materials commonly released this way is
    a. hormones.
    b. nucleic acids.
    c. sugars.
    d. cytosolic proteins.

    ANS: A DIF: Easy REF: 1.4 OBJ: 1.4.g Outline the role that transport vesicles play in endocytosis, exocytosis, and the movement of materials between one membrane-enclosed organelle and another. MSC: Remembering

26. _____ are fairly small organelles that provide a safe place within the cell to carry out certain biochemical reactions that generate harmful, highly reactive oxygen species. These chemicals are both generated and broken down in the same location.
    a. Nucleosomes
    b. Lysosomes
    c. Peroxisomes
    d. Endosomes

    ANS: C DIF: Easy REF: 1.4 OBJ: 1.4.e Compare the function of lysosomes and peroxisomes. MSC: Remembering

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27. The cytoskeleton provides support, structure, motility, and organization, and it forms tracks to direct organelle and vesicle transport. Which of the cytoskeletal elements listed below is the thickest?
    a. actin filaments
    b. microtubules
    c. intermediate filaments
    d. none of the above (all have the same thickness)

    ANS: B DIF: Easy REF: 1.4 OBJ: 1.4.i List the three major filaments of the cytoskeleton and contrast the roles they have in animal cells. MSC: Remembering

28. Despite the differences between eukaryotic and prokaryotic cells, prokaryotes have proteins that are distantly related to eukaryotic actin filaments and microtubules. What is likely to be the most ancient function of the cytoskeleton?
    a. cell motility
    b. vesicle transport
    c. membrane support
    d. cell division

    ANS: D DIF: Moderate REF: 1.4 OBJ: 1.4.i List the three major filaments of the cytoskeleton and contrast the roles they have in animal cells. MSC: Understanding

29. Choose the phrase that best completes this sentence: Microtubules _____ and are required to pull duplicated chromosomes to opposite poles of dividing cells.
    a. generate contractile forces
    b. are intermediate in thickness
    c. can rapidly reorganize
    d. are found in especially large numbers in muscle cells

    ANS: C DIF: Easy REF: 1.4 OBJ: 1.4.i List the three major filaments of the cytoskeleton and contrast the roles they have in animal cells. MSC: Understanding

30. Which pair of values best fills in the blanks in this statement: On average, eukaryotic cells are _____ times longer and have _____ times more volume than prokaryotic cells.
    a. 5; 100
    b. 10; 200
    c. 10; 100
    d. 10; 1000

    ANS: D DIF: Easy REF: 1.4 OBJ: 1.3.a Describe the structural differences between prokaryotes and eukaryotes. MSC: Remembering

31. Cells that are specialized for the secretion of proteins are likely to have which of the following features?
    a. long bundles of actin/myosin proteins
    b. small volume of cytoplasm
    c. large population of mitochondria
    d. enlarged endoplasmic reticulum

    ANS: D DIF: Easy REF: 1.4 OBJ: 1.4.f Compare the structure, location, and function of the endoplasmic reticulum and Golgi apparatus. MSC: Understanding

32. Scientists learned that cell death is a normal and even important part of life by studying the development of the nematode worm *C. elegans*. What was the most important feature of *C. elegans* for the study of programmed cell death?
    a. The nematode is smaller and simpler than the fruit fly.
    b. Seventy percent of *C. elegans* genes have homologs in humans.
    c. The developmental pathway of each cell in the adult worm was known.
    d. Its genome was partially sequenced.

    ANS: C
    This is the best answer because it was the prior developmental studies tracing cell lineages from the egg to the adult that allowed scientists to identify the precise time and location of cells that were being targeted for cell death. It was

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observed that this cell death was a normal and necessary part of the developmental pathway in the worm. Programmed cell death has since become known to be an important process in all multicellular eukaryotic organisms.
DIF: Moderate REF: 1.5 OBJ: 1.5.a Review why scientists study model organisms. MSC: Understanding

33. Biologists cannot possibly study all living species. Instead, they try to understand cell behavior by studying a select subset of species. Which of the following characteristics are useful in an organism chosen for use as a model in laboratory studies?
    a. amenability to genetic manipulation
    b. ability to grow under controlled conditions
    c. rapid rate of reproduction
    d. all of the above

    ANS: D DIF: Easy REF: 1.5 OBJ: 1.5.a Review why scientists study model organisms. MSC: Understanding

34. Which species was the key model organism for the advancement of molecular biology (understanding DNA replication, decoding the DNA to make proteins, etc.)?
    a. *E. coli*
    b. *D. melanogaster*
    c. *S. pombe*
    d. *C. elegans*

    ANS: A DIF: Easy REF: 1.5 OBJ: 1.5.b Compare *E. coli, S. cerevisiae*, and *A. thaliana* and list the types of discoveries made by studying each. MSC: Remembering

35. *A. thaliana*, or *Arabidopsis*, is a common weed. Biologists have selected it over hundreds of thousands of other flowering plant species to serve as an experimental model organism because
    a. it can withstand extremely cold climates.
    b. it can reproduce in 8–10 weeks.
    c. it produces thousands of offspring per plant.
    d. Both (B) and (C) are true.

    ANS: B DIF: Easy REF: 1.5 OBJ: 1.5.a Review why scientists study model organisms. | 1.5.c Compare flies, worm, fish, and mice as model organisms and name a benefit of studying each. MSC: Remembering

36. *Drosophila melanogaster* is a/an _____. This type of animal is the most abundant of all animal species, making it an appropriate choice as an experimental model.
    a. insect
    b. bird
    c. amphibian
    d. mammal

    ANS: A DIF: Easy REF: 1.5 OBJ: 1.5.a Review why scientists study model organisms. | 1.5.c Compare flies, worm, fish, and mice as model organisms and name a benefit of studying each. MSC: Remembering

37. *Caenorhabditis elegans* is a nematode. During its development, it produces more than 1000 cells. However, the adult worm has only 959 somatic cells. The process by which 131 cells are specifically targeted for destruction is called
    a. directed cell pruning.
    b. programmed cell death.
    c. autophagy.
    d. necrosis.

