Vivid and Instructional New Art Program for Visual Learners

The *Biology* author team collaborated with a team of medical and scientific illustrators to create the new visual program for the eighth edition. Focusing on consistency, accuracy, and pedagogical value, the team created an art program that is intimately connected with the text narrative. The resulting realistic, 3-D illustrations will stimulate student interest and help instructors teach difficult concepts.

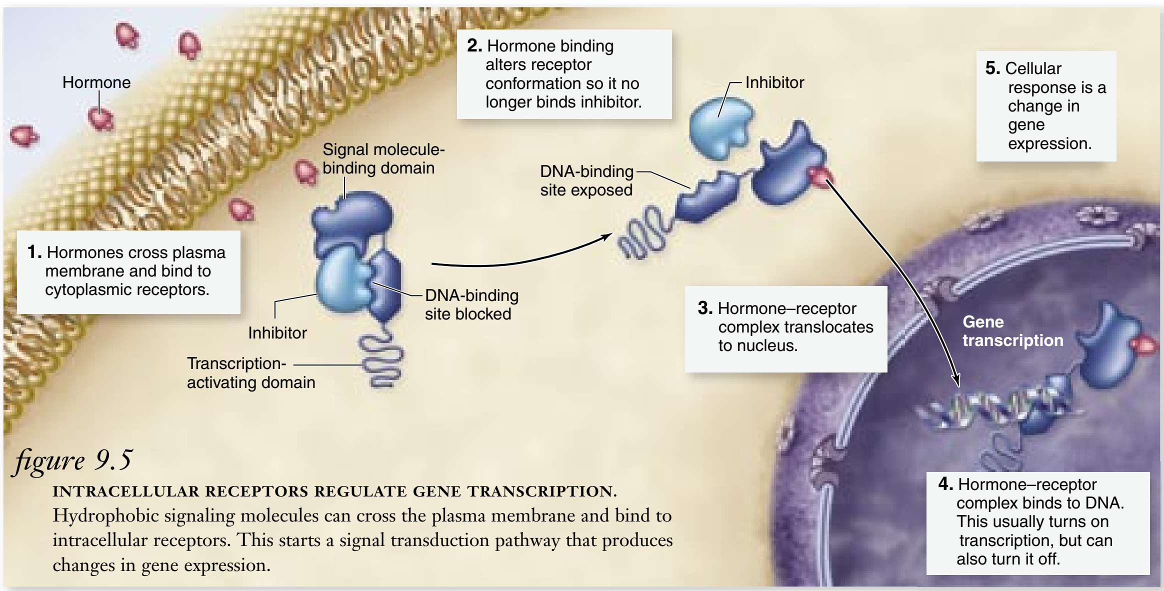


figure 9.5
INTRACELLULAR RECEPTORS REGULATE GENE TRANSCRIPTION. Hydrophobic signaling molecules can cross the plasma membrane and bind to intracellular receptors. This starts a signal transduction pathway that produces changes in gene expression.

For complex processes, figures use numbered text boxes to lead the student step-by-step through the figure.

