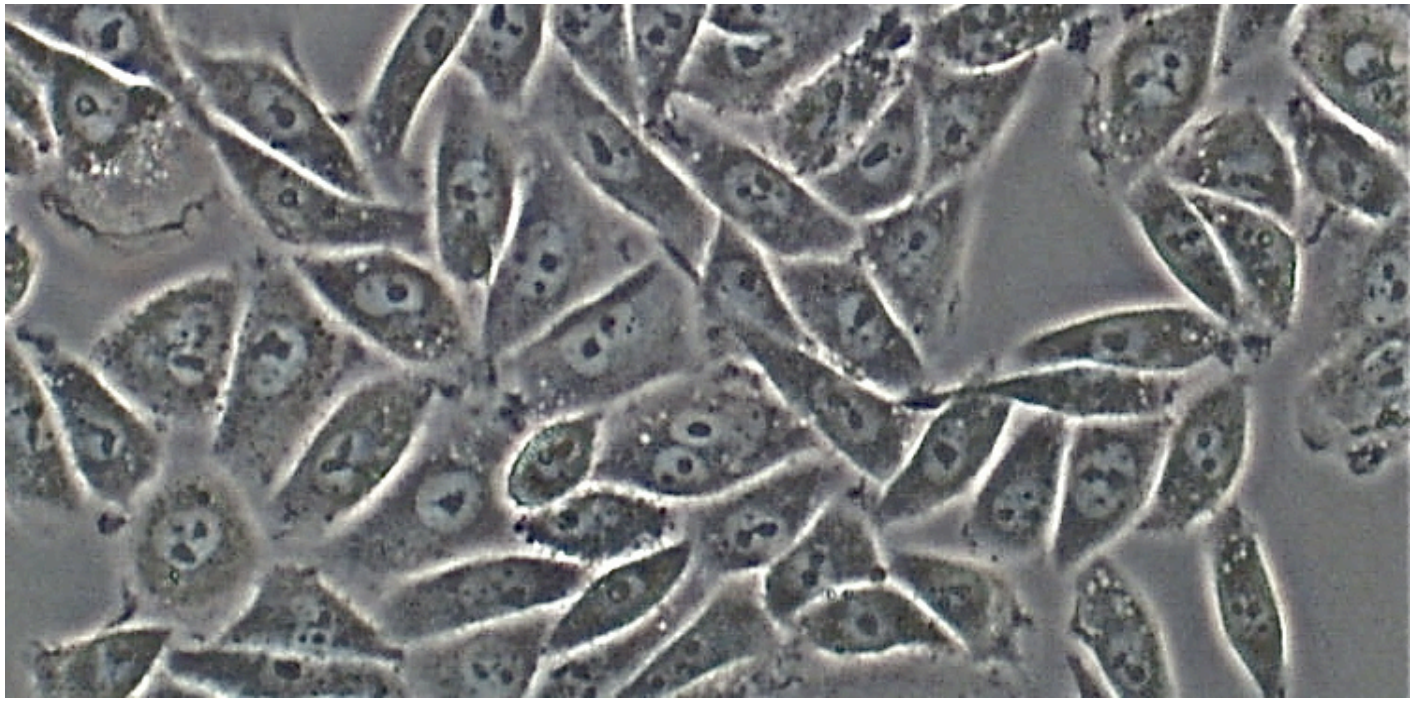
The Eukaryotic Cell



Eukaryotic cells and biomanufacturing

- Examples are CHO and *Pichia pastoris*
- Used to make products that can not be made in prokaryotes
- Such as complex proteins, antibodies, etc.

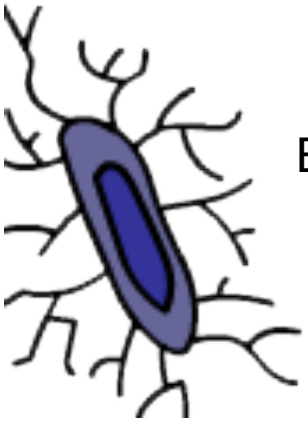
Eukaryotic Cell Structures-- The Basics

- Plasma or cell membrane
- Cytoplasm
- Nucleus and organelles

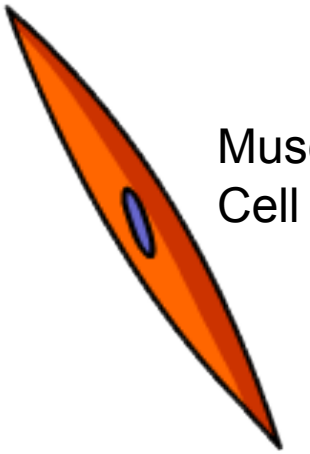
Animal vs. Plant Cells

- Most eukaryotic cells range in size between 1 and 100 µm and are thus visible only with a microscope.
- Animal cells are enclosed by a plasma membrane and containing a membrane-bound nucleus and organelles.
- In contrast plants and fungi, animal cells do not have a cell wall.
- The lack of a rigid cell wall allowed animals to develop a greater diversity of cell types, tissues, and organs. Specialized cells that formed nerves and muscles—tissues impossible for plants to evolve—gave these organisms mobility.
- Animal cells are unique because most animal tissues are bound together in an **extracellular matrix** by **collagen**.
- Plant and fungal cells are bound together in tissues or aggregations by other molecules, such as **pectin**.