    ANS: B DIF: Easy REF: 1.5 OBJ: 1.5.c Compare flies, worm, fish, and mice as model organisms and name a benefit of studying each. MSC: Remembering

38. Zebrafish (*Danio rerio*) are especially useful in the study of early development because their embryos
    a. are exceptionally large.
    b. develop slowly.
    c. are transparent.
    d. are pigmented.

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ANS: C DIF: Easy REF: 1.5 OBJ: 1.5.a Review why scientists study model organisms. | 1.5.c Compare flies, worm, fish, and mice as model organisms and name a benefit of studying each. MSC: Remembering

39. Brewer's yeast, apart from being an irreplaceable asset in the brewery and in the bakery, is an experimental organism used to study eukaryotic cells. However, it does have some limitations. Select all the processes below that CANNOT be studied in yeast.
    a. differentiation
    b. motility
    c. exocytosis
    d. cell division

    ANS: A, B DIF: Easy REF: 1.5 OBJ: 1.5.a Review why scientists study model organisms. | 1.5.c Compare flies, worm, fish, and mice as model organisms and name a benefit of studying each. MSC: Understanding

MATCHING

1. Match the following types of microscopy with the corresponding description provided below them. There is one best match for each.

    A. confocal
    B. transmission electron
    C. fluorescence
    D. phase-contrast
    E. scanning electron
    F. bright-field

    1. ____ uses a light microscope with an optical component to take advantage of the different refractive indices of light passing through different regions of the cell.
    2. ____ employs a light microscope and requires that samples be fixed and stained in order to reveal cellular details.
    3. ____ requires the use of two sets of filters. The first filter narrows the wavelength range that reaches the specimen and the second blocks out all wavelengths that pass back up to the eyepiece except for those emitted by the dye in the sample.
    4. ____ scans the specimen with a focused laser beam to obtain a series of two-dimensional optical sections, which can be used to reconstruct an image of the specimen in three dimensions. The laser excites a fluorescent dye molecule, and the emitted light from each illuminated point is captured through a pinhole and recorded by a detector.
    5. ____ has the ability to resolve cellular components as small as 2 nm.
    6. ____ requires coating a sample with a thin layer of a heavy metal to produce three-dimensional images of the sample surface.

    1. ANS: D DIF: Moderate REF: 1.2 OBJ: 1.2.b Contrast light microscopy, super-resolution fluorescence light microscopy, and electron microscopy in terms of the cell components that can generally be distinguished using each. | 1.2.c Compare how samples are prepared for light versus electron microscopy and explain how these preparations affect whether the technique can be used for viewing living cells or tissues. MSC: Analyzing
    2. ANS: F DIF: Moderate REF: 1.2 OBJ: 1.2.b Contrast light microscopy, high-resolution fluorescence light microscopy, and electron microscopy in terms of the cell components that can generally be distinguished using each. | 1.2.c Compare how samples are prepared for light versus electron microscopy and explain how these preparations affect whether the technique can be used for viewing living cells or tissues. MSC: Analyzing
    3. ANS: C DIF: Moderate REF: 1.2 OBJ: 1.2.b Contrast light microscopy, high-resolution fluorescence light microscopy, and electron microscopy in terms of the cell components that can generally be distinguished using each. | 1.2.c Compare how samples are prepared for light versus electron microscopy and explain how these preparations affect whether the technique can be used for viewing living cells or tissues. MSC: Analyzing
    4. ANS: A DIF: Moderate REF: 1.2 OBJ: 1.2.b Contrast light microscopy, high-resolution fluorescence light microscopy, and electron microscopy in terms of the cell components that can generally be distinguished using each. | 1.2.c Compare how samples are prepared for light versus electron microscopy and explain how these preparations affect whether the technique can be used for viewing living cells or tissues. MSC: Analyzing

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5. ANS: B DIF: Moderate REF: 1.2 OBJ: 1.2.b Contrast light microscopy, high-resolution fluorescence light microscopy, and electron microscopy in terms of the cell components that can generally be distinguished using each. | 1.2.c Compare how samples are prepared for light versus electron microscopy and explain how these preparations affect whether the technique can be used for viewing living cells or tissues. MSC: Analyzing
6. ANS: E DIF: Moderate REF: 1.2 OBJ: 1.2.b Contrast light microscopy, high-resolution fluorescence light microscopy, and electron microscopy in terms of the cell components that can generally be distinguished using each. | 1.2.c Compare how samples are prepared for light versus electron microscopy and explain how these preparations affect whether the technique can be used for viewing living cells or tissues. MSC: Analyzing

2. Match a structure from the list below (A–G) with the labels 1–7 in the schematic drawing of an animal cell in Figure 1-41.

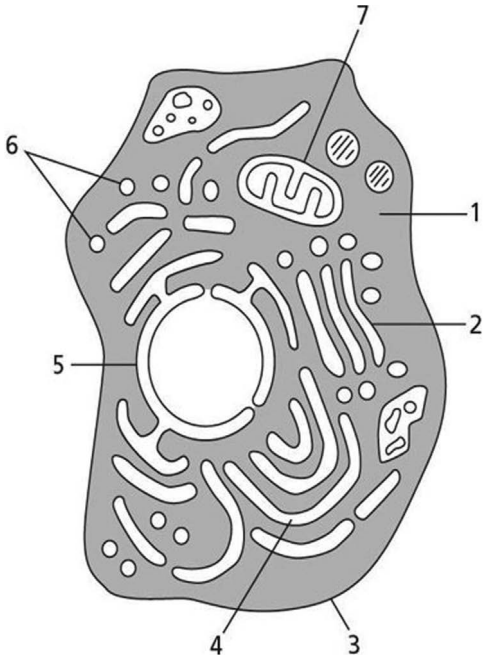


Figure 1-41

A. plasma membrane
B. nuclear envelope
C. cytosol
D. Golgi apparatus
E. endoplasmic reticulum
F. mitochondrion
G. transport vesicles