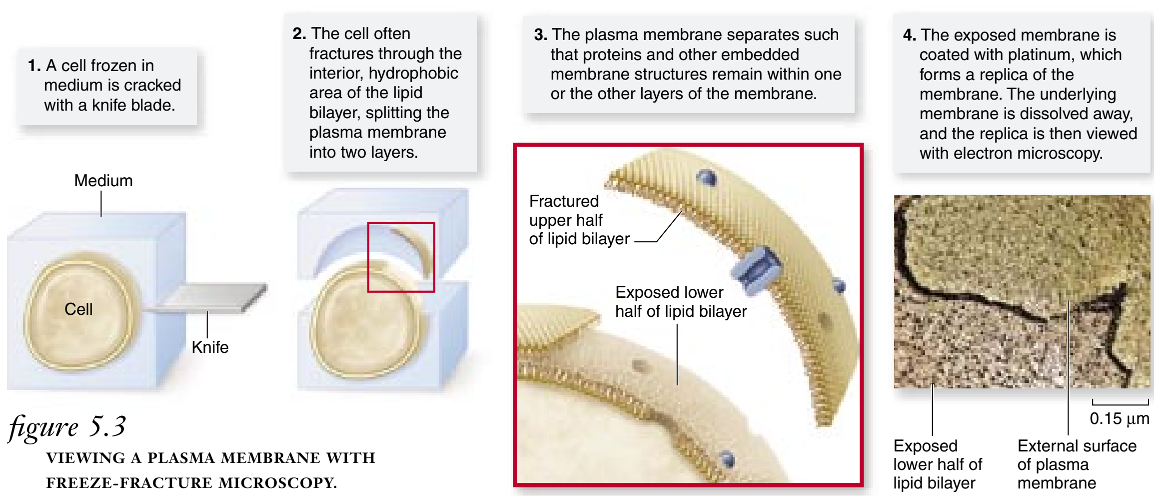
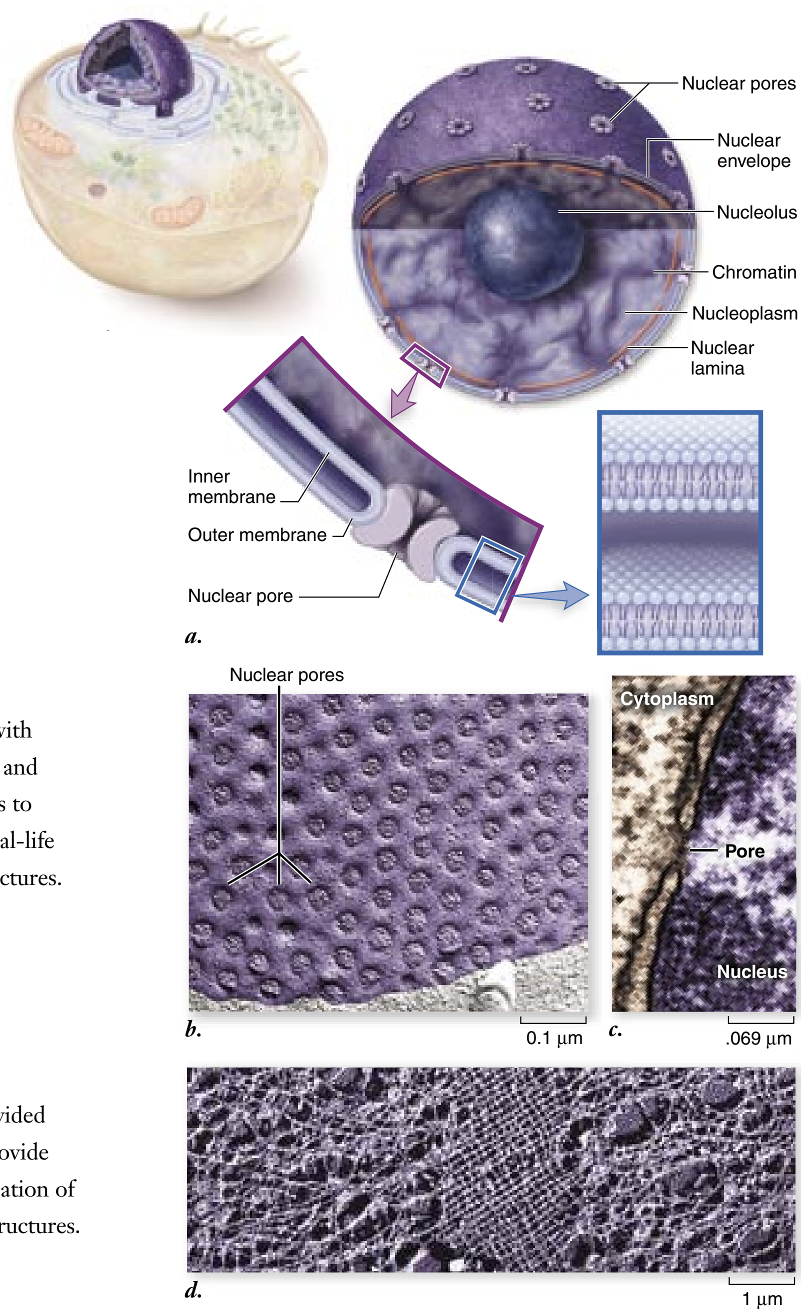


figure 5.3
VIEWING A PLASMA MEMBRANE WITH FREEZE-FRACTURE MICROSCOPY.

