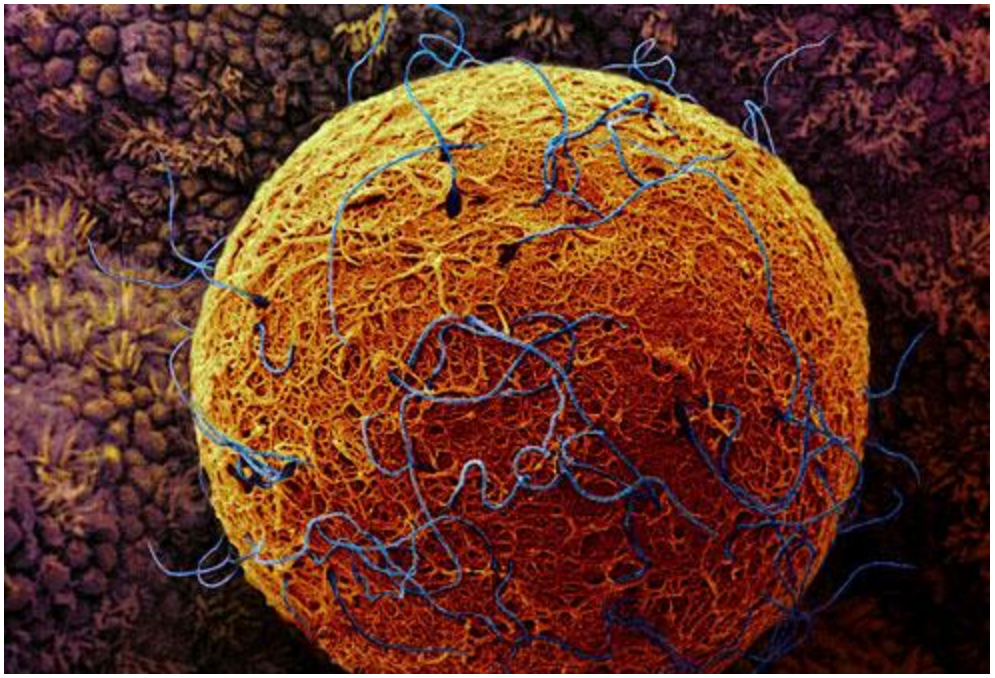
Introduction to Cells

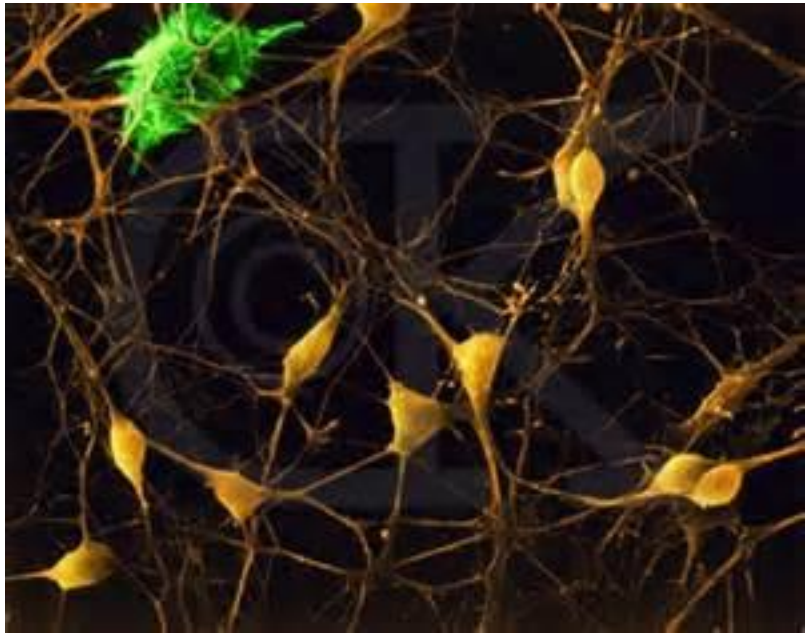
Examples of cell types

Somatic

Sex cells

Stem cells





Introducing Cells

Our bodies include more than 260 cell types

Somatic (body) **cells** have two copies of the genome and are said to be **diploid (2n)**

Sex cells (Sperm and egg cells) have one copy of the genome and are **haploid (1n)**

Stem cells can both replicate themselves and give rise to differentiated cells

Chemical Constituents

Cells contain four types of macromolecules

Type	Examples	Functions
Carbohydrates	Sugars, starches	Energy, structure
Lipids	Fats, oils	Membranes, hormones
Proteins	Myosin, collagen	Enzymes, structure
Nucleic Acids	DNA, RNA	Genetic information

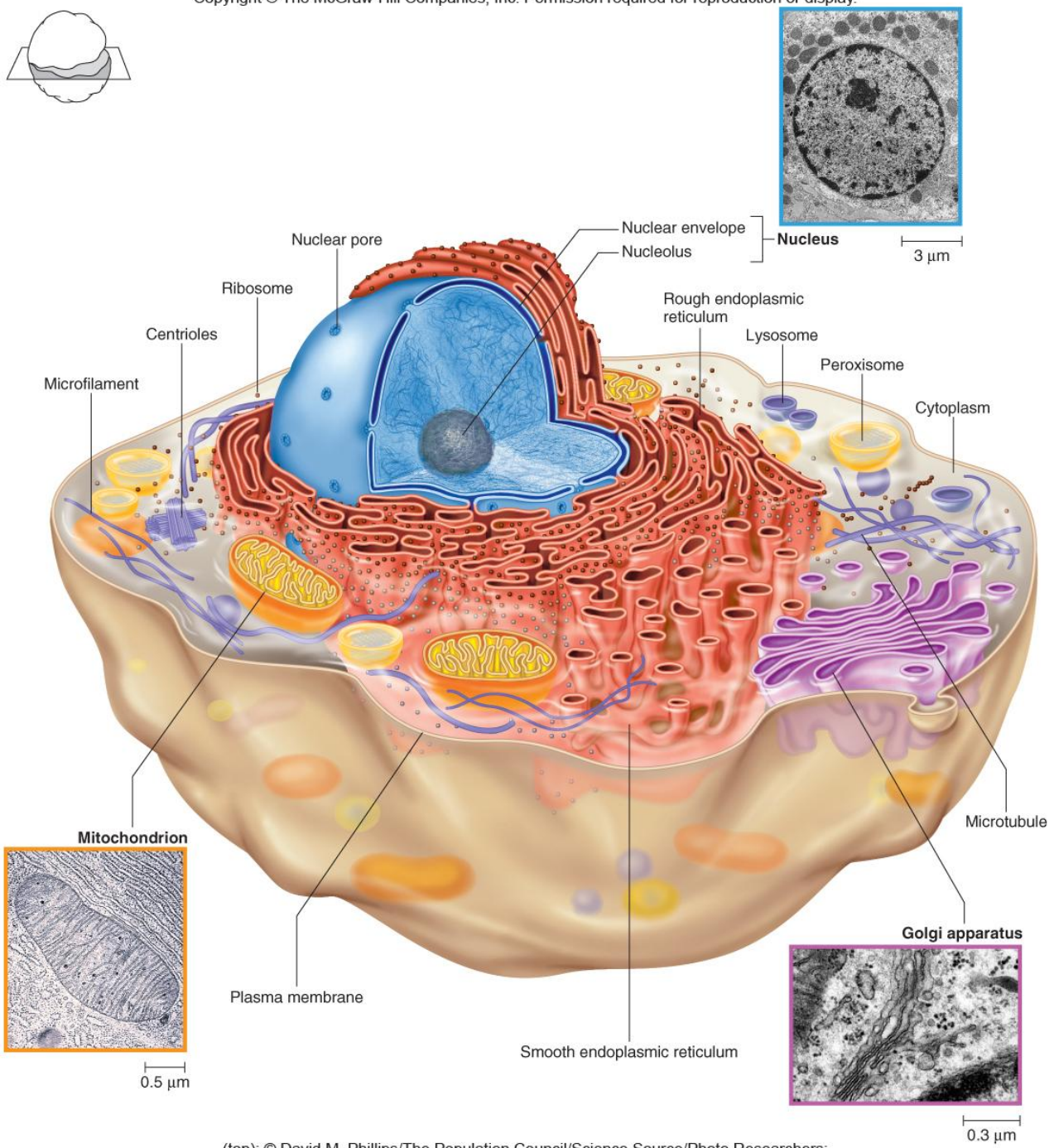
An Animal Cell

Surrounded by the **plasma membrane**

Contains:

- **Cytoplasm**
- **Organelles**
  - Divide labor by partitioning certain areas or serving specific functions

Figure 2.3



(top): © David M. Phillips/The Population Council/Science Source/Photo Researchers;
(bottom left): © K.R. Porter/Photo Researchers; (bottom right): © EM Research Services, Newcastle University

The Nucleus

The largest structure in a cell

Surrounded by a double-layered **nuclear envelope**

Contains:

- **Nuclear pores** that allow movement of some molecules in and out
- **Nucleolus**, which is the site of ribosome production
- **Chromosomes** composed of DNA and proteins