1. Label 1
ANS: C DIF: Easy REF: 1.4 OBJ: 1.4.f Compare the structure, location, and function of the endoplasmic reticulum and Golgi apparatus. | 1.4.h Relate the location of the cytosol with respect to the cell's membrane-enclosed organelles. MSC: Remembering

2. Label 2
ANS: D DIF: Easy REF: 1.4 OBJ: 1.4.f Compare the structure, location, and function of the endoplasmic reticulum and Golgi apparatus. | 1.4.h Relate the location of the cytosol with respect to the cell's membrane-enclosed organelles. MSC: Remembering

3. Label 3
ANS: A DIF: Easy REF: 1.4 OBJ: 1.4.f Compare the structure, location, and function of the endoplasmic reticulum and Golgi apparatus. | 1.4.h Relate the location of the cytosol with respect to the cell's membrane-enclosed organelles. MSC: Remembering

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4. Label 4
ANS: E DIF: Easy REF: 1.4 OBJ: 1.4.f Compare the structure, location, and function of the endoplasmic reticulum and Golgi apparatus. | 1.4.h Relate the location of the cytosol with respect to the cell's membrane-enclosed organelles.
MSC: Remembering

5. Label 5
ANS: B DIF: Easy REF: 1.4 OBJ: 1.4.f Compare the structure, location, and function of the endoplasmic reticulum and Golgi apparatus. | 1.4.h Relate the location of the cytosol with respect to the cell's membrane-enclosed organelles.
MSC: Remembering

6. Label 6
ANS: G DIF: Easy REF: 1.4 OBJ: 1.4.f Compare the structure, location, and function of the endoplasmic reticulum and Golgi apparatus. | 1.4.h Relate the location of the cytosol with respect to the cell's membrane-enclosed organelles.
MSC: Remembering

7. Label 7
ANS: F DIF: Easy REF: 1.4 OBJ: 1.4.f Compare the structure, location, and function of the endoplasmic reticulum and Golgi apparatus. | 1.4.h Relate the location of the cytosol with respect to the cell's membrane-enclosed organelles.
MSC: Remembering

3. Select all the cell types in which the listed structure or molecule can be found. Note that the structure or molecule can be found in more than one type of cell.

structure or molecule		cell type		
1	DNA	animal	plant	bacterial
2	nucleus	animal	plant	bacterial
3	plasma membrane	animal	plant	bacterial
4	chloroplast	animal	plant	bacterial
5	cell wall	animal	plant	bacterial
6	lysosome	animal	plant	bacterial
7	mitochondrion	animal	plant	bacterial
8	Golgi apparatus	animal	plant	bacterial

Figure 1-42

A. animal
B. plant
C. bacterial
D. animal and plant
E. plant and bacterial
F. animal and bacterial
G. animal, plant, and bacterial

1. DNA
ANS: G DIF: Easy REF: 1.3 OBJ: 1.3.a Describe the structural differences between prokaryotes and eukaryotes.
MSC: Analyzing

2. nucleus
ANS: D DIF: Easy REF: 1.3 OBJ: 1.3.a Describe the structural differences between prokaryotes and eukaryotes.
MSC: Analyzing

3. plasma membrane
ANS: G DIF: Easy REF: 1.3 OBJ: 1.3.a Describe the structural differences between prokaryotes and eukaryotes.
MSC: Analyzing

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4. chloroplast
ANS: E DIF: Easy REF: 1.3 OBJ: 1.3.a Describe the structural differences between prokaryotes and eukaryotes.
MSC: Analyzing

5. cell wall
ANS: E DIF: Easy REF: 1.3 OBJ: 1.3.a Describe the structural differences between prokaryotes and eukaryotes.
MSC: Analyzing

6. lysosome
ANS: D DIF: Easy REF: 1.3 OBJ: 1.3.a Describe the structural differences between prokaryotes and eukaryotes.
MSC: Analyzing

7. mitochondrion
ANS: D DIF: Easy REF: 1.3 OBJ: 1.3.a Describe the structural differences between prokaryotes and eukaryotes.
MSC: Analyzing

8. Golgi apparatus
ANS: D DIF: Easy REF: 1.3 OBJ: 1.3.a Describe the structural differences between prokaryotes and eukaryotes.
MSC: Analyzing

SHORT ANSWER

1. Indicate whether the following statements are TRUE or FALSE. If the statement is false, explain why it is false.
   A. The *Paramecium* is a multicellular microorganism covered with hair-like cilia.
   B. Cells of different types can have different chemical requirements.
   C. The branchlike extensions that sprout from a single nerve cell in a mammalian brain can extend over several hundred micrometers.

   ANS:
   A. False. The *Paramecium* is a single-celled organism.
   B. True
   C. True
   DIF: Easy REF: 1.1 OBJ: 1.1.a Compare, with examples, some ways in which cells may vary in appearance and function. MSC: Evaluating

2. For each of the following sentences, fill in the blanks with the best word or phrase selected from the list below. Not all words or phrases will be used; each word or phrase should be used only once.

amino acids	micrometer(s)	viruses
DNA	millimeter(s)	yeast
fatty acids	plants	
meter	plasma membranes	

   Cells can be very diverse: superficially, they come in various sizes, ranging from bacterial cells such as *Lactobacillus*, which is a few _____ in length, to larger cells such as a frog's egg, which has a diameter of about 1 _____. Despite the diversity, cells resemble each other to an astonishing degree in their chemistry. For example, the same 20 _____ are used to make proteins. Similarly, the genetic information of all cells is stored in their _____. Although _____ contain the same types of molecules as cells, their inability to reproduce themselves by their own efforts means that they are not considered living matter.

