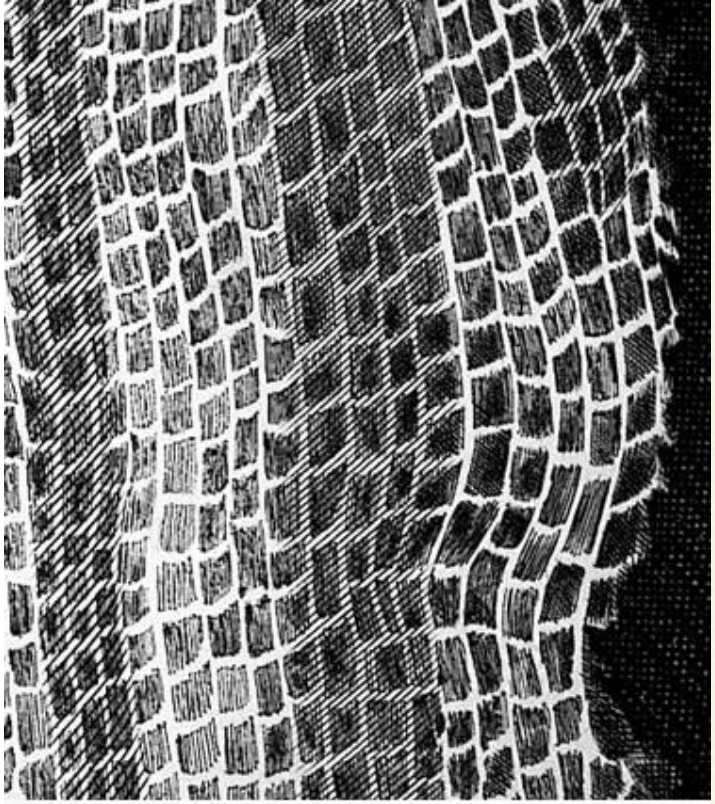
Chapter 4: Cell Structure and Function



Robert Hooke

Fig. 4-2, p.51

The Cell

- Smallest unit of life
- Can survive on its own or has potential to do so
- Is highly organized for metabolism
- Senses and responds to environment
- Has potential to reproduce

Structure of Cells

All start out life with:

- Plasma membrane
- Region where DNA is stored
- Cytoplasm

Prokaryotic and Eukaryotic Cells

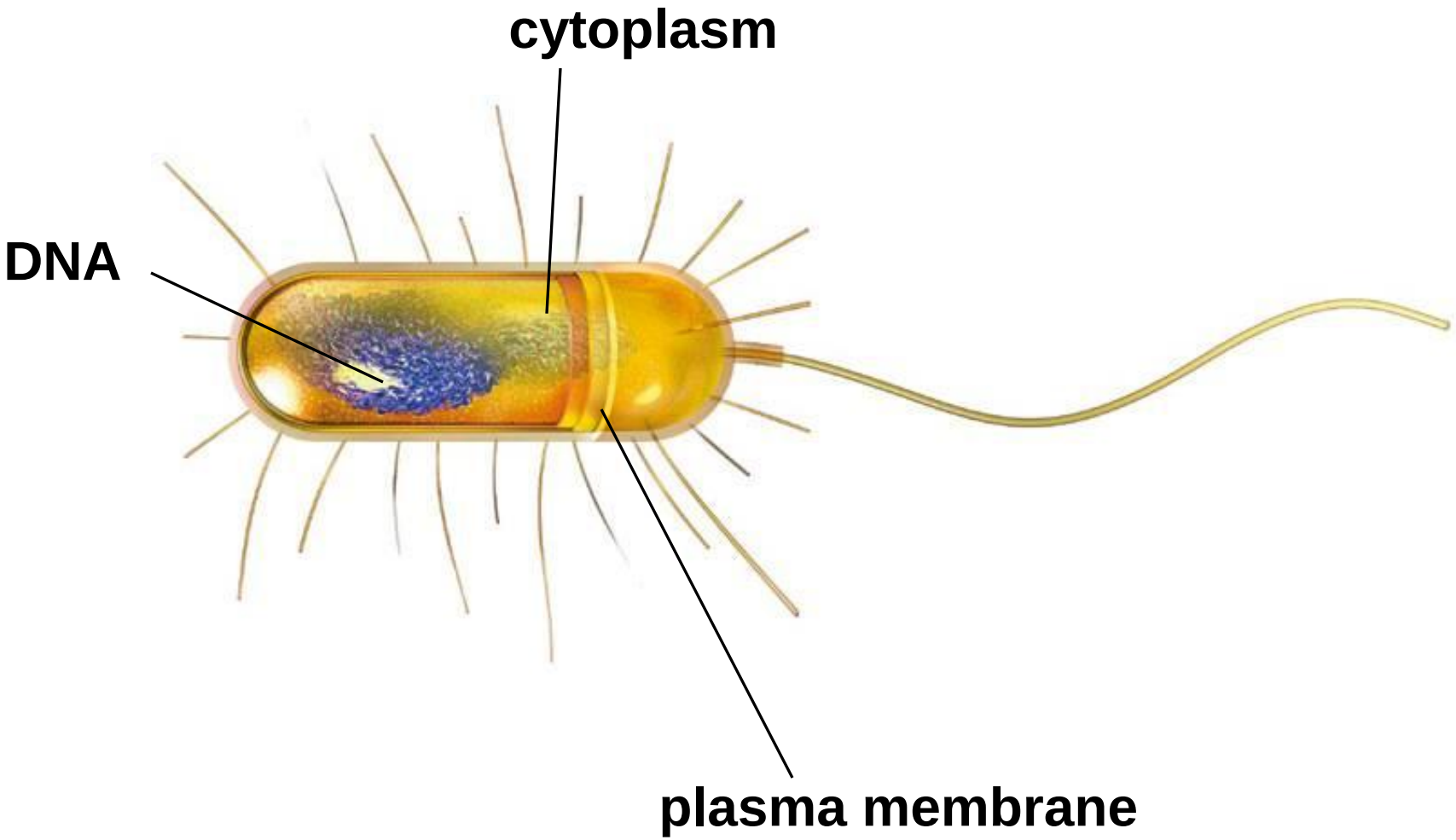


Fig. 4-3a, p.52

Prokaryotic and Eukaryotic Cells

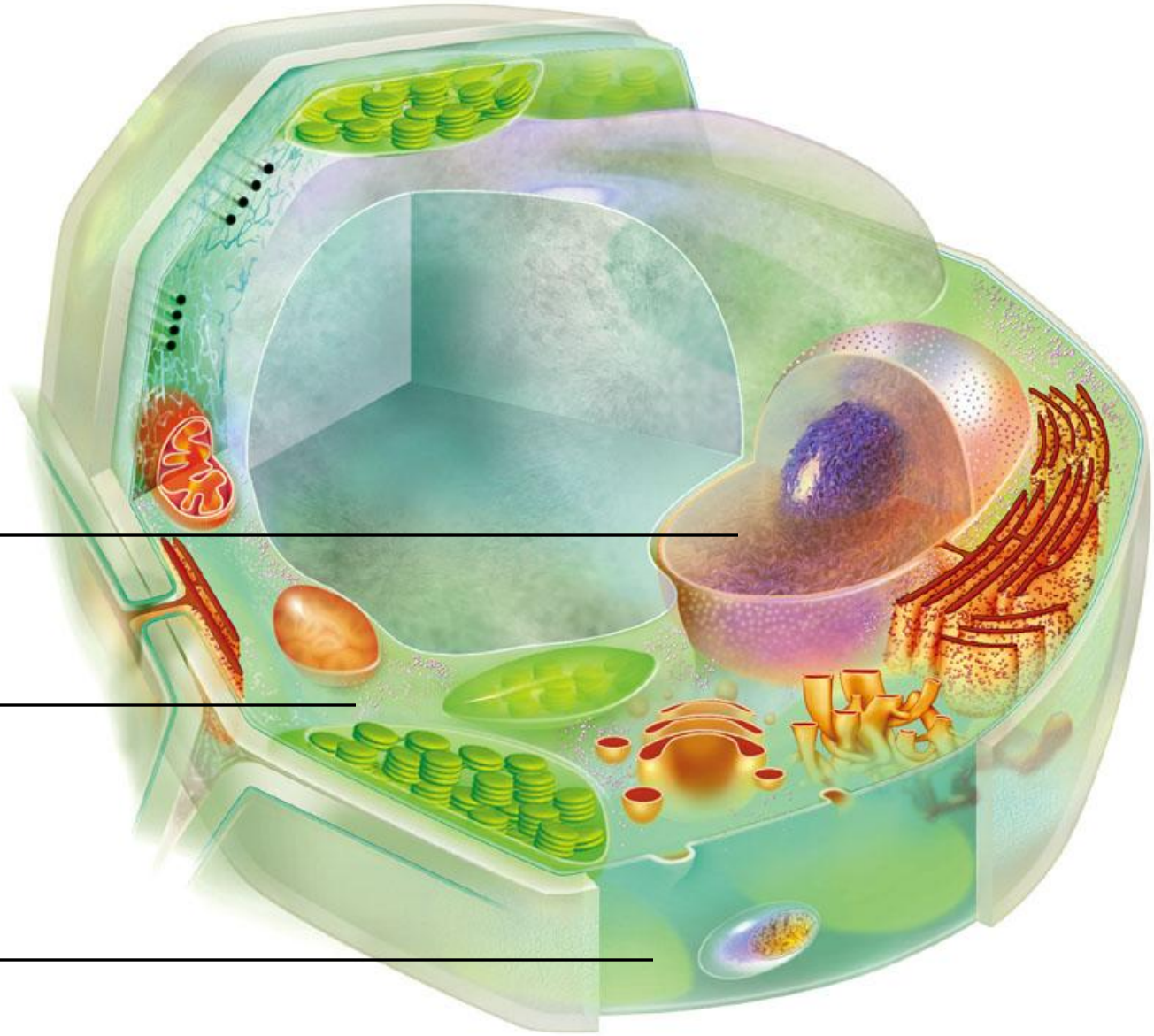


Fig. 4-3b, p.52

Prokaryotic and Eukaryotic Cells

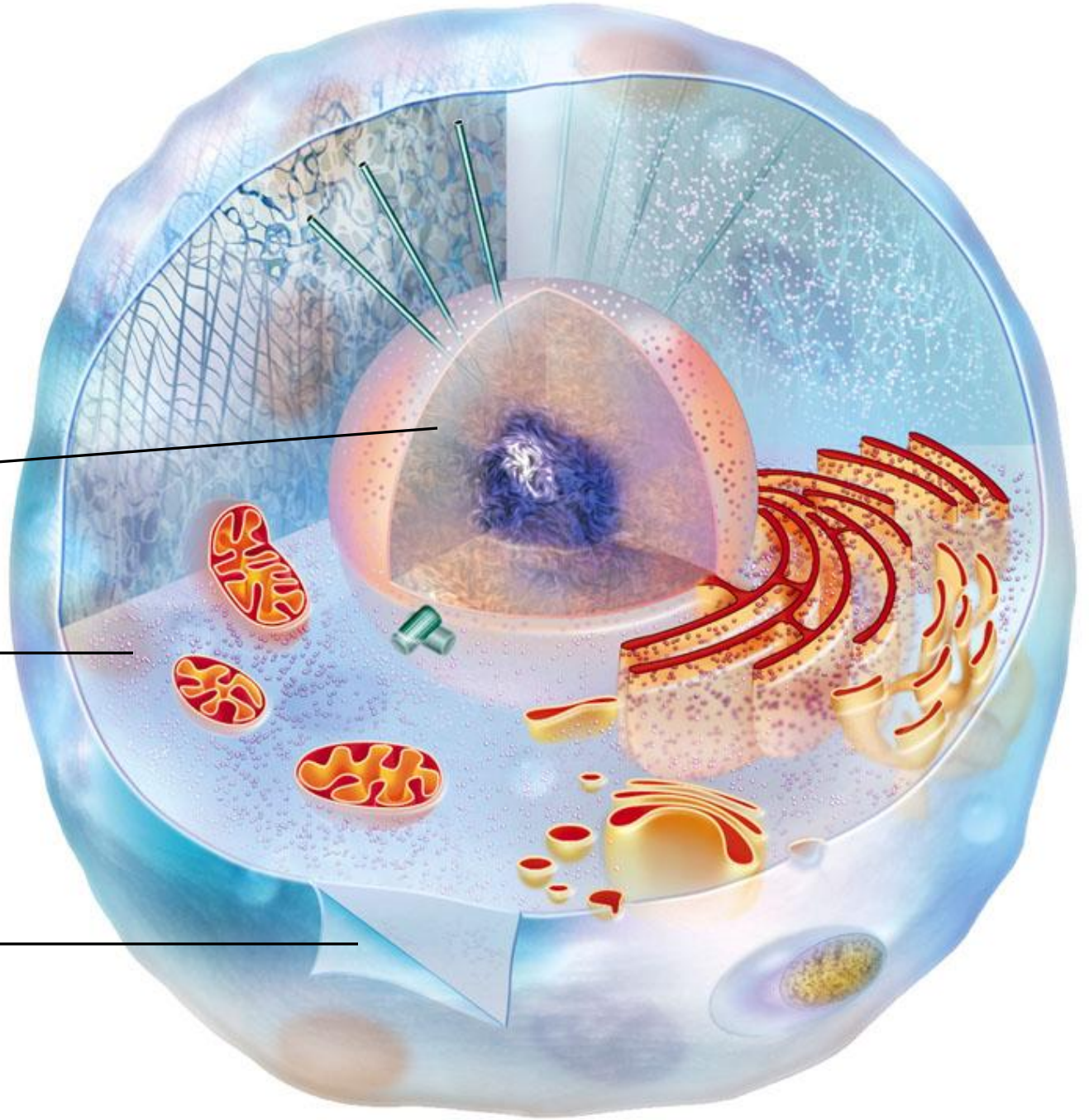


Fig. 4-3c, p.52

Plasma Membrane

- Defines the cell as a distinct entity (p52)