The Nucleus

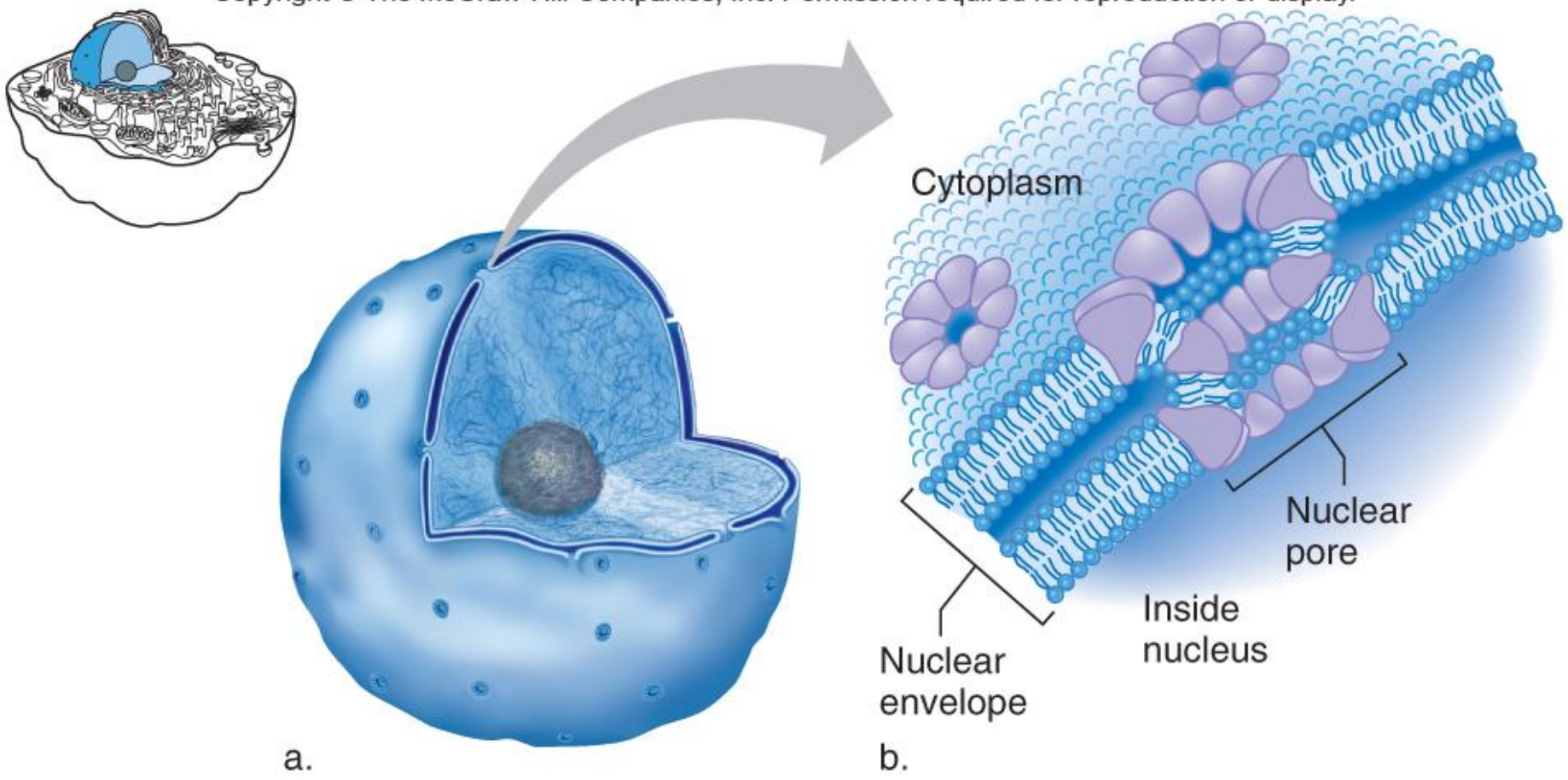


Figure 2.4

Endoplasmic Reticulum (ER)

Interconnected membranous tubules & sacs

Winds from the nuclear envelope to the plasma membrane

Rough ER contains ribosomes and is involved in protein synthesis

Smooth ER does not contain ribosomes and is important in lipid synthesis

Golgi Apparatus

Stack of flat membrane-enclosed sacs

Processing center that adds sugars forming glycoproteins and glycolipids

Site of final protein folding

Products are released into vesicles that bud off to the plasma membrane

Lysosomes

Membrane-bound sacs containing > 40 types of digestive enzymes

Break down bacteria, cellular debris, and nutrients

Tay-Sachs is an inherited lysosomal storage disorder

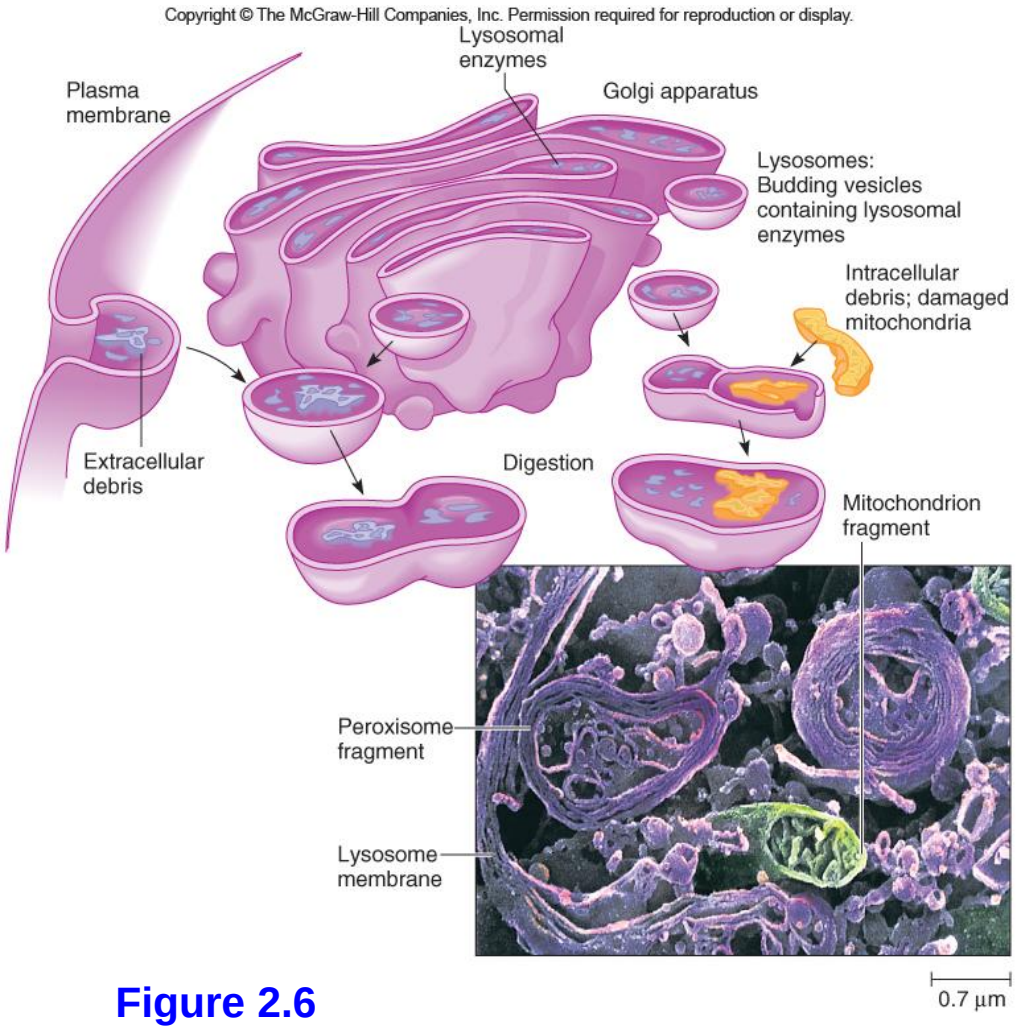


Figure 2.6

Peroxisomes

Sacs with outer membranes studded with several types of enzymes

Break down lipids, rare biochemicals

Synthesize bile acids

Detoxify compounds from free radicals

Abundant in liver and kidney cells

Mitochondria

- Surrounded by two membranes
- Site of ATP (energy) production
- Contain their own circular DNA
- Human mitochondrial DNA is inherited only from the mother

