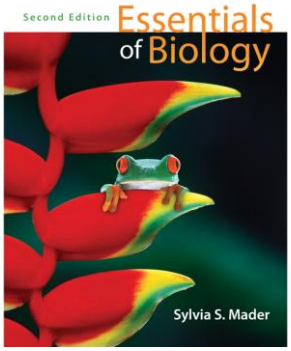
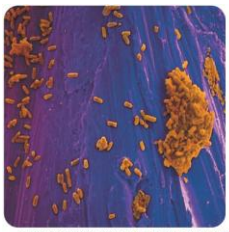


Essentials of Biology

Sylvia S. Mader

Chapter 4
Lecture Outline

Cells are tiny!!



An electron microscope can visualize objects a million times smaller than the **head of a pin.**

Cells are tiny!!

If you stacked up **8,000 cell membranes,** they would only be as thick as a page in this book.

Cells are tiny—even in an Orca!!

The cells of a whale are about **the same size** as the cells of a mouse.

Lots of Blood Stem Cell Division in your bone Marrow!!

Every second, your body produces about **2 million red blood cells.**

Biology and Society: Cells That Cure

- During a heart attack,
  - Heart muscle cells die because they are starved for oxygen.
- Unfortunately, these kinds of cells do not regenerate.

Cells Therapy

- Muscle stem cells are transplanted to the ailing heart, facilitating healing.

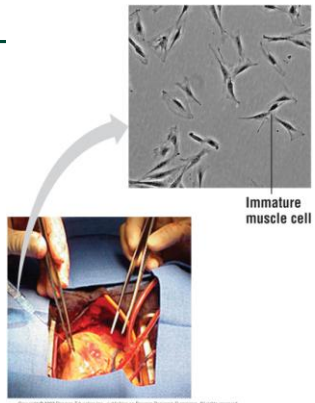


Figure 4.1

4.1 Cells Under the Microscope

- **Cells**
  - Are extremely diverse
  - Nearly all require a microscope to be seen
  - Each type in our body is specialized for a particular function

Light microscope

- Invented in 17th century
- Limited by properties of light

Electron microscope

- Invented in 1930s
- Overcomes limitation by using beam of electrons

Figure 4.1
Diversity of cells

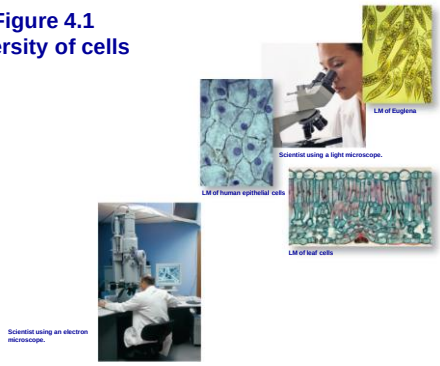
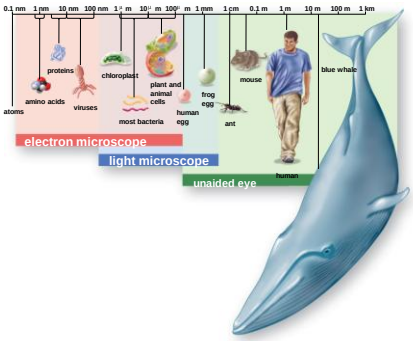
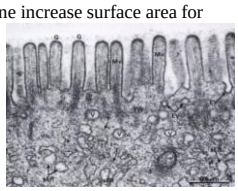


Figure 4.2 Relative sizes of some living things and their components



Why does natural selection favor small cells?

- Need large ***surface area*** for entry and exit of nutrients and wastes
- Small cells have a ***large Surface-area-to-volume-ratio***
  - Small cells have more surface area for exchange.
- Adaptations to increase surface area
  - **Microvilli** in the small intestine increase surface area for absorption of nutrients.

