CHAPTER 1
INTRODUCTION TO CELLS

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Unity and Diversity of Cells

1-1 The smallest unit of life is a(n)
(a) DNA molecule.
(b) cell.
(c) organelle.
(d) virus.
(e) protein.

1-2 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.

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 one _____. Despite the diversity, cells resemble each other to an astonishing degree in their chemistry. For example, the same twenty _____ are used to make proteins. Similarly, the genetic information of all cells is stored in their _____. Although _____ contain the same type of molecules as cells, their inability to reproduce themselves by their own efforts means that they are not considered living matter.

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

1-3 Which of the following statements about the basic chemistry of cells is TRUE?
(a) All cells contain exactly the same proteins.
(b) All proteins are constructed from the same 22 amino acids.
(c) The genetic instructions in all cells are stored in DNA.
(d) All organisms contain the same genes.
(e) All of the above

1-4 Which of the following statements is TRUE?
(a) Mutations are always harmful to an organism.
(b) Mutation is essential for evolution to occur.
(c) Mutation is the only source of genetic differences between parents and offspring in plants and animals.
(d) Mutation always leads to evolution.
(e) Mutations always lead to evolutionary "dead ends."

Cells Under the Microscope

1-5 What unit of length would you generally use to give the measurements of a typical human cell?
(a) Centimeters
(b) Nanometers
(c) Millimeters
(d) Micrometers

1-6 A. What sets the limit on the size of structure that can be seen in a light microscope?
B. Why are tissues usually cut into thin sections and stained before examination under a light microscope?

1-7 State whether you would use a **phase-contrast light microscope**, a **fluorescence microscope**, an **electron microscope**, or **none of the above** to do the following things:
A. look at unstained living animal cells.
B. look at ribosomes.
C. look at an electron.
D. look at a living cell expressing green fluorescent protein.
E. do confocal microscopy.

The Procaryotic Cell

1-8 Which of the following statements concerning procaryotes are TRUE?
(a) They have no nucleus and hence no DNA.
(b) They have no Golgi apparatus.
(c) They can form simple multicellular organisms.
(d) They include bacteria, yeast, and protozoans.
(e) They are all able to live on inorganic energy sources.

The Eucaryotic Cell

1-9 The most reliable feature distinguishing a eucaryotic cell from a procaryotic cell is the
(a) presence of a plasma membrane.
(b) presence of a nucleus.
(c) eucaryotic cell's larger size.
(d) presence of DNA.

1-10 Correct each of the following so that it becomes a TRUE statement about mitochondria.

A. Mitochondria take in carbon dioxide and release oxygen.
B. ADP is synthesized from ATP in mitochondria.
C. Mitochondria are enclosed by two membranes, the outer one of which is highly folded.
D. Mitochondria are thought to be derived from photosynthetic bacteria.
E. Mitochondria are found in aerobic procaryotes.

1-11 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.

> Eucaryotic cells are bigger and more elaborate than procaryotic cells. By definition, all eucaryotic cells have a _____, usually the most prominent organelle in the eucaryotic cell. Another organelle found in essentially all eucaryotic cells is the _____, which generates the chemical energy for the cell. On the other hand, a(n) _____ can be found only in the cells of plants and algae, and performs photosynthesis. If we were to strip away the plasma membrane from a eucaryotic 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 _____.

chloroplast	cytosol	nucleus
chromosome	endoplasmic reticulum	ribosomes
cytoskeleton	mitochondrion	

1-12 On the schematic drawing of an animal cell in Figure Q1-12 match the labels given in the list below to the numbered label lines.

A. Plasma membrane
B. Nuclear envelope
C. Cytosol
D. Golgi apparatus
E. Endoplasmic reticulum

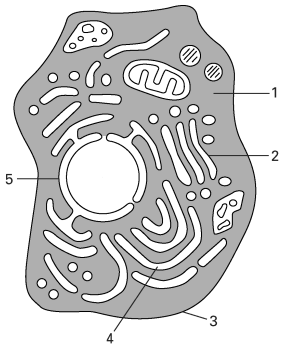

Figure Q1-12

1-13 In an aerobic bacterium, where do you think most of the proteins responsible for cellular respiration are located?

1-14 Which one of the following statements is TRUE for mitochondria only, and not for both mitochondria and chloroplasts?

(a) They are enclosed by a double membrane.
(b) They are thought to be derived from procaryotes.
(c) They cannot grow and reproduce when isolated from the cell.
(d) They reproduce by dividing in two.
(e) They are found in all aerobic eucaryotic cells.

1-15 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?

1-16 Which of the following organelles is surrounded by two layers of membrane?

(a) Endoplasmic reticulum
(b) Nucleus
(c) Lysosome
(d) Peroxisome
(e) Vacuole

1-17 In a eucaryotic cell specialized for secretion, which internal organelles would you expect to be particularly abundant?

1-18 From the list below, select the THREE cellular structures or compartments that are found in all cells.

