Chapter 4: Tour of the Cell

BIO100
Fall 2007

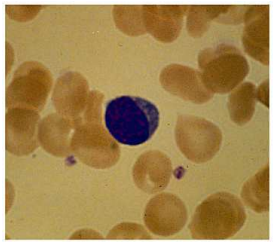
THE MICROSCOPIC WORLD OF CELLS

- Cells must be tiny for materials to move in and out of them and fast enough to meet the cell's metabolic needs.

- Organisms are either
  - Single-celled, such as most bacteria and protists
  - Multicelled, such as plants, animals, and most fungi.

Microscopes as Windows to Cells

- The light microscope is used by many scientists
  - Light passes through the specimen
  - Lenses enlarge, or magnify, the image.

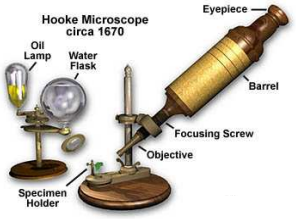


(a) Light micrograph (LM) of a white blood cell (stained purple) surrounded by red blood cells

Figure 4.2A

How We Study Cells

- **Light Microscope:**
  - **First cells observed by Robert Hooke in 1665 using a light microscope.**
- **Simple vs. Compound?**

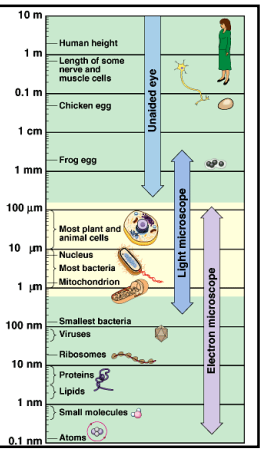


- Magnification
  - An increase in the specimen's apparent size
- Resolving power
  - The ability of an optical instrument to show two objects as separate.

- Cells were first discovered in 1665 by Robert Hooke
- The accumulation of scientific evidence led to the **cell theory,** p. 57
  - All living things are composed of cells
  - All cells form from previously existing cells
  - Cells are the smallest units capable of carrying out the processes of life: ex. respiration, digestion, reproduction, growth, ingestion, etc.

- The electron microscope (EM) uses a beam of electrons
  - It has a higher resolving power than the light microscope.

- The electron microscope can magnify up to 100,000X
  - Such power reveals the diverse parts within a cell.



Metric Prefixes:

Kilo=1000 so 10 Kcalories=10 000 calories= 10 C

Hecto=100

Deka=10

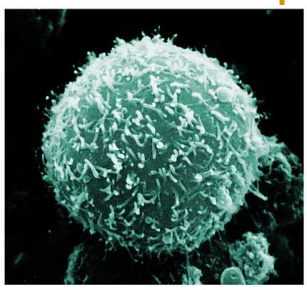
Unit=1 ex. meter, liter, gram

deci=0.1

centi=0.01 so 1 cm=10 mm

milli=0.001

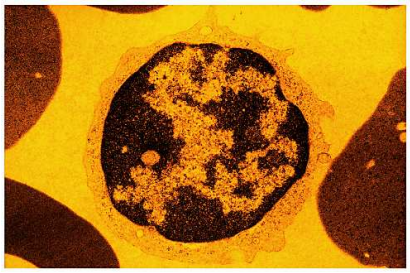
- The scanning electron microscope (SEM) is used to study the detailed architecture of the surface of a cell.



(b) Scanning electron micrograph (SEM) of a white blood cell

Figure 4.2B

- The transmission electron microscope (TEM) is useful for exploring the internal structure of a cell.



(c) Transmission electron micrograph (TEM) of a white blood cell

Figure 4.2C

The Two Major Categories of Cells

- The countless cells on earth fall into two categories
  - Prokaryotic cells
  - Eukaryotic cells

- Prokaryotic and eukaryotic cells differ in several respects.

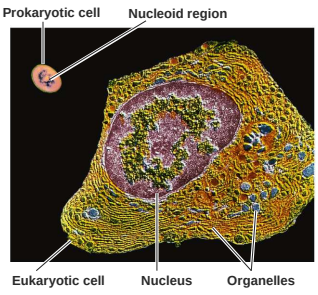


Figure 4.4

- Prokaryotic cells
  - Are smaller than eukaryotic cells
  - Lack internal structures surrounded by membranes
  - Lack a nucleus.