   ANS: Cells can be very diverse: superficially, they come in various sizes, ranging from bacterial cells such as *Lactobacillus*, which is a few **micrometers** in length, to larger cells such as a frog's egg, which has a diameter of about 1 **millimeter**. Despite the diversity, cells resemble each other to an astonishing degree in their chemistry. For example, the same 20 **amino acids** are used to make proteins. Similarly, the genetic information of all cells is stored in their **DNA**. Although **viruses** contain the same types of molecules as cells, their inability to reproduce themselves by their own efforts means that they are not considered living matter.
   DIF: Easy REF: 1.1 OBJ:1.1.a Compare, with examples, some ways in which cells may vary in appearance and function. | 1.1.b Outline, with examples, ways in which cells share a basic fundamental chemistry.
   MSC: Understanding

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3. Cellular populations in bacterial colonies and the human body both start with single founder cells, yet these two collections of cells are vastly different. What is the primary reason for these differences?

   ANS: In humans and other higher-order species, multiple cell types arise from the single founder cell to perform specialized functions for the organism. In bacterial colonies, cells do communicate, but there is no observed development into different cell types.
   DIF: Difficult REF: 1.1 OBJ: 1.1.a Compare, with examples, some ways in which cells may vary in appearance and function. MSC: Evaluating

4. Indicate whether the following statements are TRUE or FALSE. If the statement is false, explain why it is false.
   A. The nucleus of an animal cell is round, small, and difficult to distinguish using light microscopy.
   B. The presence of the plasma membrane can be inferred by the well-defined boundary of the cell.
   C. The cytosol is fairly empty, containing a limited number of organelles, which allows room for rapid movement via diffusion.
   D. The extracellular matrix is the space between individual cells and is exclusively composed of proteins.

   ANS:
   A. False. The nucleus is one of the largest organelles and is the easiest organelle to discern within a typical cell.
   B. True
   C. False. The cytosol is actually brimming with individual proteins, protein fibers, extended membrane systems, transport vesicles, and small molecules. And although cellular components do move by diffusion, the rate of movement is limited by the space available and the size of the component in question.
   D. False. The extracellular matrix contains small molecules, protein fibers, and a dense matrix of sugar chains.
   DIF: Easy REF: 1.4 OBJ: 1.4.a State the function of the nucleus and describe its structural features. | 1.4.h Relate the location of the cytosol with respect to the cell's membrane-enclosed organelles. MSC: Evaluating

5. Describe the benefits and limitations of utilizing electron microscopy to understand biological systems.

   ANS: Electron microscopy can provide biologists with the highest sample magnification and resolution in the nanometer range. Samples must be fixed, preventing researchers from observing living cells.
   DIF: Easy REF: 1.2 OBJ: 1.2.b Contrast light microscopy, high-resolution fluorescence light microscopy, and electron microscopy in terms of the cell components that can generally be distinguished using each. | 1.2.c Compare how samples are prepared for light versus electron microscopy and explain how these preparations affect whether the technique can be used for viewing living cells or tissues. MSC: Understanding

6. Indicate whether the following statements are TRUE or FALSE. If the statement is false, explain why it is false.
   A. The terms "prokaryote" and "bacterium" are synonyms.
   B. Prokaryotes can adopt several different basic shapes, including spherical, rod-shaped, and spiral.
   C. Some prokaryotes have cell walls surrounding the plasma membrane.
   D. Oxygen is toxic to certain prokaryotic organisms.
   E. Mitochondria are thought to have evolved from anaerobic bacteria.
   F. Photosynthetic bacteria contain chloroplasts.

   ANS:
   A. False. Archaea make up a class of prokaryotic organisms that are significantly different from bacteria.
   B. True
   C. True
   D. True
   E. False. Mitochondria use oxygen to generate energy and are thought to have evolved from aerobic bacteria.
   F. False. Photosynthetic bacteria have enzyme systems similar to those found in chloroplasts, which allow them to harvest light energy to fix carbon dioxide.
   DIF: Easy REF: 1.3 OBJ: 1.3.a Express the structural differences between prokaryotes and eukaryotes. | 1.3.d Summarize the division of prokaryotes into bacteria and archaea. | MSC: Evaluating

7. For each of the following sentences, fill in the blanks with the best word or phrase selected from the list below. Not all words or phrases will be used; each word or phrase should be used only once.

chloroplast	cytosol	nucleus
chromosome	endoplasmic reticulum	ribosomes
cytoskeleton	mitochondrion	

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Eukaryotic cells are bigger and more elaborate than prokaryotic cells. By definition, all eukaryotic cells have a _____, usually the most prominent organelle. Another organelle found in essentially all eukaryotic cells is the _____, which generates the chemical energy for the cell. In contrast, the _____ is a type of organelle found only in the cells of plants and algae, and performs photosynthesis. If we were to strip away the plasma membrane from a eukaryotic cell and remove all of its membrane-enclosed organelles, we would be left with the _____, which contains many long, fine filaments of protein that are responsible for cell shape and structure, and thereby form the cell's _____.

ANS: Eukaryotic cells are bigger and more elaborate than prokaryotic cells. By definition, all eukaryotic cells have a **nucleus**, usually the most prominent organelle. Another organelle found in essentially all eukaryotic cells is the **mitochondrion**, which generates the chemical energy for the cell. In contrast, the **chloroplast** is a type of organelle found only in the cells of plants and algae, and performs photosynthesis. If we were to strip away the plasma membrane from a eukaryotic cell and remove all of its membrane-enclosed organelles, we would be left with the **cytosol**, which contains many long, fine filaments of protein that are responsible for cell shape and structure and thereby form the cell's **cytoskeleton**.
DIF: Easy REF: 1.4 OBJ: 1.4.a State the function of the nucleus and describe its structural features. | 1.4.d Explain how chloroplasts and mitochondria cooperate as plant cells convert light energy into chemical energy. | 1.4.h Relate the location of the cytosol with respect to the cell's membrane-enclosed organelles. MSC: Understanding

8. You fertilize egg cells from a healthy plant with pollen (which contains the male germ cells) that has been treated with DNA-damaging agents. You find that some of the offspring have defective chloroplasts, and that this characteristic can be passed on to future generations. This surprises you at first because you happen to know that the male germ cell in the pollen grain contributes no chloroplasts to the fertilized egg cell and thus to the offspring. What can you deduce from these results?

