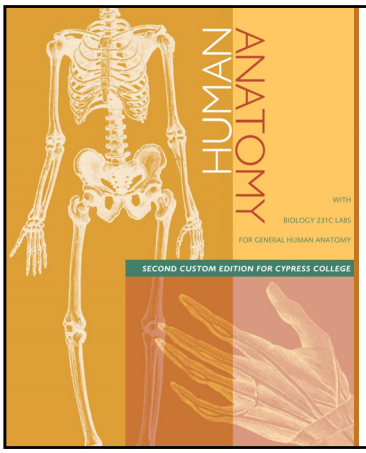


CHAPTER

2

Cells: The Living Units

Goals

By the end of this lecture you should be able to describe ….

- Similarities and differences between cells
- Why cells look and function differently
- The function of organelles in a typical eukaryotic cell
- How proteins are made
- How cells divide

Cells

- Smallest living units in the body.
- Perform all functions necessary to sustain life.
- Obtain nutrients from surrounding body fluids
- Disposes of its wastes and maintains its shape and integrity
- Produced by the division of preexisting cells – they can replicate themselves

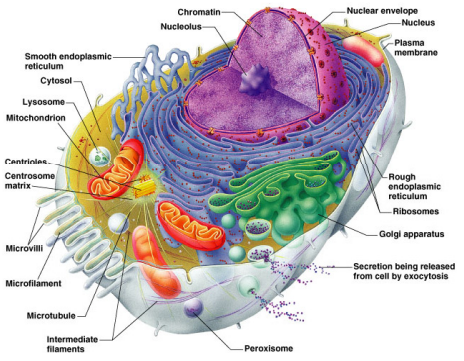
Function of Cells Due To:

- Organelles – "little organs" – carry on essential functions of cells
- Enzymes – direct chemical reactions in cells
- Metabolism – the sum of all chemical reactions in the cell

Cells have three main components

- Plasma membrane
- Cytoplasm
- Nucleus

Structure of a Generalized Cell



The Plasma Membrane

- Fluid mosaic model (lipid bilayer)
- Types of membrane proteins
  - **Integral proteins** – firmly imbedded in, or attached to lipid bilayer
    - *Transmembrane Proteins* – span across the entire membrane.
  - **Peripheral proteins** – attach to membrane surface

The Plasma Membrane

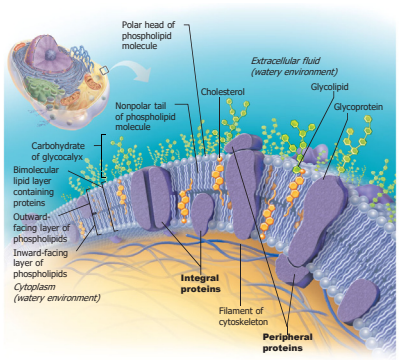


Figure 2.2

Functions of the Plasma Membrane

- Physical isolation
- Regulation of exchange with the environment
- Sensitivity
- Structural support

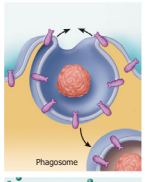
The Plasma Membrane

- Determines which substances enter or leave the cell
  - Membrane is selectively permeable
    - **Diffusion** – molecules move from a region where they are more concentrated to an area where they are less concentrated
    - **Osmosis** – the diffusion of water across a membrane

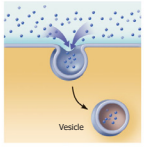
Endocytosis

- Mechanism by which particles enter cells
  - **Phagocytosis** – "cell eating"
  - **Pinocytosis** – "cell drinking"
  - **Receptor-mediated endocytosis**

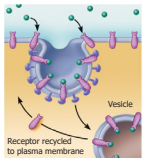
Three Types of Endocytosis



(a) Phagocytosis
The cell engulfs a large particle by forming projecting pseudopods ("false feet") around it and enclosing it within a membrane sac called a phagosome. The phagosome then combines with a lysosome, and its contents are digested. Vesicle may or may not be protein-coated but has receptors capable of binding to microorganisms or solid particles.