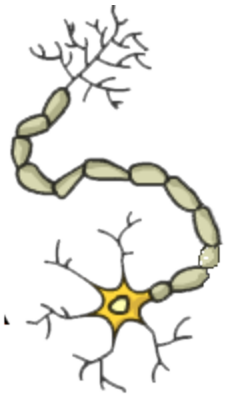
Cell Types in humans



Bone Cell



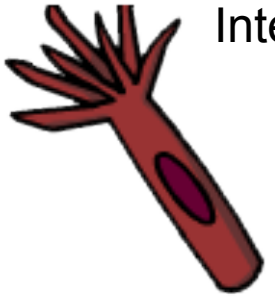
Muscle Cell



Nerve Cell

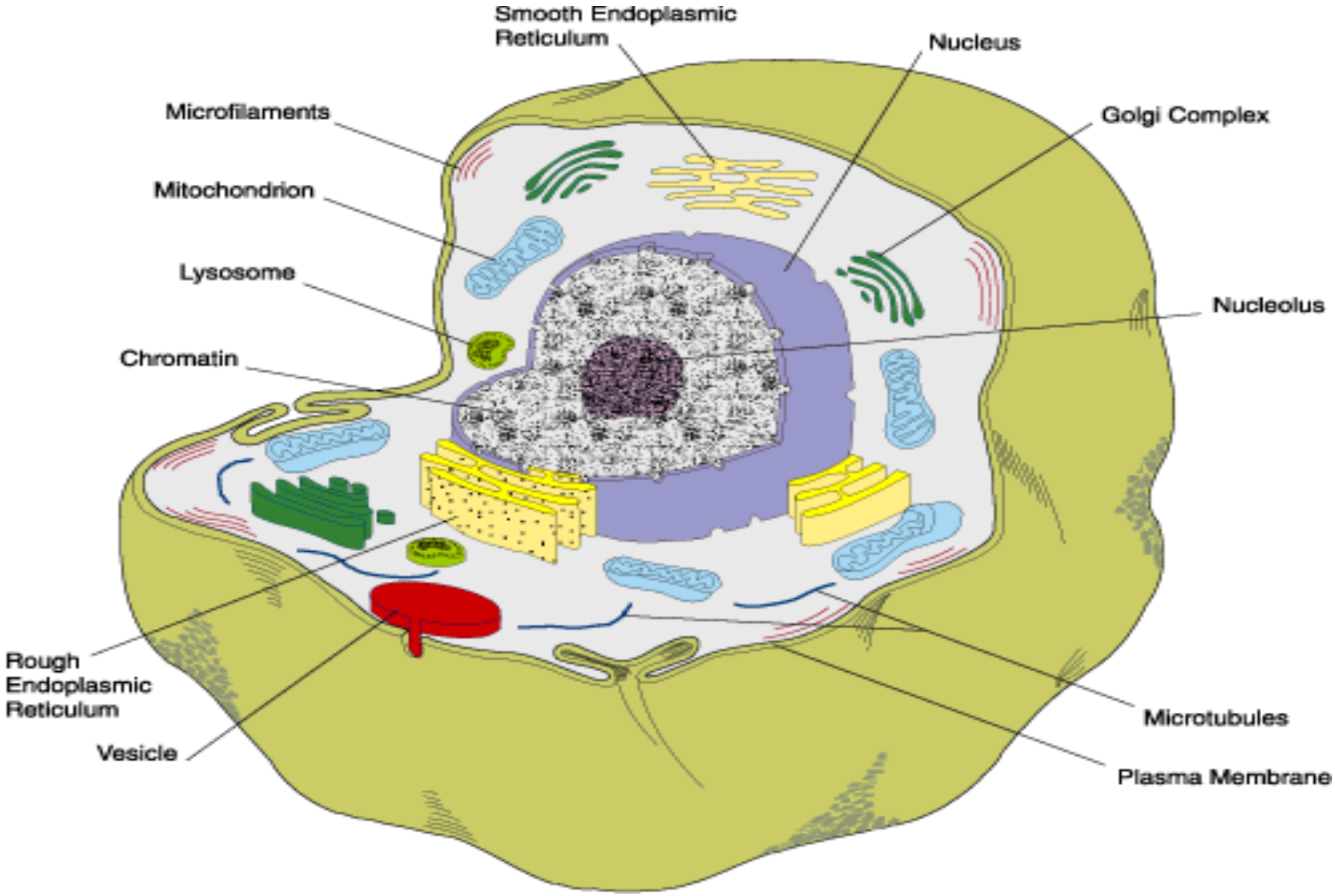
Cartilage Cell

Blood Cell



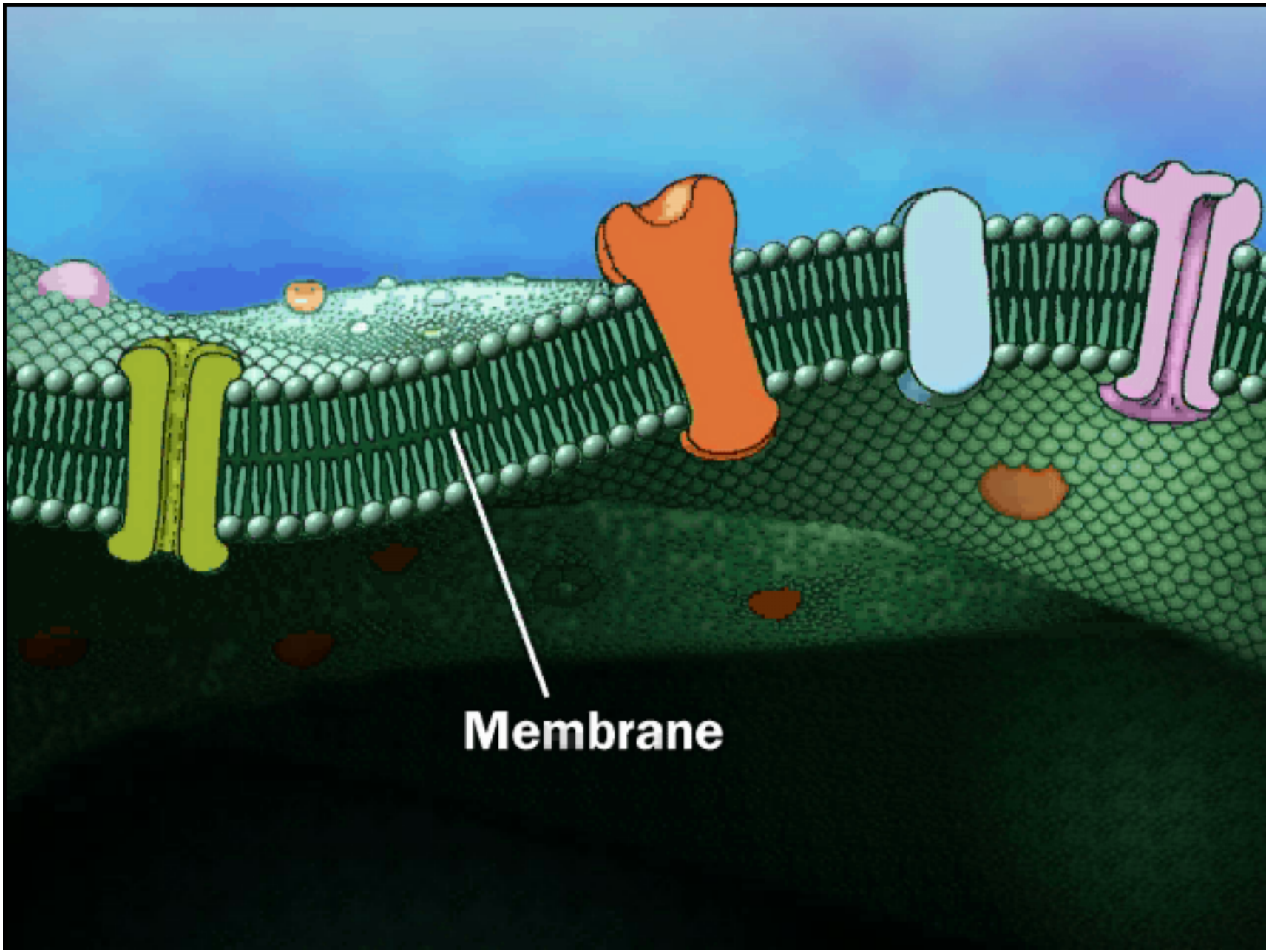
Small IntestineCell

Notice cell shape is crucial for cell function


Smooth Endoplasmic Reticulum
Nucleus
Microfilaments
Golgi Complex
Mitochondrion
Lysosome
Nucleolus
Chromatin
Rough Endoplasmic Reticulum
Microtubules
Vesicle
Plasma Membrane

Plasma Membrane

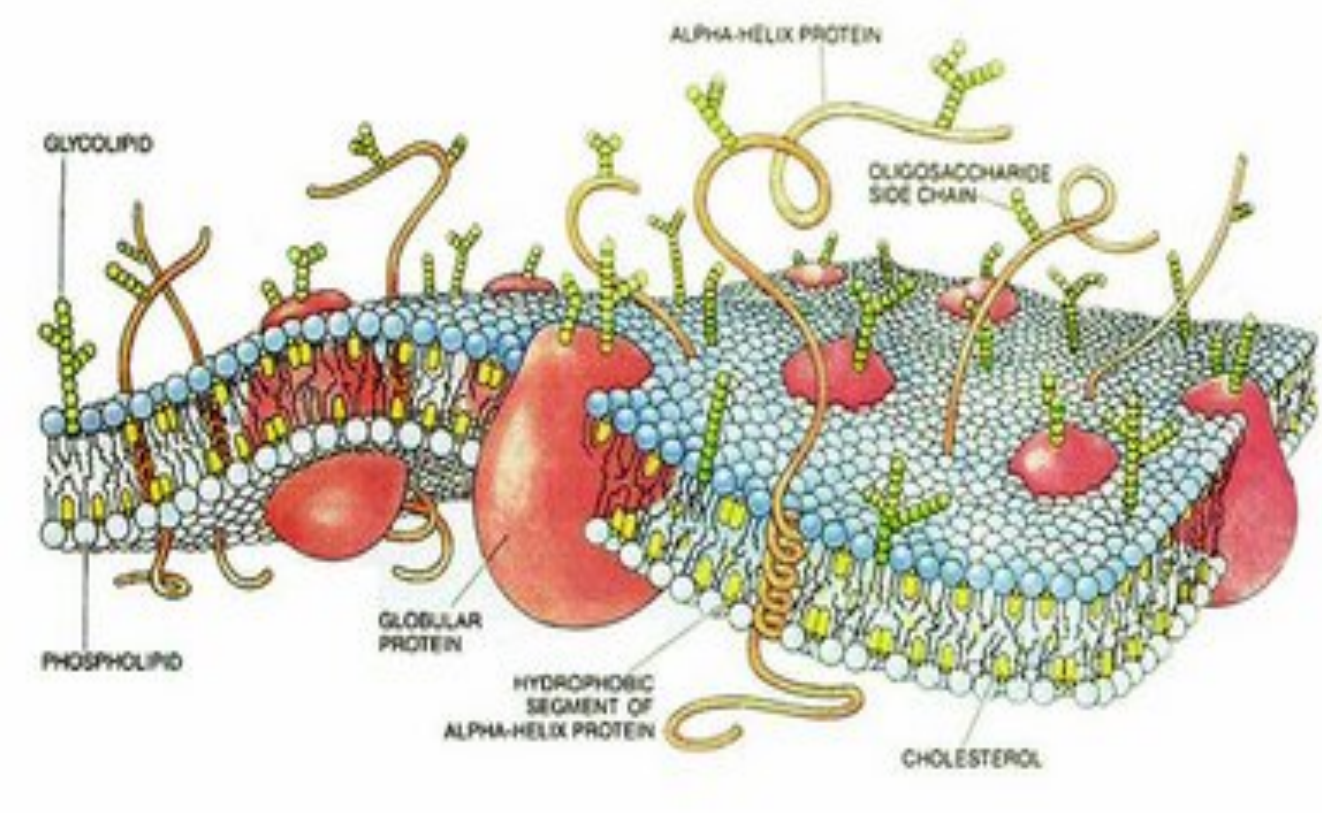
- The plasma or cell membrane surrounds the cytoplasm of the cell.
- It acts as a boundary layer to contain the cytoplasm (fluid in cell).
- It allows water, oxygen, and other materials to pass in and out of cells.


Membrane

Fluid Mosaic Model

- A mosaic is a structure made up of many different parts.
- The plasma membrane also is a fluid structure composed of different kinds of molecules.
- The components of a plasma membrane are integral proteins, peripheral proteins, glycoproteins, phospholipids, glycolipids, and in some cases cholesterol, lipoproteins.

Fluid Mosaic Model



Cytoplasm

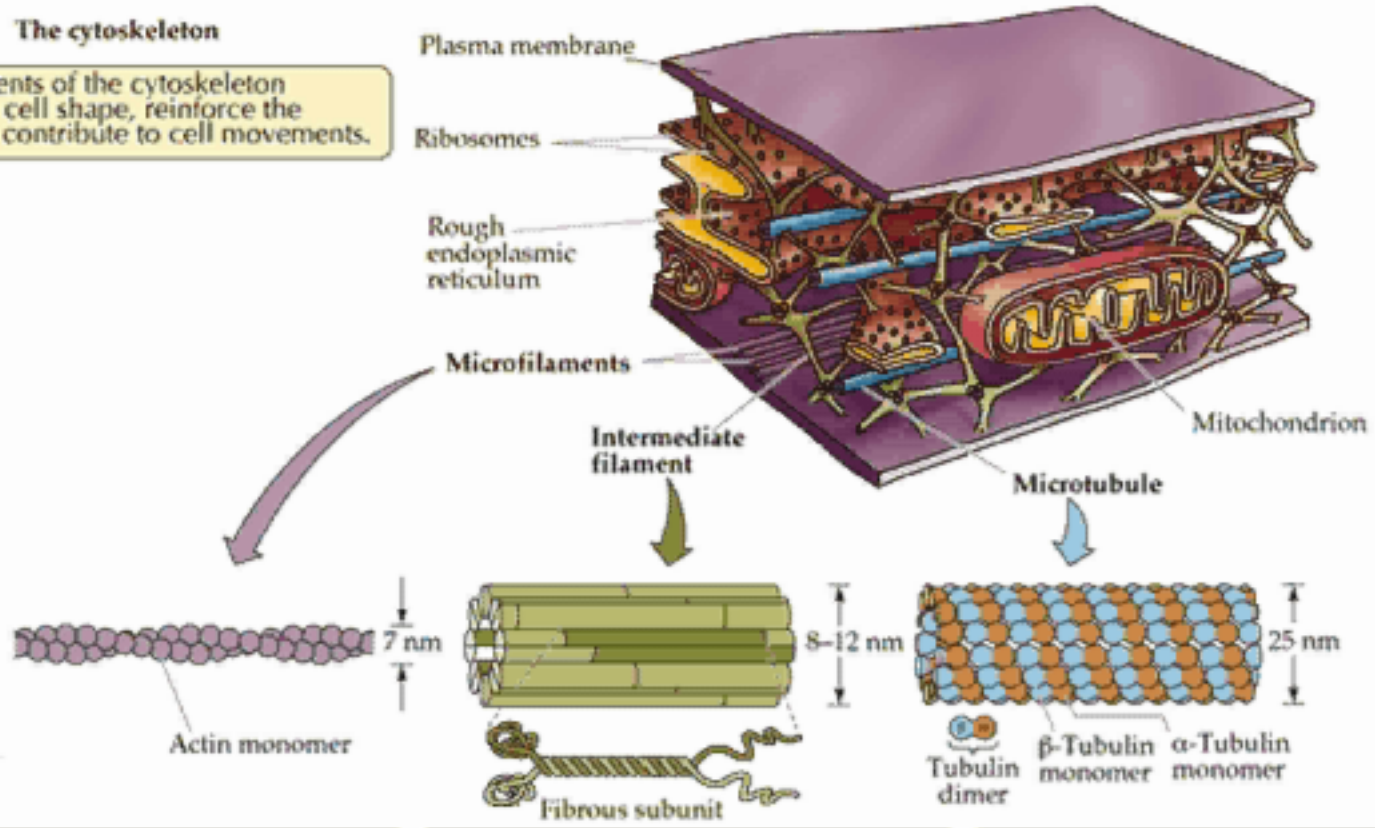
- Cytoplasm contains the cellular contents inside the plasma membrane.
- It fills the entire cell.
- It contains a large variety of organelles.
- It is about 80% water, but also stores nutrients and building blocks for the cell.