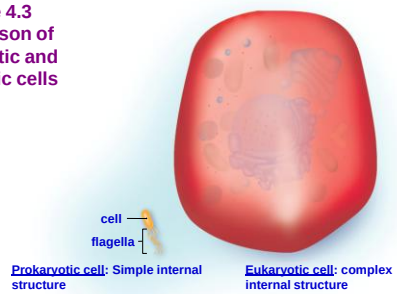


4.2 The Two Main Types of Cells

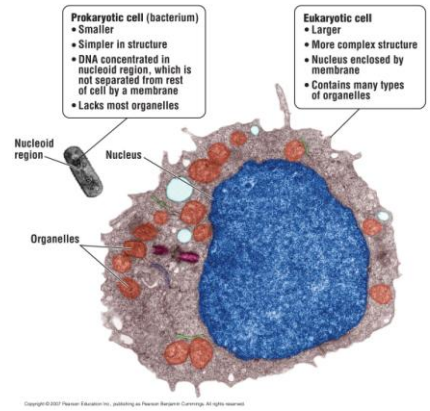
- **Cell theory**
  - All organisms composed of cells
  - All cells come only from preexisting cells.
- **All cells have a plasma membrane**.
  - Encloses cytoplasm and genetic material
- **2 main types of cells**
  - Based on organization of genetic material and complexity

1. _____**cells** – lack membrane-bounded nucleus and only ribosomes as organelles
2. _____ **cells** – have nucleus housing DNA and contain many different kinds of organelles

Figure 4.3 Comparison of prokaryotic and eukaryotic cells

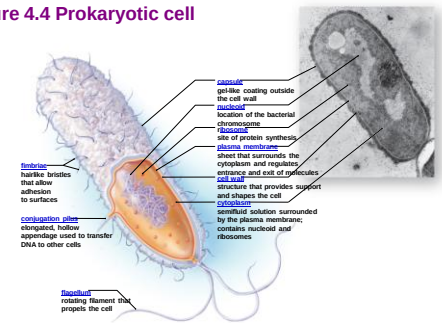


Prokaryotic vs. Eukaryotic cells



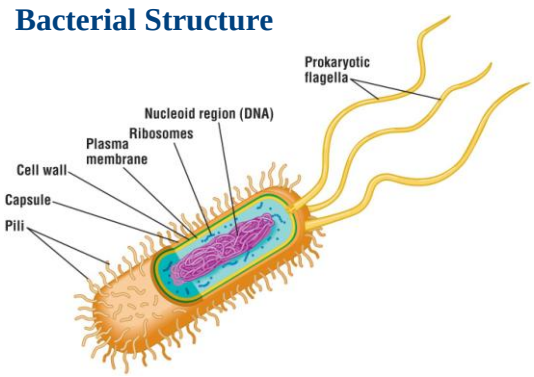
- **Prokaryotic cells**
  - From the domains **Bacteria** and **Archaea**
  - Are smaller than eukaryotic cells.
  - Lack internal structures surrounded by membranes.
  - Lack a nucleus.
  - Reproduce very quickly
- **Bacteria**
  - Well known because some cause disease
  - Others have roles in the environment
  - Some are used to manufacture chemicals, food, drugs, etc.

Figure 4.4 Prokaryotic cell



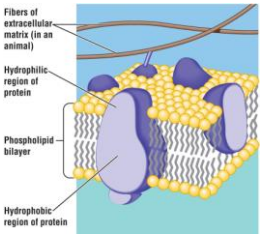
- Bacterial structure
  - Cytoplasm surrounded by **plasma membrane** and **cell wall**
    - *Sometimes a capsule* – protective layer
    - *Plasma membrane* the same as eukaryotes
  - ***Cell wall*** maintains shape of cell
  - ***DNA*** – single circular chromosome located in nucleoid (region – not membrane enclosed)
  - ***Ribosomes*** – site of protein synthesis
  - ***Appendages***
    - Flagella – propulsion
    - Fimbriae – attachment to surfaces
    - Conjugation pili – DNA transfer