(b) Pinocytosis
The cell "gulps" drops of extracellular fluid containing solutes into tiny vesicles. No receptors are used, so the process is nonspecific. Most vesicles are protein-coated.



(c) Receptor-mediated endocytosis
Extracellular substances bind to specific receptor proteins in regions of protein-coated pits, enabling the cell to ingest and concentrate specific substances in protein-coated vesicles. The ingested substance may simply be released inside the cell, or combined with a lysosome to digest contents. Receptors are recycled to the plasma membrane in vesicles.

Figure 2.4

Exocytosis

- Mechanism that moves substances out of the cell
  - Substance is enclosed in a vesicle
  - The vesicle migrates to the plasma membrane
  - Proteins from the vesicles (v-SNAREs) bind with membrane proteins (t-SNAREs)
  - The lipid layers from both membranes bind, and the vesicle releases its contents to the outside of the cell

Exocytosis

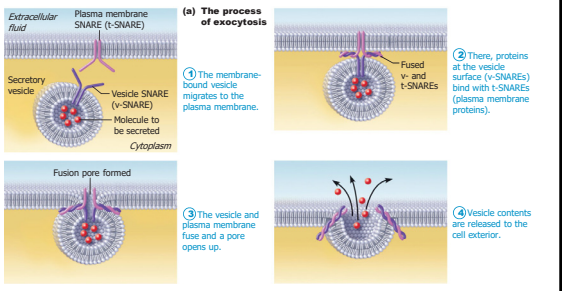


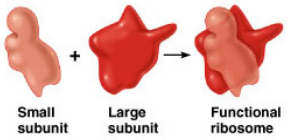
Figure 2.5

The Cytoplasm

- **Cytoplasm** – lies internal to plasma membrane
  - Consists of cytosol, organelles, and inclusions
- **Cytosol** (cytoplasmic matrix)
  - Jelly-like fluid in which other cellular elements are suspended
  - Consists of water, ions, and enzymes

Cytoplasmic Organelles

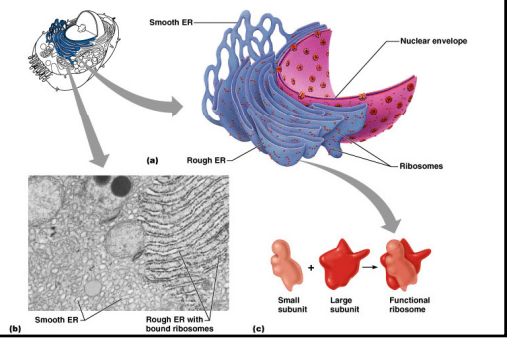
- **Ribosomes** – constructed of proteins and ribosomal RNA
  - Site of protein synthesis



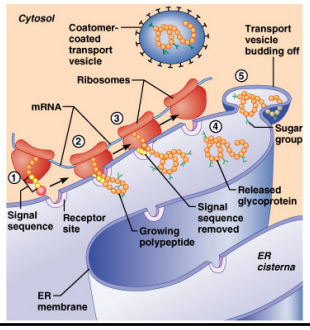
Cytoplasmic Organelles

- **Endoplasmic reticulum** – "network within the cytoplasm"
  - Rough ER – ribosomes stud the external surfaces
  - Smooth ER – consists of tubules in a branching network
    - No ribosomes are attached; therefore no protein synthesis

The Endoplasmic Reticulum and Ribosomes



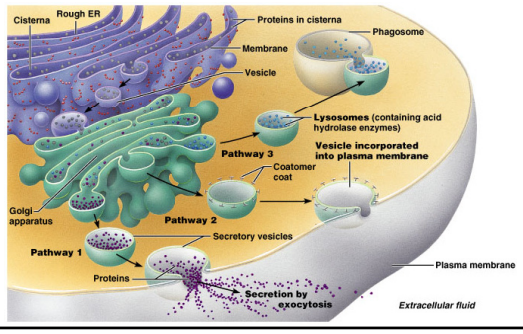
Assembly of Proteins at the Rough Endoplasmic Reticulum