Cytoskeleton

- The cytoskeleton gives the cell its structure and shape, it also allows for movement.
- Within the cytoplasm, eukaryotic cells contain three main kinds of cytoskeletal filaments:
- Microfilaments
- Intermediate filaments
- Microtubules

The cytoskeleton

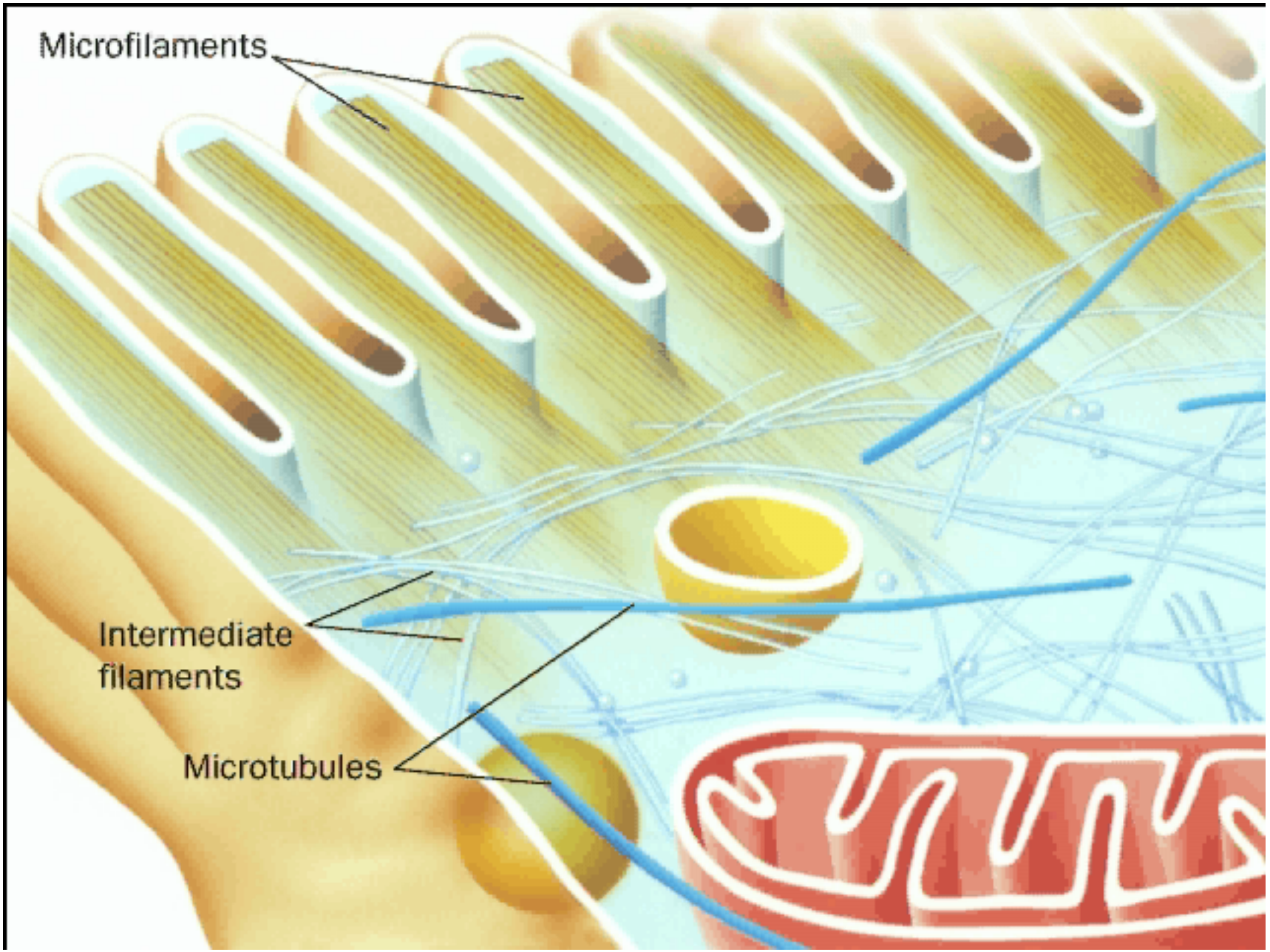
Components of the cytoskeleton maintain cell shape, reinforce the cell, and contribute to cell movements.



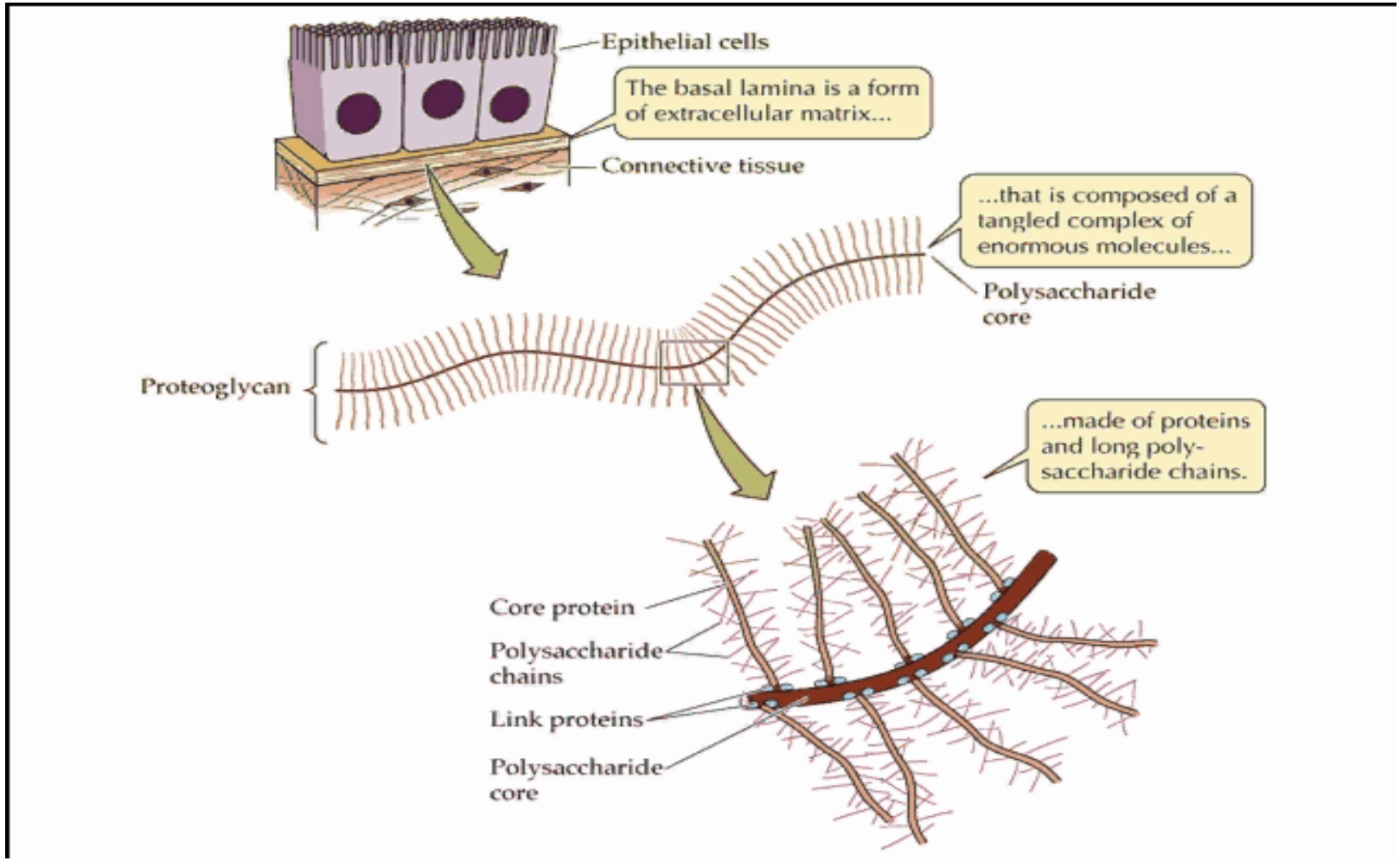
Microfilaments are made up of strands of the protein actin and often interact with strands of other proteins. Microfilaments may occur singly, or in bundles or networks. They change cell shape and drive cellular motion, including contraction, cytoplasmic streaming, and the "pinched" shape changes that occur during cell division. Microfilaments and myosin strands together drive muscle action.

Intermediate filaments are made up of fibrous proteins organized into tough,ropelike assemblages that stabilize a cell'sstructure and help maintain its shape.Some intermediate filaments hold neighboring cells together. Others make up the nuclear lamina.