Bacterial Structure



4.3 The Plasma Membrane

- Boundary between outside and inside of cell
- Regulates passage in and out of cell
- Phospholipid bilayer with embedded proteins
  - Polar heads of phospholipids face into watery medium
  - Nonpolar tails face each other
- Fluid-mosaic model (pattern that varies)



Fluid Mosaic Model

Figure 4.5 A model of the plasma membrane

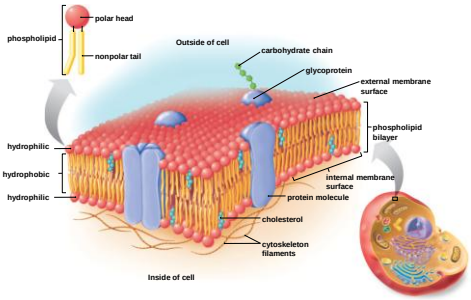
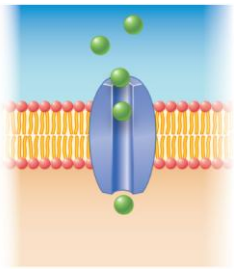


Figure 4.6 Membrane protein diversity

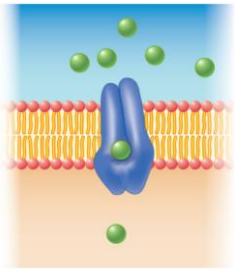
- Channel proteins
  - Form tunnel for transport of specific molecules



a. Channel protein

Figure 4.6 Membrane protein diversity

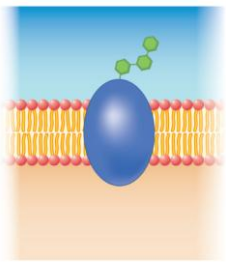
- Transport proteins
  - Involved in passage of molecules & ions
  - Sometimes requires input of energy (ATP)



b. Transport protein

Figure 4.6 Membrane protein diversity

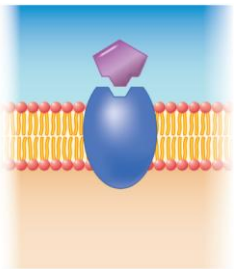
- Cell recognition proteins
  - Allow body to distinguish our own cells from foreign cells.



c. Cell recognition protein

Figure 4.6 Membrane protein diversity

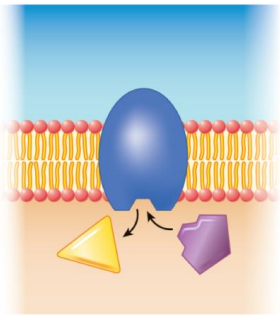
- Receptor proteins
  - Allow signal molecule to bind causing a cellular response
  - e.g. Signal molecules
    - Hormones
    - Growth factors



d. Receptor protein

Figure 4.6 Membrane protein diversity

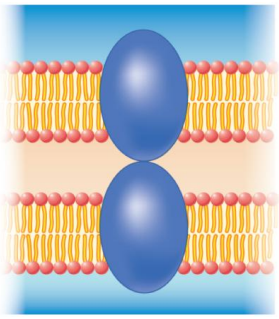
- Enzymatic proteins
  - Speed up metabolic reactions in cell



e. Enzymatic protein

Figure 4.6 Membrane protein diversity

- Junction proteins
  - Form points of contact between cells
  - Cell-to-cell adhesion and communication



f. Junction proteins

4.4 Eukaryotic cells

- Protists, fungi, plants, and animals
- Have a membrane-bounded nucleus housing DNA
- Much larger than prokaryotic cells
- Compartmentalized and contain organelles
- 4 categories of organelles
  1. **Nucleus and ribosomes**
  2. **Endomembrane system**
  3. **Energy-related**
  4. **Cytoskeleton**