Cytoplasmic Organelles

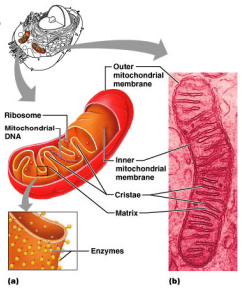
- **Golgi apparatus** – a stack of three to ten disk-shaped envelopes
  - Sorts products of rough ER and sends them to proper destination

Role of the Golgi Apparatus in Packaging Products of Rough ER



Mitochondria

- **Mitochondria** – generate most of the cell's energy; most complex organelle



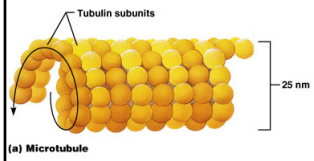
Cytoplasmic Organelles

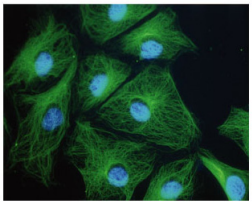
- **Lysosomes** – membrane-walled sacs containing digestive enzymes
  - Digest unwanted substances
- **Peroxisomes** – membrane-walled sacs of oxidase enzymes
  - Enzymes neutralize free radicals and break down poisons
  - Break down long chains of fatty acids
  - Are numerous in the liver and kidneys

Cytoplasmic Organelles

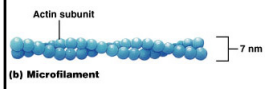
- **Cytoskeleton** – "cell skeleton" – an elaborate network of rods
  - Contains three types of rods
    - **Microtubules** – cylindrical structures made of proteins
    - **Microfilaments** – filaments of contractile protein actin
    - **Intermediate filaments** – protein fibers

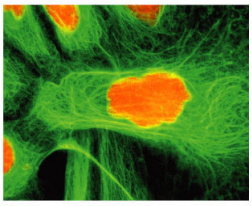
Cytoskeleton: Microtubule



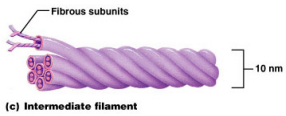


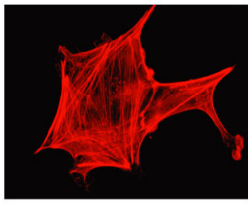
Cytoskeleton: Microfilament





Cytoskeleton: Intermediate Filament





Centrosomes and centrioles

- **Centrosome** – a spherical structure in the cytoplasm
  - Composed of centrosome matrix and centrioles
- **Centrioles** – paired cylindrical bodies
  - Consists of 27 short microtubules
  - Act in forming cilia

Centrosomes and centrioles

Cytoplasmic Inclusions

- Temporary structures – not present in all cell types
- May consist of pigments, crystals of protein, and food stores
  - **Lipid droplets** – found in liver cell and fat cells
  - **Glycosomes** – store sugar in the form of glycogen

The Nucleus

- **The nucleus** – "central core" or "kernel" – control center of cell
  - DNA directs the cell's activities
  - Nucleus is approximate 5μm in diameter

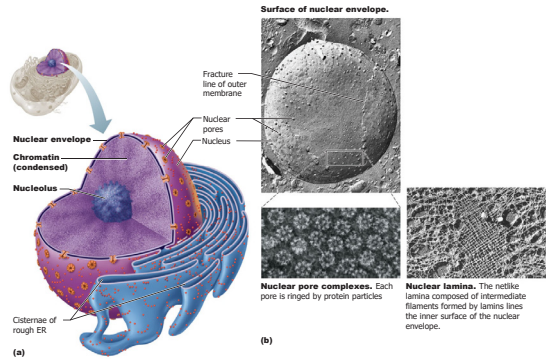


Figure 2.13

The Nucleus

- **Nuclear envelope** – two parallel membranes separated by fluid-filled space
- **Chromatin** – composed of DNA and histone proteins
  - Condensed chromatin – contains tightly coiled strands of DNA
  - Extended chromatin – contains uncoiled strands of DNA
    - DNA's genetic code is copied onto mRNA (transcription)