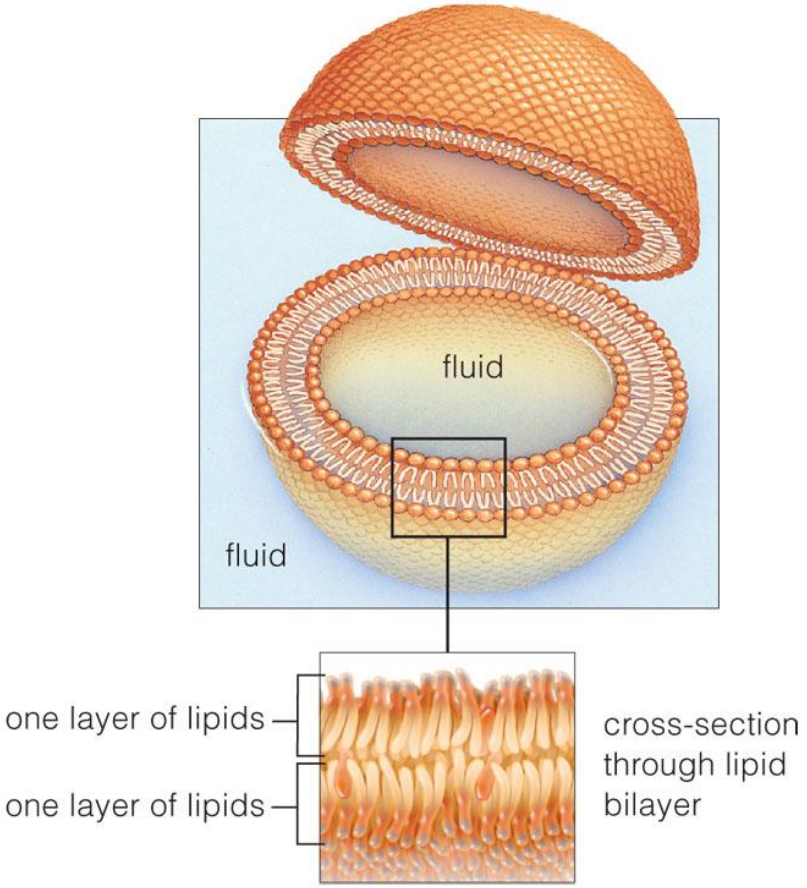


Fig. 4-4, p.52

Plasma Membrane

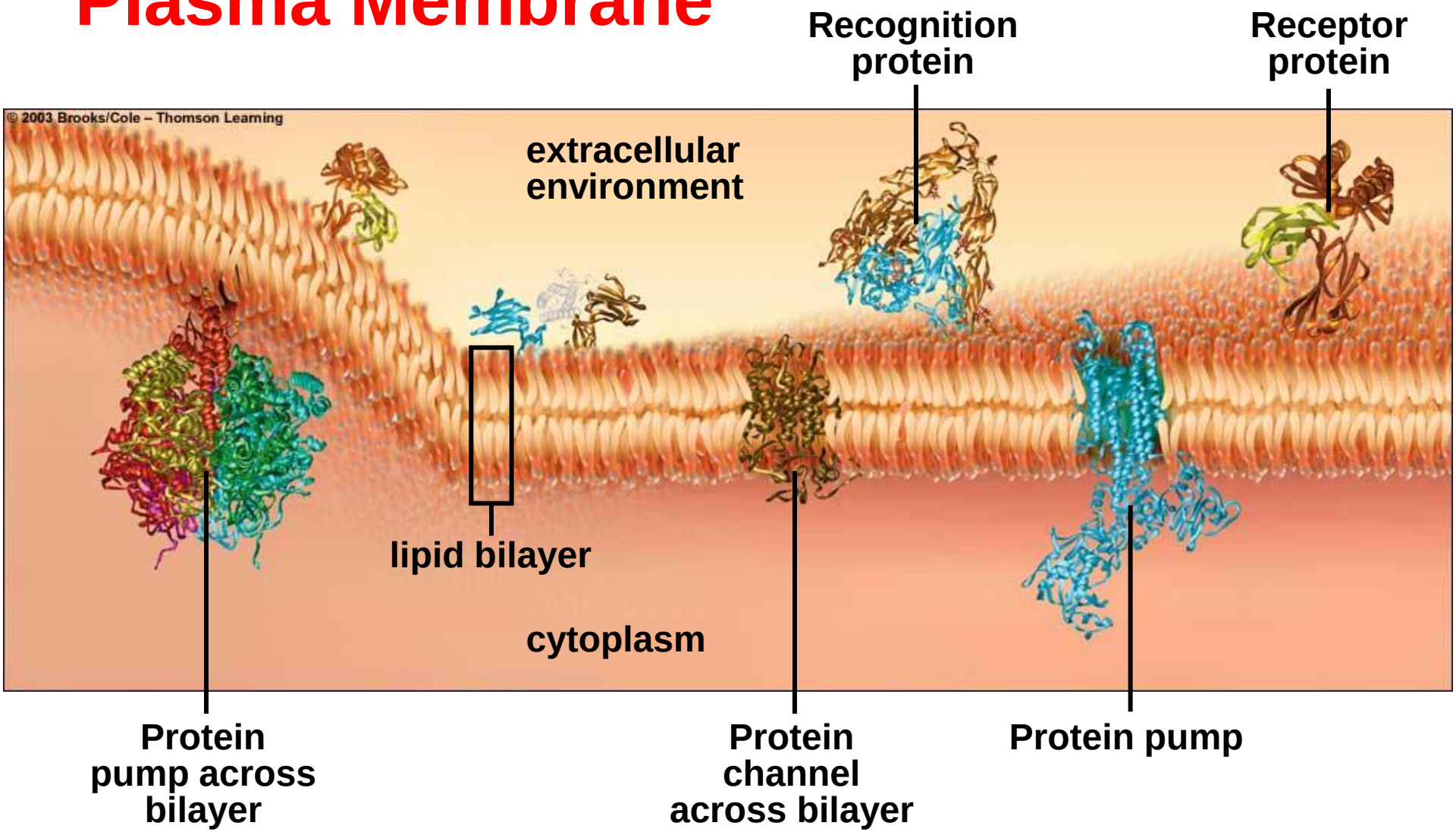


Fig. 4-5a, p.53

Plasma Membrane

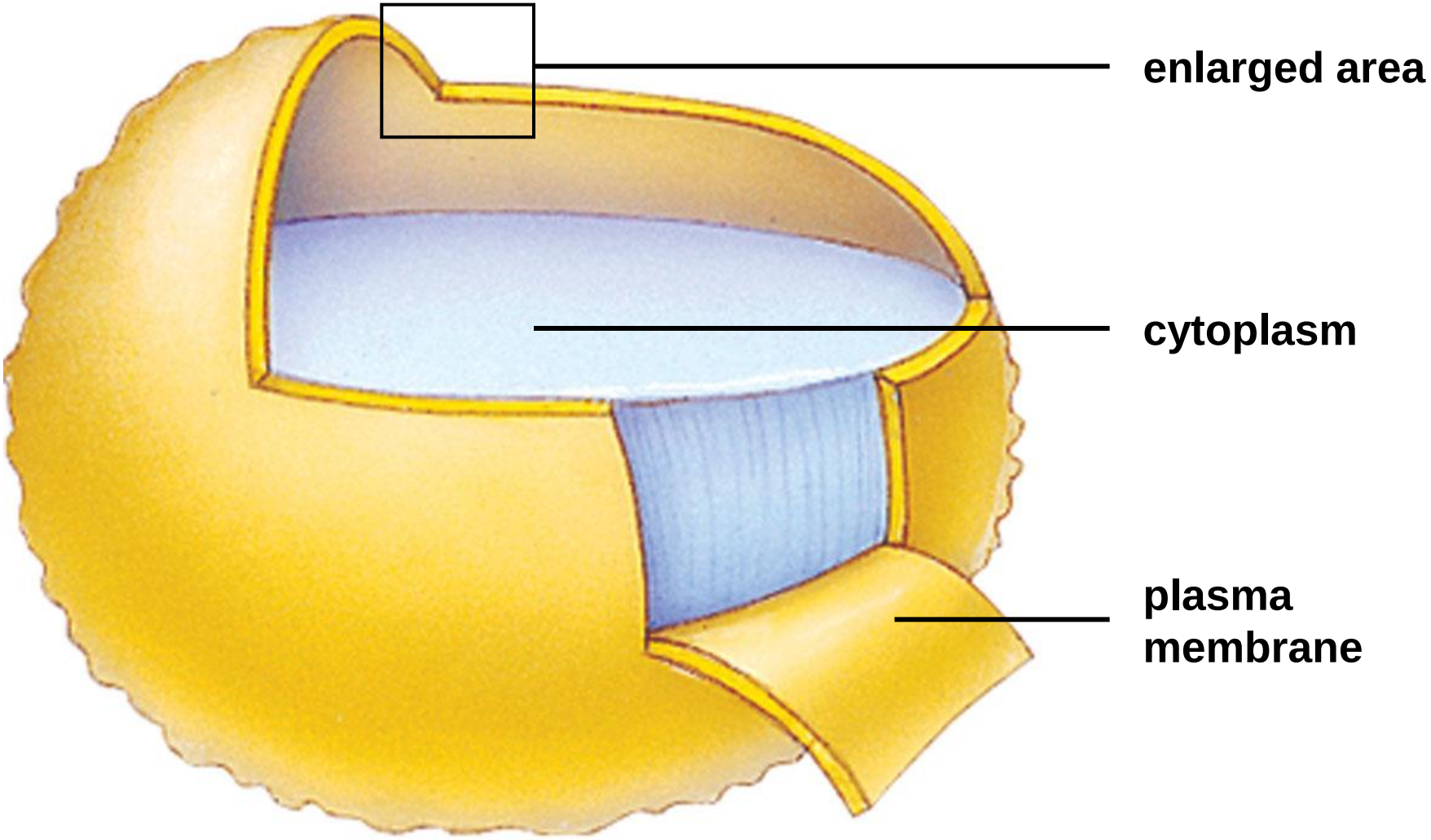


Fig. 4-5b, p.53

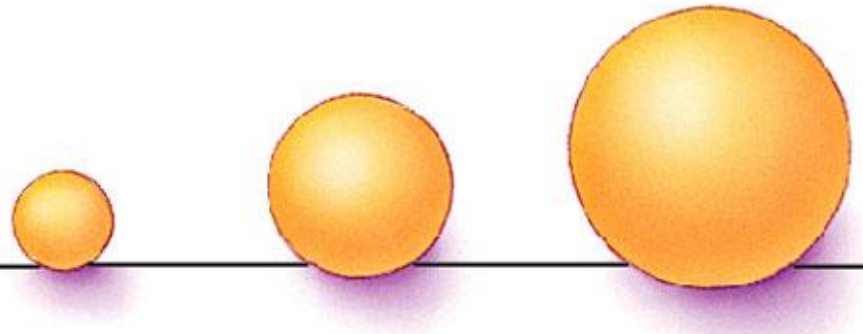
Fluid Mosaic Model

- Membrane is a mosaic of
  - Phospholipids
  - Glycolipids
  - Sterols
  - Proteins
- Most phospholipids and some proteins can drift through membrane

Why Are Cells So Small?

- Surface-to-volume ratio
- The bigger a cell is, the less surface area there is per unit volume
- Above a certain size, material cannot be moved in or out of cell fast enough

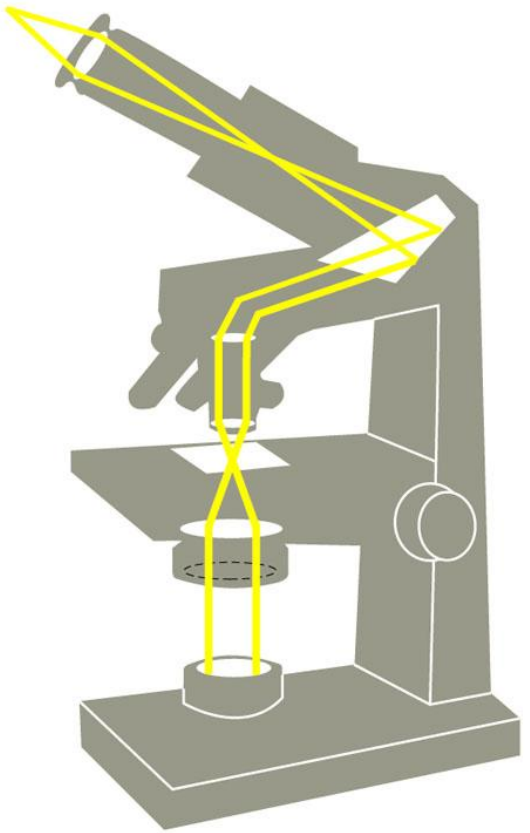
Surface-to-Volume Ratio



diameter (cm):	0.5	1.0	1.5
surface area (cm^2):	0.79	3.14	7.07
volume (cm^3):	0.06	0.52	1.77
surface-to-volume ratio:	13.17:1	6.04:1	3.99:1

Microscopes

- Create detailed images of something that is otherwise too small to see
- Light microscopes
  - Simple or compound
- Electron microscopes
  - Transmission EM or Scanning EM

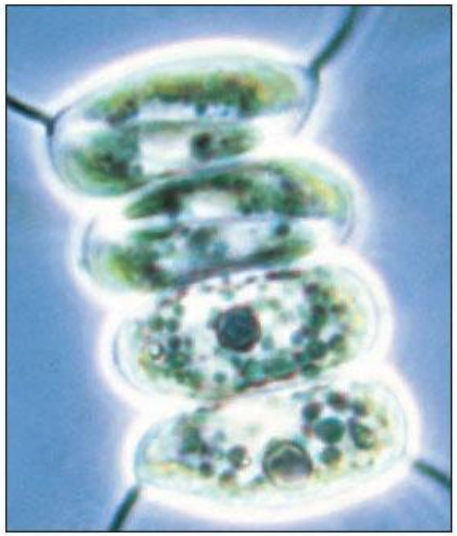


Cell Theory

1) Every organism is composed of one or more cells
2) Cell is smallest unit having properties of life
3) Continuity of life arises from growth and division of single cells

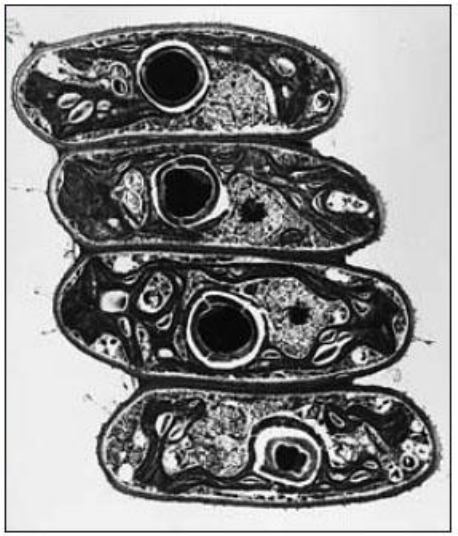
Fig. 4-7b, p.54

Fig. 4-8a, p.54

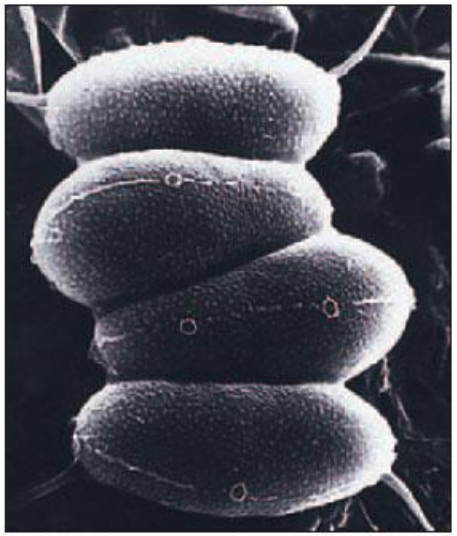


a Light micrograph (phase-contrast process)

b Light micrograph (Nomarski process)