   ANS: Your results show that not all of the information required for making a chloroplast is encoded in the chloroplast's own DNA; some, at least, must be encoded in the DNA carried in the nucleus. The reasoning is as follows. Genetic information is carried only in DNA, so the defect in the chloroplasts must be due to a mutation in DNA. But all of the chloroplasts in the offspring (and thus all of the chloroplast DNA) must derive from those in the female egg cell, since chloroplasts only arise from other chloroplasts. Hence, all of the chloroplasts contain undamaged DNA from the female parent's chloroplasts. In all the cells of the offspring, however, half of the nuclear DNA will have come from the male germ-cell nucleus, which combined with the female egg nucleus at fertilization. Since this DNA has been treated with DNA-damaging agents, it must be the source of the heritable chloroplast defect. Thus, some of the information required for making a chloroplast is encoded by the nuclear DNA.
   DIF: Difficult REF: 1.1 OBJ: 1.1.d Summarize how the processes of mutation and selection promote the gradual evolution of individuals best suited for survival in a wide range of habitats. MSC: Applying

9. Indicate whether the following statements are TRUE or FALSE. If the statement is false, explain why it is false.
   A. With respect to cellular respiration, the only organelles used by animal cells are mitochondria, while plant cells use both mitochondria and chloroplasts.
   B. The number of mitochondria inside a cell remains constant over the life of the cell.
   C. Membrane components in the cell are made in the endoplasmic reticulum.
   D. The Golgi apparatus is made up of a series of membrane-enclosed compartments through which materials destined for secretion must pass.
   E. Lysosomes are small organelles where fatty acid synthesis occurs.

   ANS:
   A. False. In plants, only mitochondria perform cellular respiration (using oxygen to break down organic molecules to produce carbon dioxide) just as in animal cells. Chloroplasts perform photosynthesis in which water molecules are split to generate oxygen and fix carbon dioxide molecules.
   B. False. Mitochondria have their own division cycle and their numbers change based on the rate of division.
   C. True
   D. True
   E. False. Lysosomes house enzymes that break down nutrients for use by the cell and help recycle materials that cannot be used, which will later be excreted from the cell.

   DIF: Moderate REF: 1.4 OBJ: 1.4.d Explain how chloroplasts and mitochondria cooperate as plant cells convert light energy into chemical energy. | 1.4.e Compare the function of lysosomes and peroxisomes. | 1.4.f Compare the structure, location, and function of the endoplasmic reticulum and Golgi apparatus. MSC: Evaluating

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10. Number the following cells based on when they are believed to have evolved.
    ___ anaerobic eukaryote
    ___ aerobic prokaryote
    ___ anaerobic prokaryote
    ___ photosynthetic eukaryote
    ___ aerobic eukaryote
    ___ photosynthetic prokaryote

    ANS:
    _2_ anaerobic eukaryote
    _4_ aerobic prokaryote
    _1_ anaerobic prokaryote
    _6_ photosynthetic eukaryote
    _5_ aerobic eukaryote
    _3_ photosynthetic prokaryote
    DIF: Difficult REF: 1.3 OBJ: 1.3.b Analyze how eukaryotic cells and organisms rely on the function of prokaryotic cells and their descendants. MSC: Analyzing

11. The protozoan *Didinium* feeds on other organisms by engulfing them. Describe the cellular characteristics necessary to feed this way and explain why this is not a mechanism by which bacteria can acquire energy. Are bacteria, in general, unable to feed on other cells in this way?

    ANS: For *Didinium* to engulf its prey, it needs to be larger than the cellular target, it needs to be mobile, and it needs to be able to change its shape. Movement and changing shape requires a flexible membrane and a dynamic cytoskeleton. By comparison, Bacteria are small, have no cytoskeleton and cannot easily change their shape because they are generally surrounded by a rigid cell wall.
    DIF: Difficult REF: 1.4 OBJ: 1.3.a Express the structural differences between prokaryotes and eukaryotes.
    MSC: Analyzing

12. Indicate whether the following statements are TRUE or FALSE. If the statement is false, explain why it is false.
    A. Plants do not require a cytoskeleton because they have a cell wall that lends structure and support to the cell.
    B. The cytoskeleton is used as a transportation grid for the efficient, directional movement of cytosolic components.
    C. Thermal energy promotes random movement of proteins, vesicles, and small molecules in the cytosol.

    ANS:
    A. False. Although plant cells do have a cell wall that lends structure and support, they still need a cytoskeleton, which also helps with connections between cells and the transport of vesicles inside the cell.
    B. True
    C. True
    DIF: Easy REF: 1.4 OBJ: 1.4.j Outline the role the cytoskeleton plays in plant cells. MSC: Evaluating

13. Indicate whether the following statements are TRUE or FALSE. If the statement is false, explain why it is false.
    A. Primitive plant, animal, and fungal cells probably acquired mitochondria after they diverged from a common ancestor.
    B. Protozoans are single-celled eukaryotes with cell morphologies and behaviors that can be as complex as those of some multicellular organisms.
    C. The first eukaryotic cells on Earth must have been aerobic; otherwise, they would not have been able to survive when the planet's atmosphere became oxygen-rich.

    ANS:
    A. False. The mitochondria in modern plant, animal, and fungal cells are very similar, implying that these lines diverged after the mitochondrion was acquired by the ancestral eukaryote.
    B. True
    C. False. The first eukaryotic cells likely contained a nucleus but no mitochondria. These ancestral eukaryotes subsequently adapted to survive in a world filled with oxygen by engulfing primitive aerobic prokaryotic cells.
    DIF: Easy REF: 1.4 OBJ: 1.4.k Describe the ancestral cell that likely engulfed the aerobic bacteria that gave rise to mitochondria and explain why this event is thought to have preceded the acquisition of chloroplasts.
    MSC: Evaluating

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14. Given what you know about the differences between prokaryotic cells and eukaryotic cells, rate the following biological processes as "suitable" or "unsuitable" for study using *E. coli* as the model organism. Provide a short explanation for each answer.
    1. formation of the endoplasmic reticulum
    2. DNA replication
    3. how the actin cytoskeleton contributes to cell shape
    4. how cells decode their genetic instructions to make proteins
    5. how mitochondria get distributed to cells during cell division

    ANS:
    1. Unsuitable because prokaryotes do not have organelles.
    2. Suitable because DNA replication is a process that that occurs in all cells.
    3. Unsuitable because prokaryotes lack cytoskeletons.
    4. Suitable because the genetic code and the processes of transcription and translation is highly conserved across all species.
    5. Unsuitable because prokaryotes do not have organelles—mitochondria are thought to be derived from early aerobic bacteria, and may be instead suitable for studying the mechanism for consuming oxygen to generate ATP.