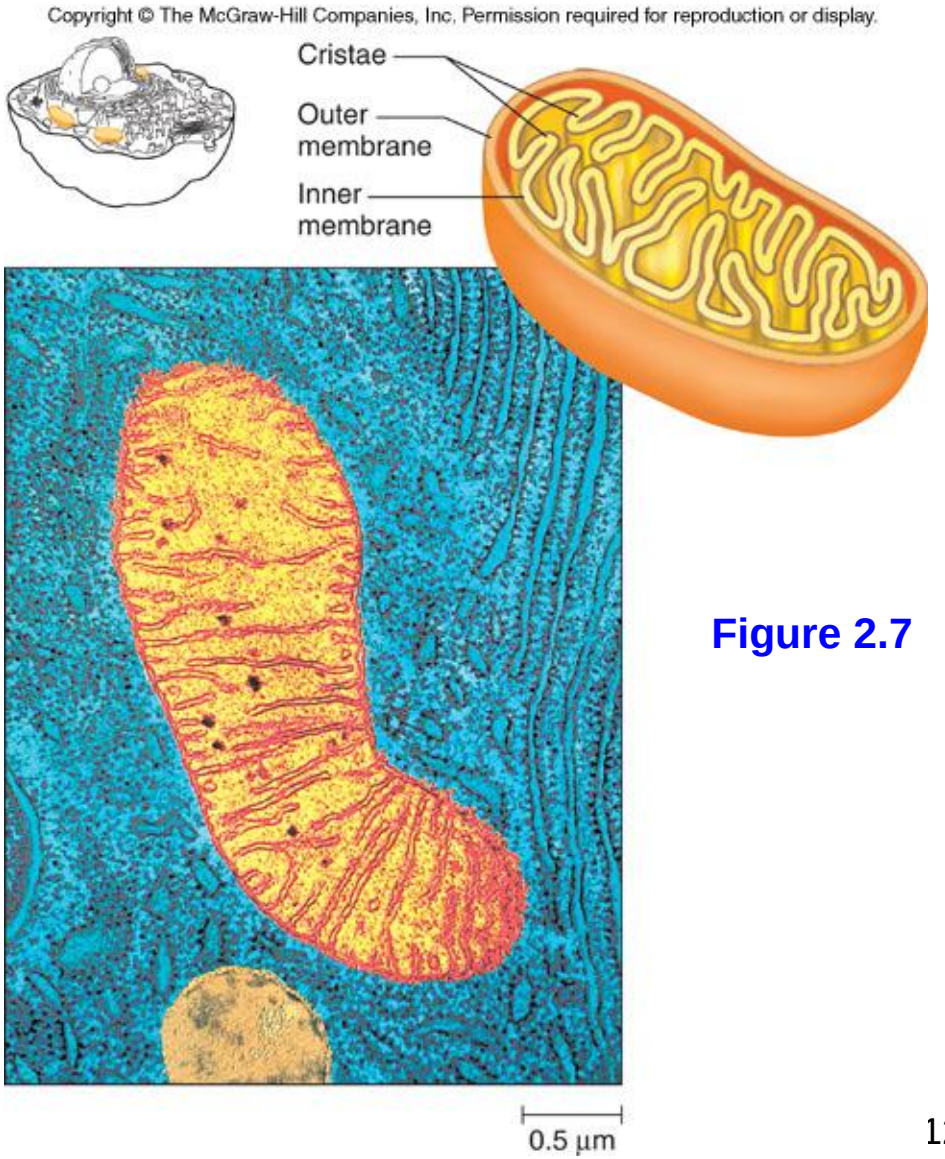


Figure 2.7

Plasma Membrane

Forms a selective barrier

A **phospholipid bilayer**

- Phosphate end (hydrophilic)
- Fatty acid chains (hydrophobic)

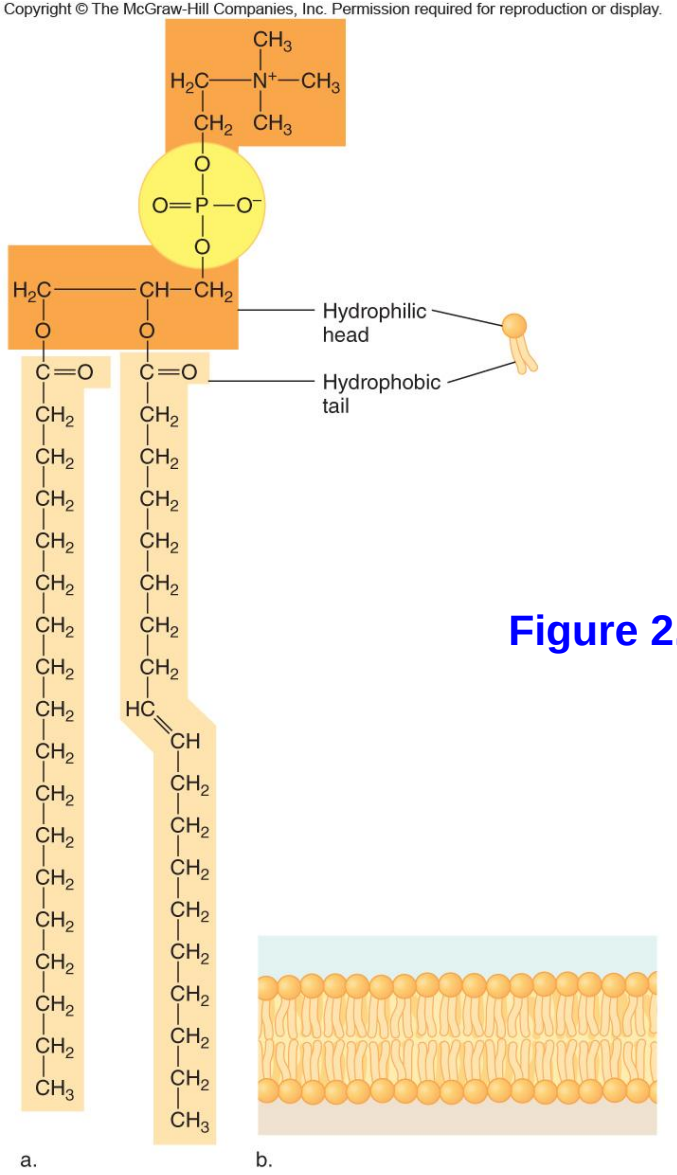
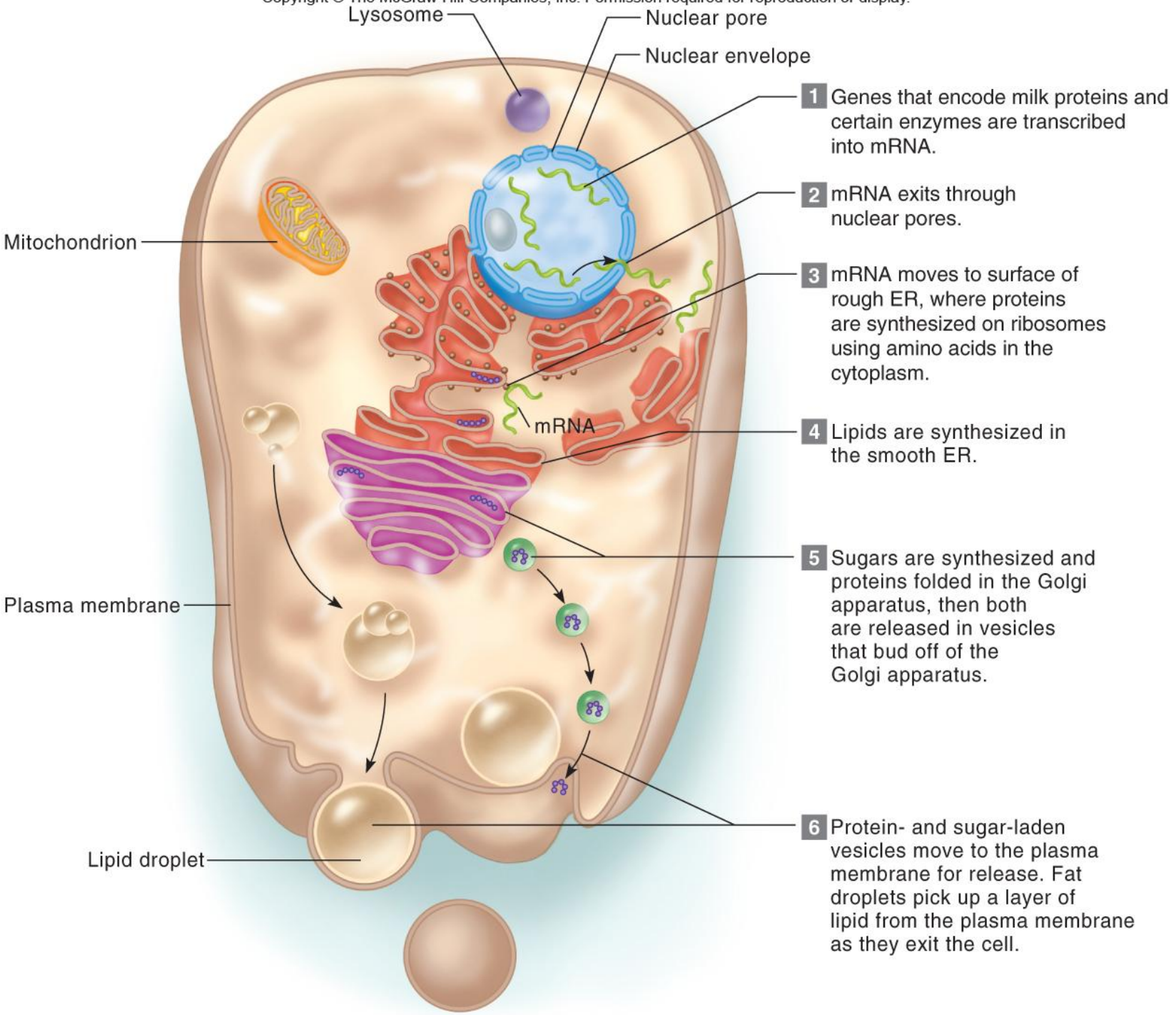


Figure 2.8

Table 2.1 Structures and Functions of Organelles

Organelle	Structure	Function
Endoplasmic reticulum	Membrane network; rough ER has ribosomes, smooth ER does not	Site of protein synthesis and folding; lipid synthesis
Golgi apparatus	Stacks of membrane-enclosed sacs	Site where sugars are made and linked into starches or joined to lipids or proteins; proteins finish folding; secretions stored
Lysosome	Sac containing digestive enzymes	Degrades debris; recycles cell contents
Mitochondrion	Two membranes; inner membrane enzyme-studded	Releases energy from nutrients, participates in cell death
Nucleus	Porous sac containing DNA	Separates DNA within cell
Peroxisome	Sac containing enzymes	Breaks down and detoxifies various molecules
Ribosome	Two associated globular subunits of RNA and protein	Scaffold and catalyst for protein synthesis
Vesicle	Membrane-bounded sac	Temporarily stores or transports substances



Plasma Membrane

Contains proteins, glycoproteins, and glycolipids

- Important to cell function and interactions
- May be receptors
- Form channels for ions