c Transmission electron micrograph, thin section



d Scanning electron micrograph

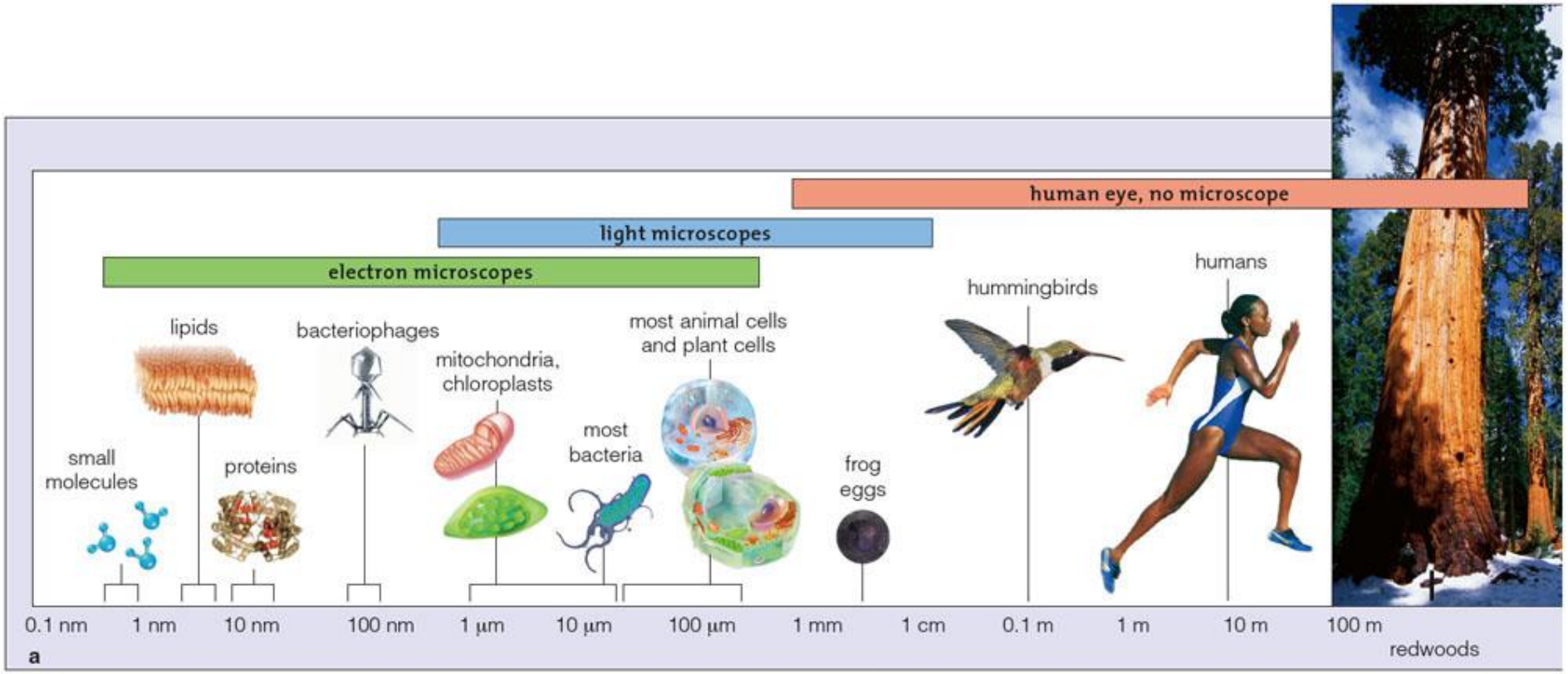


Fig. 4-9, p.55

Prokaryotic Cells

- **Archaea and eubacteria**
- **DNA is *not* enclosed in nucleus**
- **Generally the smallest, simplest cells**
- **No organelles**

Examples of Prokaryotic Cells

Fig. 4-11a, p.56

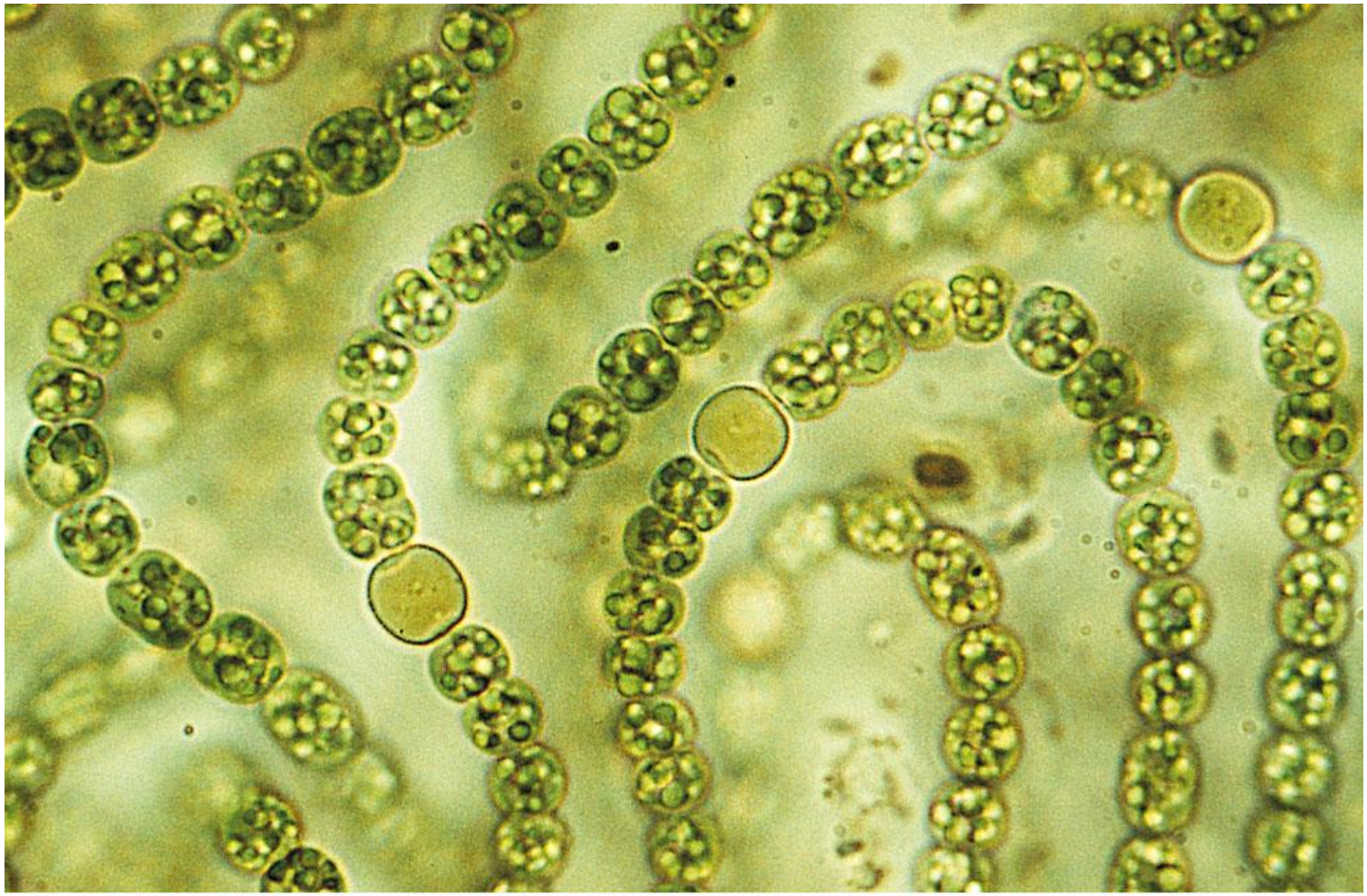


Fig. 4-11b, p.56

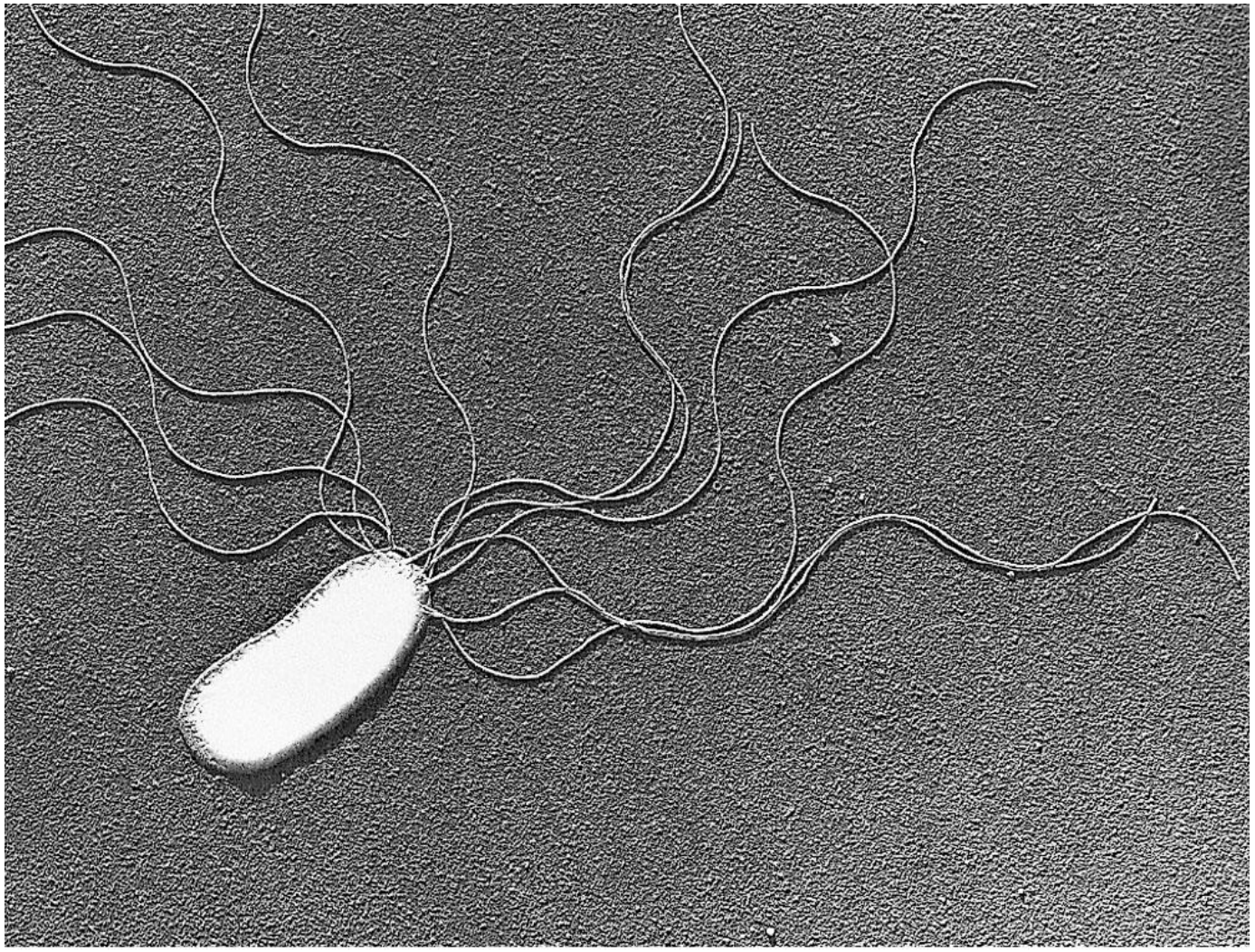
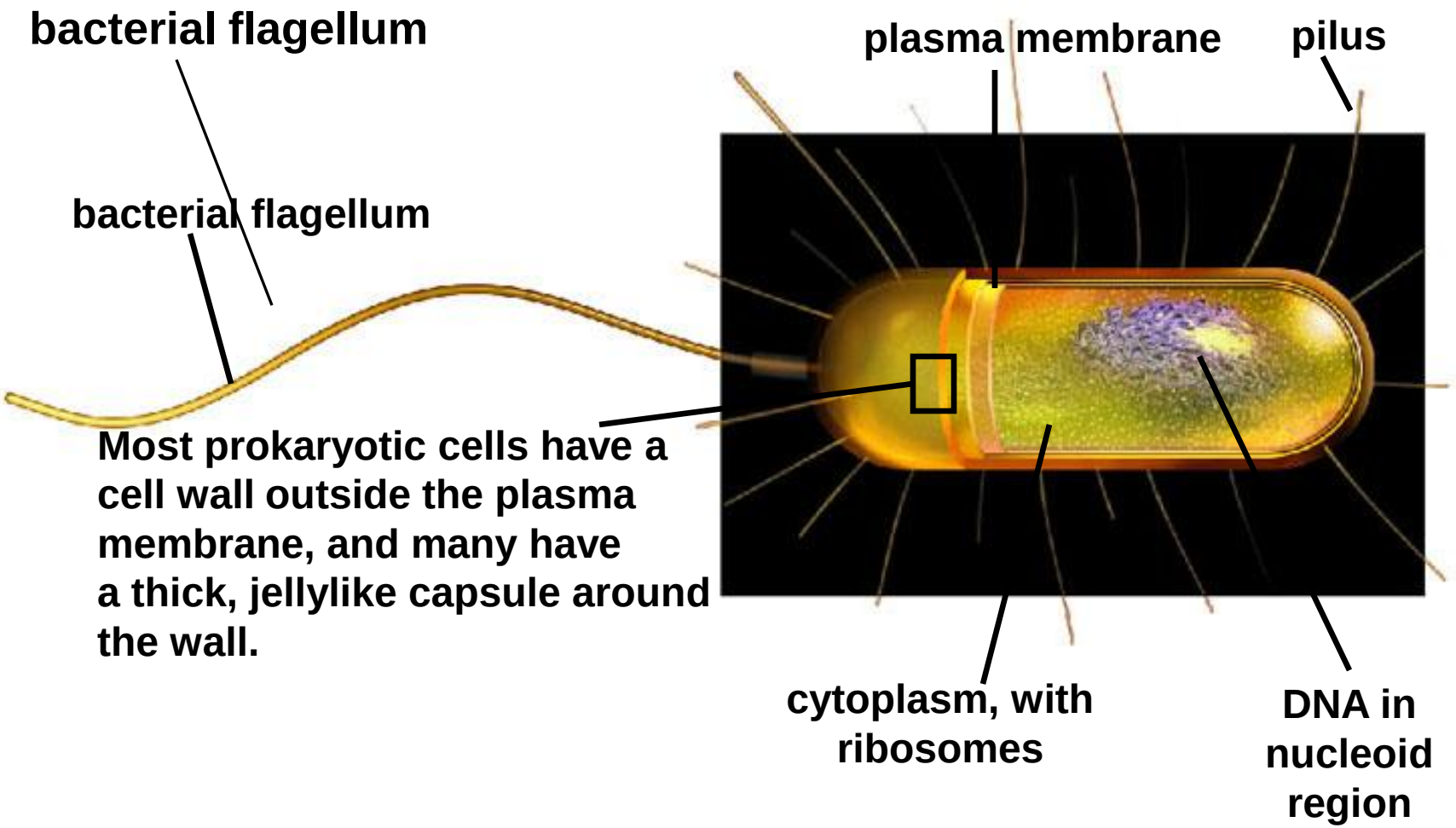