    DIF: Moderate REF: 1.3 OBJ: 1.3.a Express the structural differences between prokaryotes and eukaryotes. MSC: Evaluating

15. For each process (A–D), identify the simplest model organism from the list of three that would be best used for investigation:

	process	model organism		
A	programmed cell death	*E. coli*	yeast	*C. elegans*
B	chloroplast function	*C. elegans* *Drosophila*	*Arabidopsis*	
C	immunology	mouse *Arabidopsis*	yeast	
D	development of a multicellular tissue	*Drosophila*	*E. coli*	yeast

Figure 1-57

    ANS:
    (A) *C. elegans*
    (B) *Arabidopsis*
    (C) mouse
    (D) *Drosophila*

    DIF: Easy REF: 1.5 OBJ: 1.5.a Review why scientists study model organisms. | 1.5.c Compare flies, worm, fish, and mice as model organisms and name a benefit of studying each. MSC: Analyzing

16. You wish to explore how mutations in specific genes affecting sugar metabolism might alter tooth development. Which organism is likely to provide the best model system for your studies, and why?
    a. horses
    b. mice
    c. *E. coli*
    d. *Arabidopsis*

    ANS: (B) Mice are likely to provide the best model system. Mice have teeth and have long been used as a model organism. Mice reproduce relatively rapidly, and the extensive scientific community that works with mice has developed techniques to facilitate genetic manipulations. *E. coli* (a bacterium) and *Arabidopsis* (a plant) do not have teeth. Horses like sugar and have big teeth, but they would not be a good model organism. There is not an extensive scientific community working on the molecular and biochemical mechanisms of cell behaviors in horses; they are expensive and have a long reproduction time, which makes genetic studies costly and slow; and tools for genetic manipulation (other than traditional breeding) have not been developed.

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DIF: Easy REF: 1.5 OBJ: 1.5.c Compare flies, worm, fish, and mice as model organisms and name a benefit of studying each. MSC: Evaluating

17. Indicate whether the following statements are TRUE or FALSE. If the statement is false, explain why it is false.
    A. The human genome is roughly 30 times larger than the *Arabidopsis* genome, but contains approximately the same number of protein-coding genes.
    B. The variation in genome size among protozoans is larger than that observed across all species of mammals, birds, and reptiles.
    C. The vast majority of our genome encodes functional RNA molecules or proteins and most of the intervening DNA is nonfunctional.

    ANS:
    A. True
    B. True
    C. False. It is a relatively small proportion of our DNA that encodes RNA and protein molecules. The majority of non-encoding sequences is probably involved in critical regulatory processes.

    DIF: Difficult REF: 1.5 OBJ: 1.5.g Summarize the roles played by the nucleotide sequences contained in an organism's genome. | 1.5.e Assess the relationship between genome size and gene number. MSC: Evaluating

18. Genes that have homologs in a variety of species have been discovered through the analysis of genome sequences. In fact, it is not uncommon to find a family of homologous genes encoding proteins that are unmistakably similar in amino acid sequence in organisms as diverse as budding yeast, archaea, plants, and humans. Even more remarkably, many of these proteins can substitute functionally for their homologs in other organisms (i.e., if we delete a native gene and replace it with a homologous gene from another species, the protein will be produced and its function preserved). Use your understanding of evolution to explain how this is possible.

    ANS: All living beings on Earth (and thus, all cells) are thought to be derived from a common ancestor. Solutions to many of the essential challenges that face a cell (such as the synthesis of proteins, lipids, and DNA) seem to have been achieved in this ancient common ancestor. The ancestral cell therefore possessed sets of proteins to carry out these essential functions. Many of the essential challenges facing modern-day cells are the same as those facing the ancestral cell, and the ancient solutions are often still effective. Thus, it is not uncommon for organisms to use proteins and biochemical pathways inherited from their ancestors. Although these proteins usually show some species-specific diversification, they still retain the basic biochemical characteristics of the ancestral protein. For example, homologous proteins often retain their ability to interact with a specific protein target, even in cells of diverse species. Because the basic biochemical characteristics are retained, homologous proteins are often capable of functionally substituting for one another.
    DIF: Moderate REF: 1.5 OBJ: 1.5.f Classify the nature of homologous genes and proteins. MSC: Evaluating

19. Match each biological process with the model organism that is best suited or most specifically useful for its study, based on information provided in your textbook. You may use individual processes more than once and more than one process can be matched with each organism.
    A. cell division
    B. development (multicellular)
    C. programmed cell death
    D. photosynthesis
    E. immunology

    1. _____ *A. thaliana* (*Arabidopsis*)
    2. _____ *M. musculus* (mouse)
    3. _____ *S. pombe*
    4. _____ *C. elegans*
    5. _____ *S. cerevisiae*
    6. _____ *D. rerio* (zebrafish)
    7. _____ *D. melanogaster*

    1. ANS: B, D *A. thaliana* (*Arabidopsis*)
    2. ANS: B, E *M. musculus* (mouse)
    3. ANS: A *S. pombe*

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4. ANS: C *C. elegans*
5. ANS: A *S. cerevisiae*
6. ANS: B *D. rerio* (zebrafish)
7. ANS: B *D. melanogaster*

DIF: Easy REF: 1.5 OBJ: 1.5.a Review why scientists study model organisms | 1.5.c Compare flies, worm, fish, and mice as model organisms and name a benefit of studying each. MSC: Analyzing

20. Generate an analogy to describe the cell as the simplest unit of life to somebody who has not studied biology. Be sure to incorporate the observable features of living organisms, which distinguishes them from inanimate objects.