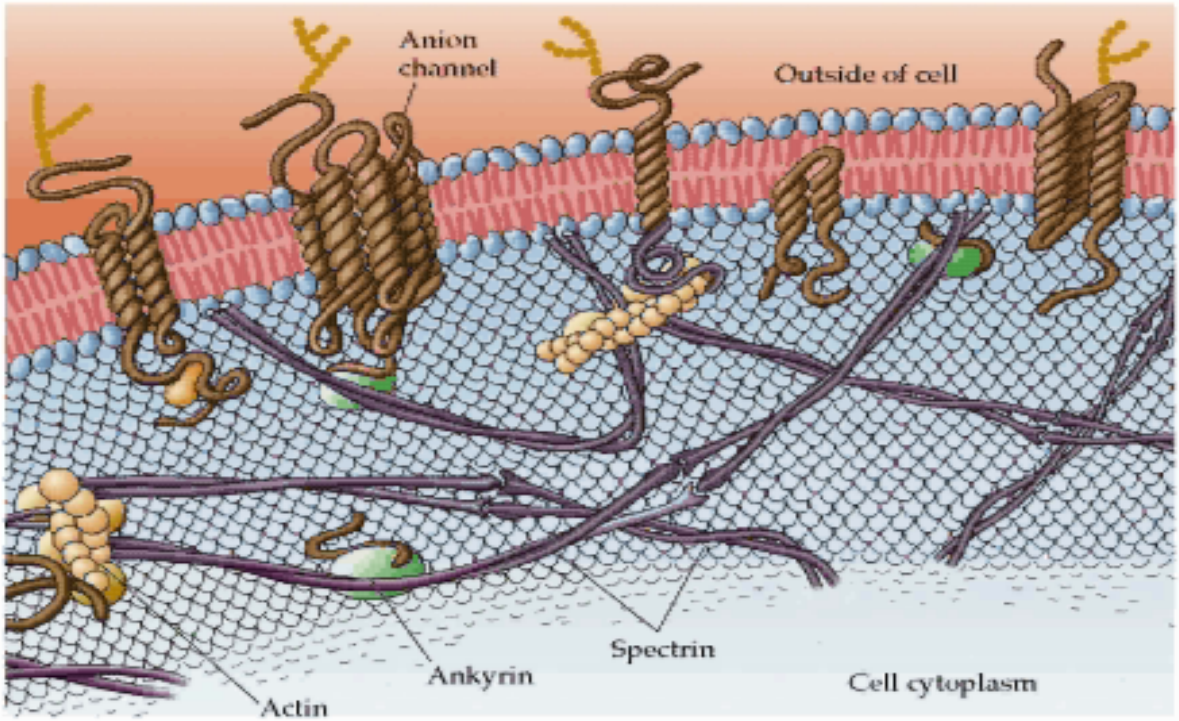
Microtubules are long, hollow cylinders made up of many molecules of the protein tubulin. Tubulin consists of two subunits, α-tubulin and β-tubulin. Microtubules lengthen or shorten by adding or subtracting tubulin dimers. Microtubule shortening moves chromosomes. Interactions between microtubules drive the movement of cells. Microtubules serve as "tracks" for the movement of vesicles.


Microfilaments
Intermediate filaments
Microtubules

Extracellular matrix includes the interstitial matrix and the basement membrane. Interstitial matrix is present between various cells (i.e., in the intercellular spaces).



Interaction between the cytoskeleton and the plasma membrane



Cells in Motion

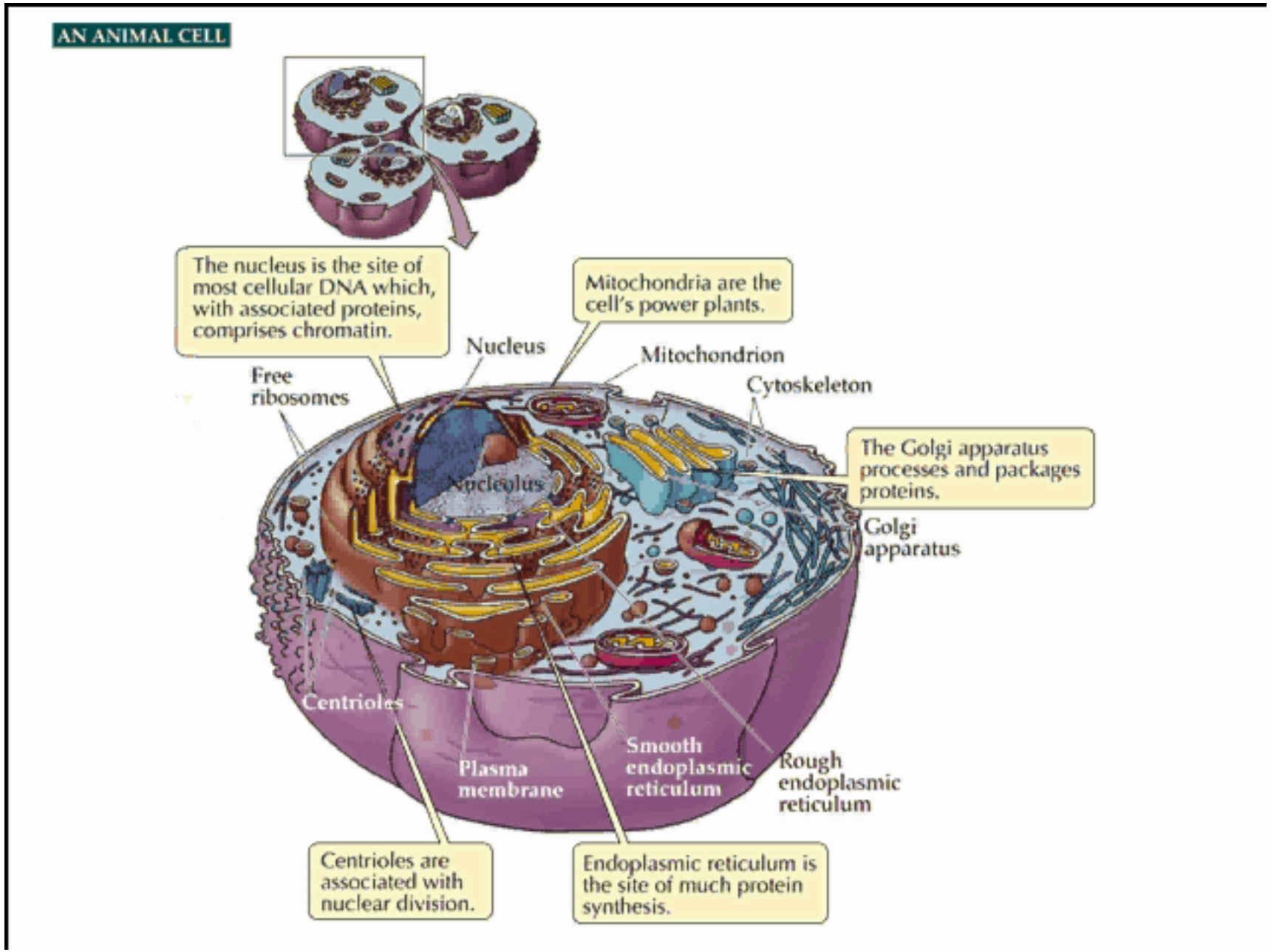
- In multicellular tissues, cells employ a variety of mechanisms to maneuver through spaces in the extracellular matrix and over the surfaces of other cells.

- Examples are the rapid movement of cells in developing embryos, organ-to-organ spreading of malignant cancer cells, and the migration of neural axons to synaptic targets.

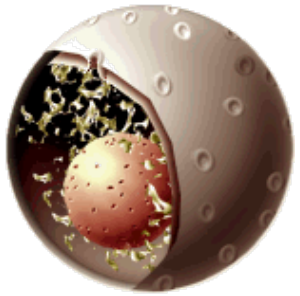
- Crawling cells in culture do not possess cilia or flagella, but tend to move by coordinated projection of the cytoskeleton in repeating cycles of extension and retraction (pseudopod formation).

Organelles

- Organelles are small structures that help carry out the day-to-day operations of the cell.
- Each organelle tends to perform a specific function for the cell.
- Organelles are membrane bound.


AN ANIMAL CELL
The nucleus is the site of most cellular DNA which, with associated proteins, comprises chromatin.
Mitochondria are the cell's power plants.
Nucleus
Mitochondrion
Free ribosomes
Cytoskeleton
The Golgi apparatus processes and packages proteins.
Nucleolus
Golgi apparatus
Centrioles
Plasma membrane
Smooth endoplasmic reticulum
Rough endoplasmic reticulum
Centrioles are associated with nuclear division.
Endoplasmic reticulum is the site of much protein synthesis.

Nucleus



- The nucleus is a highly specialized organelle that serves as the information processing and administrative center of the cell.
- This organelle has two major functions:
  - it stores the cell's hereditary material, or DNA
  - it coordinates the cell's activities, which include growth, intermediary metabolism, protein synthesis, and reproduction (cell division).