Fig. 4-11c, p.56

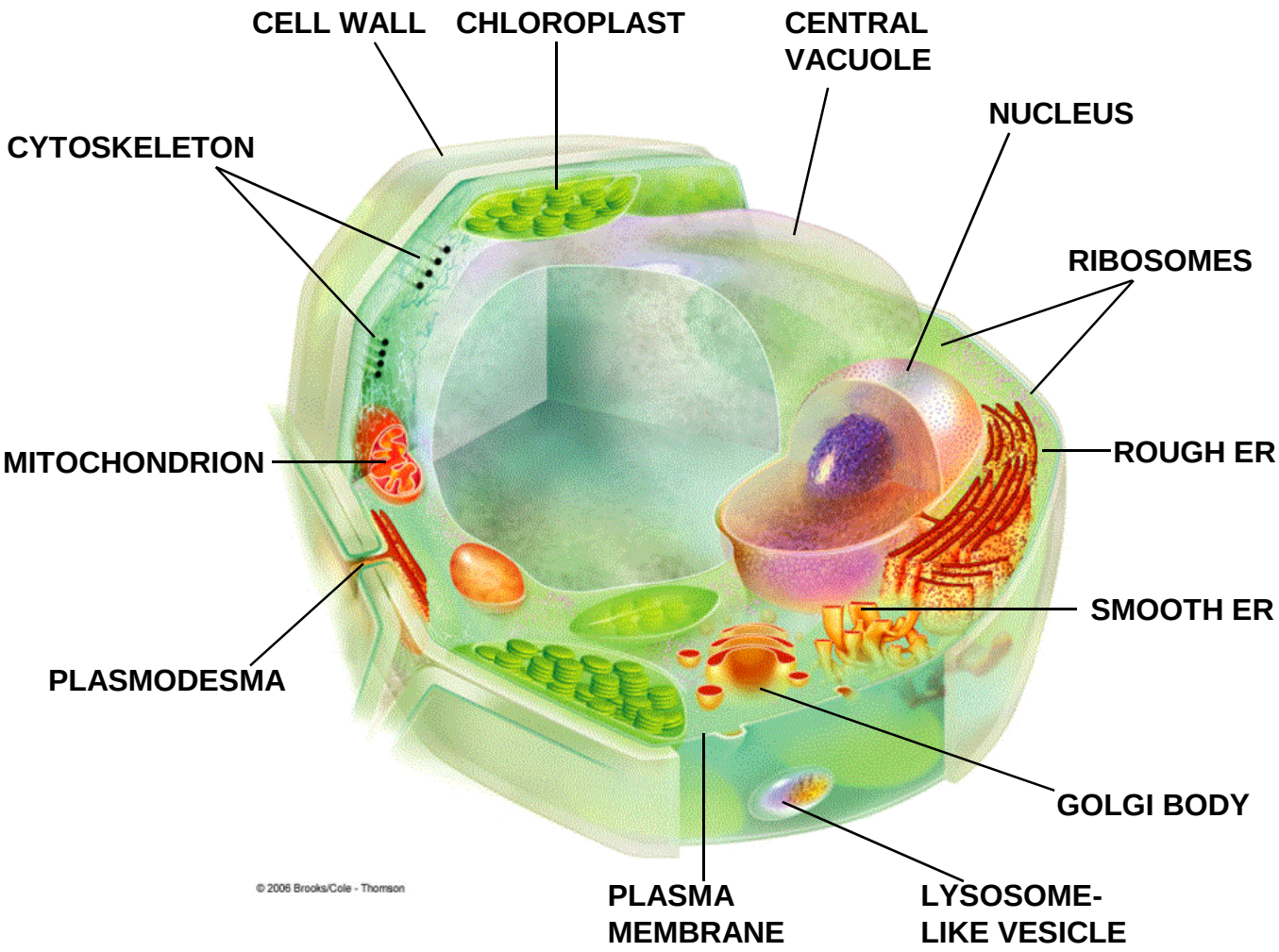
Prokaryotic Structure



Eukaryotic Cells

- Have a nucleus and other organelles
- Eukaryotic organisms
  - Plants
  - Animals
  - Protistans
  - Fungi

Plant Cell Features



Animal Cell Features

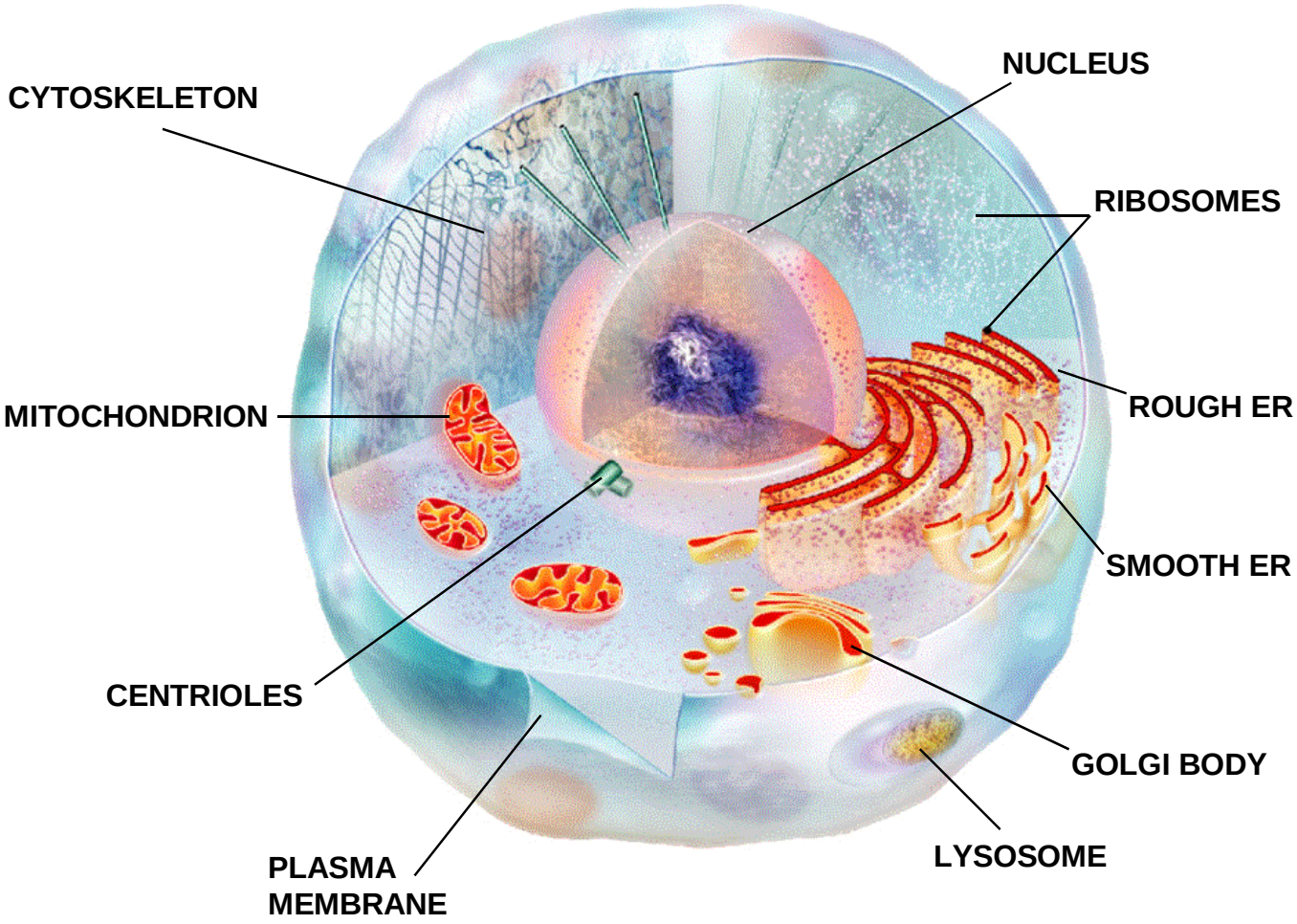


Table 4.1 Components of the Nucleus

Nuclear envelope	Pore-riddled double-membrane system that selectively controls which substances enter and leave the nucleus
Nucleoplasm	Semifluid interior portion of the nucleus
Nucleolus	Rounded mass of proteins and copies of genes for ribosomal RNA used to construct ribosomal subunits
Chromosome	One DNA molecule and the many proteins that are intimately associated with it
Chromatin	Total collection of all DNA molecules and their associated proteins in the nucleus

Functions of Nucleus

- Keeps the DNA molecules of eukaryotic cells separated from metabolic machinery of cytoplasm

- Makes it easier to organize DNA and to copy it before parent cells divide into daughter cells

Components of Nucleus

- Nuclear envelope
- Nucleoplasm
- Nucleolus
- Chromatin

Nucleus

Table 4.1 Components of the Nucleus

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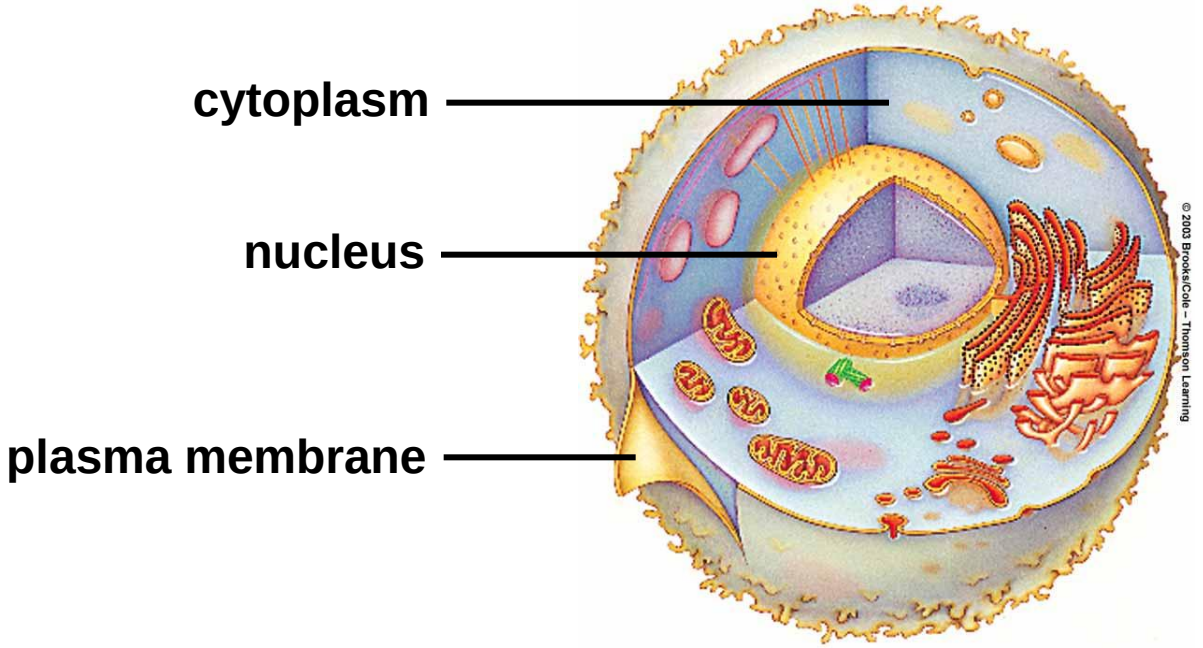
Nucleus



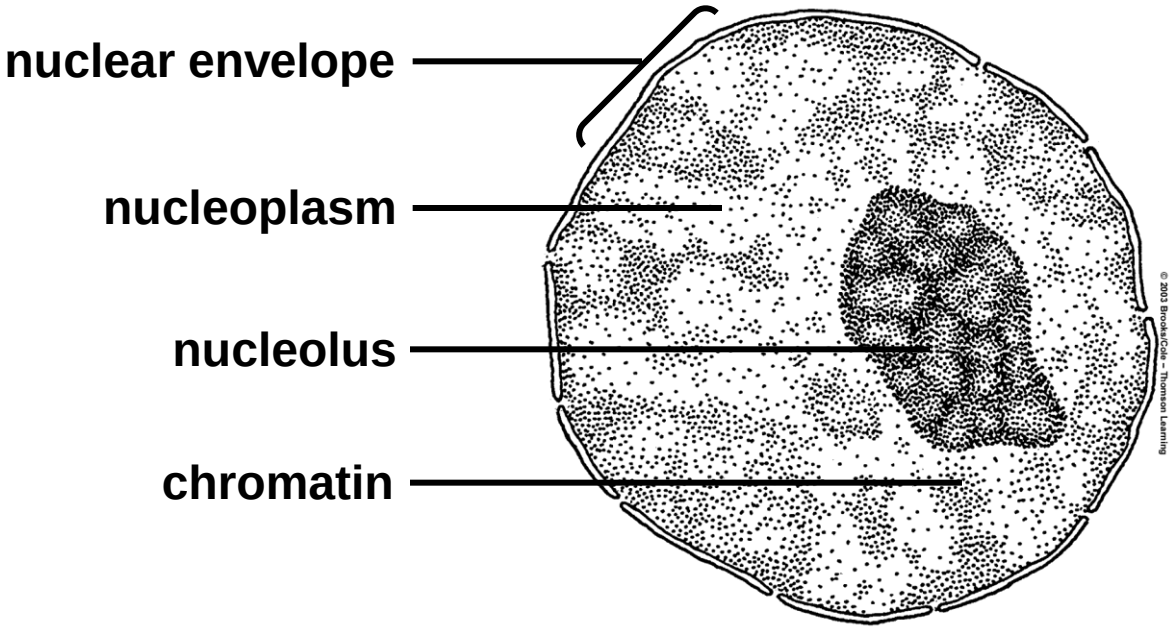
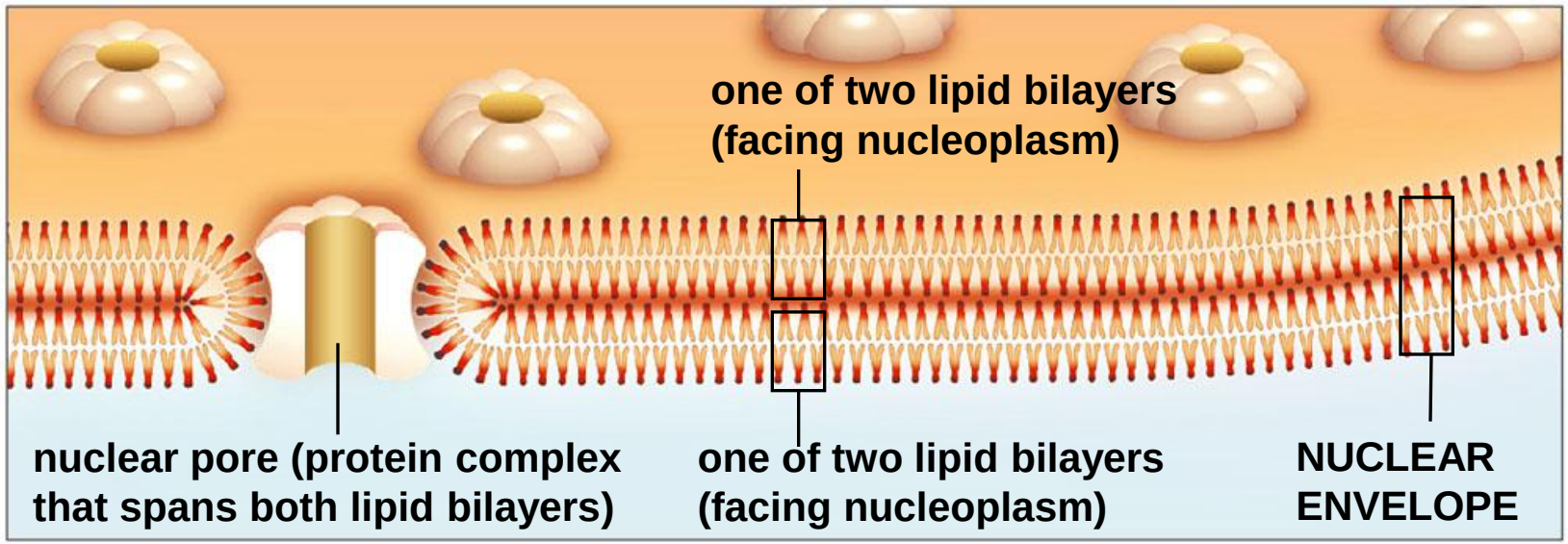


Fig. 4-16a, p.60

Nuclear Envelope

- Two outer membranes (lipid bilayers)
- Innermost surface has DNA attachment sites
- Pores span bilayer



Chromatin

- Cell's collection of DNA and associated proteins
- Chromosome is one DNA molecule and its associated proteins
- Appearance changes as cell divides