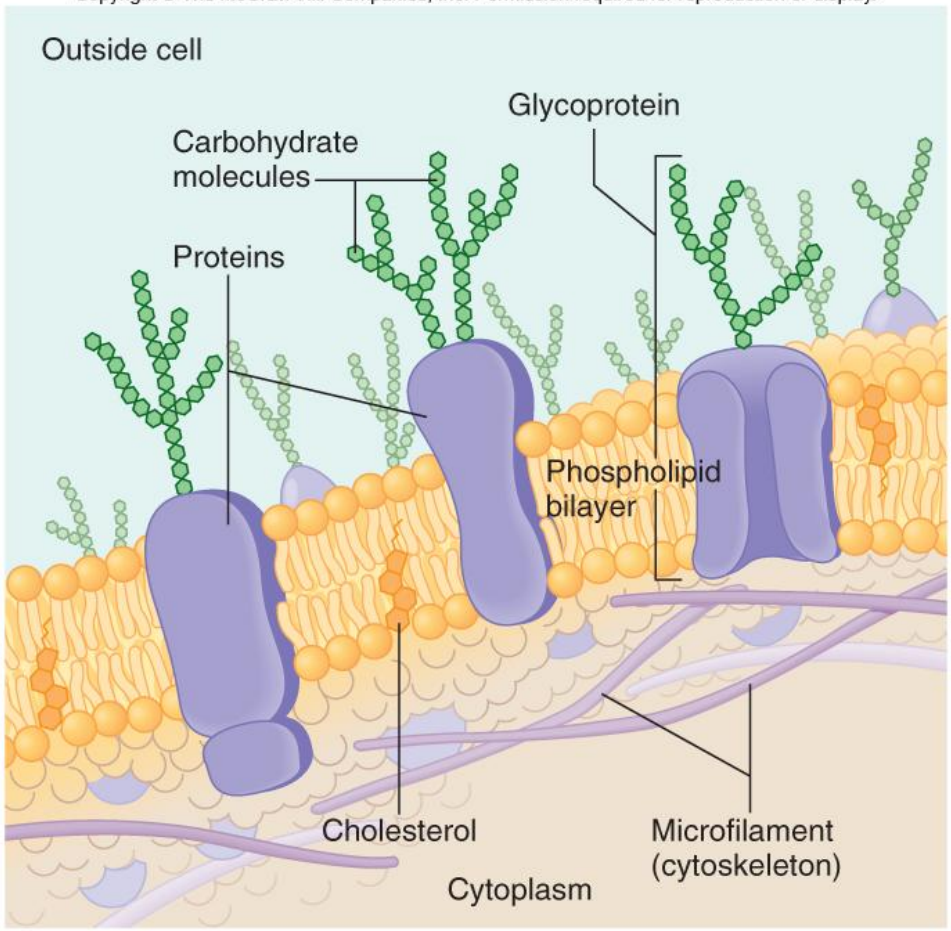


Figure 2.9

Faulty Ion Channels Cause Inherited Diseases

Sodium channels

- Mutations lead to absence or extreme pain

Potassium channels

- Mutations lead to impaired heart function and deafness

Chloride channels

- Mutations lead to cystic fibrosis

Cell Division and Death

Normal growth and development require an intricate interplay between the rates of two processes

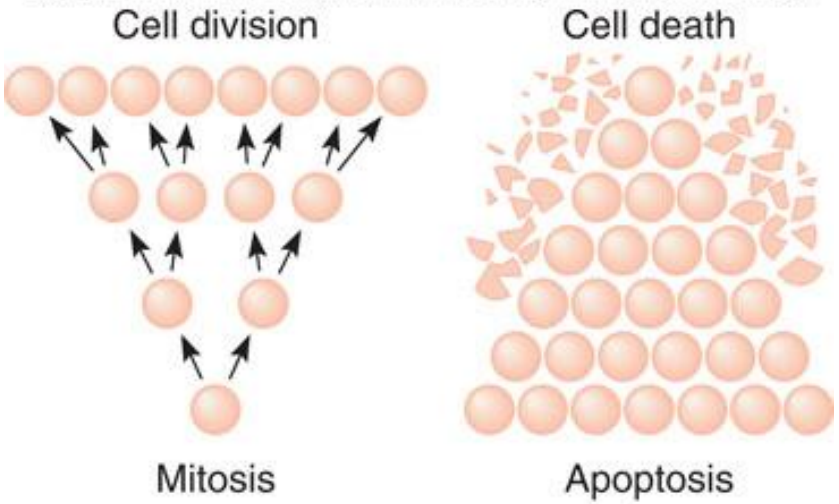
Mitosis – Cell division

- Produces two somatic cells from one

Apoptosis – Cell death

- Precise genetically-programmed sequence

Figure 2.13



a.

b.

The Cell Cycle

The sequence of events associated with cell division

G phase: Gap for growth

S phase: DNA synthesis

M phase: Mitosis (nuclear division)

Cytokinesis: Cell division

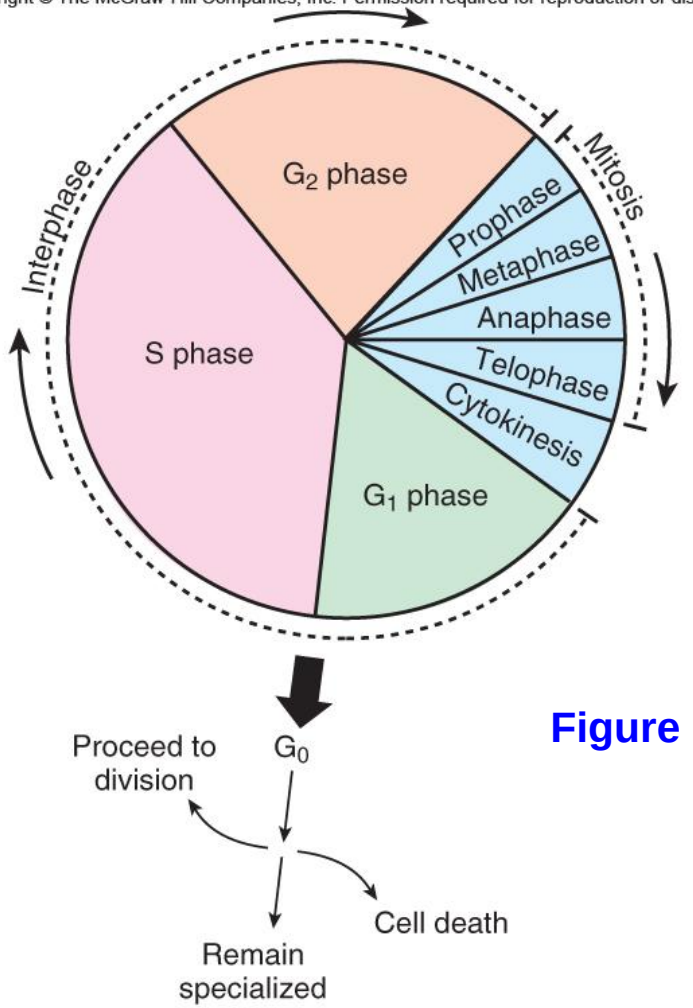


Figure 2.14

Stages of the Cell Cycle

Interphase

- Prepares for cell division
- Replicates DNA and subcellular structures
- Composed of G_1, S, and G_2
- Cells may exit the cell cycle at G_1 or enter G_0, a quiescent phase