Figure 4.7 Structure of typical animal cell

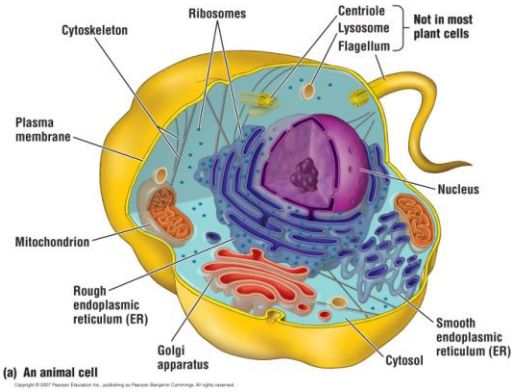
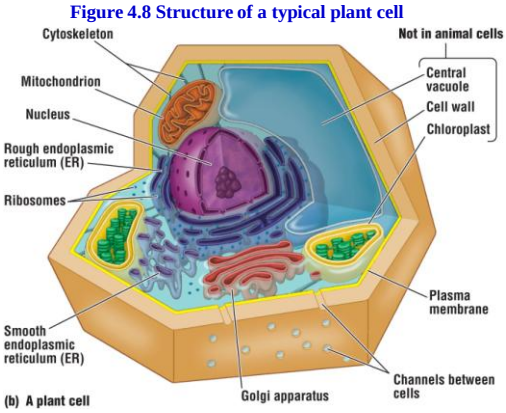


Figure 4.8 Structure of a typical plant cell



1. The Nucleus and Ribosomes: Genetic Control of the Cell

- The nucleus is the manager of the cell.
  - Genes in the nucleus store information necessary to produce _____?????_____.

Structure and Function of the Nucleus

- The nucleus is bordered by a *double membrane* called the **nuclear envelope**.
  - Function of pores??
- Nucleus contains
  - **chromatin**: diffuse DNA surrounded by a coat of protein,
    - Prior to cell division DNA compacts into chromosomes.
  - **Nucleolus**
    - Makes ___???____.

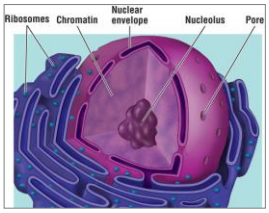


Figure 4.9 Structure of the nucleus

How DNA Controls the Cell

- **DNA** transfers its coded information into **RNA**.
- The information in the **RNA** is used to make **proteins**.
- Types of proteins made determine **phenotype**

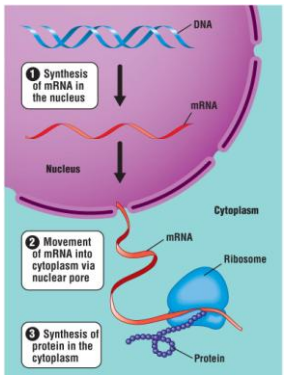
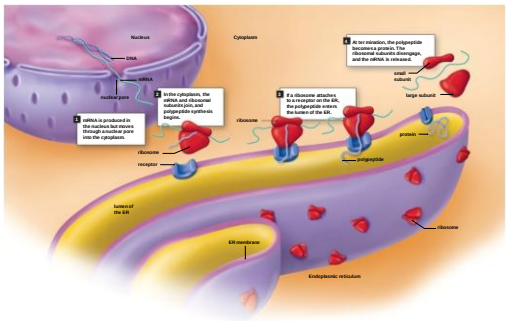


Figure 4.10 The nucleus, ribosomes & endoplasmic reticulum (ER)



Ribosomes

- Carry out protein synthesis
- Found in both prokaryotes and eukaryotes
- Mix of proteins and ribosomal RNA (rRNA)
- Receive mRNA as instructions sequence of amino acids in a polypeptide
- In eukaryotes,
  - Some ribosomes free in cytoplasm
  - Many attached to endoplasmic reticulum

2. Endomembrane System: Manufacturing and Distributing Cellular Products

- Endomembrane system:
  - **Nuclear envelope**
  - **Endoplasmic reticulum**
  - **Golgi apparatus,**
  - **Vesicles**
- Helps compartmentalize cell
- Restricts certain reactions to specific regions