Multilevel figures

take students from a macro to micro view using “blow-out” arrows to help students put concepts into context.

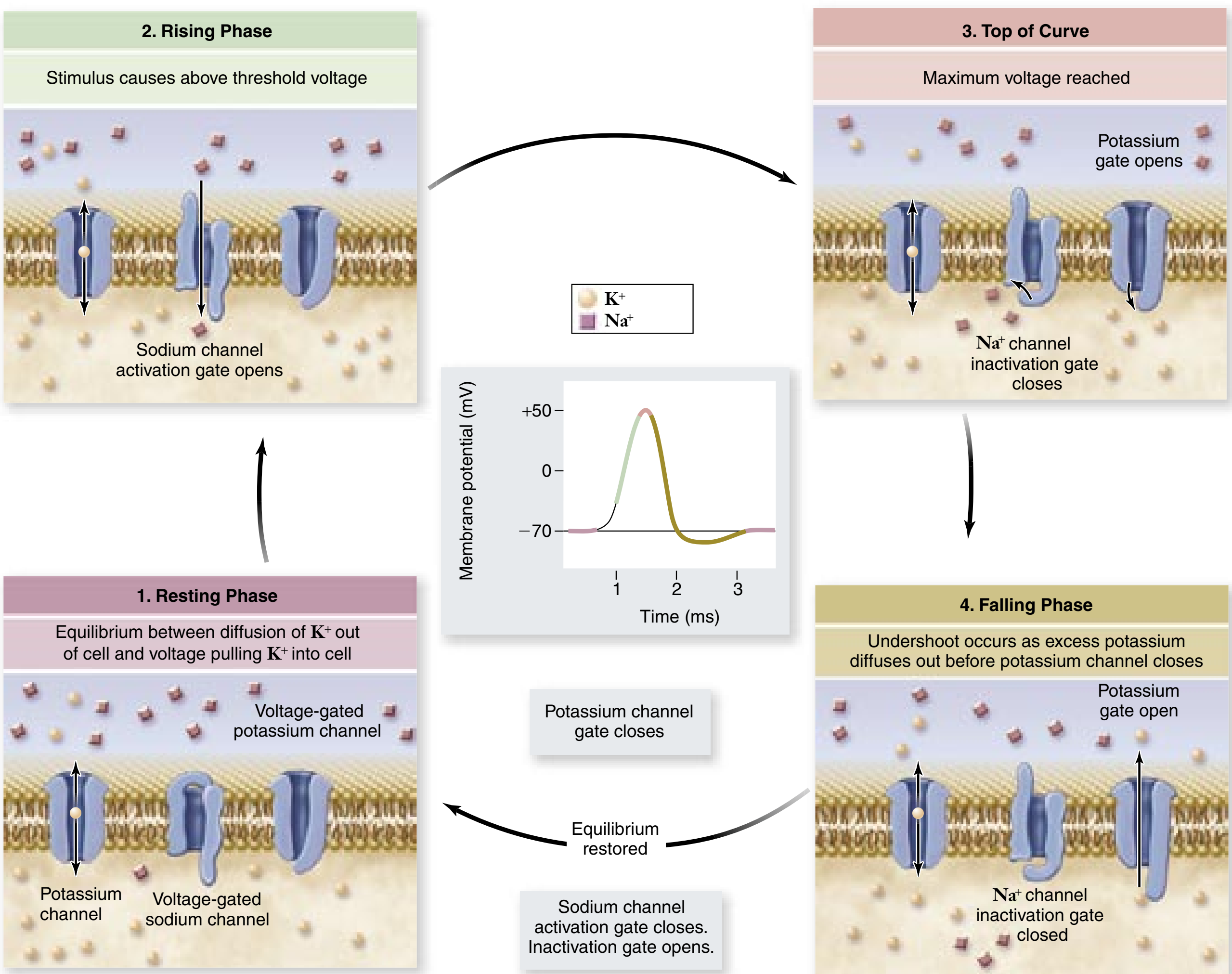


Illustrations are paired with high-quality LM, SEM, and TEM photomicrographs to provide students with real-life examples of cellular structures.