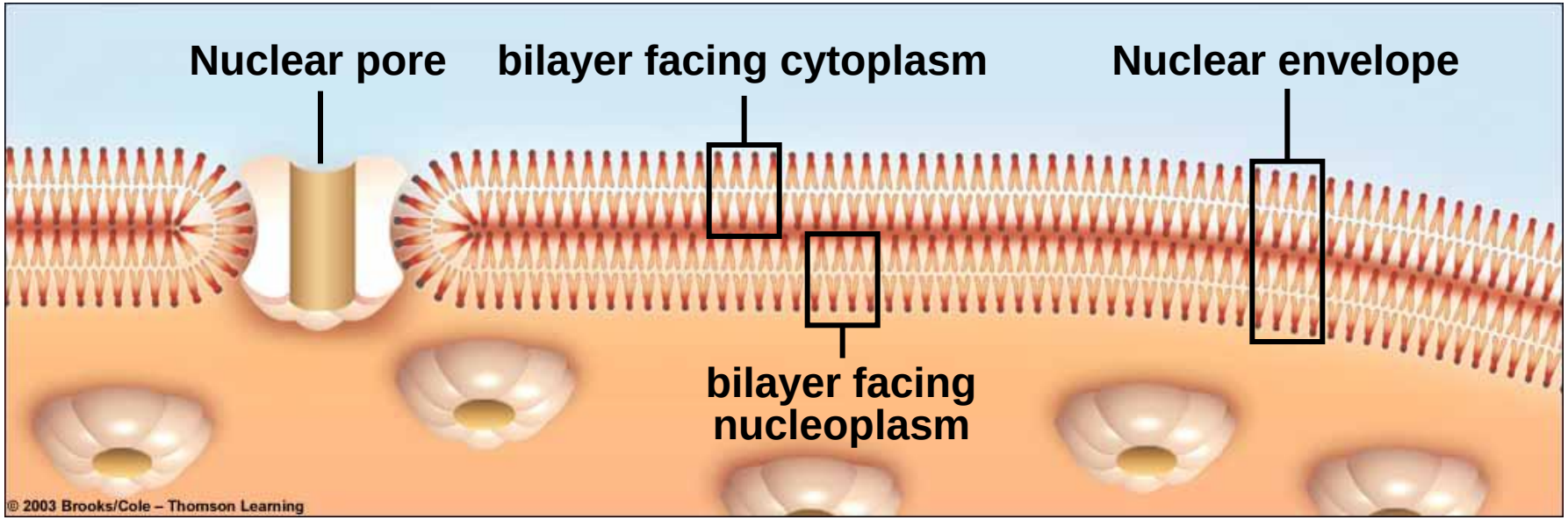

Nuclear pore
bilayer facing cytoplasm
Nuclear envelope
bilayer facing nucleoplasm
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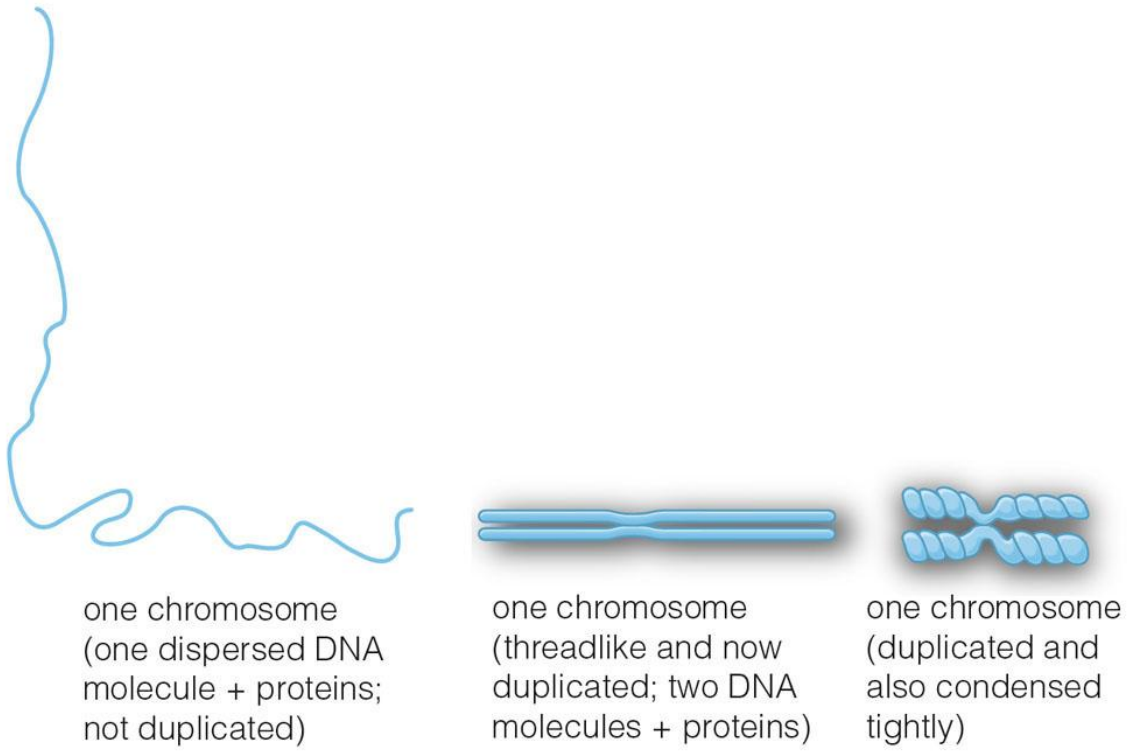
Fig. 4-17, p.61

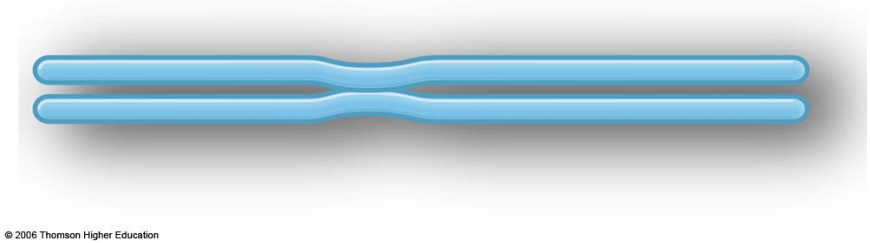
Nuclear DNA

- The changing appearance of a chromosome

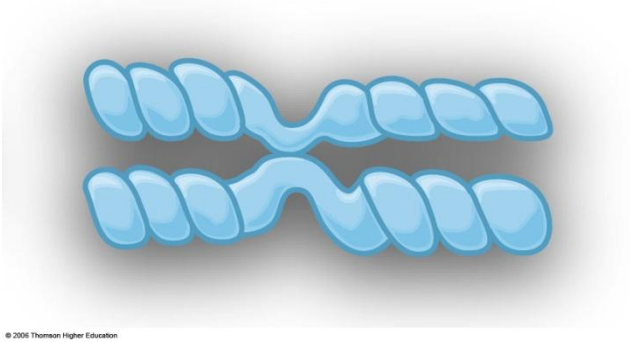


Nuclear DNA

one chromosome (one dispersed DNA molecule + proteins; not duplicated)



one chromosome (threadlike and now duplicated; two DNA molecules + proteins)



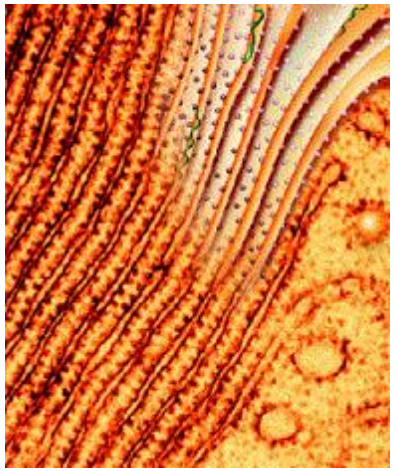
one chromosome (duplicated and also condensed tightly)

Endomembrane System

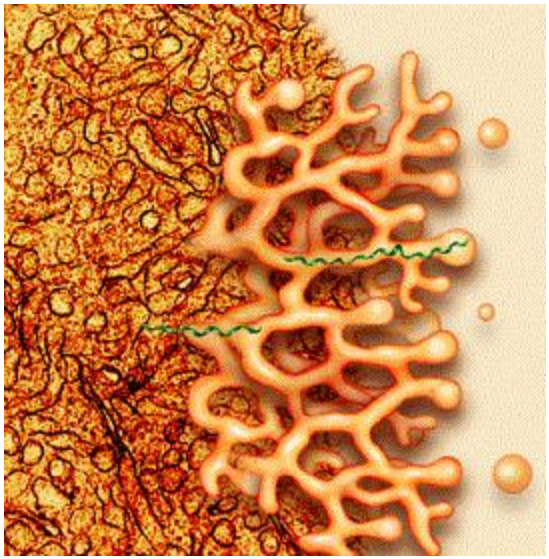
- Group of related organelles in which lipids are assembled and new polypeptide chains are modified
- Products are sorted and shipped to various destinations
- Rough and Smooth ER, Golgi body, vessicles

Rough ER

- Arranged into flattened sacs
- **Ribosomes on surface give it a rough appearance**
- **Some polypeptide chains enter rough ER and are modified**
- Cells that specialize in secreting proteins have lots of rough ER



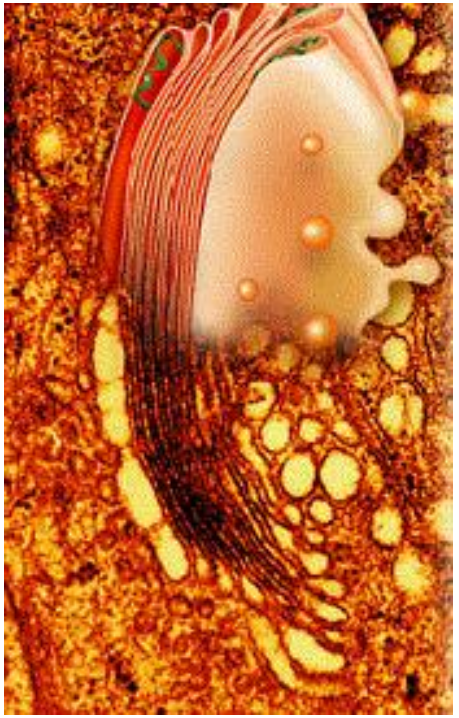
Smooth ER



- A series of interconnected tubules
- **No ribosomes on surface**
- **Lipids assembled inside tubules**
- **Smooth ER of liver inactivates wastes, drugs**
- Sarcoplasmic reticulum of muscle is a specialized form

Golgi Bodies

- **Put finishing touches on proteins and lipids that arrive from ER**
- **Package finished material for shipment to final destinations**
- Material arrives and leaves in vesicles



Vesicles

- Membranous sacs that move through the cytoplasm
- Lysosomes
- Peroxisomes

Central Vacuole

- **Fluid-filled organelle**
- **Stores amino acids, sugars, wastes**
- As cell grows, expansion of vacuole as a result of fluid pressure forces cell wall to expand
- In mature cell, central vacuole takes up 50-90 percent of cell interior

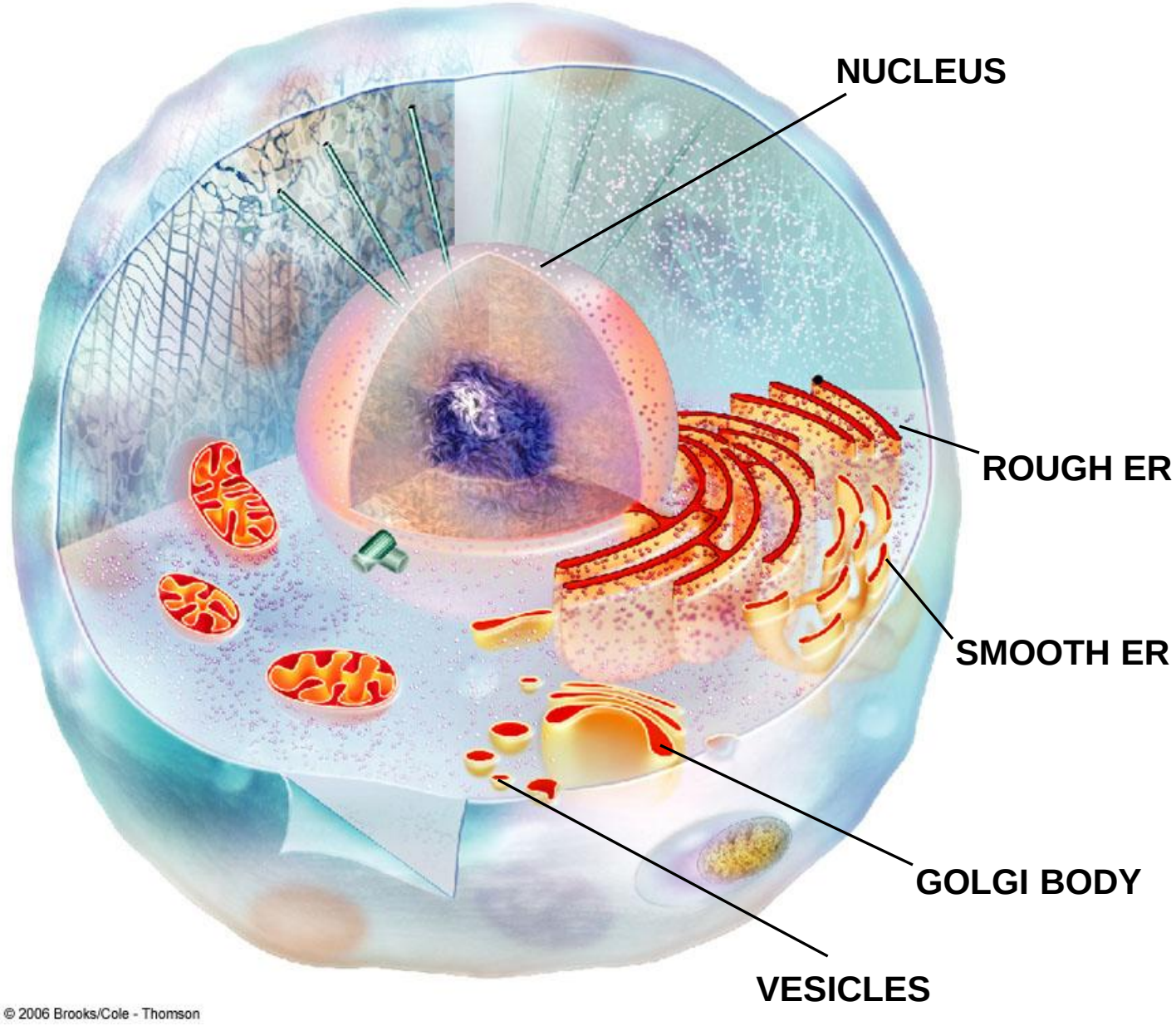
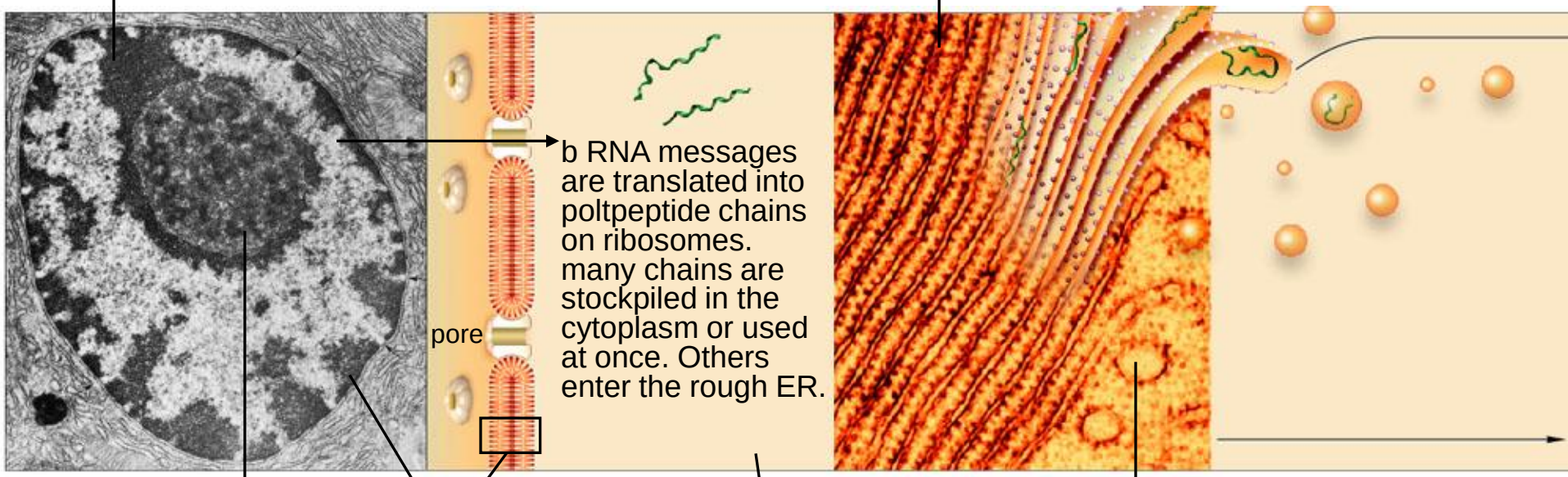