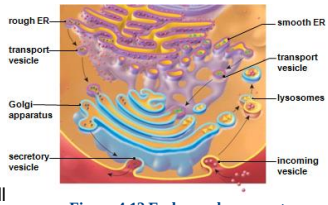
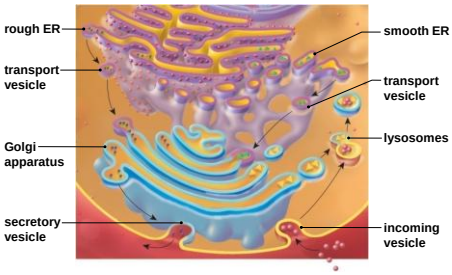


Figure 4.12 Endomembrane system

Figure 4.12 Endomembrane system



The Endoplasmic Reticulum (ER)

- System of membranous channels and saccules
- Connected to of nuclear envelope
- **Rough ER**
  - Studded with **ribosomes**
    - Produce membrane proteins and proteins exported from cell
  - Forms transport vesicles going to Golgi apparatus
- **Smooth ER**
  - Continuous with rough ER
  - No ribosomes
  - Function depends on cell
    - Produce lipids (e.g. steroids, testosterone)
    - Detoxify drugs (e.g. liver)

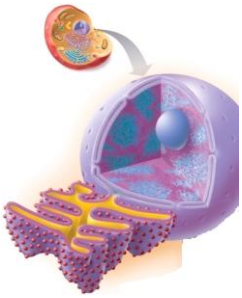
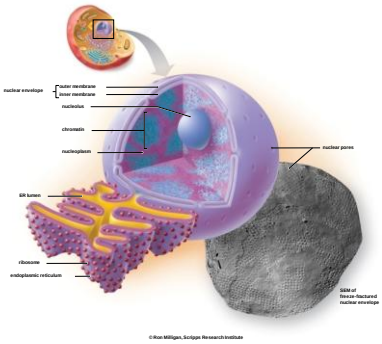
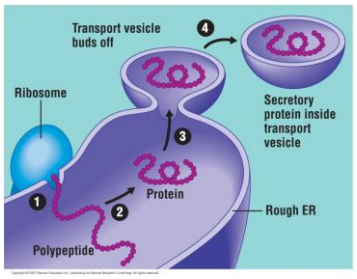


Figure 4.11 Rough ER

Figure 4.11 Endoplasmic reticulum (ER)



- After the rough ER synthesizes a protein, it packages the molecule into transport vesicles.

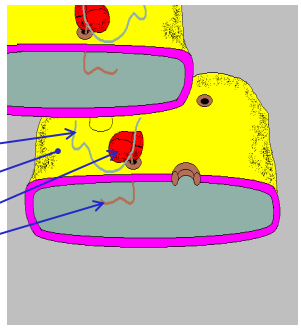


Ribosome on Rough ER Producing a Protein such as Insulin

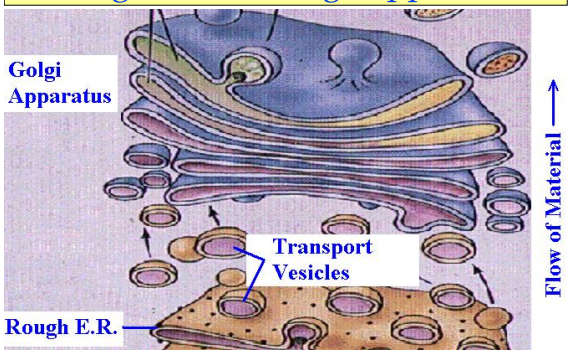
- **A ribosome reads mRNA to produce a protein molecule**

ID of structures...