    ANS: Cities, factories, other types of human communities provide good models for analogical thinking about cells and organisms. Key elements that should be included are: Organization: Cities have organizational requirements for delivery of water, heat, and light, and for determining how things are moving/transported.
    Homeostasis: An example would include snow removal from city streets and thermostat-controlled temperatures inside buildings. Homeostasis also can include waste removal (sewers and garbage trucks).
    Reproduction: Blueprints and structural information for an entire city could be used to create a replica of any city.
    Growth and development: Cities grow in response to increases in population. Resources are expended to build new dwellings and increase the capacity to provide energy to them.
    DIF: Moderate REF: 1.1 OBJ: 1.1.b Outline, with examples, ways in which cells share a basic fundamental chemistry. MSC: Creating

21. Employ the principles of evolution discussed in this chapter to explain how the specific features and predatory behaviors of some primitive eukaryotes may have given them a selective advantage over others 1.5 billion years ago.

    ANS: The Earth's atmosphere became oxygen-rich roughly 1.5 billion years ago. If some primitive predatory eukaryotic cells were similar to modern-day protozoans, they may have been mobile and able to engulf other cells. These characteristics would have been advantageous in the face of a changing atmosphere, and the establishment of a symbiotic relationship with an engulfed aerobe would have been selected for in the eukaryotic cell populations.
    DIF: Difficult REF: 1.4 OBJ: 1.4.k Describe the ancestral cell that likely engulfed the aerobic bacteria that gave rise to mitochondria and explain why this event is thought to have preceded the acquisition of chloroplasts. MSC: Applying

22. Evolutionary biologists have always used a broad range of modern organisms to infer the characteristics that ancestral organisms may have possessed. Genomic sequences are now available for an increasing number of species, and scientists studying evolutionary processes can take advantage of this enormous amount of data to bring evolution into the arena of molecular studies. By aligning the sequences of homologous genes and looking for regions of similarity and where changes have occurred, it is possible to infer the sequence of the ancestral gene.
    A. What term is used to describe the changes in gene sequences that have occurred? How can we use what we know about this process to construct a time line showing when various sequence changes occurred and when they led to the modern sequences that we know today?
    B. It is possible to express an ancestral gene sequence in modern organisms and subsequently compare the function of its product with that of the modern protein. Why might this approach give misleading conclusions?

    ANS:
    A. Changes in gene sequence occur through mutation. Mutations accumulate over time, occurring independently and at different sites in each gene lineage. Homologous genes that diverged recently will differ only slightly; genes that diverged long ago will differ more. Knowing the average mutation rate, you can estimate the time that has elapsed since the different versions of the gene diverged. By seeing how closely the various members of the family of homologous genes resemble one another, you can draw up a family tree, showing the sequence of lineage splits that lead from the ancestral gene to its many modern descendants. Suppose this family tree shows that family members A and B diverged from one another long ago, but that C diverged from B more recently; and suppose that at a certain site in the gene, A and B have the same sequence but C is different. Then, it is likely that the sequence of A and B is ancestral, while that of C reflects a recent mutation that has occurred in the lineage of C alone.
    B. Although an inferred ancestral sequence can be reconstructed, and the protein expressed, you would be placing an inferred, ancient protein in the context of a modern cell. If there are important interacting partners for the modern protein, there is a chance they may not recognize the ancestral protein, and therefore any information about its function may be inaccurate.

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DIF: Difficult REF: 1.5 OBJ: 1.5.f Classify the nature of homologous genes and proteins. | 1.5.g Summarize the roles played by the nucleotide sequences contained in an organism's genome. MSC: Evaluating

23. The antibiotic streptomycin inhibits protein synthesis in bacteria. If this antibiotic is added to a culture of animal cells, protein synthesis in the cytosol continues normally. However, over time, the population of mitochondria in the cell becomes depleted. Specifically, it is observed that the protein-synthesis machinery inside the mitochondria is inhibited.
    A. Explain this observation based on what you know about the origins of the modern eukaryote.
    B. What do you expect to observe if, in a new experiment, animal cells are treated with diphtheria toxin, a compound that is known to block cytosolic protein synthesis but does not have any impact on bacterial growth?

    ANS:
    A. If the mitochondria originated from an ancient aerobic bacterium that was engulfed by an ancient eukaryote, as postulated, it is possible that an antibiotic that inhibits protein synthesis in bacteria could also block that process in mitochondria.
    B. We would expect that although cytosolic protein synthesis would stop, mitochondrial protein synthesis should still occur normally (at least for a little while). This result would lend further support to the idea that mitochondria are derived from a noneukaryotic organism. If this were not the case, these compounds would be expected to affect protein synthesis at both locations.

    DIF: Difficult REF: 1.4 OBJ: 1.4.k Describe the ancestral cell that likely engulfed the aerobic bacteria that gave rise to mitochondria and explain why this event is thought to have preceded the acquisition of chloroplasts.
    MSC: Applying

24. You have been following the recent presidential elections and have heard some candidates disparaging excessive and "unnecessary" federal government expenditures. One particular candidate asks: "Why are we spending millions of dollars studying fruit flies? How can that possibly help us find a cure for cancer?" Use your knowledge of model organisms to explain why studies in *D. melanogaster* (the fruit fly) are actually an excellent use of research funding.