Mitosis – Division of the nucleus

Cytokinesis – Division of the cytoplasm

Replication of Chromosomes

Chromosomes are replicated during S phase prior to mitosis

The result is two sister **chromatids** held together at the **centromere**

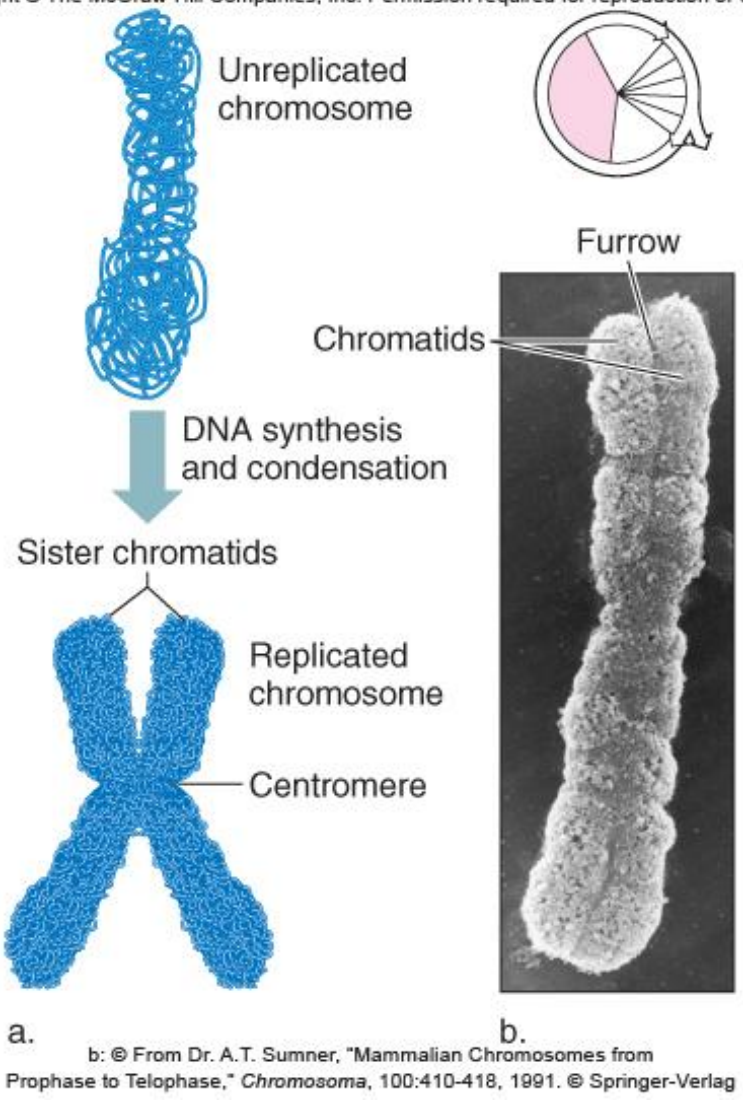
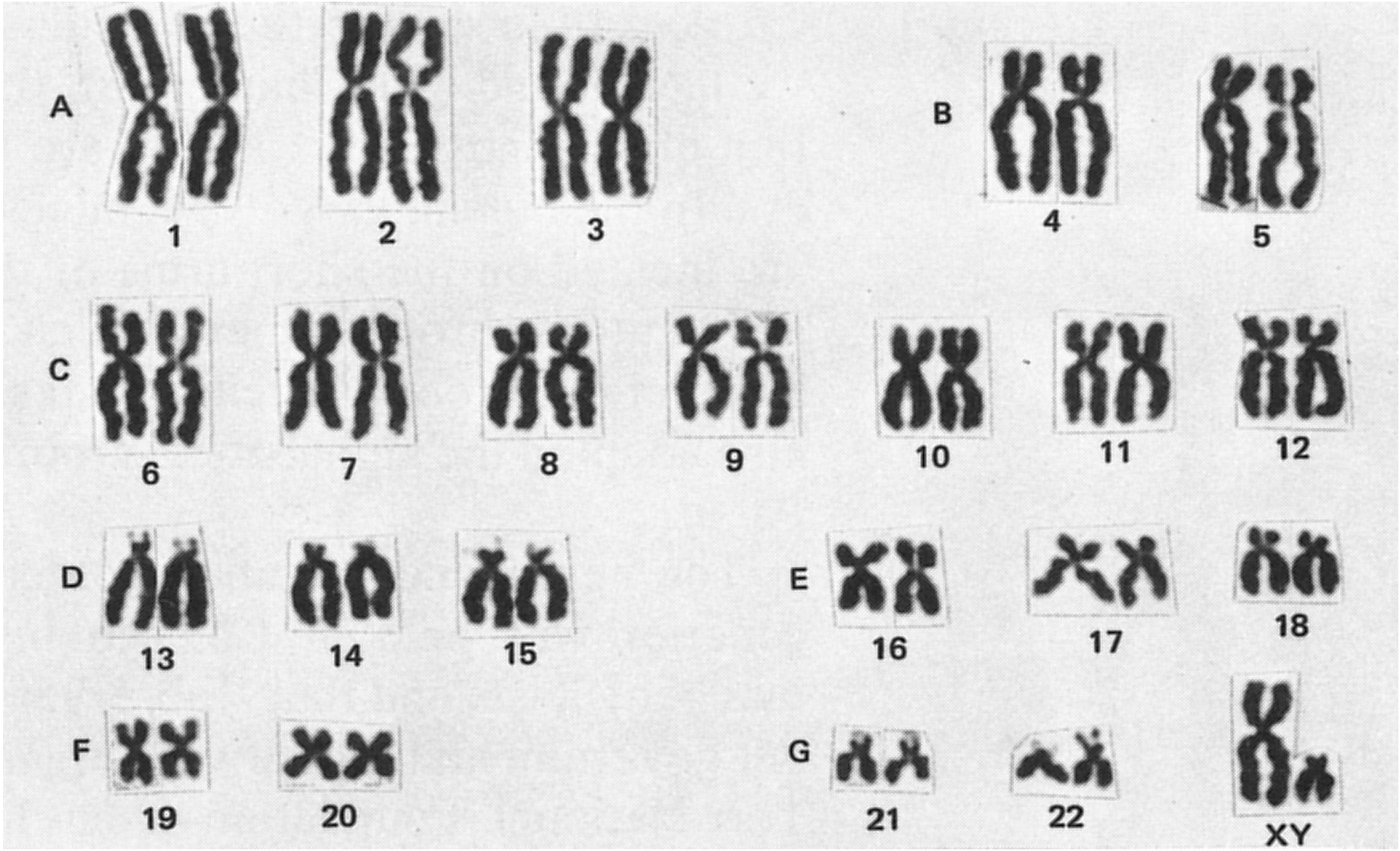


Figure 2.15

b: © From Dr. A.T. Sumner, "Mammalian Chromosomes from Prophase to Telophase," *Chromosoma*, 100:410-418, 1991. © Springer-Verlag

What do we call this picture?



Mitosis

Used for growth, repair, and replacement

Consists of a single division that produces two identical daughter cells

A continuous process divided into 4 phases

- Prophase
- Metaphase
- Anaphase
- Telophase

Mitosis in a Human Cell

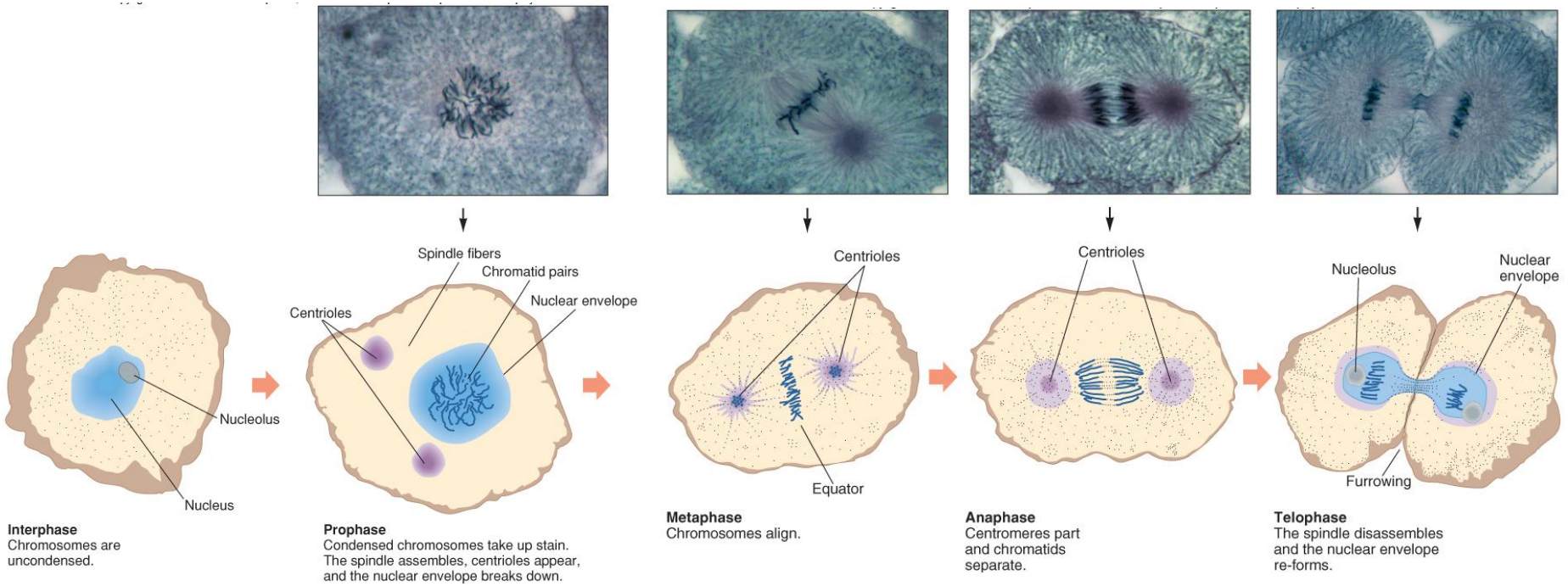


Figure 2.16

Prophase

- Replicated chromosomes condense
- Microtubules organize into a spindle
- Nuclear envelope and nucleolus break down