(a) Nucleus
(b) Ribosomes
(c) Cytosol
(d) Mitochondria
(e) Chloroplasts
(f) Plasma membrane
(g) Endoplasmic reticulum
(h) Lysosomes

1-19 You have grown a culture of human cells and discover that it is heavily contaminated with bacteria. Which of the following procedures will most likely eliminate the bacteria without killing the human cells?

(a) Treating the culture with a drug that causes microtubules to fall apart.
(b) Diluting a small portion of the contaminated culture with 1000 times as much fresh nutrient broth and regrowing the cells.
(c) Treating the culture with a drug that damages DNA.
(d) Treating the culture with a drug that dissolves cell walls.
(e) Treating the culture with a detergent that destroys cell membranes.

1-20 Circle 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		
A.	DNA	animal	plant	bacterial
B.	nucleus	animal	plant	bacterial
C.	plasma membrane	animal	plant	bacterial
D.	chloroplast	animal	plant	bacterial
E.	cell wall	animal	plant	bacterial
F.	lysosome	animal	plant	bacterial
G.	mitochondrion	animal	plant	bacterial
H.	Golgi apparatus	animal	plant	bacterial

1-21 The protozoan *Didinium* feeds on other organisms by engulfing them. Why are bacteria, in general, unable to feed on other cells in this way?

1-22 The specialized cell types in the body of a multicellular organism are different from each other chiefly because

(a) each cell type contains different genes.
(b) different genes are switched on in different cell types.
(c) some cell types have lost some of the genes that were present in the fertilized egg.
(d) the fertilized egg divides by cell divisions that do not give rise to genetically identical cells.
(e) the different cell types contain fundamentally different organelles.

1-23 List the following items in order of size from the smallest to the largest.

A. Protein molecule
B. Human fat cell
C. Carbon atom
D. Ribosome
E. Yeast cell
F. Mitochondrion

Model Organisms

1-24 Given what you know about the differences between procaryotic cells and eucaryotic cells, rate the following things as "good" or "bad" processes to study in the model organism, *E. coli*.

A. formation of the endoplasmic reticulum
B. DNA replication
C. how the actin cytoskeleton contributes to cell shape
D. how cells decode their genetic instructions to make proteins
E. how mitochondria get distributed to cells during cell division

1-25 A. In what way does a fungal cell structurally resemble a plant cell, rather than an animal cell?

B. Which principal organelle does a plant cell contain that a fungal cell does not?

1-26 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) Humans
(b) Mice
(c) *E. coli*
(d) *Arabidopsis*
(e) Gorillas

1-27 Circle the simplest model organism best used to study the following processes:

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

1-28 When the genomes of distantly related organisms, such as a fly and a mouse, are compared, they are found to contain some genes that encode proteins with almost identical amino acid sequences. Explain how this happens.

1-29 Genes that have homologues in a variety of species have been discovered through the analysis of genome sequences. In fact, it is not uncommon for a homologous gene to encode a protein that looks similar in amino acid sequence in organisms as diverse as budding yeast, archeons, plants, and humans. Even more remarkably, many of these proteins can functionally substitute for their homologues in other organisms. Explain what it is about the origins of cells that makes it possible for proteins expressed by homologous genes to be functionally interchangeable in different organisms.

1-30 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. However, he's never taken Cell Biology, so he asks you determine whether his claim is true. In order to verify or dispute your friend's claim, you realize that you must first make a list of characteristics common to all procaryotes and eucaryotes, so that you can check whether this new life form is similar or different from all other types of life on Earth. Name two basic characteristics that you could check to distinguish all procaryotes and eucaryotes from newly derived life forms.

How We Know: Life's Common Mechanisms

1-31 One effective strategy for investigating how a particular cellular process works is to identify the gene required for the process to be carried out normally. A common technique used to identify these genes is to isolate organisms that are defective in particular cellular functions by randomly inducing mutations in individual genes. When a gene is mutant, the protein encoded by this gene no longer functions, and the organism shows a defect in the cellular function of interest; these organisms are considered mutants. Thus, scientists look for mutant organisms whose cells cannot carry out the process of interest and then determine the identity of the gene whose function has been altered. Sometimes scientists are interested in studying processes that are essential to the cell (required for the cell to live). Explain what temperature-sensitive mutants are and why they are helpful for the study of essential processes, especially in single-celled organisms such as yeast and bacteria.

Answers

1-1 (b)

1-2 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 one **millimeter**. Despite the diversity, cells resemble each other to an astonishing degree in their chemistry. For example, the same twenty **amino acids** are used to make proteins. Similarly, the genetic information of all cells is stored in their **DNA**. Although **viruses** contain the same type of molecules as cells, their inability to reproduce themselves by their own efforts means that they are not considered living matter.

1-3 (c)

1-4 (b)

1-5 (d)

1-6
A. The wavelength of visible light.
B. Most tissues are not transparent enough to be examined directly in a light microscope. Transparency is increased by slicing them into thin sections, and staining shows the different cellular structures in contrasting colors.