The Nucleus

- Chromosomes – highest level of organization of chromatin
  - Contains a long molecule of DNA

The Nucleus

- Nucleolus – "little nucleus" – in the center of the nucleus
  - Contains parts of several chromosomes
  - Site of ribosome subunit manufacture

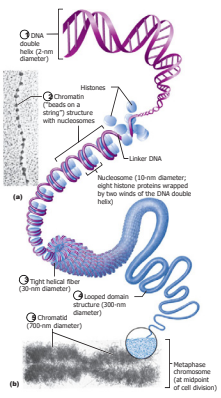


Figure 2.15

The Cell Life Cycle

- Is the series of changes a cell goes through
  - Interphase
    - G1 phase – growth 1 phase – the first part of interphase
      - Centrioles begin to replicate near the end of G1

The Cell Life Cycle

- S (synthetic) phase – DNA replicates itself
  - Ensures that daughter cells receive identical copies of the genetic material
- G2 phase – growth 2 phase– centrioles finish copying themselves
  - During S (synthetic) and G2 phases – cell carries on normal activities

The Cell Life Cycle

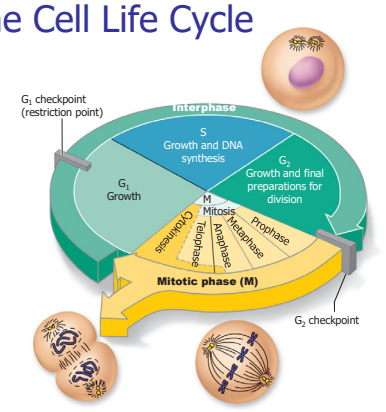


Figure 2.16

The Cell Life Cycle

- Cell division
  - M (mitotic) phase – cells divide during this stage
    - Follows interphase

The Cell Life Cycle

- Cell division involves:
  - Mitosis – division of the nucleus during cell division
    - Chromosomes are distributed to the two daughter nuclei
  - Cytokinesis – division of the cytoplasm
    - Occurs after the nucleus divides

The Stages of Mitosis

- Prophase – the first and longest stage of mitosis
  - Early prophase – chromatin threads condense into chromosomes
    - Chromosomes are made up of two threads called chromatids
    - Chromatids are held together by the centromere
    - Centriole pairs separate from one another
    - The mitotic spindle forms

The Stages of Mitosis

- Prophase (continued)
  - Late prophase – centrioles continue moving away from each other
    - Nuclear membrane fragments

The Stages of Mitosis

- Metaphase – the second stage of mitosis
  - Chromosomes cluster at the middle of the cell
    - Centromeres are aligned along the equator
- Anaphase – the third and shortest stage of mitosis
  - Centromeres of chromosomes split

The Stages of Mitosis

- Telophase – begins as chromosomal movement stops
  - Chromosomes at opposite poles of the cell uncoil
  - Resume their thread-like extended-chromatin form
  - A new nuclear membrane forms
- Cytokinesis – completes the division of the cell into two daughter cells

Early Prophase and Late Prophase

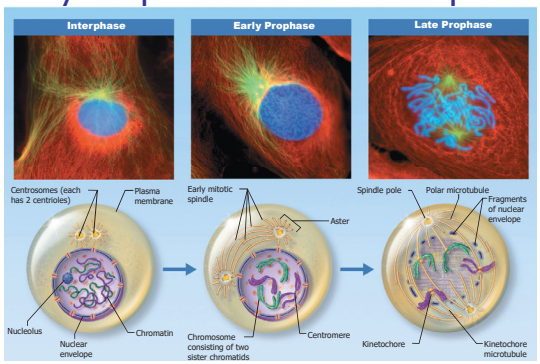


Figure 2.17 (1 of 2)