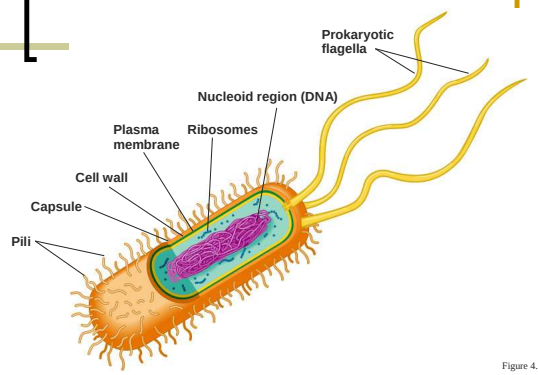


Figure 4.5

A Panoramic View of Eukaryotic Cells

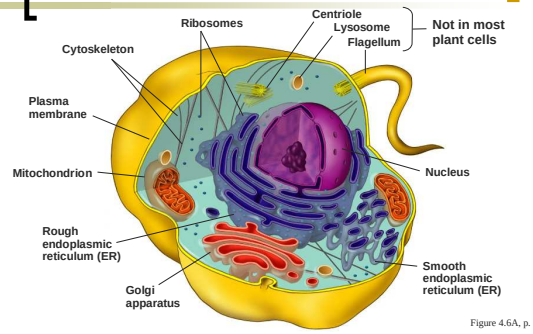


Figure 4.6A, p. 59

- An idealized plant cell.

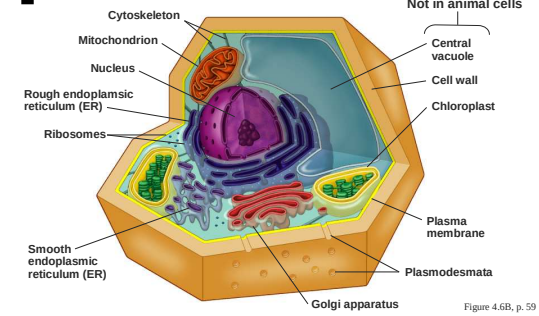


Figure 4.6B, p. 59

The nucleus is an organelle which contains long fibers made of DNA molecules and associated proteins. Each fiber, known as chromatin, becomes a **chromosome**

Humans have 46 chromosomes in the nucleus of each and every cell

Also within the nucleus is the **nucleolus** which is a ball-like mass of fibers and granules which produces the component parts of ribosomes.

Ribosomes move through the pores of the nucleus then are responsible for protein synthesis. Some are associated with “rough” ER others remain suspended in the cytosol.

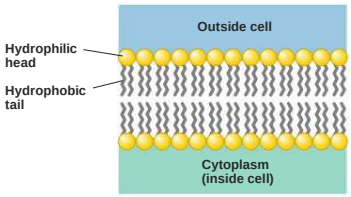
MEMBRANE STRUCTURE AND FUNCTION

- The **plasma membrane** separates the living cell from its nonliving surroundings
- The entire region of cell between the nucleus and plasma membrane is the **cytoplasm**
- Cytoplasm consists of organelles surrounded by a liquid known as **cytoso**l.

A Fluid Mosaic of Lipids and Proteins

- The membranes of cells are composed of
  - Lipids
  - Proteins.

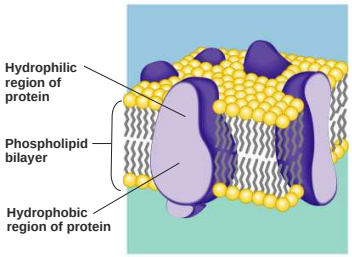
- Phospholipids form a two-layered membrane, the phospholipid bilayer.
  - The lipids belong to a special category called phospholipids



(a) Phospholipid bilayer of membrane

Figure 4.7A

- Most membranes have specific proteins embedded in the phospholipid bilayer.