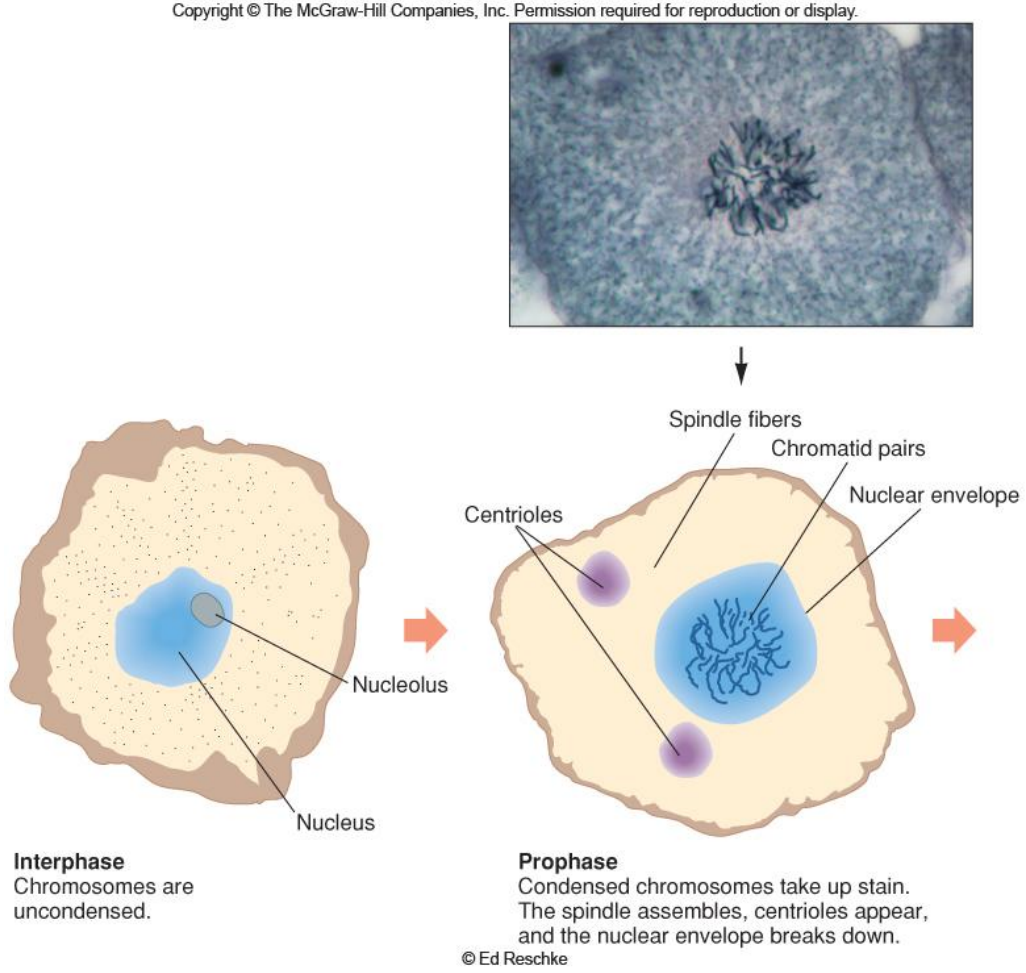


Figure 2.16

Metaphase

Chromosomes line up on the cell's equator

Spindle microtubules are attached to centromeres of chromosomes

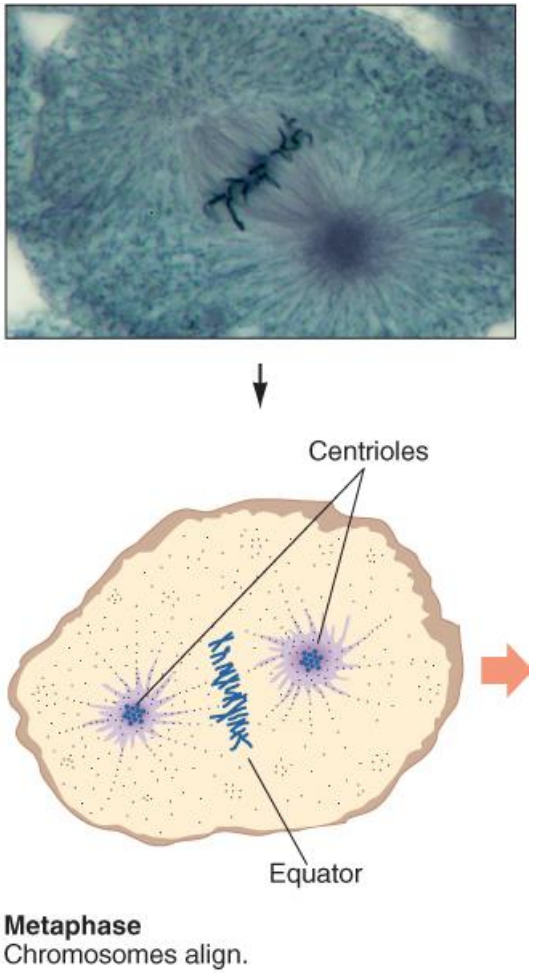


Figure 2.16

Anaphase

Centromeres divide

Chromatids separate and become independent chromosomes

- They move to opposite ends of the cell

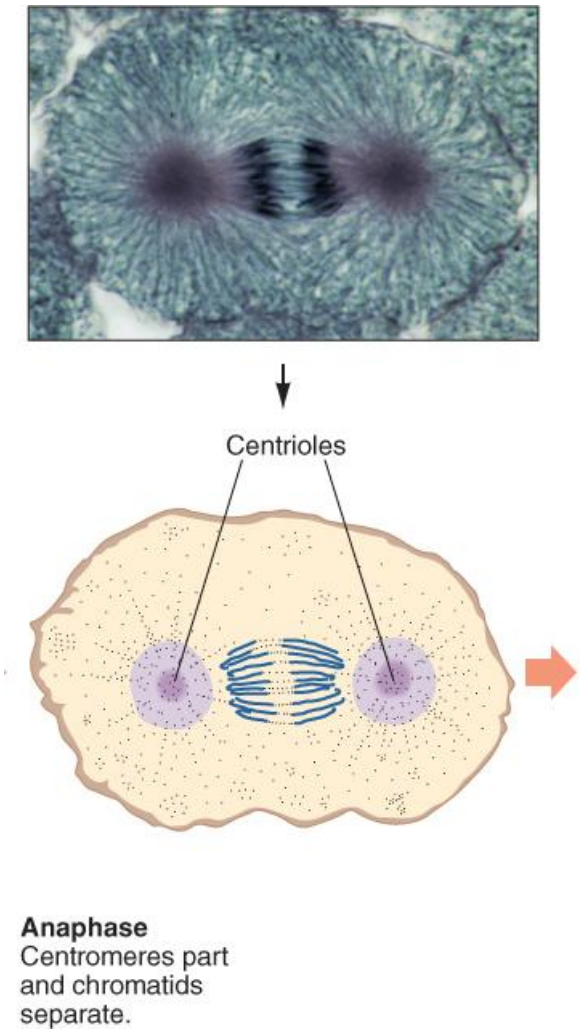


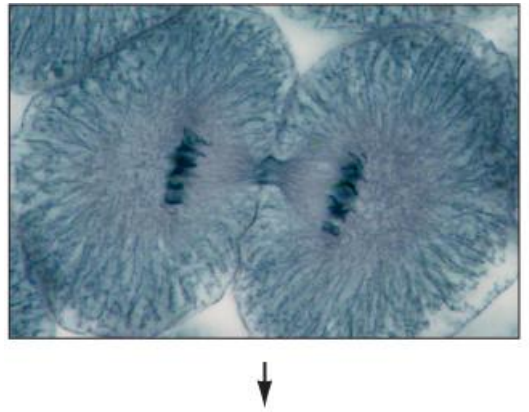
Figure 2.16

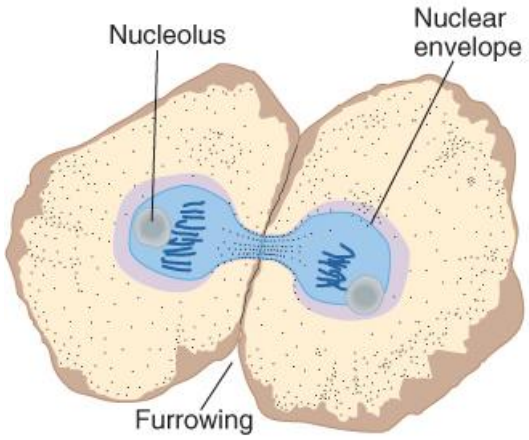
Telophase

Chromosomes uncoil

Spindle disassembles

Nuclear envelope reforms





Telophase
The spindle disassembles and the nuclear envelope re-forms.

Figure 2.16

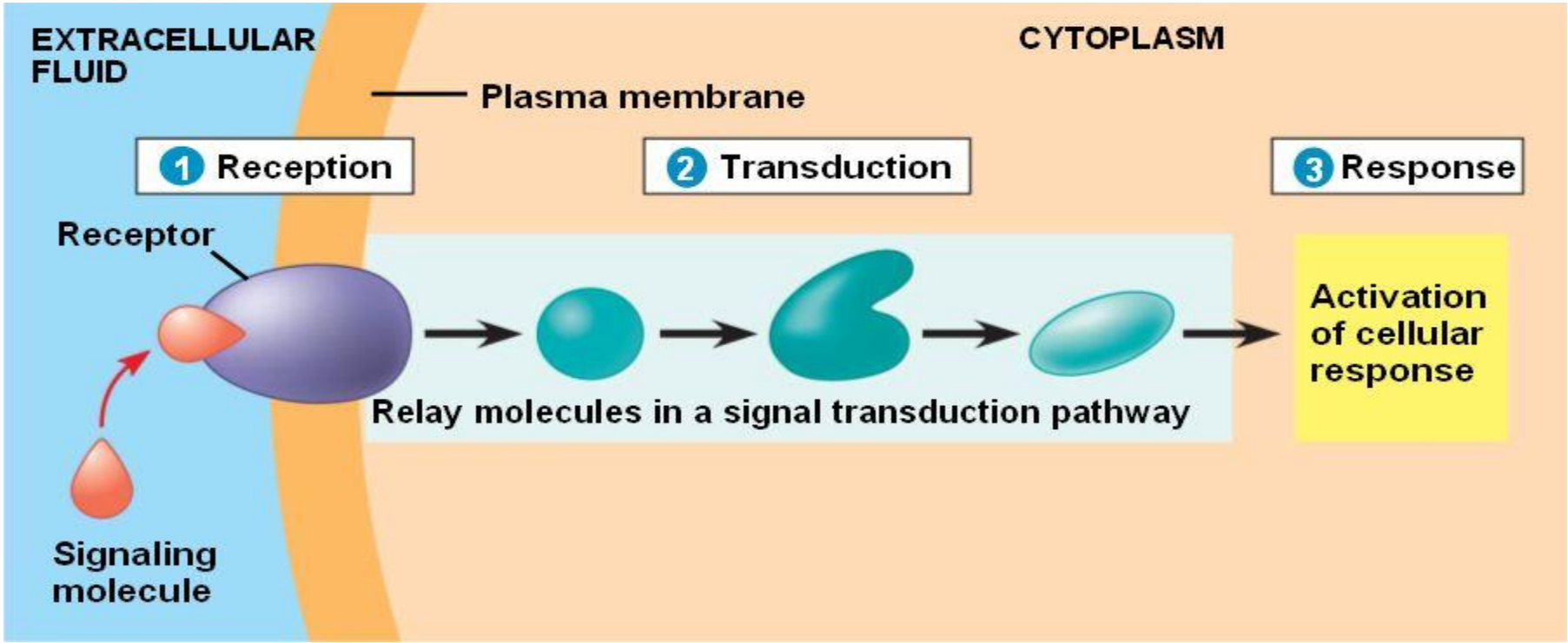
Cytokinesis

Cytoplasmic division occurs after nuclear division is complete

Organelles and macromolecules are distributed between the two daughter cells

Microfilament band contracts, separating the two cells

How do cells communicate during development?