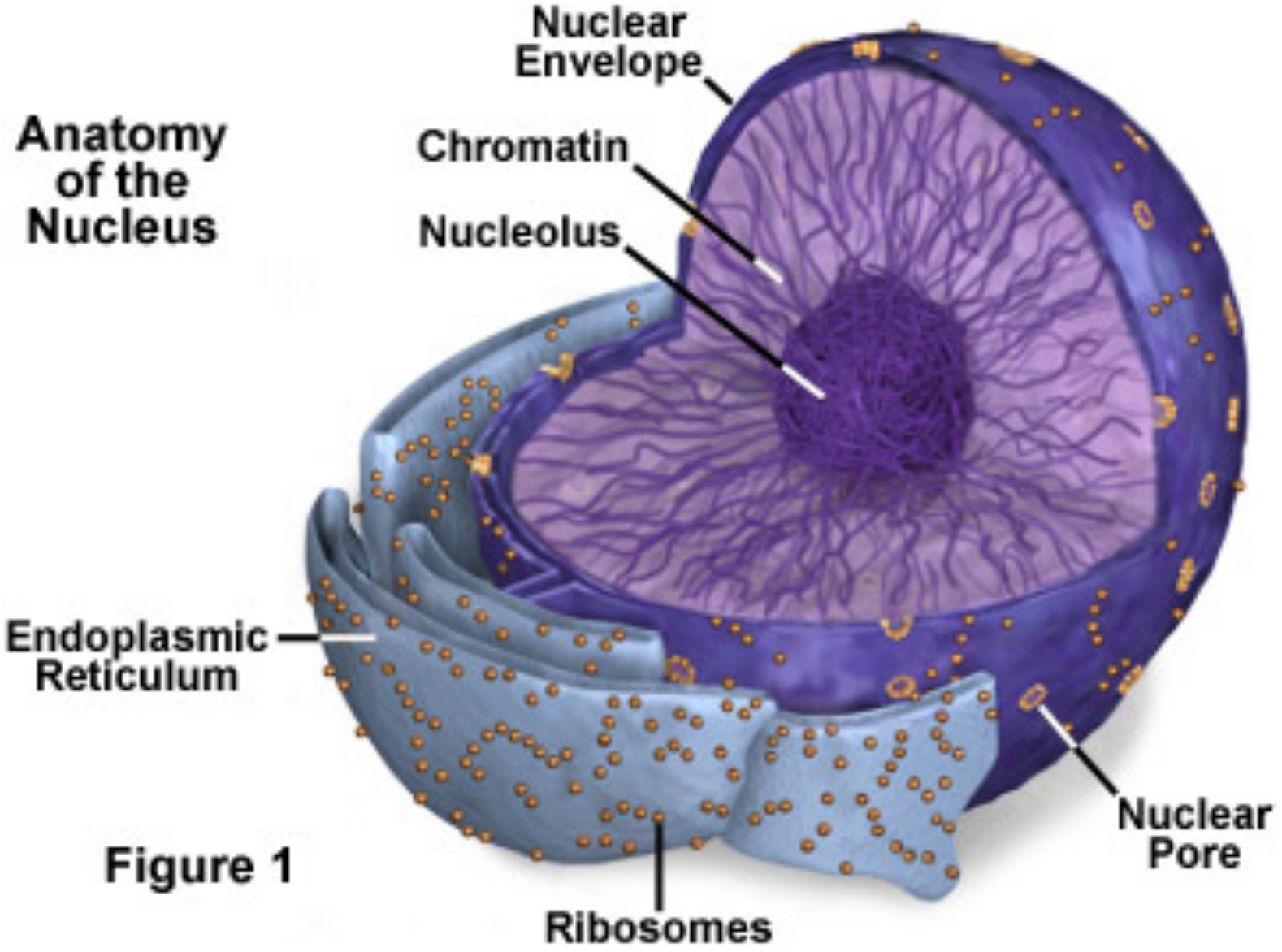
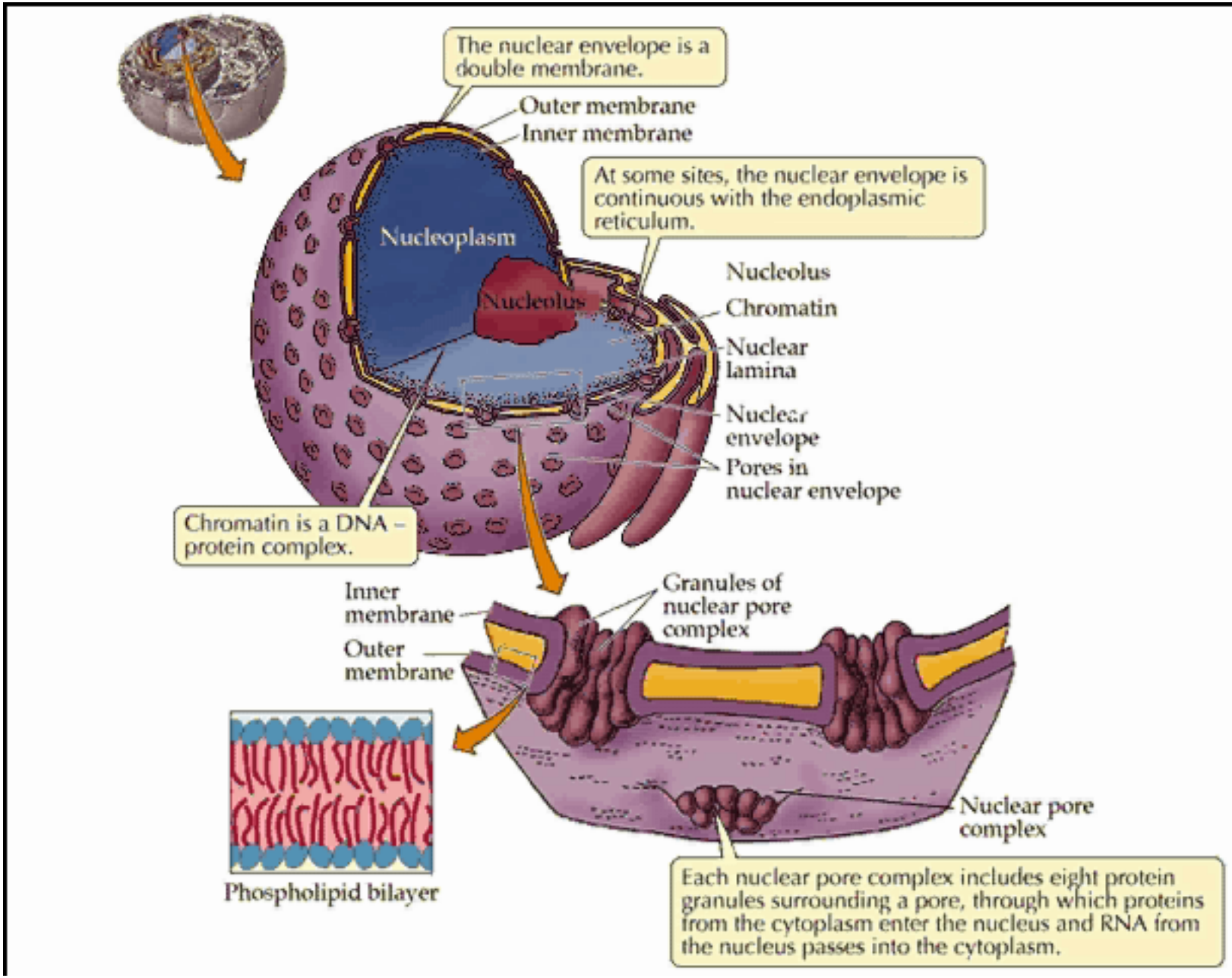
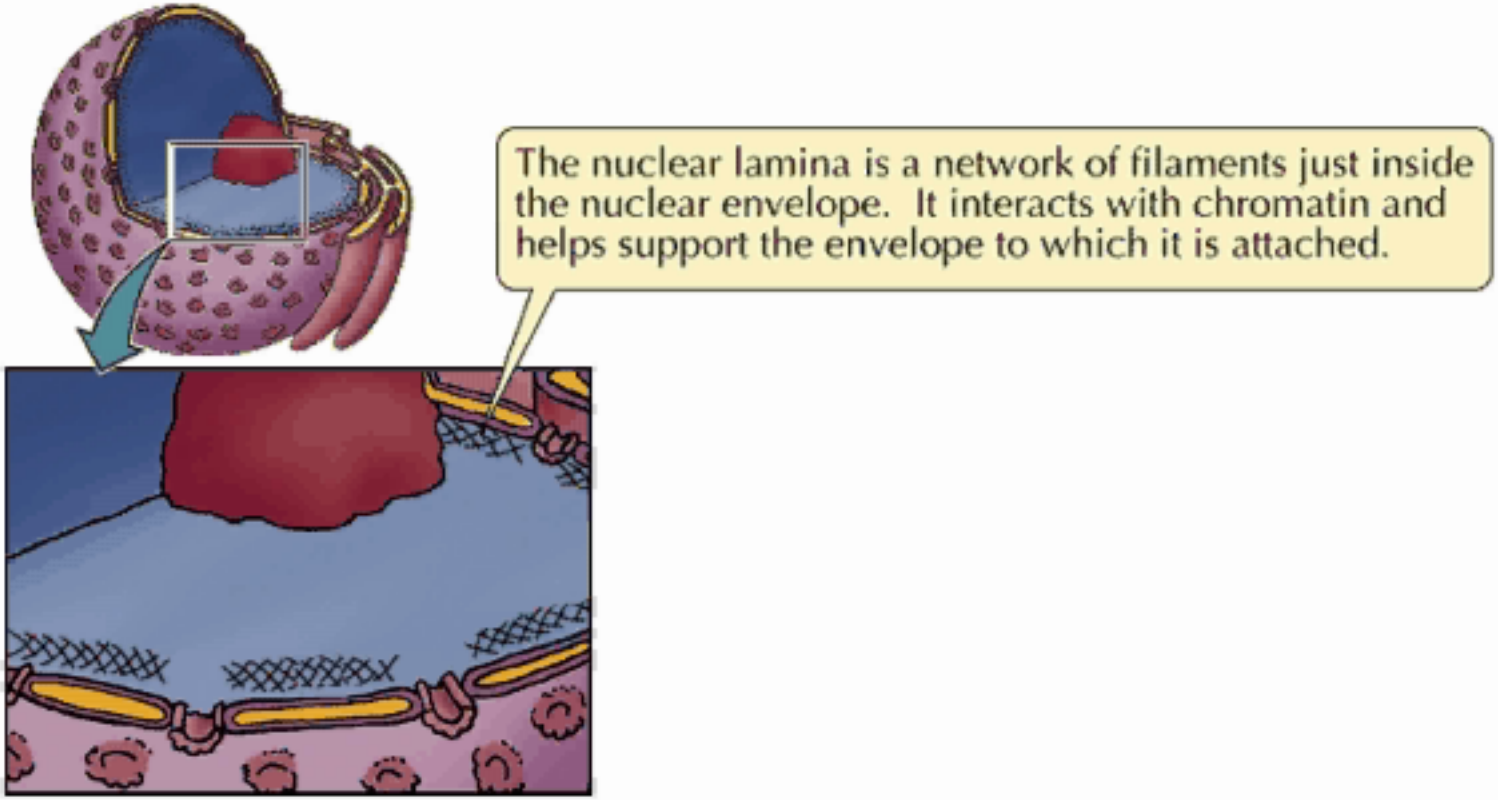
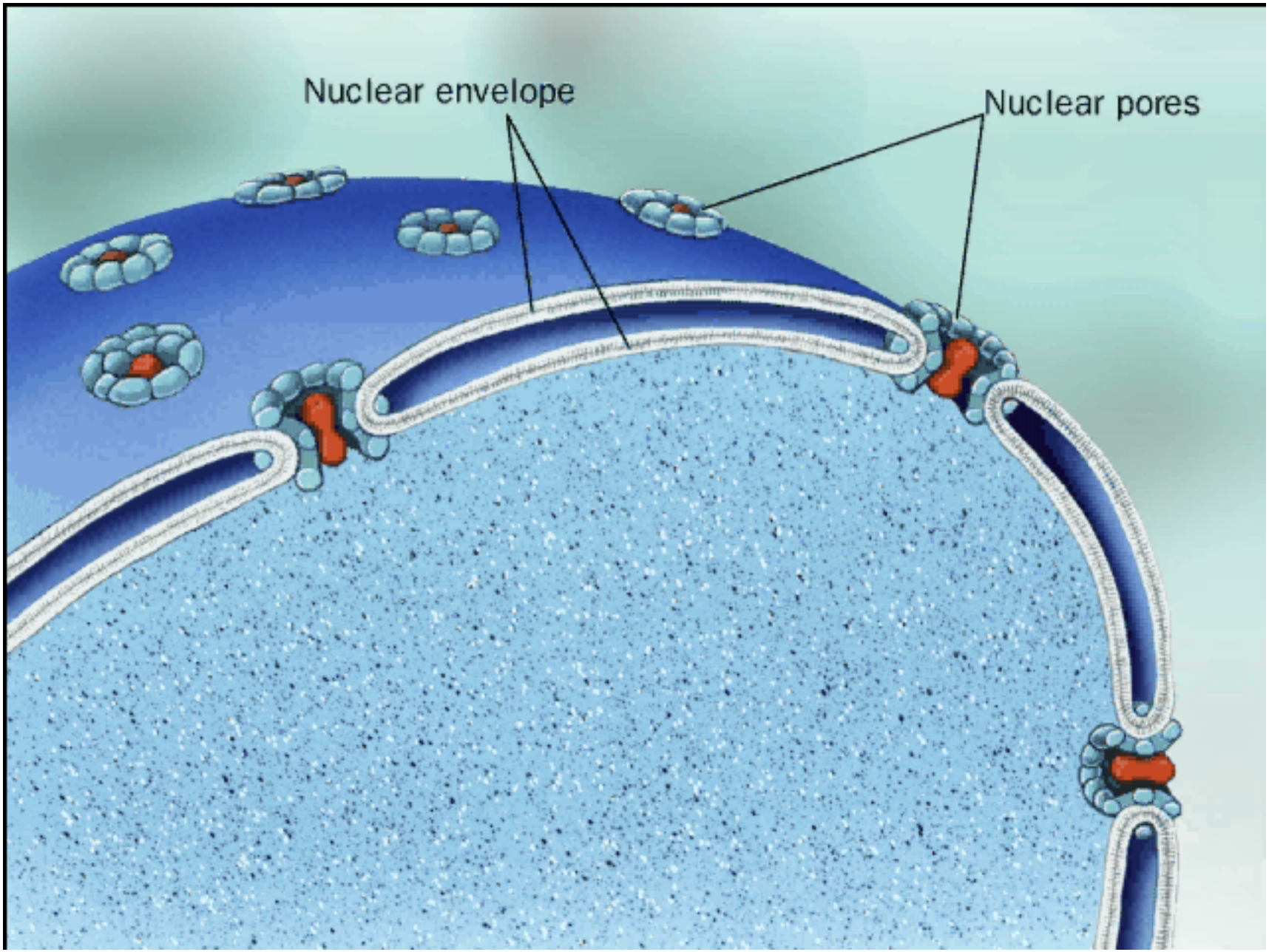