    ANS: Funding research on *D. melanogaster* is a worthwhile investment for several reasons: (1) working with insect animal models is relatively inexpensive; (2) fruit flies have historically proven useful in helping understand eukaryotic chromosome behavior; and (3) many of the genes in *Drosophila* are highly similar in sequence to the homologous human genes, and thus can be used to study human diseases.
    DIF: Moderate REF: 1.5 OBJ: 1.5.a Review why scientists study model organisms. | 1.5.c Compare flies, worm, fish, and mice as model organisms and name a benefit of studying each. MSC: Evaluating

25. Cellular processes are often regulated by unknown mechanisms. In many cases, biologists work backward in an attempt to understand a process in which they are interested. This was the case when Nurse and Hartwell were trying to understand how cell division is controlled in yeast. Describe the process by which they "broke" the system and then supplied the "missing parts" to get the cell cycle running again. What further evidence did they collect to show that human cells and yeast cells regulate the cell cycle using a similar mechanism?

    ANS: Nurse and Hartwell first treated yeast cells with a chemical mutagen. The mutated population of cells was then grown and observed. Cells that demonstrated defects in cell-cycle regulation (characterized by cell-cycle arrest, larger-than-normal cells, and smaller-than-normal cells) were then isolated. The use of a library of plasmids that each express a normal gene from yeast cells allowed the scientists to identify exactly which gene could be used to "rescue" the mutant, because when the normal gene is expressed again, the cells return to a normal cell cycle. After this big result, the scientists went on to show that the homologous gene from other organisms could also rescue the mutant phenotype. The most exciting result was obtained with the human version of the *cdc2* gene, which demonstrated that there are common principles underlying cell-cycle regulation across a large range of eukaryotic organisms.
    DIF: Moderate REF: 1.5 OBJ: 1.5.a Review why scientists study model organisms. | 1.5.f Classify the nature of homologous genes and proteins. | 1.5.h Outline an experiment that would allow investigators to determine whether proteins from different eukaryotes are functionally interchangeable. MSC: Understanding

26. Your friend has just returned from a deep-sea mission and claims to have found a new single-celled life form. He believes this new life form may not have descended from the common ancestor that all types of life on Earth share. You are convinced that he must be wrong, and you manage to extract DNA from the cells he has discovered. He says that the mere presence of DNA is not enough to prove the point: his cells might have adopted DNA as a useful molecule quite independently of all other known life-forms. What could you do to provide additional evidence to support your argument?

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ANS: You could use modern technology to discover the sequence of the DNA. If you are right, you would expect to find parts of this sequence that are unmistakably similar to corresponding sequences in other, familiar, living organisms; it would be highly improbable that such similar sequences would have evolved independently. You could, of course, also analyze other features of the chemistry of his cells; for example, do they contain proteins made of the same set of 20 amino acids? This could all be supporting evidence that this newly discovered species arose from the same common ancestral cells as all other life on Earth.
DIF: Easy REF: 1.5 OBJ: 1.5.f Classify the nature of homologous genes and proteins. | 1.5.g Summarize the roles played by the nucleotide sequences contained in an organism's genome. MSC: Applying

27. Draw and annotate a diagram that explains how living systems are autocatalytic.

ANS: Use Figure 4.1 for reference. Important points for student annotations should include:

- Nucleotides are building blocks for DNA and RNA.
- RNA polynucleotides contain ordered information templating the assembly of amino acids into functional proteins.
- Some proteins are catalysts necessary to produce DNA and RNA from individual nucleotides.

DIF: Easy REF: 1.1 OBJ: 1.1.c Explain how the relationship between DNA, RNA, and protein—as laid out in the central dogma—makes the self-replication of living cells possible. MSC: Creating

28. Use the list of structures below to label the schematic drawing of an animal cell in Figure 1-41.

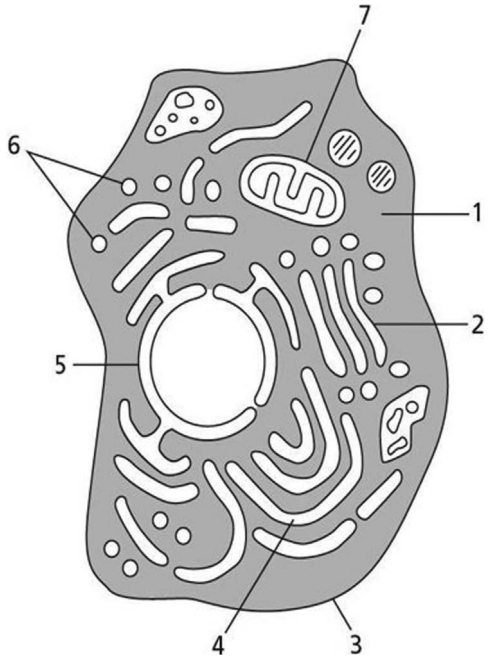


Figure 1-41

A. plasma membrane
B. nuclear envelope
C. cytosol
D. Golgi apparatus
E. endoplasmic reticulum
F. mitochondrion
G. transport vesicles

ANS:
A. plasma membrane—3
B. nuclear envelope—5
C. cytosol—1

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D. Golgi apparatus—2
E. endoplasmic reticulum—4
F. mitochondrion—7
G. transport vesicles—6

DIF: Easy REF: 1.4 OBJ: 1.4.f Compare the structure, location, and function of the endoplasmic reticulum and Golgi apparatus. | 1.4.h Relate the location of the cytosol with respect to the cell's membrane-enclosed organelles.
MSC: Remembering

29. Identify the appropriate cell type in which the listed structure or molecule can be found. Note that the structure or molecule can be found in more than one type of cell.

	structure or molecule	cell type		
1	DNA	animal	plant	bacterial
2	nucleus	animal	plant	bacterial
3	plasma membrane	animal	plant	bacterial
4	chloroplast	animal	plant	bacterial
5	cell wall	animal	plant	bacterial
6	lysosome	animal	plant	bacterial
7	mitochondrion	animal	plant	bacterial
8	Golgi apparatus	animal	plant	bacterial

Figure 1-71

ANS:

1	animal	plant	bacterial
2	animal	plant	
3	animal	plant	bacterial
4		plant	bacterial
5		plant	bacterial
6	animal	plant	
7	animal	plant	
8	animal	plant	

Figure 1-71A

DIF: Easy REF: 1.3 OBJ: 1.3.a Describe the structural differences between prokaryotes and eukaryotes.
MSC: Analyzing

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