1-7
A. phase-contrast light microscope
B. electron microscope
C. none of the above
D. fluorescence microscope
E. fluorescence microscope

1-8 (b) and (c)

1-9 (b)

1-10
A. Mitochondria take in **oxygen** and release **carbon dioxide**.
B. **ATP** is synthesized from **ADP** in mitochondria.
C. Mitochondria are enclosed by two membranes, the **inner** one of which is highly folded.
D. Mitochondria are thought to be derived from **aerobic** bacteria.
E. Mitochondria are found in aerobic **eucaryotes**.

1-11 Eucaryotic cells are bigger and more elaborate than procaryotic cells. By definition, all eucaryotic cells have a **nucleus**, usually the most prominent organelle in the eucaryotic cell. Another organelle found in essentially all eucaryotic cells is the **mitochondrion**, which generates the chemical energy for the cell. On the other hand, a(n) **chloroplast** can be found only in the cells of plants and algae, and performs photosynthesis. If we were to strip away the plasma membrane from a eucaryotic 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**.

1-12 A. Plasma membrane—3
B. Nuclear envelope—5
C. Cytosol—1;
D. Golgi apparatus—2
E. Endoplasmic reticulum—4

1-13 In the plasma membrane. According to the theory of mitochondrial origin outlined in this chapter, the plasma membrane of the engulfed bacterium would become the inner mitochondrial membrane, where most of the proteins involved in cellular respiration are located.

1-14 (e)

1-15 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 only carried in DNA, thus 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.

1-16 (b)

1-17 the endoplasmic reticulum and the Golgi apparatus

1-18 (b), (c), and (f)

1-19 (d) Bacteria have cell walls, whereas mammalian cells do not.

1-20

A.	animal	plant	bacterial
B.	animal	plant	
C.	animal	plant	bacterial
D.		plant	bacterial
E.		plant	bacterial
F.	animal	plant	
G.	animal	plant	
H.	animal	plant	

1-21 *Didinium* engulfs prey by changing its shape, and for this it uses its cytoskeleton. Bacteria have no cytoskeleton, and cannot easily change their shape because they are generally surrounded by a tough cell wall.

1-22 (b)

1-23 1—C, 2—A, 3—D, 4—F, 5—E, 6—B

1-24
A. bad
B. good
C. bad
D. good
E. bad

1-25
A. Like plant cells, fungal cells have cell walls.
B. Chloroplasts

1-26 (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 on mice have developed techniques to facilitate genetic manipulations.
Humans are not a model system. *E. coli* (a bacterium) and *Arabadopsis* (a plant) do not have teeth. Gorillas, although they have teeth, would not be a good model organism for many reasons. First, there is not an extensive scientific community working on the molecular and biochemical mechanisms of cellular behaviors in gorillas. Second, gorillas are expensive to house and, thus, perform experiments on. Third, gorillas do not reproduce rapidly, a characteristic desirable in model organisms. Finally, techniques for facile genetic manipulations on gorillas have not been extensively developed.

1-27
A. *C. elegans*
B. *Arabidopsis*
C. mouse
D. *Drosophila*

1-28 All living organisms are descended from a common ancestor. This means that their individual genes are also descended from common ancestral genes. Genes in different species that trace their descent back to a common ancestral gene in this way (that is, homologous genes) become different from one another through mutation and natural selection. However, the protein products of many genes are highly optimized for specific functions, involving precisely adjusted interactions of the protein molecule with other molecules in the cell. Almost any mutation altering the amino acid sequence of such a protein will be harmful and will be eliminated by natural selection. As a result, the amino acid sequence of the protein may remain almost unchanged over long periods of evolutionary time.

1-29 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) appear 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. While these proteins often 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 diverse cell types. Because the basic biochemical characteristics are retained, homologous proteins are capable of functionally substituting for one another.

1-30 Any two reasonable answers are OK. For example:

1. The genomic information is encoded in nucleic acids.
2. A particular set of twenty amino acids is used to make protein.
3. Phospholipids are used to create cell membranes.

Nucleic acids, proteins made of amino acids, and phospholipids are all complex molecules produced and utilized by all known living cells on Earth. These compounds are not easily created in the absence of life. If one were to discover a new life form that did not contain these compounds, which are central to life as we know it, it would be likely that this new life form comes from an ancestor that used very different strategies to survive.

1-31 Temperature-sensitive mutants are organisms that contain a genetic mutation to make them sensitive to temperature. A temperature-sensitive mutant usually has a mutation in a gene that results in the production of a protein that does not function properly at a certain temperature (the restrictive temperature). At the permissive temperature, the mutant cells can live and reproduce normally. However, at the restrictive temperature, the cells will display the fatal defect.

If a scientist is interested in an essential process, the scientist may set out to isolate mutant organisms defective in that essential process. In order to study an organism, it is important to be able to propagate it. However, a single-celled organism whose cells are defective in an essential process will die (and be unable to be propagated). Temperature-sensitive mutations permit the organisms to be propagated at the permissive temperature (where the proteins function normally) and allow the scientist to study the consequences of a lack of the essential gene function at the restrictive temperature (where the protein is defective).