Fig. 4-18a, p.62



b THE CELL NUCLEUS **c ROUGH ER**

Fig. 4-18b,c, p.62

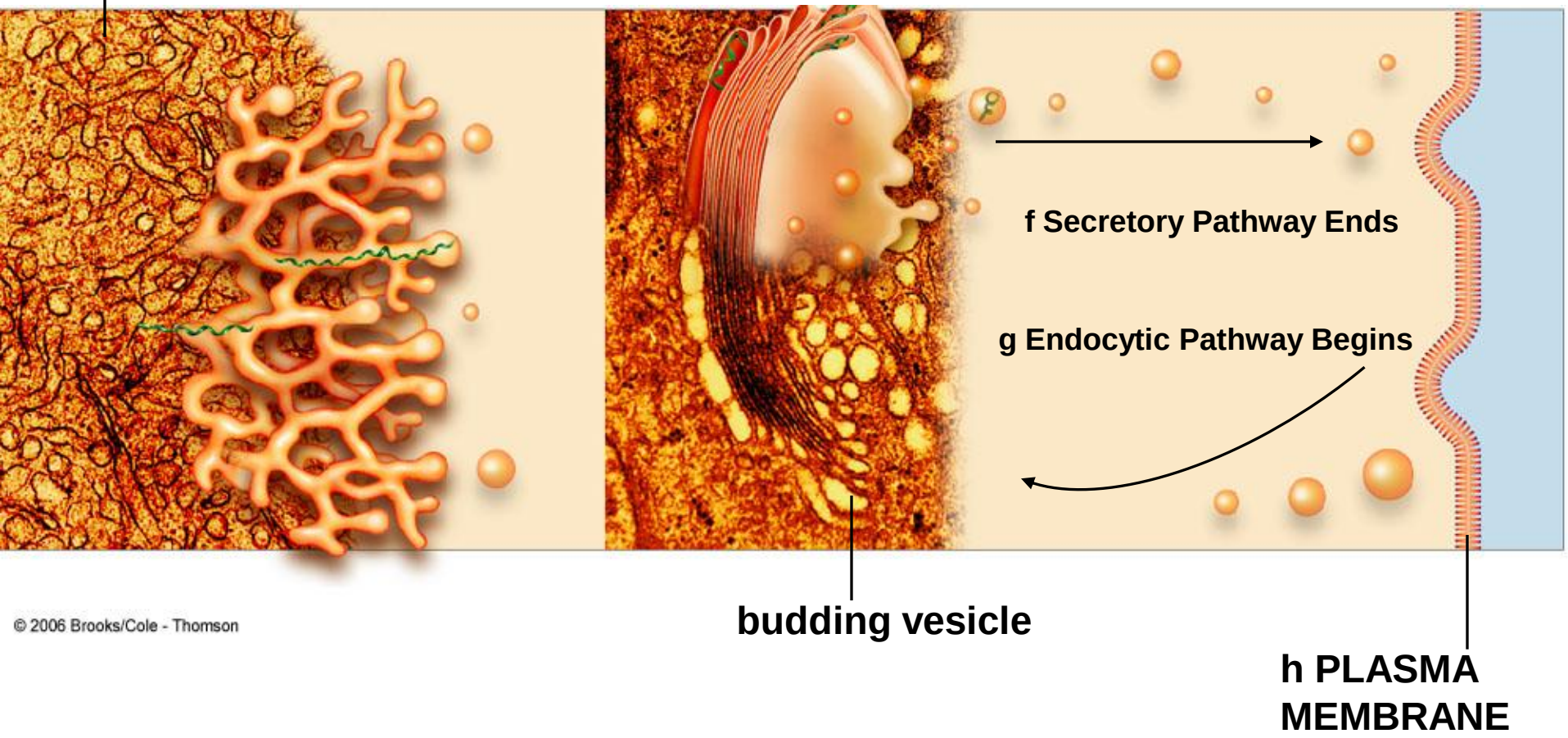
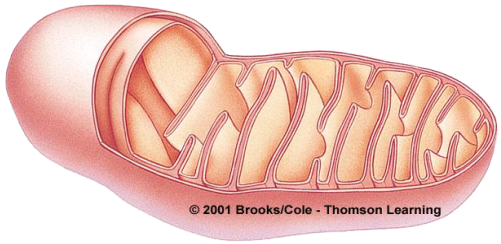


Fig. 4-18d-g, p.63

Mitochondria



- ATP-producing powerhouses
- Double-membrane system
- Carry out the most efficient energy-releasing reactions
- These reactions require oxygen

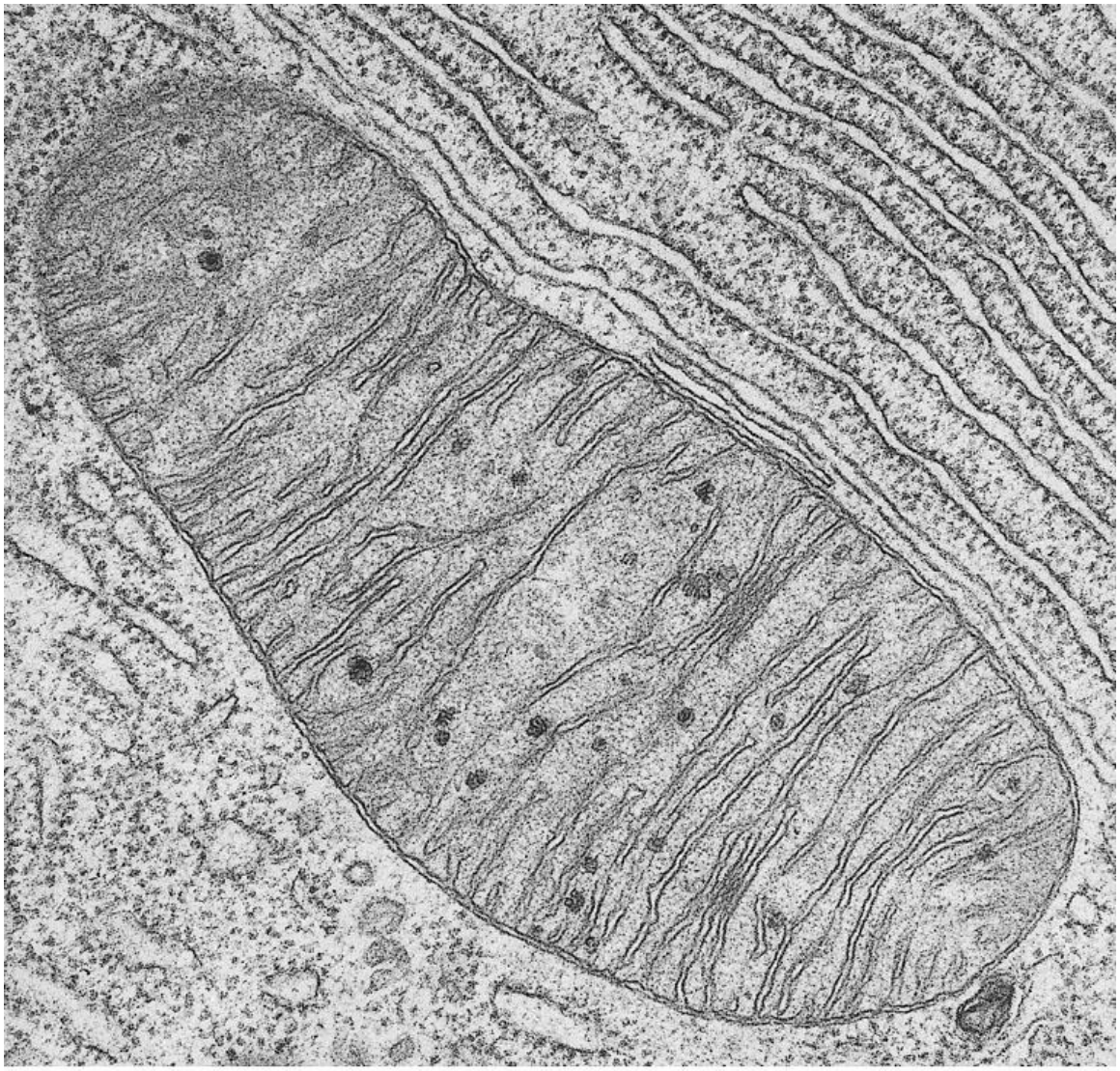


Fig. 4-19c, p.64

Mitochondria

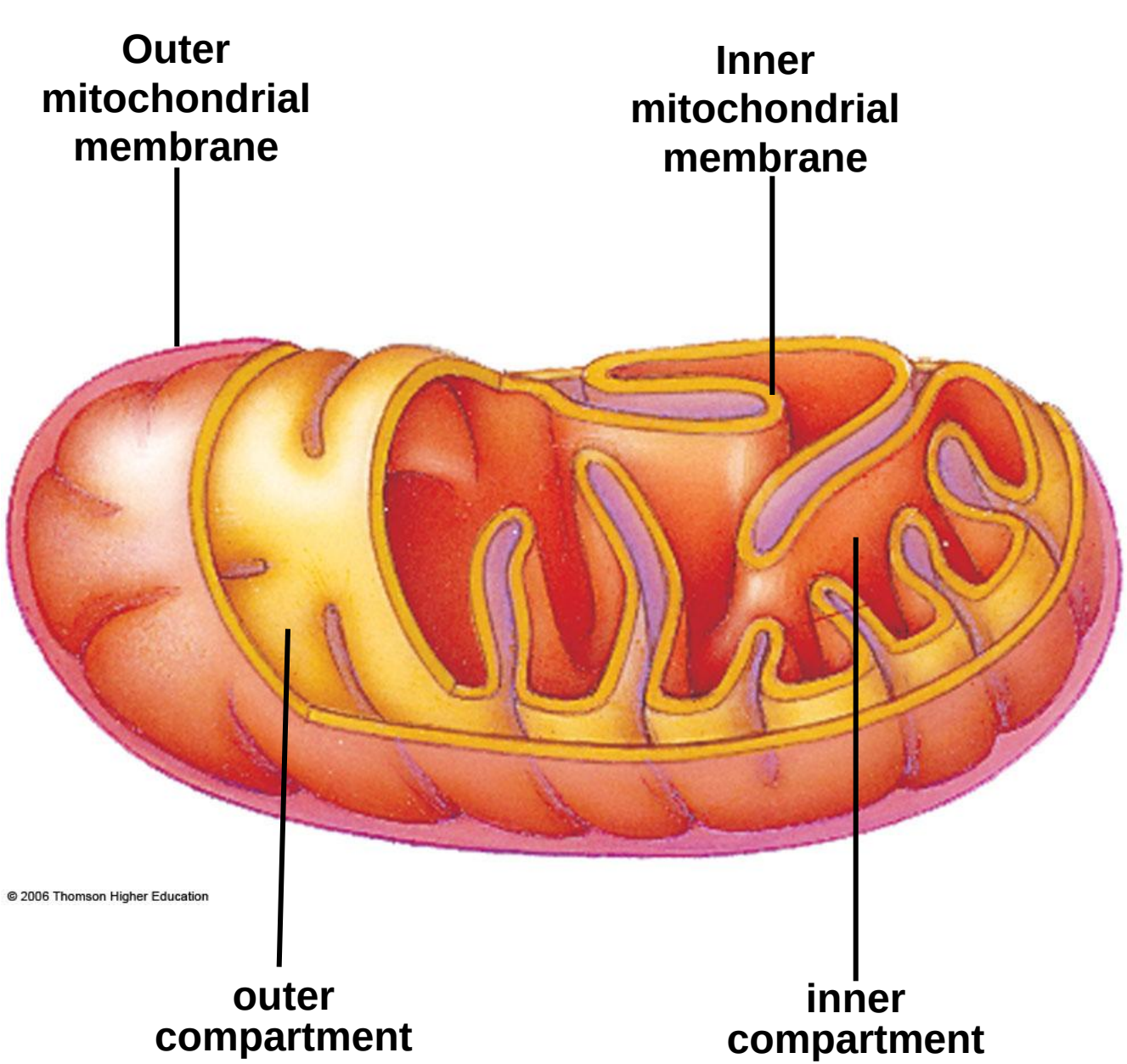


Fig. 4-19b, p.64

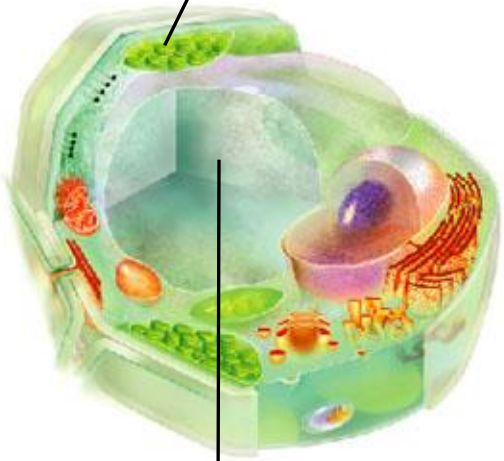
Mitochondrial Structure

- Outer membrane faces cytoplasm
- Inner membrane folds back on itself
- Membranes form two distinct compartments
- ATP-making machinery is embedded in the inner mitochondrial membrane