1. _____
2. _____
3. _____
4. _____



Rough E.R. to Golgi Apparatus



Transport from Golgi Apparatus

- **Proteins modified by Golgi Apparatus are either...**

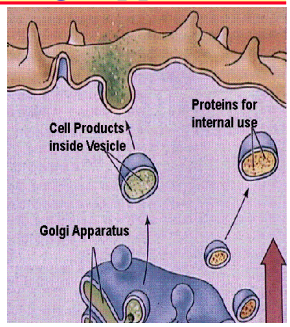
  Used inside cell

  e.g._____

  Or

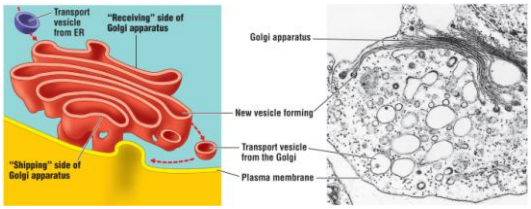
  Exported from cell

  e.g. _____



The Golgi Apparatus

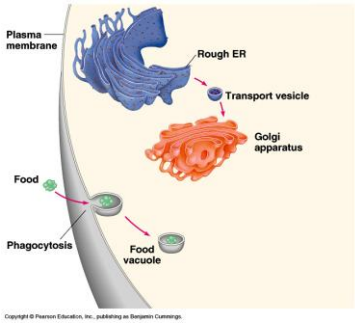
- The Golgi apparatus
  - Transfer or processing station
  - Receives vesicles from ER
  - Modifies molecules
  - Sorts and repackages for new destination
    - Some are lysosomes



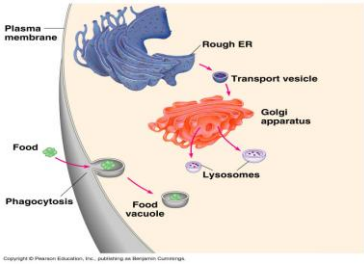
Lysosomes

- Vesicles that digest molecules or portions of the cell
  - Have a double membrane
- Digestive enzymes
  - break down macromolecules in monomers

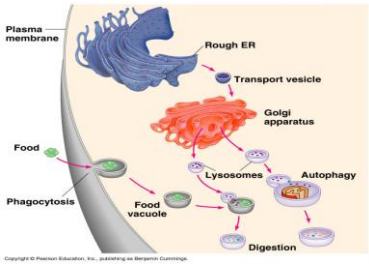
The formation and functions of lysosomes (Layer 1)



The formation and functions of lysosomes (Layer 2)



The formation and functions of lysosomes (Layer 3)



Macrophages: "Big Eaters"

- Eat dead, injured, and foreign cells
- Engulfed cells transported to lysosome for digestion

ID each of the following

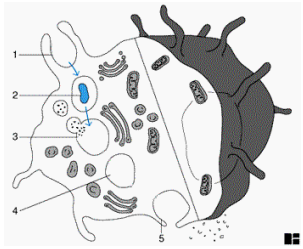
1 =

2 =

3 =

4 =

5 =



Phagocytosis – a macrophage snacking on bacteria

Vacuoles vs. Vesicles

Vacuoles

- Also membranous sacs
- Larger than vesicles
- Some pump excess water from cell
- Digestion
- Storage
  - Plants: pigments, sugars
  - Animals: adipocytes (fat cells!)

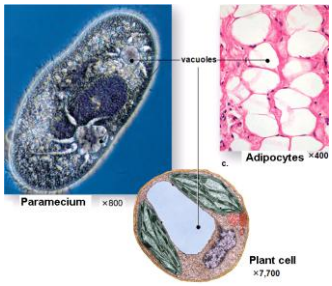


Figure 4.13 Vacuoles

3. Energy-related organelles

Chloroplasts

- Site of photosynthesis
- Use solar energy to synthesize carbohydrates
- Only in plants
- **Endosymbiosis** – origin of chloroplasts
  - Chloroplast DNA & ribosomes similar to that of prokaryotes
  - What does this suggest?