Whenever possible, a measurement bar is provided with a micrograph to provide students with an appreciation of the scale of biological structures.

Consistent color coding

means that students immediately recognize the biological structures used throughout the book. Their study time is spent learning concepts rather than orienting themselves to figure conventions. In some figures, color coding is also used to give the student visual cues to how information is related.



Consistent Pedagogical Aids to Promote Learning

Each chapter in the eighth edition is structured using the same set of pedagogical devices, which enables the student to develop a consistent learning strategy. These tools work together to provide a clear content hierarchy, break content into smaller, more accessible chunks, repeat important concepts, and provide students with opportunities for higher level thought.

chapter 24

Genome Evolution

introduction

GENOMES CONTAIN THE RAW MATERIAL for evolution, and many clues to evolution are hidden in the ever-changing nature of genomes. As more genomes have been sequenced, the new and exciting field of comparative genomics has emerged and has yielded some surprising results and many, many questions. Comparing whole genomes, not just individual genes, enhances our ability to understand the workings of evolution, to improve crops and to identify the genetic basis of disease so that we may develop more effective treatments with minimal side effects. The focus of this chapter is on how comparative genomics is enhancing our understanding of genome evolution and how this new knowledge can be applied to improve our lives.

concept outline

471

Chapter openers

include an outline comprised of the chapter headings, which provides a consistent framework for the student. Declarative, numbered main headings and sentence-style supporting headings result in a cogent overview of the content to be covered.

1. Interim summaries

review key points from the section so students can easily identify the take-away message.

2. Numbered main headings

clearly identify the start of a new concept section.

3. Inquiry questions

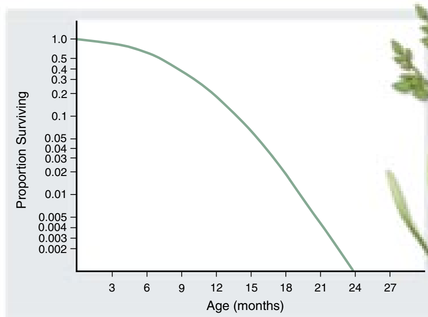
challenge students to think about what they are reading at a more sophisticated level.

are shown in figure 55.11. Oysters produce vast numbers of offspring, only a few of which live to reproduce. However, once they become established and grow into reproductive individuals, their mortality rate is extremely low (type III survivorship curve). Note that in this type of curve, survival and mortality rates are inversely related. Thus, the rapid decrease in the proportion of oysters surviving indicates that few individuals survive, thus producing a high mortality rate. In contrast, the relatively flat line at older ages indicates high survival and low mortality.

In hydra, animals related to jellyfish, individuals are equally likely to die at any age. The result is a straight survivorship curve (type II).

Finally, mortality rates in humans, as in many other animals and in protists, rise steeply later in life (type I survivorship curve).

Of course, these descriptions are just generalizations, and many organisms show more complicated patterns. Examination of the data for *P. annua*, for example, reveals that it is most similar to a type II survivorship curve (figure 55.12).



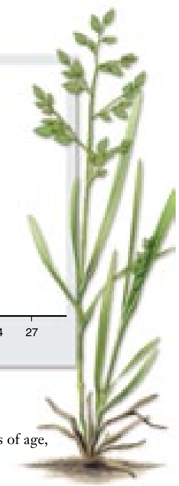


figure 55.12

SURVIVORSHIP CURVE FOR A COHORT OF THE MEADOW GRASS *POA ANNUA*. After several months of age, mortality increases at a constant rate through time.

1

The growth rate of a population is a sensitive function of its age structure. The age structure of a population and the manner in which mortality and birthrates vary among different age cohorts determine whether a population will increase or decrease in size.

inquiry

?

Suppose you wanted to keep meadow grass in your room as a houseplant. Suppose, too, that you wanted to buy an individual plant that was likely to live as long as possible. What age plant would you buy? How might the shape of the survivorship curve affect your answer?