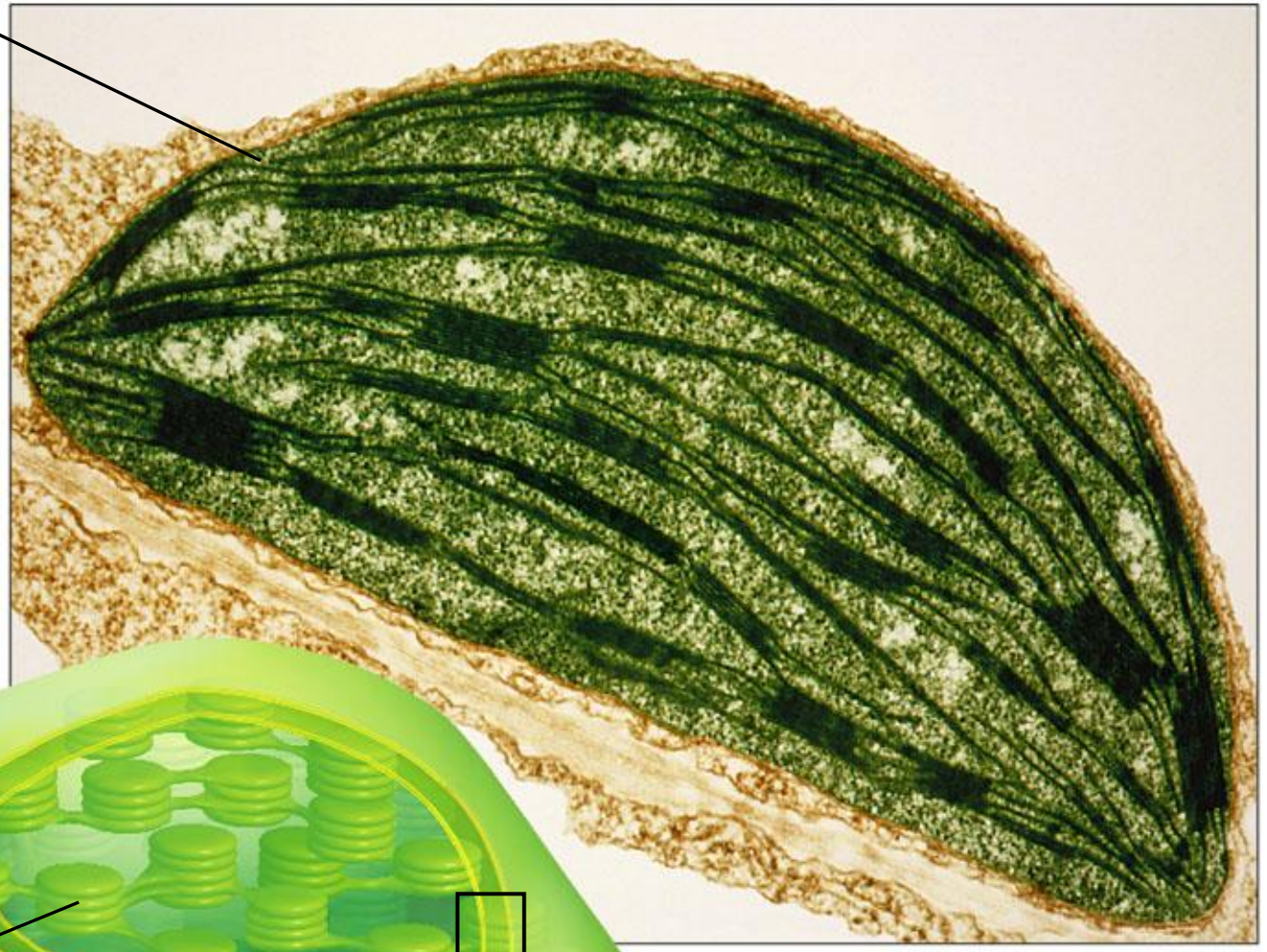
Chloroplasts

Convert sunlight energy to ATP through photosynthesis

chloroplast in the cytoplasm of a plant cell



central vacuole



Thylakoid membrane, a much-folded single flattened compartment inside the stroma

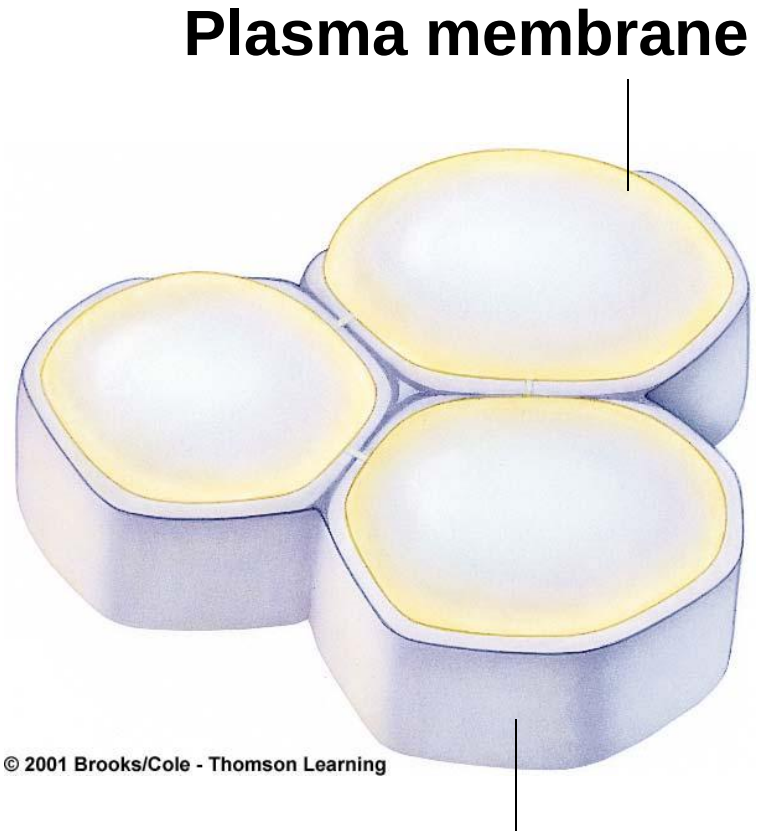
two outer membranes

stroma (semifluid interior)

Fig. 4-20, p.65

Cell Wall

- Structural component that wraps around the plasma membrane
- Occurs in plants, some fungi, some protistans



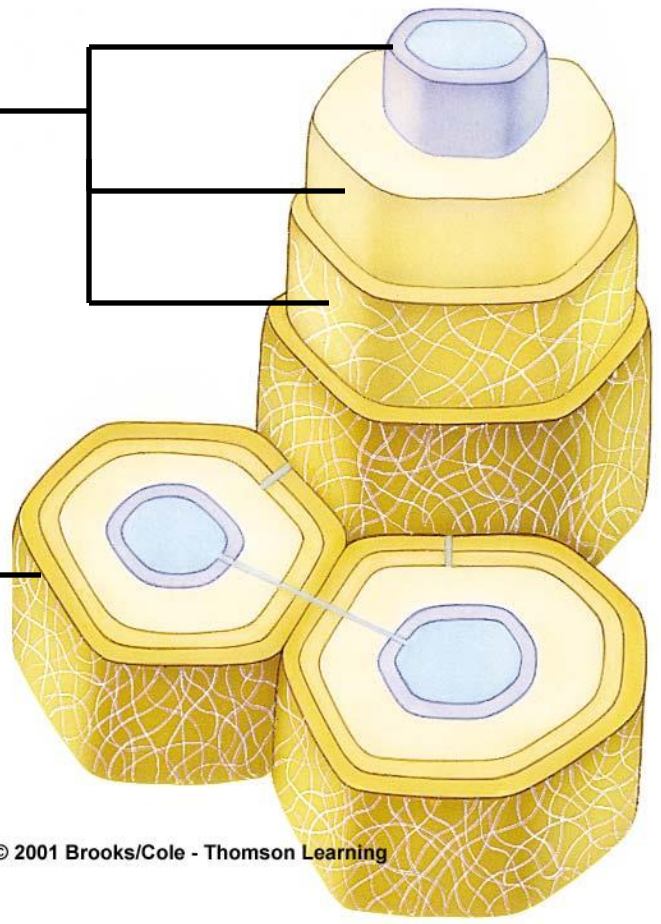
Like Bacteria?

- **Both mitochondria and chloroplasts resemble bacteria**
- **Have own DNA, RNA, and ribosomes**

Plant Cell Walls

Secondary cell wall
(3 layers)

Primary cell wall



Plant Cuticle

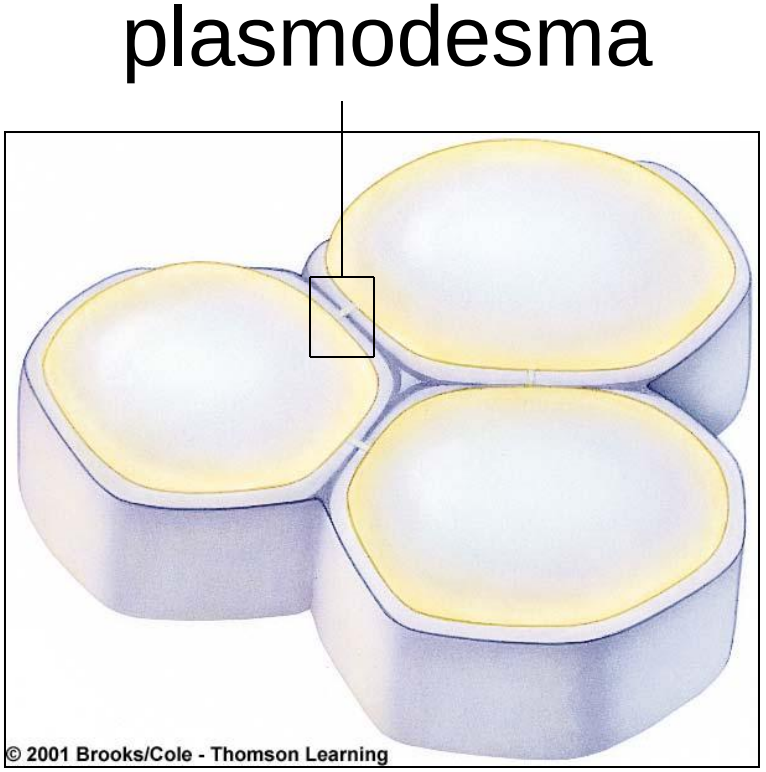
- Cell secretions and waxes accumulate at plant cell surface
- Semi-transparent
- Restricts water loss

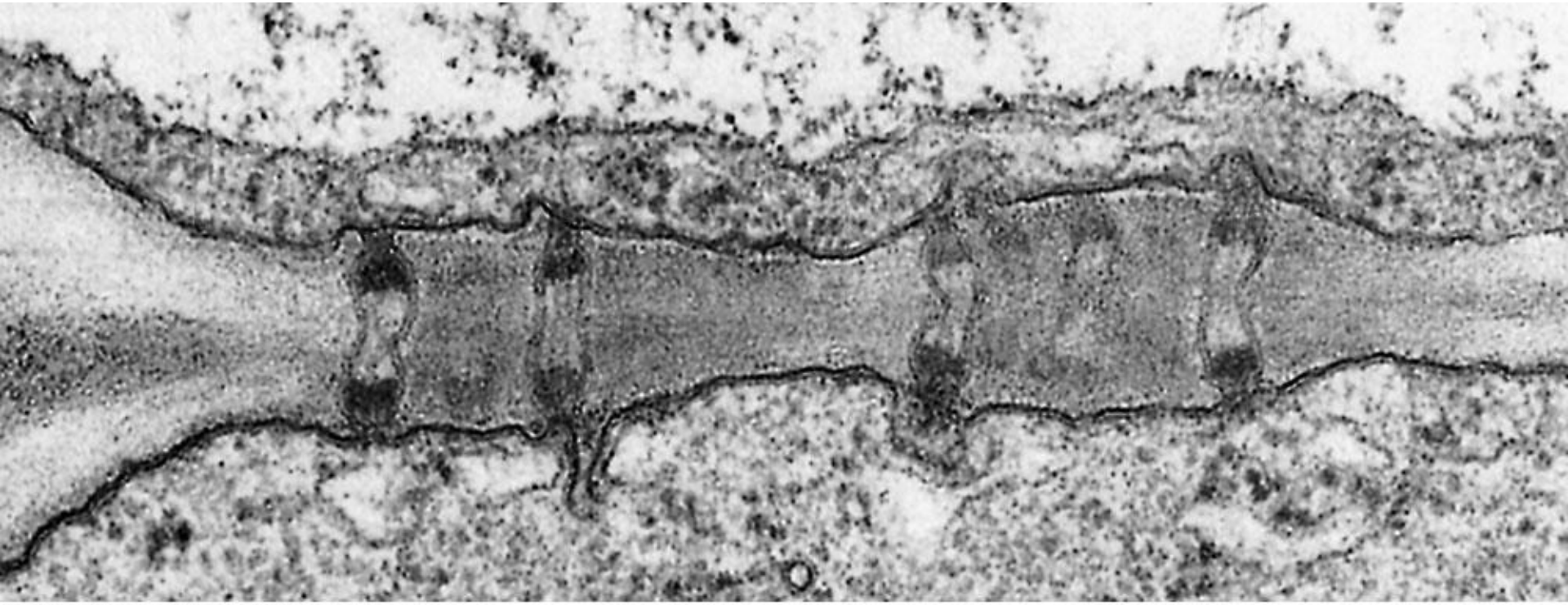
Matrixes between Animal Cells

- Animal cells have no cell walls
- Some are surrounded by a matrix of cell secretions and other material

Cell Junctions

- Plants
  - Plasmodesmata
- Animals
  - Tight junctions
  - Adhering junctions
  - Gap junctions