Anatomy of the Nucleus
Nuclear Envelope
Chromatin
Nucleolus
Endoplasmic Reticulum
Nuclear Pore
Ribosomes

Figure 1

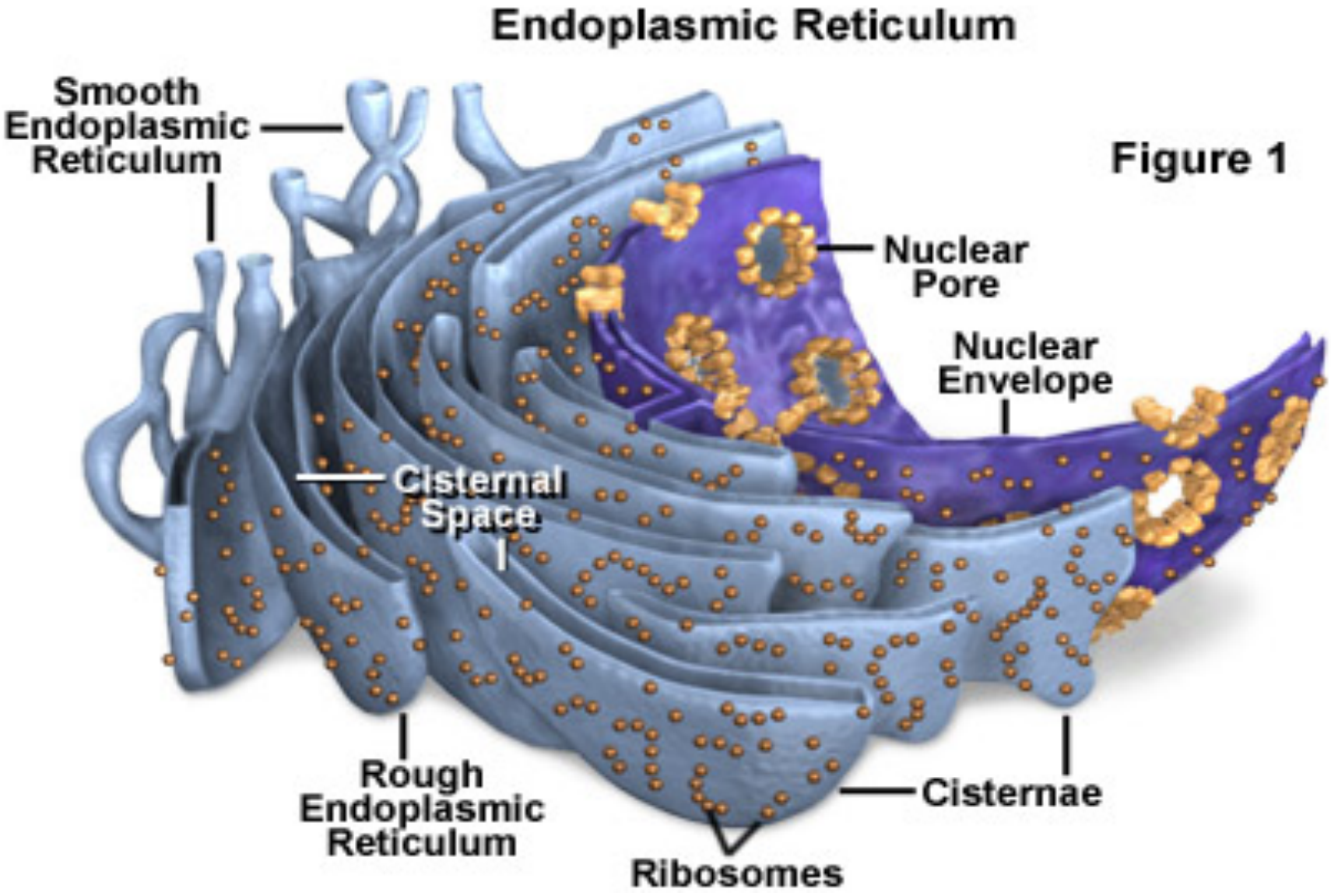

The nuclear envelope is a double membrane.
Outer membrane
Inner membrane
At some sites, the nuclear envelope is continuous with the endoplasmic reticulum.
Nucleoplasm
Nucleolus
Nucleolus
Chromatin
Nuclear lamina
Nuclear envelope
Pores in nuclear envelope
Chromatin is a DNA – protein complex.
Inner membrane
Outer membrane
Granules of nuclear pore complex
Nuclear pore complex
Phospholipid bilayer
Each nuclear pore complex includes eight protein granules surrounding a pore, through which proteins from the cytoplasm enter the nucleus and RNA from the nucleus passes into the cytoplasm.

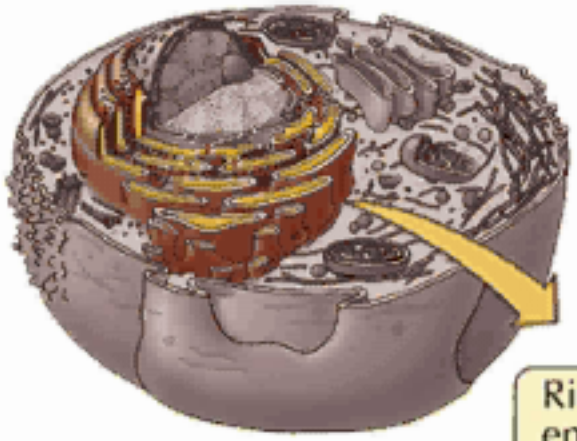

The nuclear lamina is a network of filaments just inside the nuclear envelope. It interacts with chromatin and helps support the envelope to which it is attached.


Nuclear envelope
Nuclear pores

Endoplasmic reticulum

- The endoplasmic reticulum (ER) is a network of sacs that manufactures, processes, and transports molecules for use inside and outside of the cell.
- The ER is connected to the double-layered nuclear envelope, providing a pipeline between the nucleus and the cytoplasm.
- There are two types of ER, rough and smooth ER.
  - Rough ER has ribosomes attached to it, and smooth ER does not.


Endoplasmic Reticulum
Smooth Endoplasmic Reticulum
Figure 1
Nuclear Pore
Nuclear Envelope
Cisternal Space
Rough Endoplasmic Reticulum
Cisternae
Ribosomes



Ribosomes

Ribosomes of the rough endoplasmic reticulum are sites for protein synthesis. They produce its rough appearance.

The interior of the endoplasmic reticulum compartment is called the lumen.

Smooth endoplasmic reticulum is a site for lipid synthesis and chemical modification of proteins.

Membranes

Golgi Apparatus

- The Golgi apparatus is the distribution and shipping department for the cell's biochemical products. It modifies proteins and fats built in the endoplasmic reticulum and prepares them for export to the outside of the cell.
- This organelle modifies molecules and packages them into small membrane bound sacs called vesicles.
- These sacs can be targeted at various locations in the cell and even to its exterior.