3

55.4 Life History and the Cost of Reproduction

2

Natural selection favors traits that maximize the number of surviving offspring left in the next generation. Two factors affect this quantity: how long an individual lives, and how many young it produces each year.

Why doesn't every organism reproduce immediately after its own birth, produce large families of offspring, care for them intensively, and perform these functions repeatedly throughout a long life, while outcompeting others, escaping predators, and capturing food with ease? The answer is that no one organism can do all of this, simply because not enough resources are available. Consequently, organisms allocate resources either to current reproduction or to increasing their prospects of surviving and reproducing at later life stages.

The complete life cycle of an organism constitutes its **life history.** All life histories involve significant trade-offs. Because resources are limited, a change that increases reproduction may decrease survival and reduce future reproduction. As one example, a Douglas fir tree that produces more cones increases its current reproductive success—but it also grows more slowly. Because the number of cones produced is a function of how large a tree is, this diminished growth will decrease the number of cones it can produce in the fu-

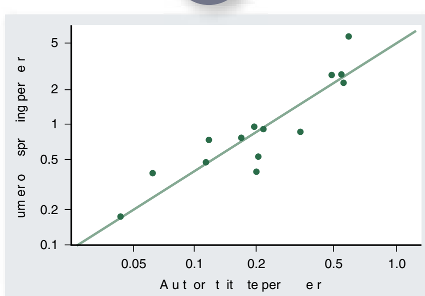


figure 55.13

REPRODUCTION HAS A PRICE. Data from many bird species indicate that increased fecundity in birds correlates with higher mortality, ranging from the albatross (lowest) to the sparrow (highest). Birds that raise more offspring per year have a higher probability of dying during that year.

1154 *part* VIII *ecology and behavior*

1

TABLE 15.2	Differences Between Prokaryotic and Eukaryotic Gene Expression	
Characteristic	**Prokaryotes**	**Eukaryotes**
Introns	No introns, although some archaeal genes possess them.	Most genes contain introns.
Number of genes in mRNA	Several genes may be transcribed into a single mRNA molecule. Often these have related functions and form an operon. This coordinates regulation of biochemical pathways.	Only one gene per mRNA molecule; regulation of pathways accomplished in other ways.
Site of transcription and translation	No membrane-bounded nucleus, transcription and translation are coupled.	Transcription in nucleus; mRNA moves out of nucleus for translation.
Initiation of translation	Begins at AUG codon preceded by special sequence that binds the ribosome.	Begins at AUG codon preceded by the 5′ cap (methylated GTP) that binds the ribosome.
Modification of mRNA after transcription	None; translation begins before transcription is completed.	A number of modifications while the mRNA is in the nucleus: Introns are removed and exons are spliced together; a 5′ cap is added; a poly-A tail is added.

1. Summary Tables are used extensively to help students study and review the chapter content. Illustrations are added in some cases to further aid students in recall.

2. Self Test Questions are a mixture of knowledge and comprehension questions that test a student's basic understanding of the main concepts from the chapter.

3. Challenge Questions are application and analysis questions that measure a student's ability to use terms and concepts learned from the chapter in new situations.

4. Concept Review summarizes the main concepts from the chapter and their supporting ideas. Key figures are cited to alert students to particularly relevant illustrations.

review questions

2

SELF TEST

1. Which of the following statements is NOT part of theory?
   a. All organisms are composed of one or more cells.
   b. Cells come from other cells by division.
   c. Cells are the smallest living things.
   d. Eukaryotic cells have evolved from prokaryotic cells.
2. The most important factor that limits the size of a cell is—
   a. the amount of proteins and organelles that can be made by a cell
   b. the rate of diffusion
   c. the surface-area-to-volume ratio of the cell
   d. the amount of DNA in the cell
3. What type of microscope would you use to examine the surface details of a cell?
   a. Compound light microscope
   b. Transmission electron microscope
   c. Scanning electron microscope
   d. Confocal microscope
4. All cells have all of the following except—
   a. Plasma membrane
   b. Genetic material
   c. Cytoplasm
   d. Cell wall
5. Eukaryotic cells are more complex than prokaryotic cells. Which of the following would you NOT find in a prokaryotic cell?
   a. Cell wall
   b. Plasma membrane
   c. Nucleus
   d. Ribosomes
6. The difference between a gram-positive and gram-negative bacteria is—
   a. the thickness of the peptidoglycan cell wall
   b. the type of polysaccharide present in the cell wall
   c. the type and amount of protein in the cell wall