(b) Fluid mosaic model of membrane

Figure 4.7B

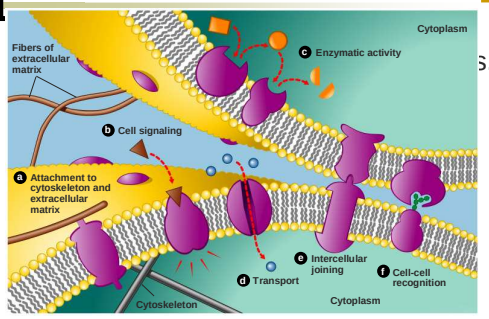


Figure 4.8

- Membrane phospholipids and proteins can drift about in the plane of the membrane
- This behavior leads to the description of a membrane as a fluid mosaic
  - Molecules can move freely within the membrane
  - A diversity of proteins exists within the membrane.

Selective Permeability

- Membranes of the cell are selectively permeable
  - They allow some substances to cross more easily than others
  - They block passage of some substances altogether.

- The traffic of some substances can only occur through transport proteins
  - Glucose, for example, requires a transport protein to move it into the cell.

THE NUCLEUS AND RIBOSOMES: GENETIC CONTROL OF THE CELL

- The nucleus is the manager of the cell
  - Genes found on the chromosomes within the nucleus store information necessary to produce proteins.

Structure and Function of the Nucleus

- The nucleus is bordered by a double membrane called the nuclear envelope
  - It contains chromatin
  - It contains a nucleolus.

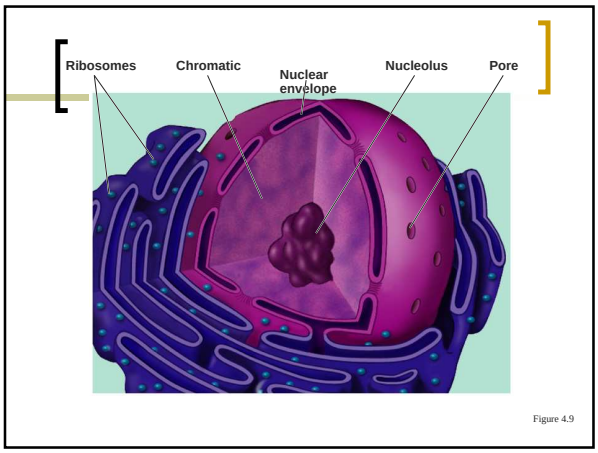


Figure 4.9

Ribosomes

- Ribosomes build all the cell's proteins.

How DNA Controls the Cell

- DNA controls the cell by transferring its coded information into RNA
  - The information in the RNA is used to make proteins.

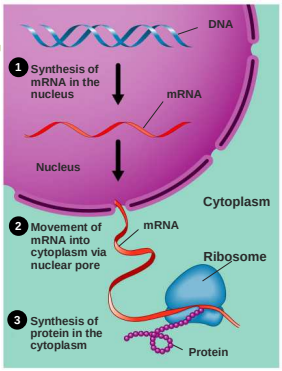


Figure 4.10

THE ENDOMEMBRANE SYSTEM: MANUFACTURING AND DISTRIBUTING CELLULAR PRODUCTS

- Many of the membranous organelles in the cell belong to the endomembrane system.

The Endoplasmic Reticulum

- The endoplasmic reticulum (ER)
  - Produces an enormous variety of molecules
  - Is composed of smooth and rough ER.

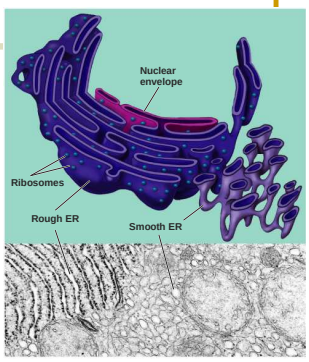


Figure 4.11

Rough ER

- Again, the “roughness” of the rough ER is due to ribosomes that stud the outside of the ER membrane.

- The functions of the rough ER include
  - Producing proteins
  - Producing new membrane.