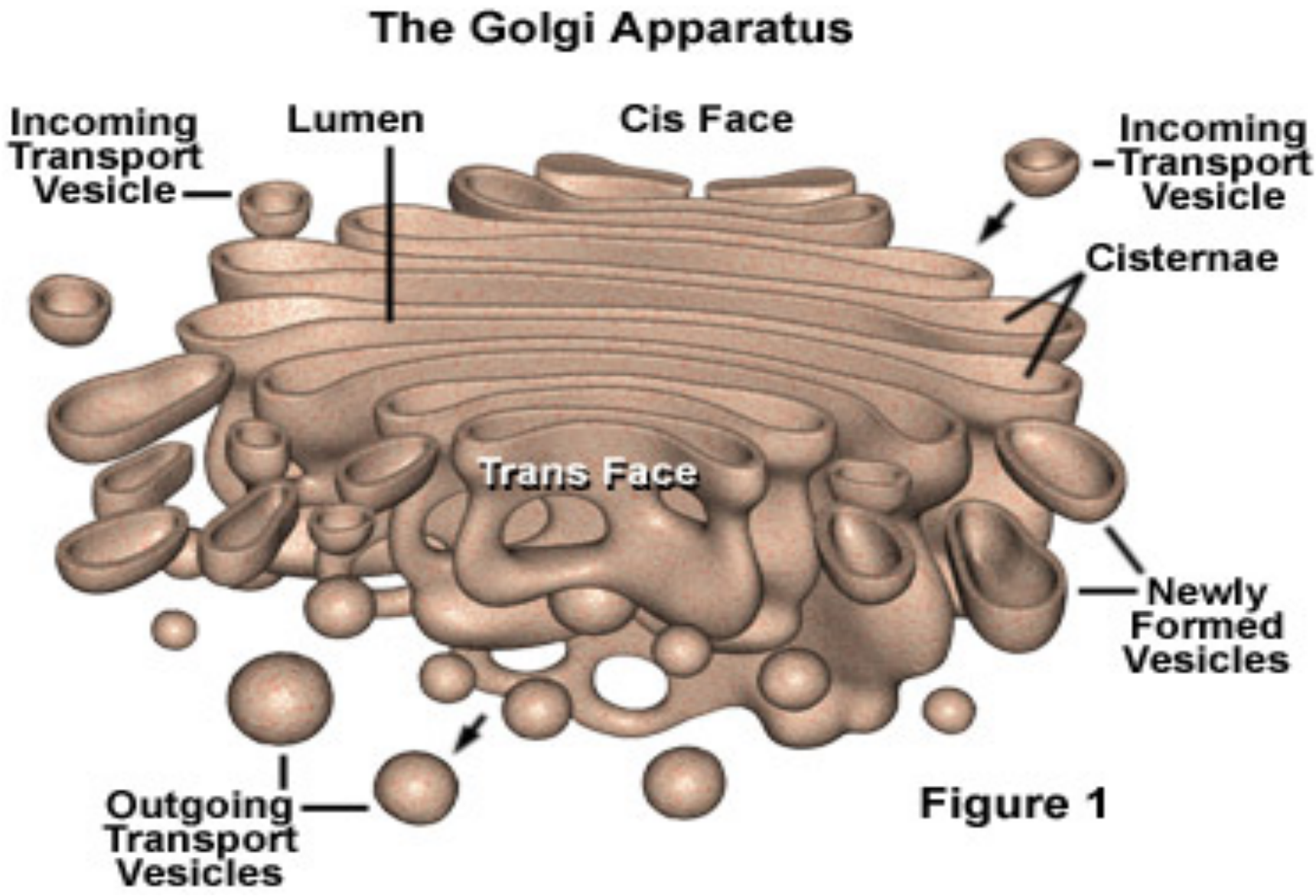
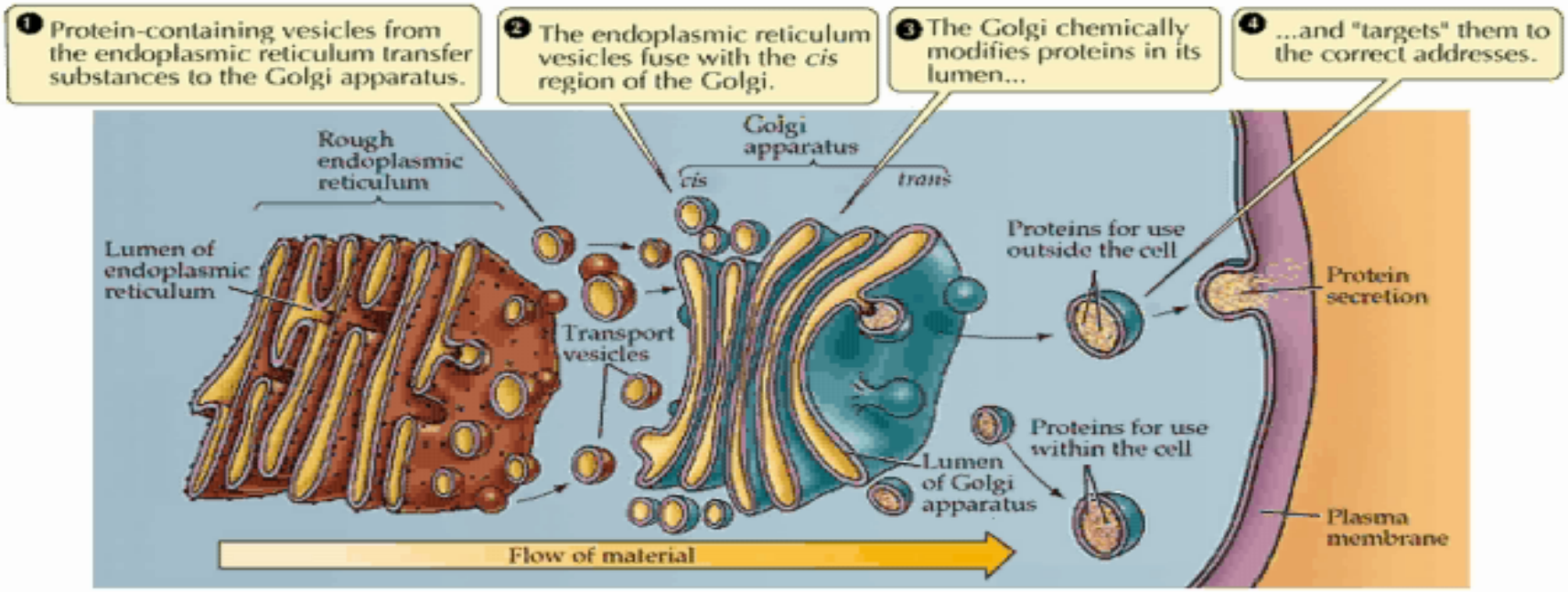

The Golgi Apparatus
Incoming Transport Vesicle
Lumen
Cis Face
Incoming Transport Vesicle
Cisternae
Trans Face
Newly Formed Vesicles
Outgoing Transport Vesicles

Figure 1

Protein Transport



Lysosome

- The main function of the lysosome is digestion.
- Lysosomes break down molecules into their base components with strong digestive enzymes.
- These components are then transferred to the cytoplasm as new cell-building materials.
- This demonstrates an advantage of the compartmentalization of the eukaryotic cell: the cell could not support such destructive enzymes if they were not contained in a membrane-bound lysosome .
- Specific to animal cells.

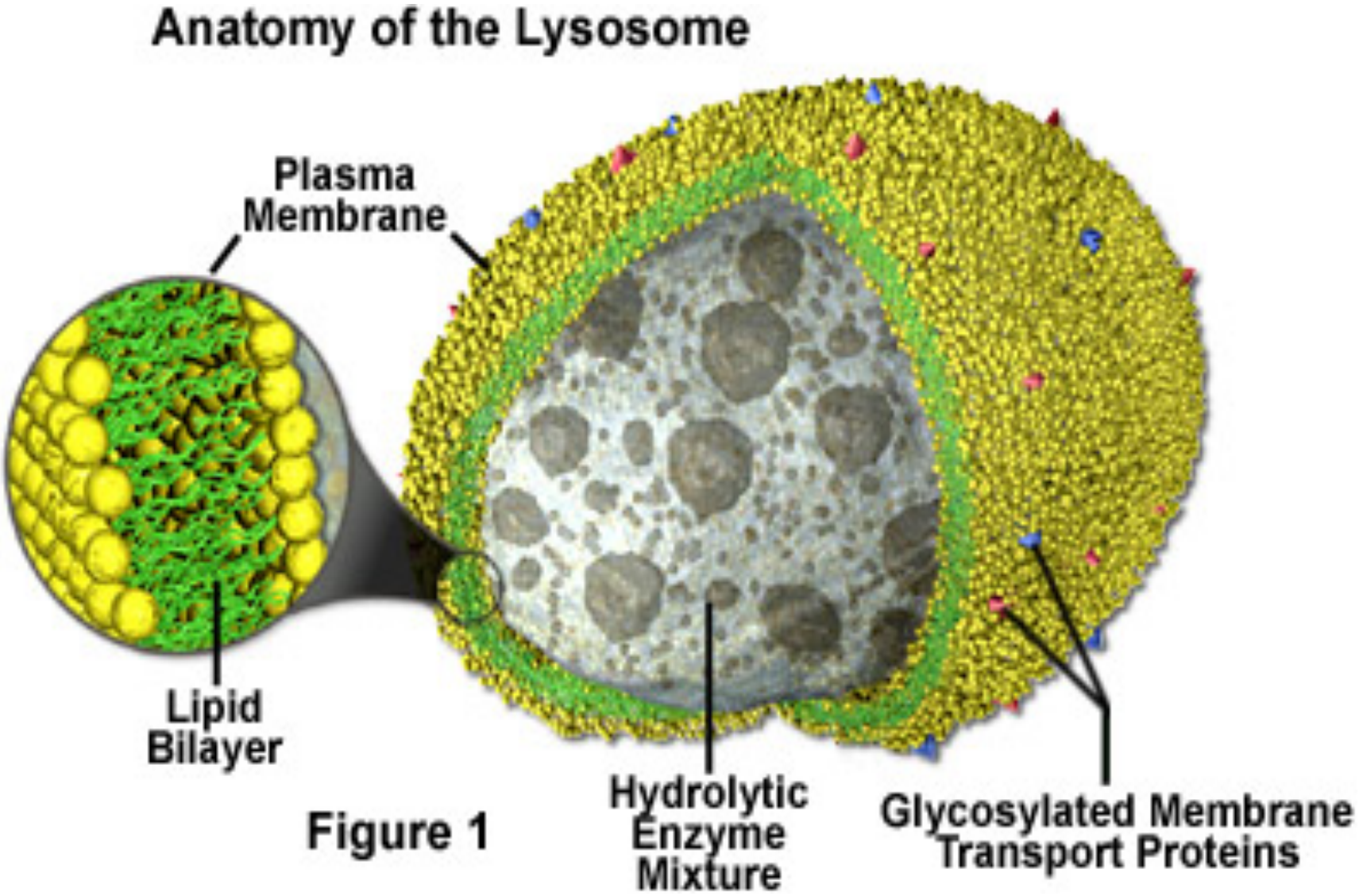
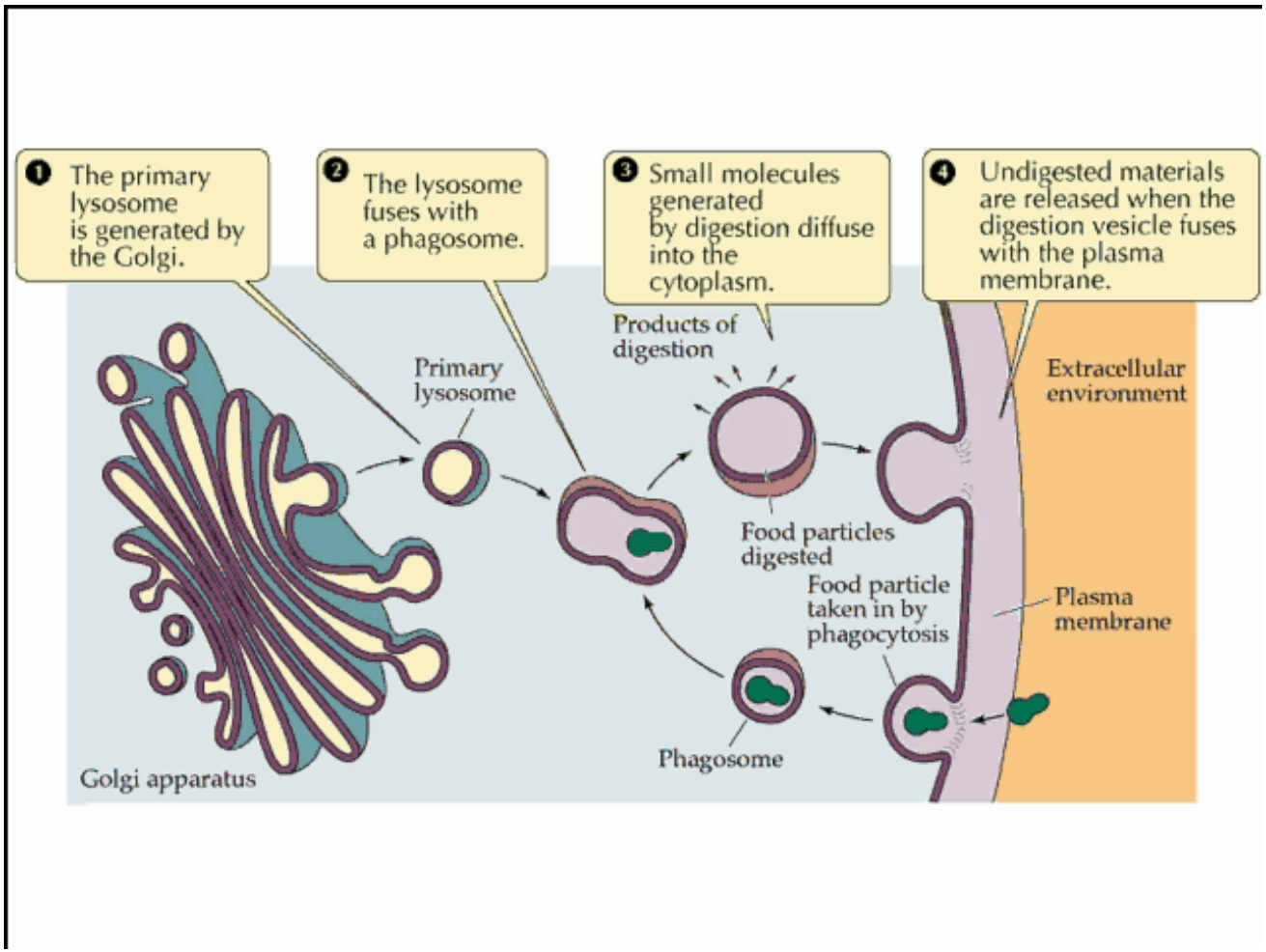