11. Proteins can move from the Golgi apparatus to—
    a. the extracellular fluid
    b. transport vesicles
    c. lysosomes
    d. all of the above
12. Lysosomes function to—
    a. carry proteins to the surface of the cell
    b. add short-chain carbohydrates to make glycoproteins
    c. break down organelles, proteins, and nucleic acids
    d. remove electrons and hydrogen atoms from hydrogen peroxide
13. What do chloroplasts and mitochondria have in common?
    a. Both are present in animal cells.
    b. Both have an outer membrane and an elaborate inner membrane.
    c. Both are present in all eukaryotic cells.
    d. Both organelles function to produce glucose.
14. Eukaryotic cells are composed of three types of cytoskeletal filaments. How are these three filaments similar?
    a. They contribute to the shape of the cell.
    b. They are all made of the same type of protein.
    c. They are all the same size and shape.
    d. They are all equally dynamic and flexible.
15. Animal cells connect to the extracellular matrix through—
    a. glycoproteins
    b. fibronectins
    c. integrins
    d. collagen

CHALLENGE QUESTIONS

3

1. Eukaryotic cells are typically larger than prokaryotic ce (refer to figure 4.2). How might the difference in the cellula structure of eukaryotic versus a prokaryotic cell help to explain this observation?
2. The smooth endoplasmic reticulum is the site of synthesis of the phospholipids that make up all the membranes of a cell—especially the plasma membrane. Use the diagram of an animal cell (figure 4.6) to trace a pathway that would carry a phospholipid molecule from the SER to the plasma membrane. What endomembrane compartments would the phospholipids travel through? How can a phospholipid molecule move between membrane compartments?
3. Use the information provided in table 4.3 to develop a set of predictions about the properties of mitochondria and chloroplasts if these organelles were once free-living prokaryotic cells. How do your predictions match with the evidence for endosymbiosis?
4. In evolutionary theory, homologous traits are those with a similar structure and function derived from a common ancestor. Analogous traits represent adaptations to a similar environment, but from distantly related organisms. Consider the structure and function of the flagella found on eukaryotic and prokaryotic cells. Are the flagella an example of a homologous or analogous trait? Defend your answer.
5. The protist, *Giardia lamblia*, is the organism associated with water-borne diarrheal diseases. *Giardia* is an unusual eukaryote because it seems to lack mitochondria. Explain the existence of a mitochondria-less eukaryote in the context of the endosymbiotic theory.

4

concept review

4.1 Cell Theory

Modern cell theory states that organisms are composed of one or more cells. Cells are the smallest unit of life and arise from preexisting cells.

- Cell size is constrained by the effective distance of diffusion within a cell, from the surface to the interior of the cell.
- As a cell increases in size the surface area increases as a square function and the volume increases as a cubic function.
- Large cells deal with the diffusion problem by having more than one nucleus or by becoming flattened or elongated.
- The visualization of cells and their components is facilitated by microscopes and staining cell structures.
- All cells have DNA, a cytoplasm, a plasma membrane, and ribosomes.

4.2 Prokaryotic Cells (figure 4.3)

Prokaryotic cells do not have a nucleus or an internal membrane system, and they lack membrane-bounded organelles.

- The plasma membrane is surrounded by a rigid cell wall that maintains shape and helps maintain osmotic balance.
- The plasma membrane in some prokaryotes is infolded and provides similar functions to eukaryotic internal membranes.
- Bacteria have a cell wall made up of peptidoglycan. Archaeal cell walls have different architecture.
- Archaeal plasma membranes differ from bacteria and eukaryotes.
- The plasma membrane in some archaea is a monolayer composed of saturated lipids attached to glycerol at each end.
- Structurally Archaea resemble prokaryotes, but functionally they more closely resemble eukaryotes.
- Prokaryotic flagella rotate because of proton transfer.