- After the rough ER synthesizes a molecule it packages the molecule into **transport vesicles**

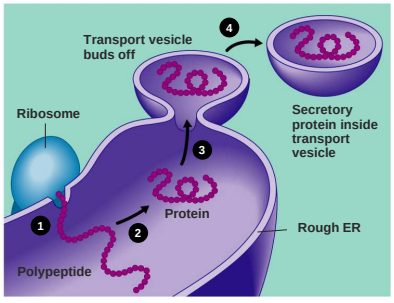


Figure 4.12

Smooth ER

- The smooth ER lacks the surface ribosomes of ER and produces lipids, including steroids.

The Golgi Apparatus

- Works in partnership with the ER
- Refines, stores, and distributes the products of cells.

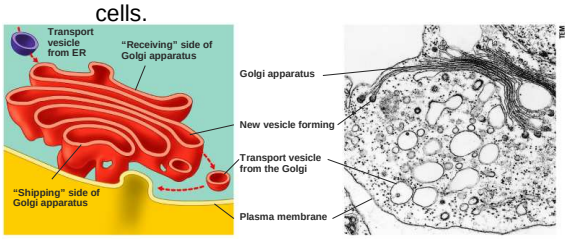


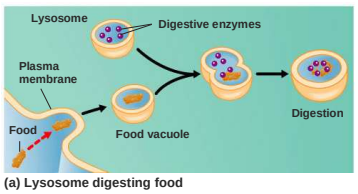
Figure 4.13

Lysosomes

- A lysosome is a membrane-enclosed sac
- It contains digestive enzymes
- The enzymes break down macromolecules. So lysosomes are responsible for intracellular digestion.
- If its membrane were to break its contents would digest the cell

Lysosomes have several types of digestive functions

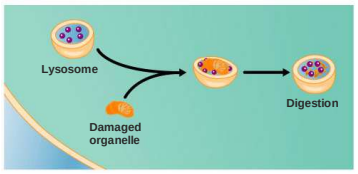
- They fuse with food vacuoles to digest the food.



(a) Lysosome digesting food

Figure 4.14a

- They break down damaged organelles
- They carry out the intracellular digestion.

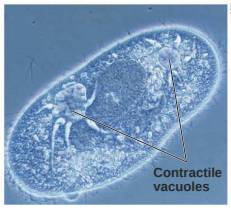


(b) Lysosome breaking down damaged organelle

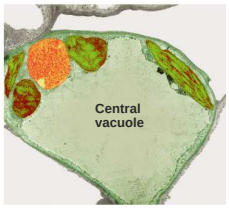
Figure 4.14b

Vacuoles

- Vacuoles are membranous sacs
  - Two types are the contractile vacuoles of protists and the central vacuoles of plants.



(a) Contractile vacuoles in a protist



(b) Central vacuole in a plant cell

Figure 4.15

- A review of the endomembrane system.

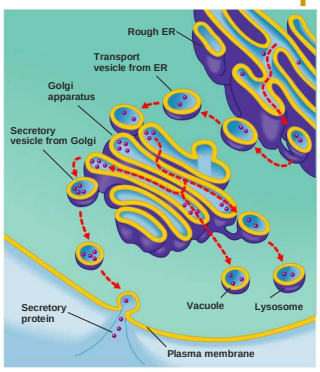


Figure 4.16

CHLOROPLASTS AND MITOCHONDRIA: ENERGY CONVERSION

- Cells require a constant energy supply to do all the work of life.
- Nuclei, chloroplasts, and mitochondria are organelles having double membranes.

CHLOROPLASTS

- **Chloroplasts** are the sites of photosynthesis, the conversion of light energy to chemical energy.

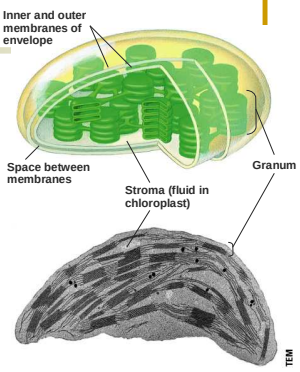


Figure 4.17

Mitochondria

- **Mitochondria** are the sites of cellular respiration, which involves the production of ATP from food molecules.