Metaphase and Anaphase

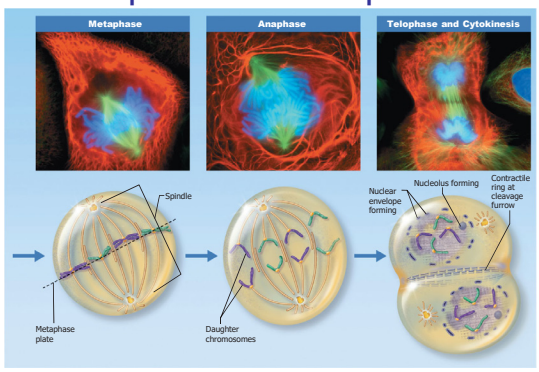


Figure 2.17 (2 of 2)

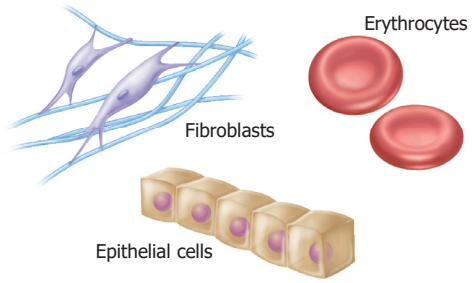
Cellular Diversity

- Specialized functions of cells relates to:
  - Shape of cell
  - Arrangement of organelles

Cellular Diversity

- Cells that connect body parts or cover organs
  - Fibroblast – makes and secretes protein component of fibers
  - Erythrocyte – concave shape provides surface area for uptake of the respiratory gases
  - Epithelial cell – hexagonal shape allows maximum number of epithelial cells to pack together

Cells that Connect Body Parts or Cover Organs



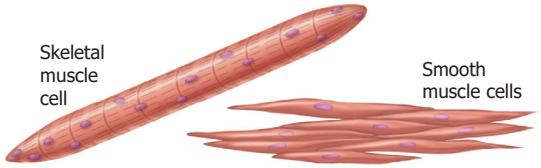
(a) Cells that connect body parts, form linings, or transport gases

Figure 2.18a

Cellular Diversity

- Cells that move organs and body parts
  - Skeletal and smooth muscle cells
    - Elongated and filled with actin and myosin
    - Contract forcefully

Cells that Connect Organs and Body Parts



(b) Cells that move organs and body parts

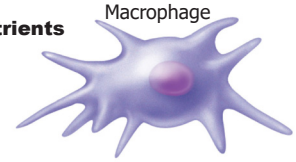
Figure 2.18b

Cellular Diversity

- Cells that store nutrients
  - Fat cell – shape is produced by large fat droplet in its cytoplasm
- Cells that fight disease
  - Macrophage – moves through tissue to reach infection sites

Cells that Store Nutrients and Cells that Fight Disease

(c) Cell that stores nutrients

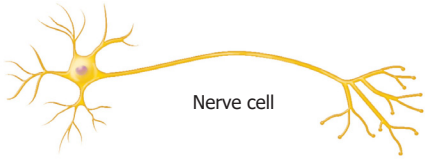


(d) Cell that fights disease

Figure 2.18c, d

Cellular Diversity

- Cells that gather information
  - **Neuron**—has long processes for receiving



(e) Cell that gathers information and controls body functions

Figure 2.18e

Cellular Diversity

- Cells of reproduction
  - **Sperm** (male) – possesses long tail for swimming to the egg for fertilization

(f) Cell of reproduction

Figure 2.18f

Developmental Aspects of Cells

- Youth – begin as a fertilized egg
  - Cells in embryo
    - Exposed to chemical signals
    - Chemicals channel cells into specific pathways of development
  - Cell specialization leads to structural variation of cell types

Developmental Aspects of Cells

- Aging – a complex process caused by a variety of factors
  - Free radical theory
    - Damage from byproducts of cellular metabolism
    - Radicals build up and damage essential molecules of cells
  - Mitochondrial theory – a decrease in production of energy by mitochondria weakens and ages our cells

Developmental Aspects of Cells

- Genetic theory – proposes that aging is programmed by genes
  - Telomeres – "end caps" on chromosomes
  - Telomerase – prevents telomeres from degrading