4.3 Eukaryotic Cells (figures 4.6 and 4.7)

Eukaryotic cells have a membrane-bounded nucleus, an endomembrane system, and many different organelles.

- The nucleus contains genetic information.
- The nuclear envelope consists of two phospholipid bilayers; the outer layer is contiguous with the ER.
- The inside of the nuclear envelope is covered with nuclear lamins, which maintain the shape of the nucleus.
- Nuclear pores allow exchange of small molecules between the nucleoplasm and the cytoplasm.
- DNA is organized with proteins into chromatin.
- The nucleolus is a region of the nucleoplasm where rRNA is transcribed and ribosomes are assembled.
- Ribosomes are composed of RNA and protein and use information in mRNA to direct the synthesis of proteins.

4.4 The Endomembrane System

The endomembrane system forms compartments and vesicles and provides channels to carry molecules and surfaces for synthesis of macromolecules.

- The endoplasmic reticulum (ER) creates channels and passages within the cytoplasm (figure 4.11).
- The interior compartment of the ER is called the cisternal space, or lumen.
- The rough endoplasmic reticulum (RER) has ribosomes on the surface and is composed mainly of flattened sacs. RER is involved in protein synthesis and modification.
- The smooth endoplasmic reticulum (SER) lacks ribosomes and is composed more of tubules. SER is involved in synthesis of carbohydrates and lipids and in detoxification.
- The Golgi apparatus receives vesicles from the ER on the *cis* face, modifies and packages macromolecules, and transports them in vesicles formed on the *trans* face (figure 4.13).
- Lysosomes are vesicles containing enzymes that break down macromolecules located in food vacuoles and recycle the components of old organelles (figure 4.14).
- Microbodies contain enzymes and grow by incorporating lipids and proteins before they divide.
- Peroxisomes contain enzymes that catalyze oxidation reactions, resulting in the formation of hydrogen peroxide.
- Plants have many specialized vacuoles. The conspicuous central vacuole, surrounded by the tonoplast membrane, is used for storage, maintaining water balance, and growth.

4.5 Mitochondria and Chloroplasts: Cellular Generators

Mitochondria and chloroplasts have a double-membrane structure, contain their own DNA, can synthesize proteins, can divide, and are involved in energy metabolism.

- Mitochondria produce ATP using energy-contained macromolecules (figure 4.17).
  - *The inner membrane is extensively folded into layers called cristae.*
  - *The intermembrane space is a compartment between the inner and outer membrane.*
  - *The mitochondrial matrix is a compartment consisting of the fluid within the inner membrane.*
- Chloroplasts use light to generate ATP and sugars (figure 4.18).
  - *In addition to a double membrane, chloroplasts also have stacked membranes called grana that contain vesicles called thylakoids.*
  - *The fluid stroma surrounds the thylakoids.*
- Evidence indicates that mitochondria and chloroplasts arose via endosymbiosis.

4.6 The Cytoskeleton

The cytoskeleton is composed of three different fibers that support cell shape and anchors organelles and enzymes (figure 4.20).

- Actin filaments, or microfilaments, are long, thin polymers responsible for cell movement, cytoplasmic division, and formation of cellular extensions.
- Microtubules are hollow structures that are used in cell movement and movement of materials within a cell.
- Intermediate filaments are stable structures that serve a wide variety of functions.
- Paired centrioles, located in the centrosome, help assemble the nuclear division apparatus of animal cells (figure 4.21).
- Molecular motors move vesicles along microtubules.

4.7 Extracellular Structures and Cell Movement

Extracellular structures provide protection, support, strength, and cell recognition.

- Plants have cell walls composed of cellulose fibers. Fungi have cell walls composed of chitin.
- Animals have a complex extracellular matrix.
- Cell crawling occurs as actin polymerization forces the cell membrane forward while myosin pulls the cell forward.
- Eukaryotic flagella have a 9 + 2 structure and arise from a basal body.
- Cilia are shorter and more numerous flagella.

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chapter 4 cell structure 83