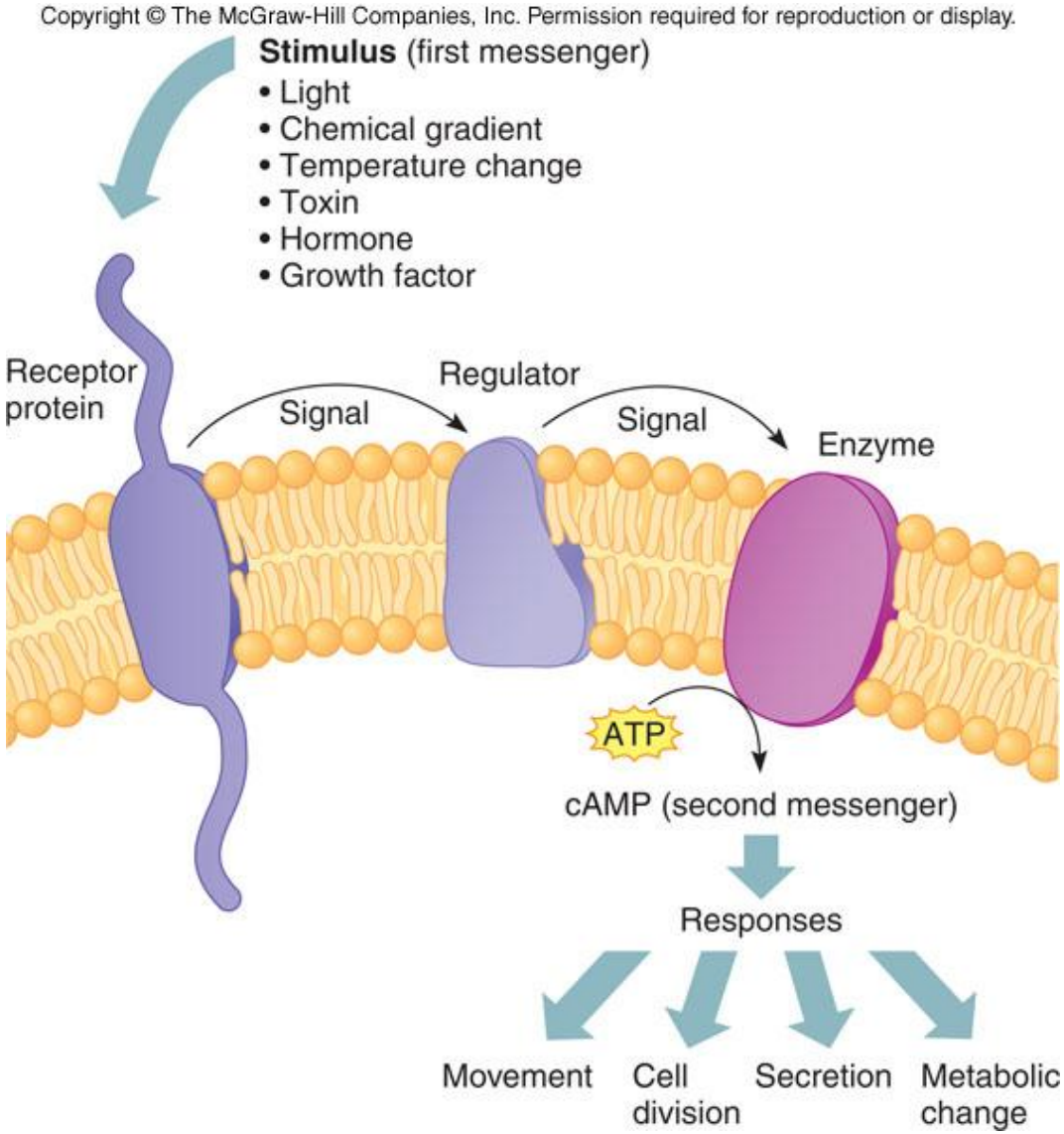
Signal Transduction

The process of transmitting a signal from the environment to a cell

- Receptor binds to “first messenger”
- Interacts with regulator
- Causes enzyme to produce “second messenger”
- Elicits cellular response, which is typically enzyme activation
- Amplification due to cascade

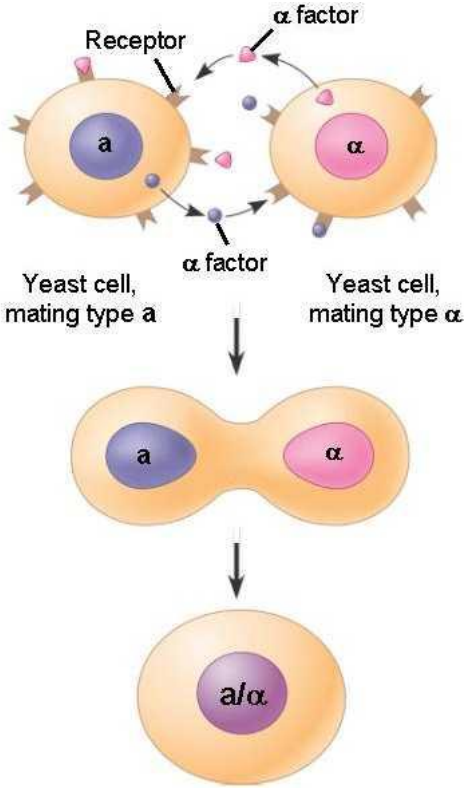
Signal Transduction

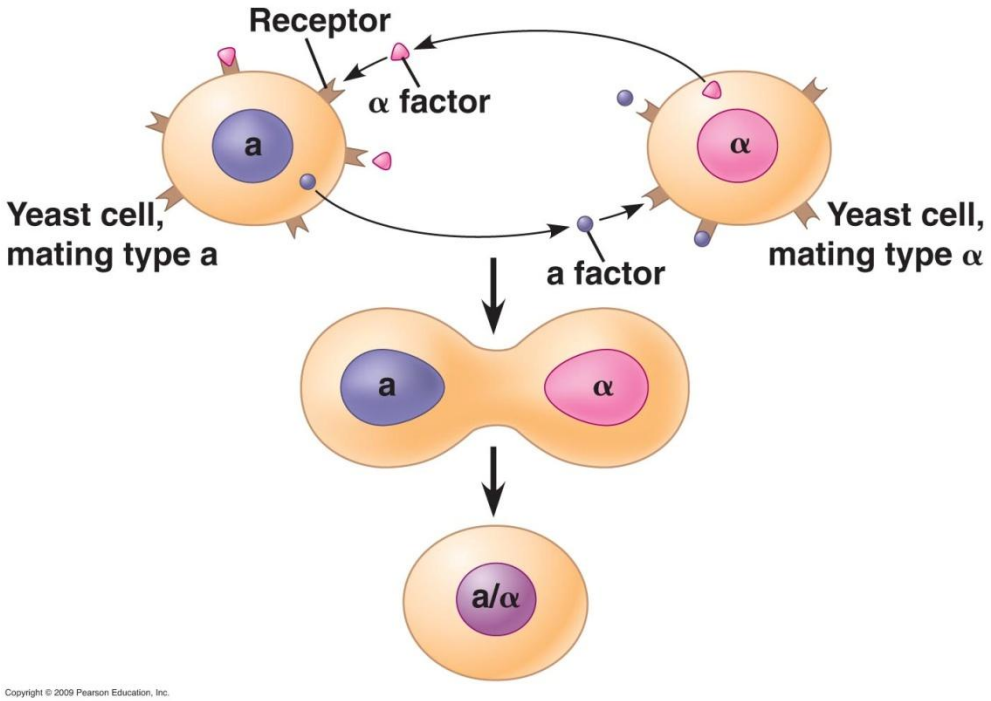
Figure 2.20

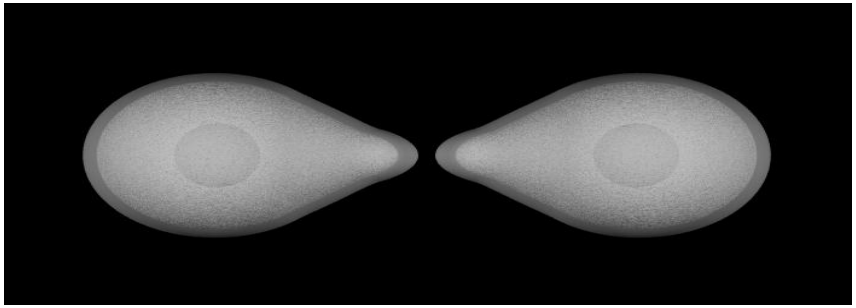


How do cells respond to a chemical signal? Yeast

1. **Exchange of mating factors.** Each cell type secretes a mating factor that binds to receptors on the other cell type.
2. **Mating.** Binding of the factors to receptors induces changes in the cells that lead to their fusion.
3. **New a/α cell.** The nucleus of the fused cell includes all the genes from the a and α cells.