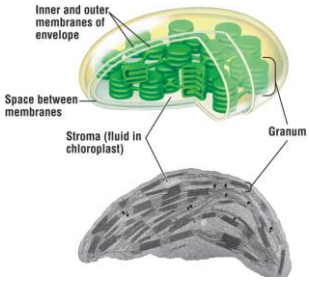


Figure 4.14 Chloroplast

3. Energy-related organelles

Mitochondria

- "Powerhouse of the cell"
- Cellular Respiration:
  - Break down carb's and fats to produce ATP
  - Uses O_2 and produces CO_2 and water
- Found in BOTH plants and animals
- **Endosymbiosis** – origin of mitochondria
  - Mitochondrial DNA & ribosomes similar to that of prokaryotes
  - What does this suggest?

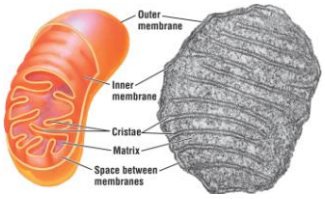
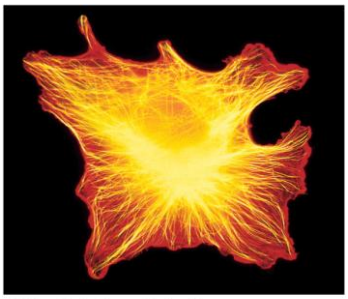


Figure 4.15 Mitochondrion structure

4. Cytoskeleton

- Maintains cell shape
- Network of protein fibers
- Extend from the nucleus to the plasma membrane
- Only in eukaryotes
- With motor proteins, allows cell and organelles to move



(a) Microtubules in an animal cell

4. Cytoskeleton

Microtubules

- hollow protein cylinders
- Help maintain cell shape
- Act as track ways to move organelles
- Move chromosomes in cell division

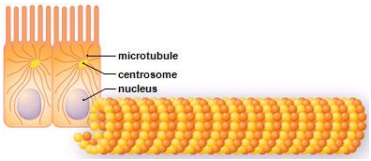
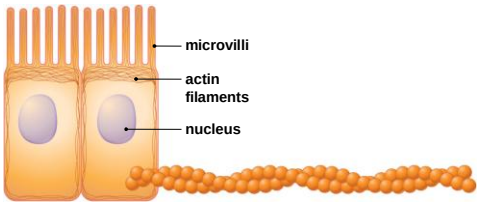


Figure 4.16 Microtubules

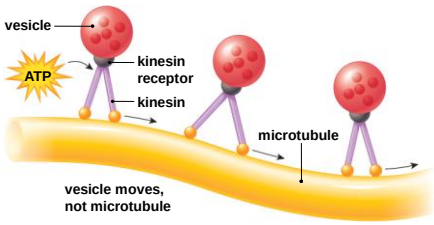
•Actin filaments
- 2 chains of monomers twisted in a helix
- Forms a dense web to support the cell

Figure 4.17 Actin filaments



- Motor proteins
  - Instrumental in allowing cellular movements
  - Myosin
    - Interacts with actin
    - Cells move in amoeboid fashion
    - Muscle contraction
  - Kinesin and dynein
    - Move along microtubules
    - Transport vesicles from Golgi apparatus to final destination

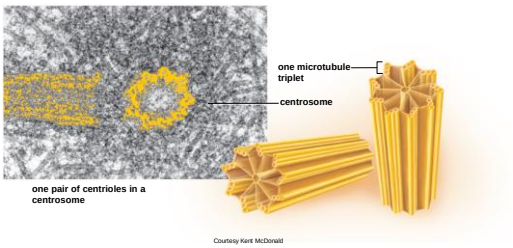
Figure 4.18 Motor proteins



b. Kinesin

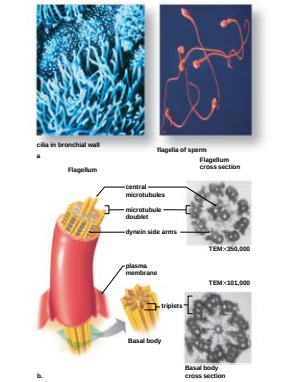
- Centrioles
  - Made of 9 sets of microtubule triplets
  - Two centrioles lie at right angles
  - In animal cells, not present in plant cells