Animal Cell Junctions

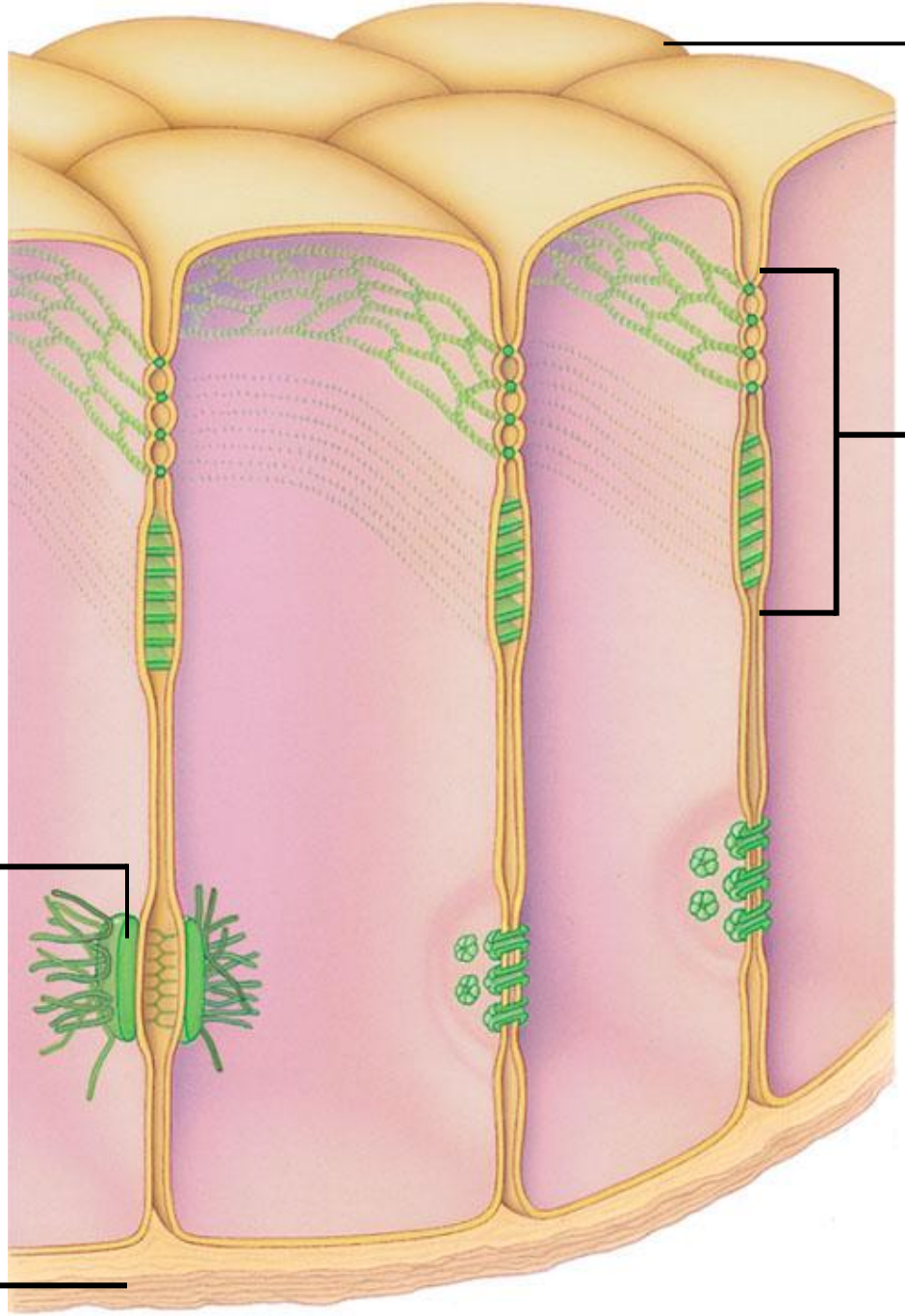


Fig. 4-23, p.67

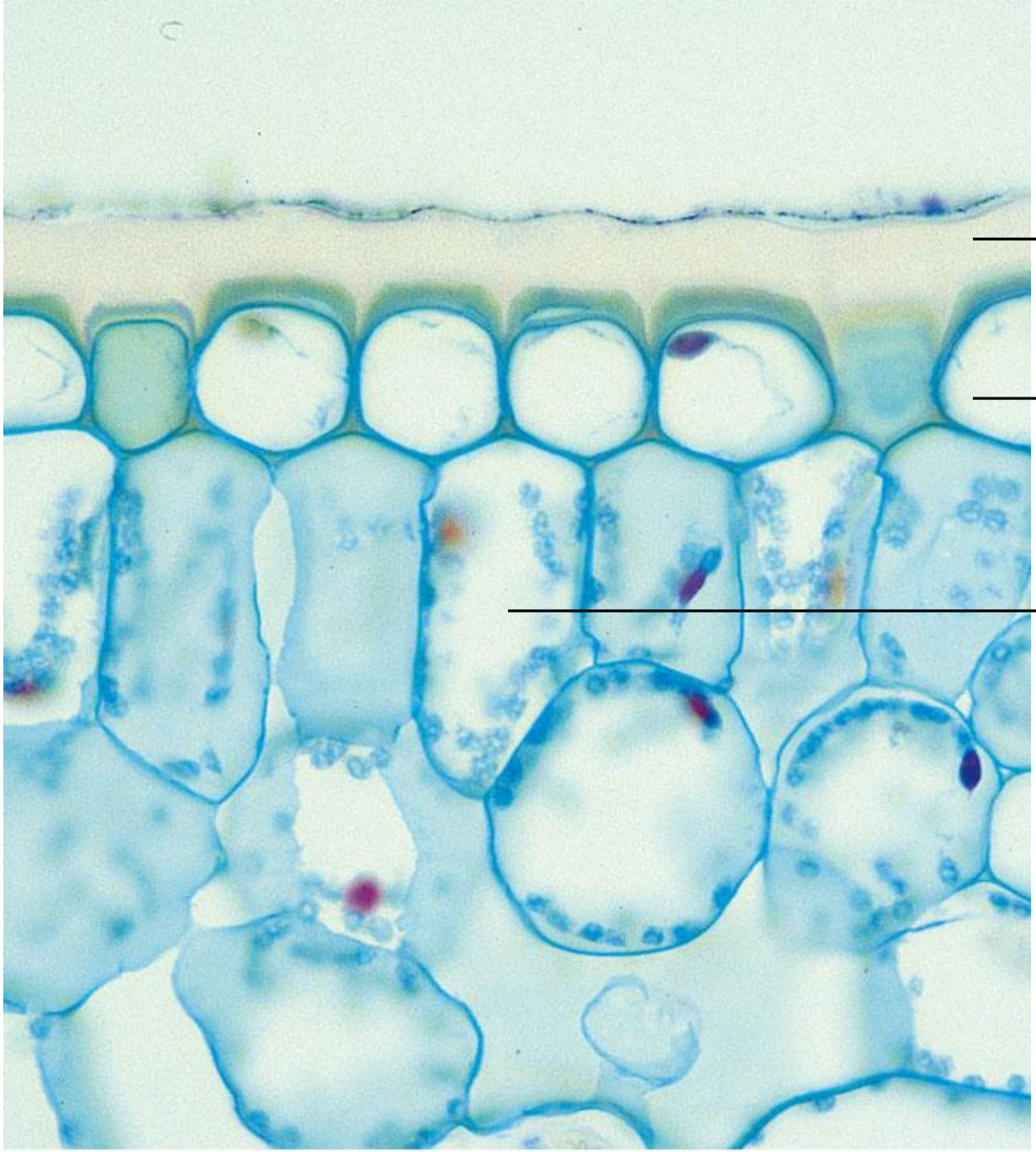
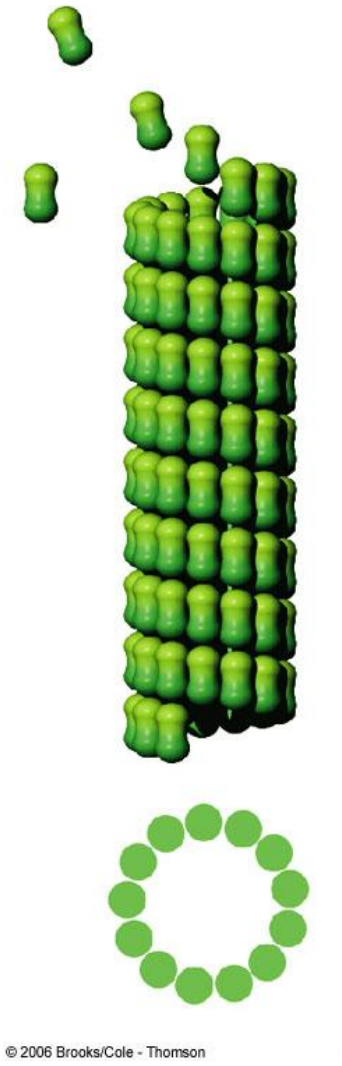


Fig. 4-22a, p.67

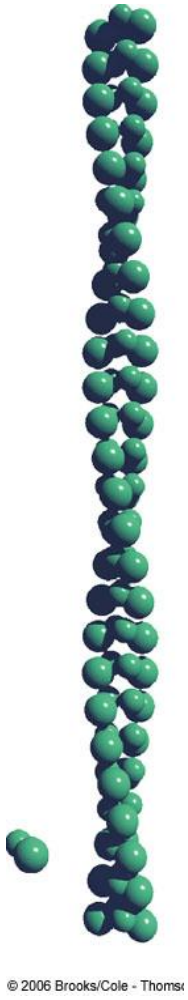
Cytoskeleton

- Present in all eukaryotic cells
- Basis for cell shape and internal organization
- Allows organelle movement within cells and, in some cases, cell motility

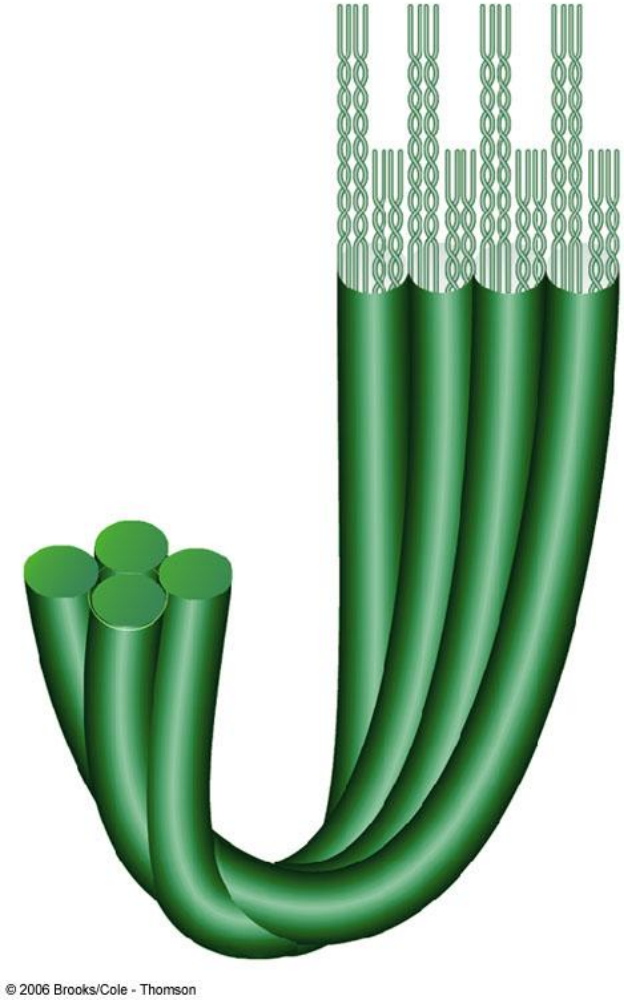
Cytoskeletal Elements



microtubule



microfilament



intermediate filament

Cilia

Fig. 4-28a, p.70

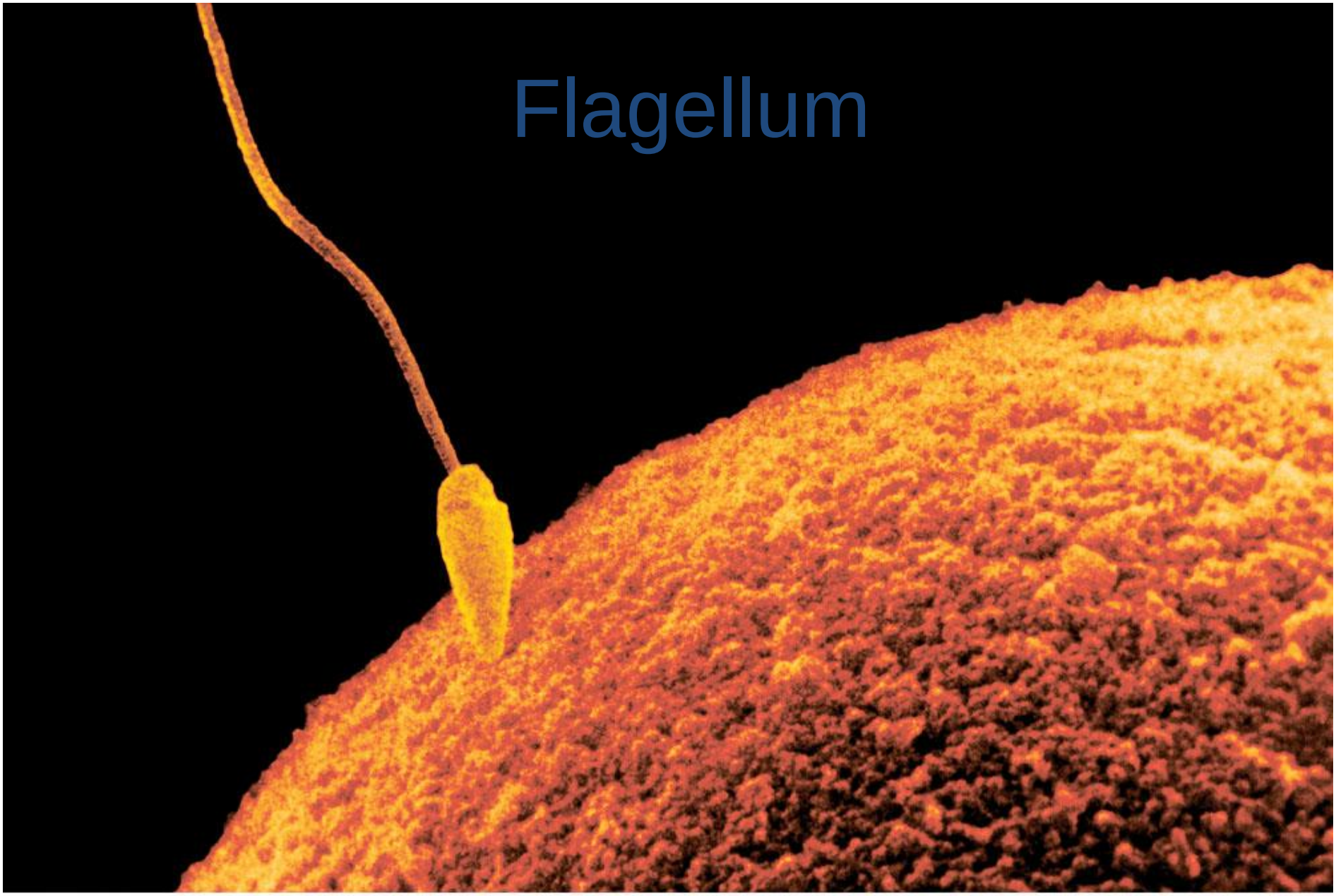


Fig. 4-28b,c, p.70

Table 4.2 Summary of Typical Components of Prokaryotic and Eukaryotic Cells

Cell Component	Function	Prokaryotic	Eukaryotic			
		Bacteria, Archaea	Protists	Fungi	Plants	Animals
Cell wall	Protection, structural support	✓*	✓*	✓	✓	*None*
Plasma membrane	Control of substances moving into and out of cell	✓	✓	✓	✓	✓
Nucleus	Physical separation and organization of DNA	*None*	✓	✓	✓	✓
DNA	Encoding of hereditary information	✓	✓	✓	✓	✓
RNA	Transcription, translation of DNA messages into polypeptide chains of specific proteins	✓	✓	✓	✓	✓
Nucleolus	Assembly of subunits of ribosomes	*None*	✓	✓	✓	✓
Ribosome	Protein synthesis	✓	✓	✓	✓	✓
Endoplasmic reticulum (ER)	Initial modification of many of the newly forming polypeptide chains of proteins; lipid synthesis	*None*	✓	✓	✓	✓
Golgi body	Final modification of proteins, lipids; sorting and packaging them for use inside cell or for export	*None*	✓	✓	✓	✓
Lysosome	Intracellular digestion	*None*	✓	✓*	✓*	✓

Mitochondrion	ATP formation	**	✓	✓	✓	✓
Photosynthetic pigments	Light–energy conversion	✓*	✓*	*None*	✓	*None*
Chloroplast	Photosynthesis; some starch storage	*None*	✓*	*None*	✓	*None*
Central vacuole	Increasing cell surface area; storage	*None*	*None*	✓*	✓	*None*
Bacterial flagellum	Locomotion through fluid surroundings	✓*	*None*	*None*	*None*	*None*
Flagellum or cilium with 9+2 microtubular array	Locomotion through or motion within fluid surroundings	*None*	✓*	✓*	✓*	✓
Complex cytoskeleton	Cell shape; internal organization; basis of cell movement and, in many cells, locomotion	*Rudimentary****	✓*	✓*	✓*	✓