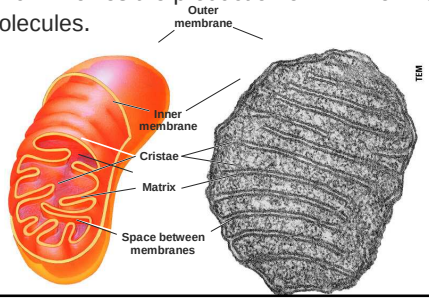
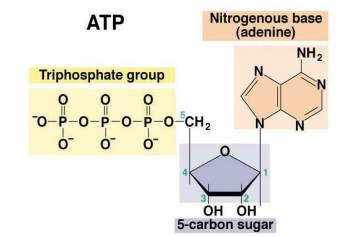


Figure 4.18

ATP

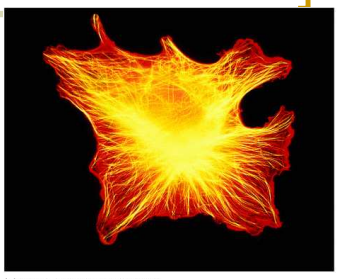


THE CYTOSKELETON: CELL SHAPE AND MOVEMENT

- The cytoskeleton is an infrastructure of the cell consisting of a network of fibers.

Maintaining Cell Shape

- One function of the cytoskeleton
  - Provide mechanical support to the cell and maintain its shape.



(a) Microtubules in an animal cell

Figure 4.19A

- The cytoskeleton can change the shape of a cell
  - This allows cells like amoebae to move.

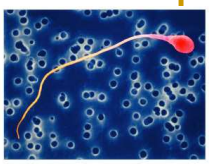
(b) Amoeboid movement

Figure 4.19B

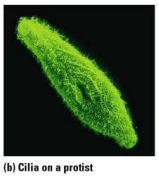
Cilia and Flagella

- Cilia and flagella are motile appendages.

- Flagella propel the cell in a whip-like motion
- Cilia move in a coordinated back-and-forth motion.



(a) Flagellum of a human sperm cell



(b) Cilia on a protist

Figure 4.20A, B

- Some cilia or flagella extend from nonmoving cells
  - The human windpipe is lined with cilia.

(c) Cilia lining the respiratory tract

Figure 4.20C

CELL SURFACES: PROTECTION, SUPPORT, AND CELL-CELL INTERACTIONS

- Most cells secrete materials that are external to the plasma membrane.

Plant Cell Walls and Cell Junctions

- Plant cells are encased by cell walls
  - These provide support for the plant cells.

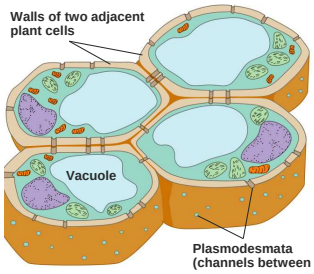


Figure 4.21

Animal Cell Surfaces and Cell Junctions

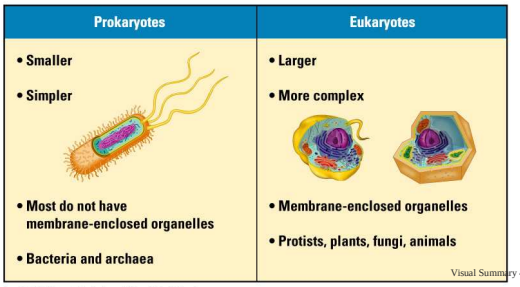
- Animal cells lack cell walls
  - They secrete a sticky covering called the extracellular matrix
  - This layer helps hold cells together.

THE ORIGIN OF MEMBRANES

- Phospholipids were probably among the first organic molecules on the early Earth.

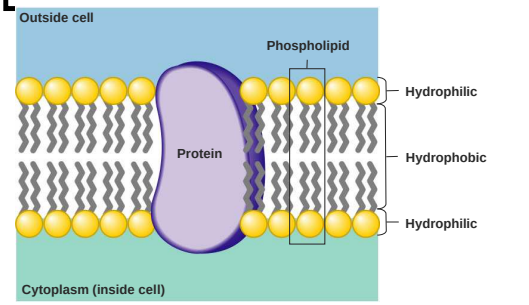
SUMMARY OF KEY CONCEPTS

- The Two Major Categories of Cells.



Membrane Structure and Function

- A Fluid Mosaic of Lipids and Proteins.



Visual Summary 4.2