Figure 4.19 Centrioles



Courtesy Kent McDonald

- Cilia and flagella
  - Eukaryotes
  - For movement of the cell or fluids past the cell
  - Similar construction in both
    - 9+2 pattern of microtubules
  - Cilia shorter and more numerous than flagella



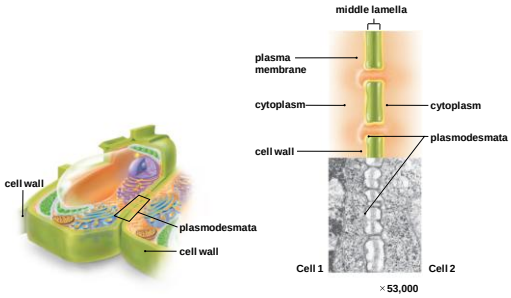
a(cilia): © Manfred Kage/Peter Arnold; (sperm): © David M. Phillips/Photo Researchers, Inc.; b: (flagellum, basal body): © William L. Dentler/BPS

Figure 4.20 Cilia and flagella

4.5 Outside the Eukaryotic Cell

- Plant cell walls
  - Primary cell walls
    - Cellulose fibrils and noncellulose substances
    - Wall stretches when cell is growing
  - Secondary cell walls
    - Forms inside primary cell wall
    - Woody plants
    - Lignin adds strength
  - Plasmodesmata
    - Plant cells connected by numerous channels that pass through cell walls
    - For exchange of water and small solutes between cells

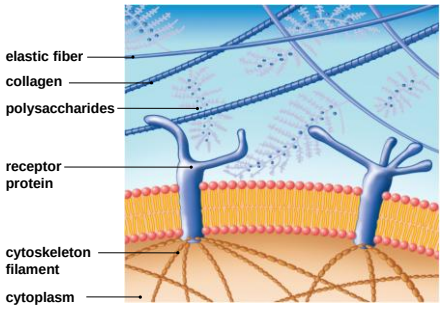
Figure 4.21 Plasmodesmata



© E.H. Newcomb/BPS

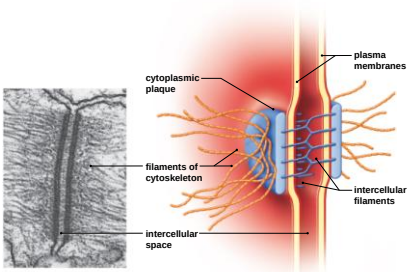
- Exterior cell surfaces in animals
  - No cell wall
  - Extracellular matrix (ECM)
    - Meshwork of fibrous proteins and polysaccharides
    - Collagen and elastin well-known proteins
    - Matrix varies – flexible in cartilage, hard in bone

Figure 4.22 Animal cell extracellular matrix



- Junctions between cells
  - Adhesion junctions
    - Internal cytoplasmic plaques joined by intercellular filaments
    - Sturdy but flexible sheet of cells

Figure 4.23 Junctions between cells of the intestinal wall

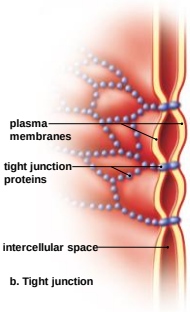


a. Adhesion junction

a. From Douglas E. Kelly, Journal of Cell Biology, 28 (1966:51). Reproduced by permission of The Rockefeller University Press

- Tight junctions
  - Plasma membrane proteins attach to each other
  - Zipperlike
  - Cells of tissues that serve as barriers

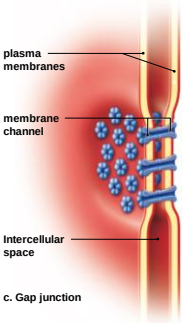
Figure 4.23 continued



b. Tight junction

- Gap junctions
  - Allow cells to communicate through plasma membrane channels
  - Lends strength while allowing small molecules and ions to pass through

Figure 4.23 continued



c. Gap junction