Additional information we will cover in class
Stem Cells

A **stem cell** divides by mitosis

- Produces daughter cells that retain the ability to divide and some that specialize

Progenitor cells do not have the capacity of **self-renewal**

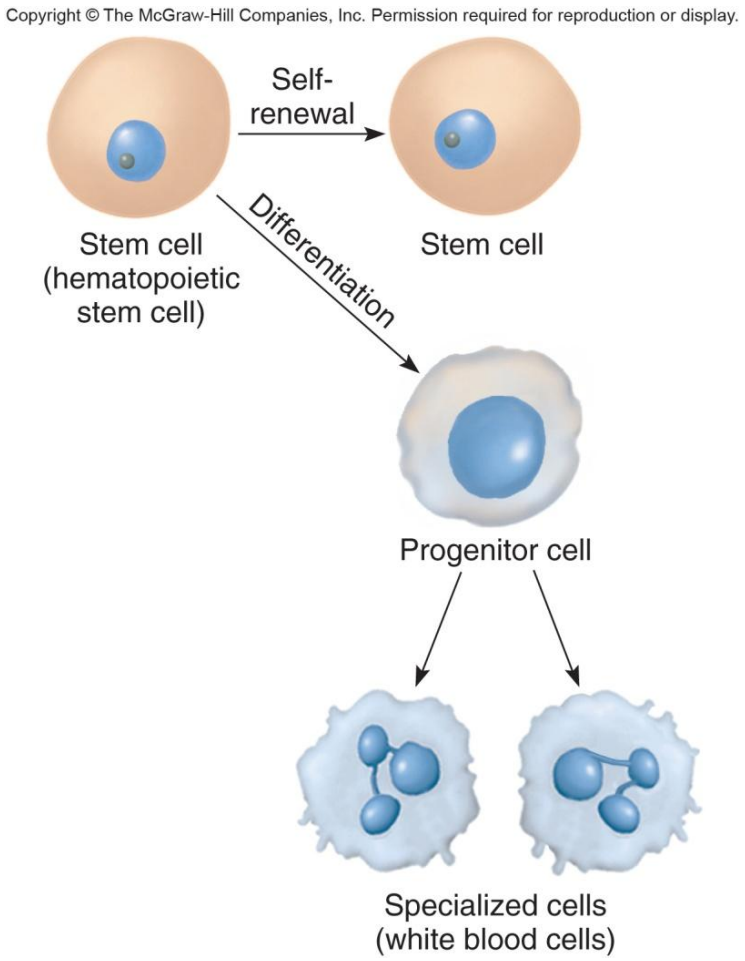


Figure 2.22

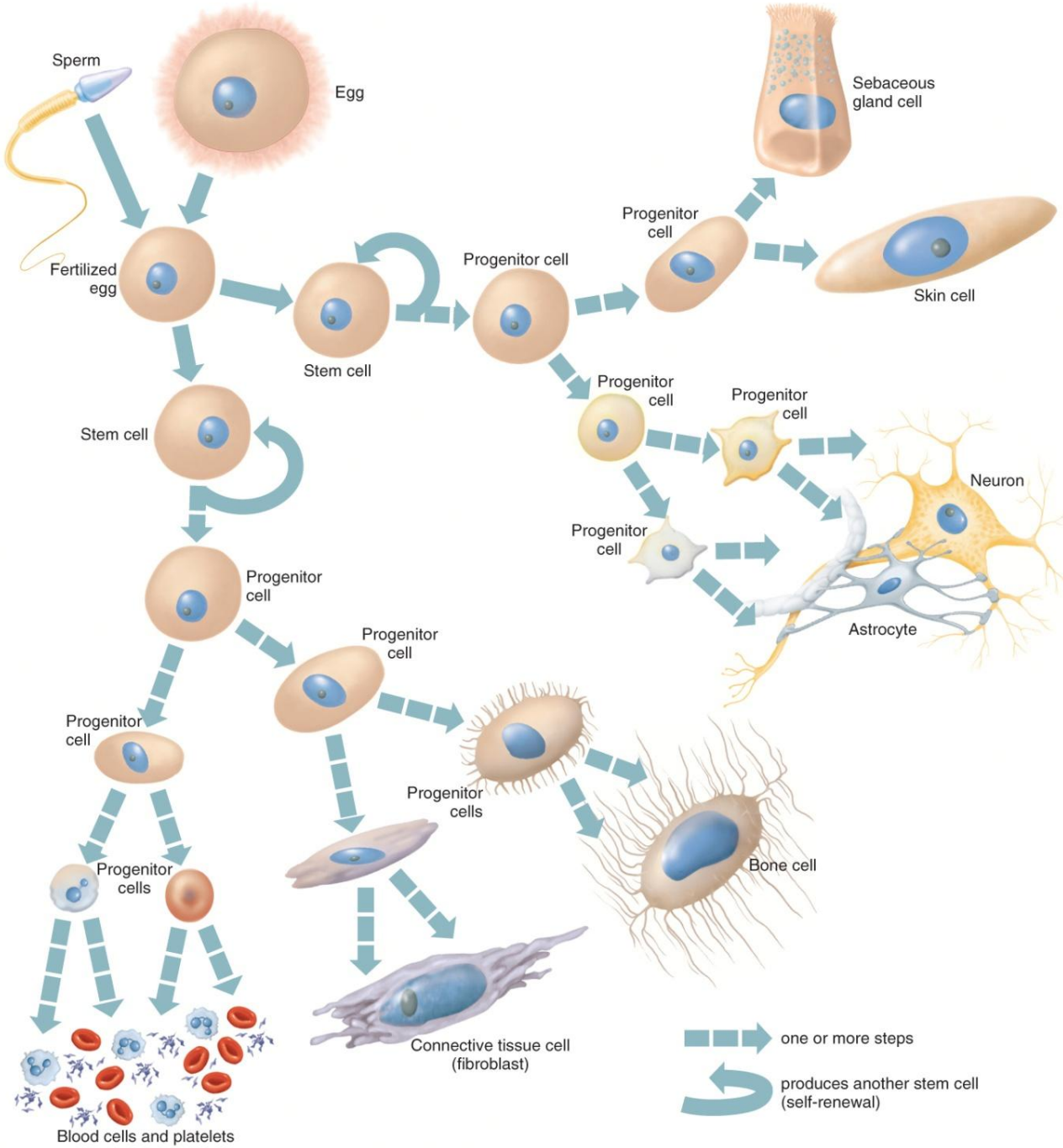
Stem Cells

All cells in the human body descend from stem cells via mitosis and differentiation

Cells differentiate down cell lineages by differential gene expression

Stem cells are present throughout life and provide growth and repair

Figure 2.23



Stem Cells

Stem cells and progenitor cells are described in terms of their developmental potential

Totipotent – Can give rise to every cell type

Pluripotent – Have fewer possible fates

Multipotent – Have only a few fates

Stem Cells in Health Care

There are 3 general sources of human stem cells

1) **Embryonic stem cells** – Created in a lab dish using the inner cell mass (ICM) of an embryo

2) **Induced pluripotent stem (iPS) cells** – Somatic cells reprogrammed to differentiate into any of several cell types

3) **Adult stem cells** – Tissue-specific or somatic stem cells

Stem Cells in Health Care

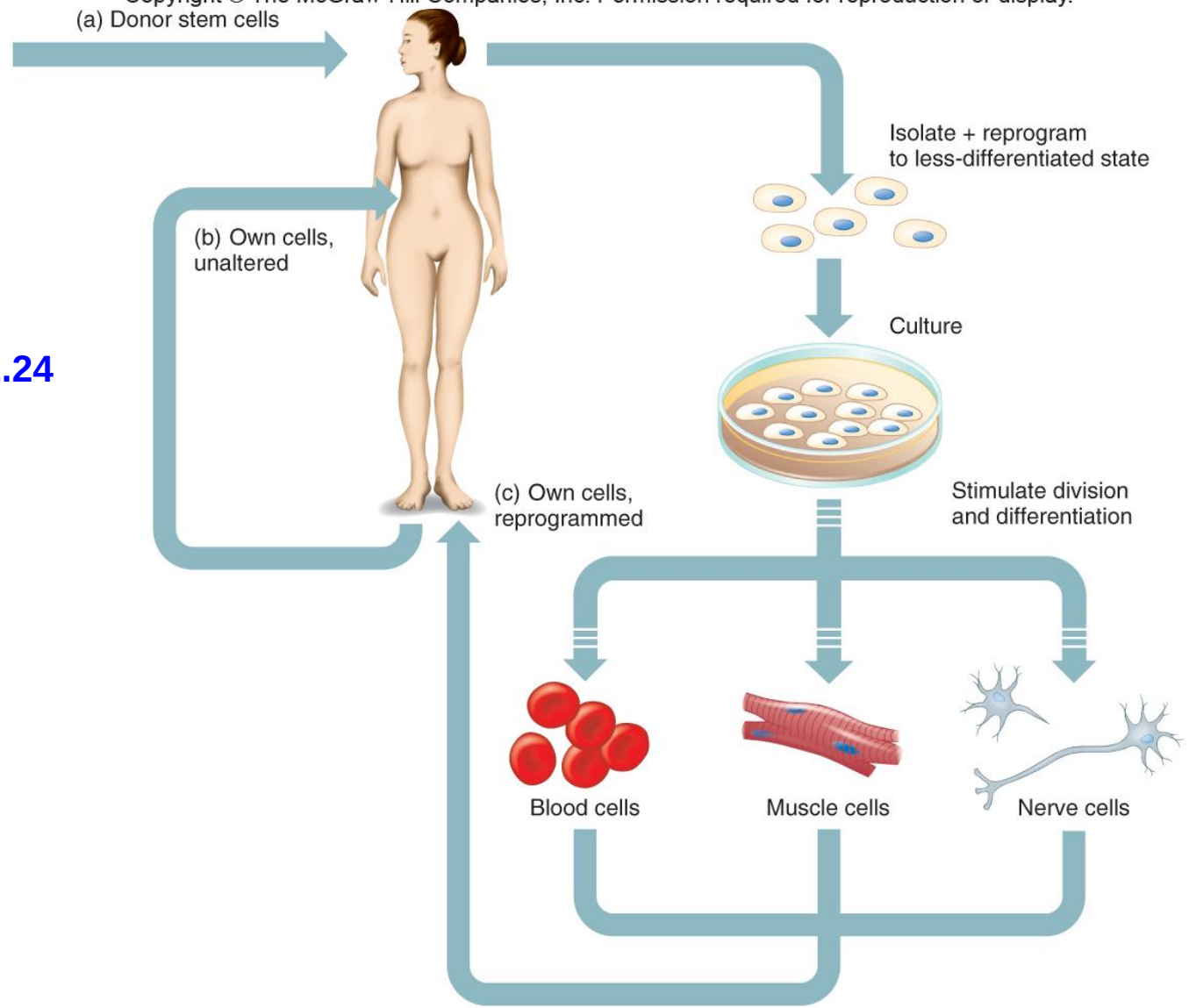


Figure 2.24