Anatomy of the Lysosome
Plasma Membrane
Lipid Bilayer
Hydrolytic Enzyme Mixture
Glycosylated Membrane Transport Proteins

Figure 1

The Lysosome originates from the Golgi



Peroxisome

- Peroxisomes function to rid the cell of toxic substances, such as H2O2. They are also involved in breaking down lipids/fatty acids.
- They have a single membrane that separates their contents from the cytoplasm and that contains membrane-proteins critical for various functions, such as importing proteins into the organelles.
- Unlike lysosomes, which are formed in the secretory pathway, peroxisomes usually self-replicate by enlarging and then dividing, although there is some indication that new ones may be formed directly.
- Found in both plant and animal cells.

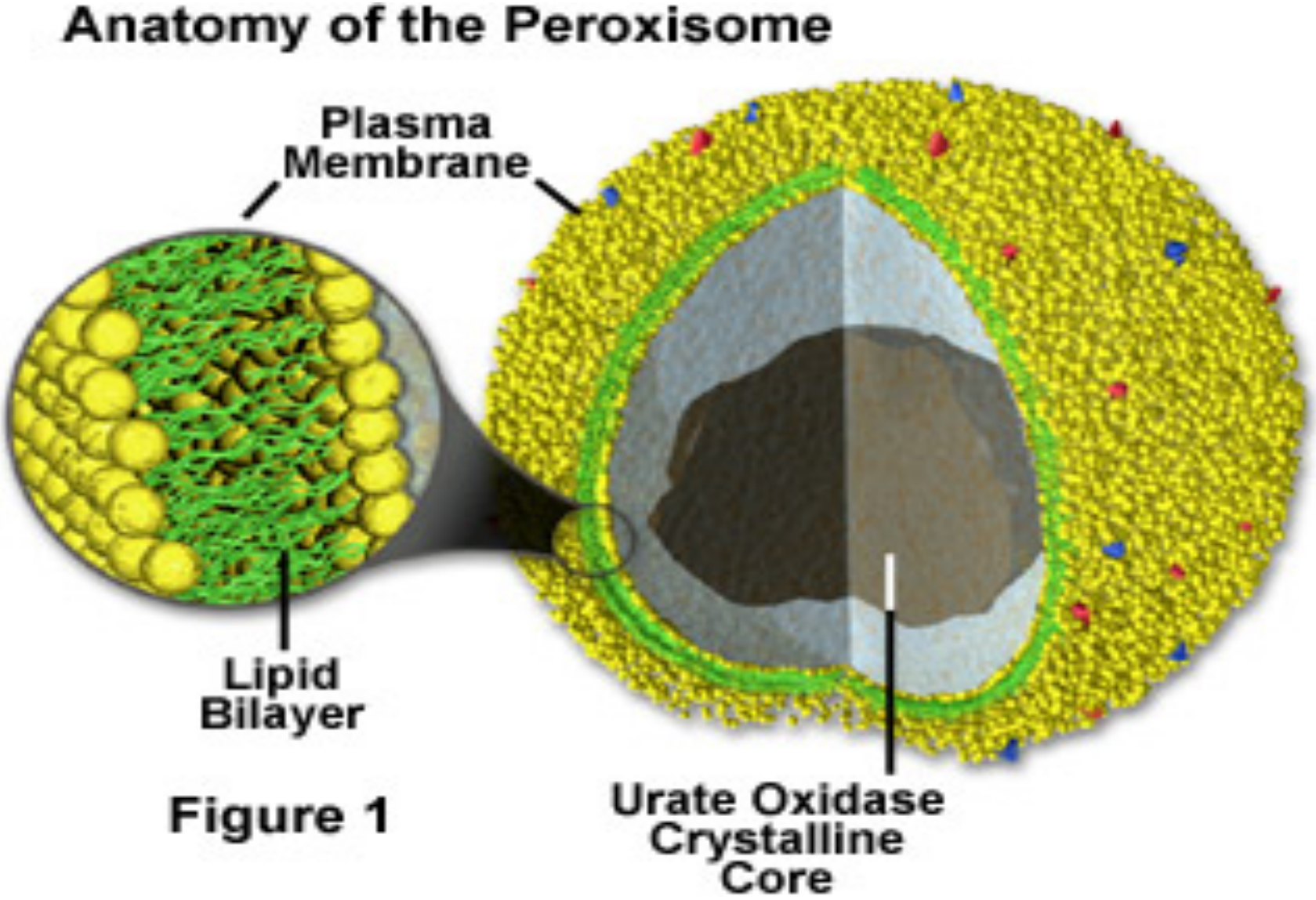

Anatomy of the Peroxisome
Plasma Membrane
Lipid Bilayer
Urate Oxidase Crystalline Core

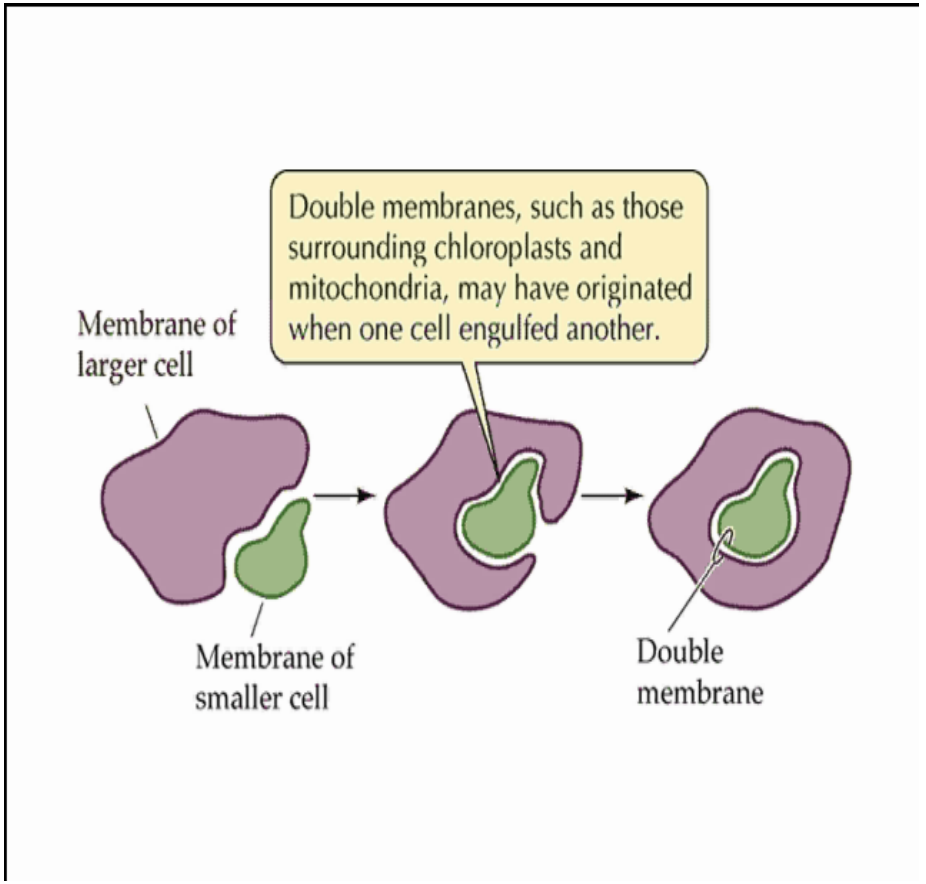
Figure 1

Mitochondria

- Mitochondria are found in the cytoplasm of every eukaryotic cell. In the animal cell, they are the main power generators, converting oxygen and nutrients into energy.
- Provide the energy for the cell
- Have two membranes, an inner and an outer
  - Inner membranes is highly folded, this is to increase the surface area of the membrane, so more reactions can take place at this site
- Have their own DNA and ribosomes

Endosymbiotic Theory

- The existence of the double membrane has led to the theory that mitochondria are the descendants of some bacteria that was endocytosed by a larger cell billions of years ago, but not digested.
- Additional supporting evidence of this theory is the fact that mitochondria have their own DNA and their own ribosomes; and those ribosomes are more similar to bacterial ribosomes than to eukaryotic ribosomes.
- Plant cell chloroplasts also are thought to have a similar past.



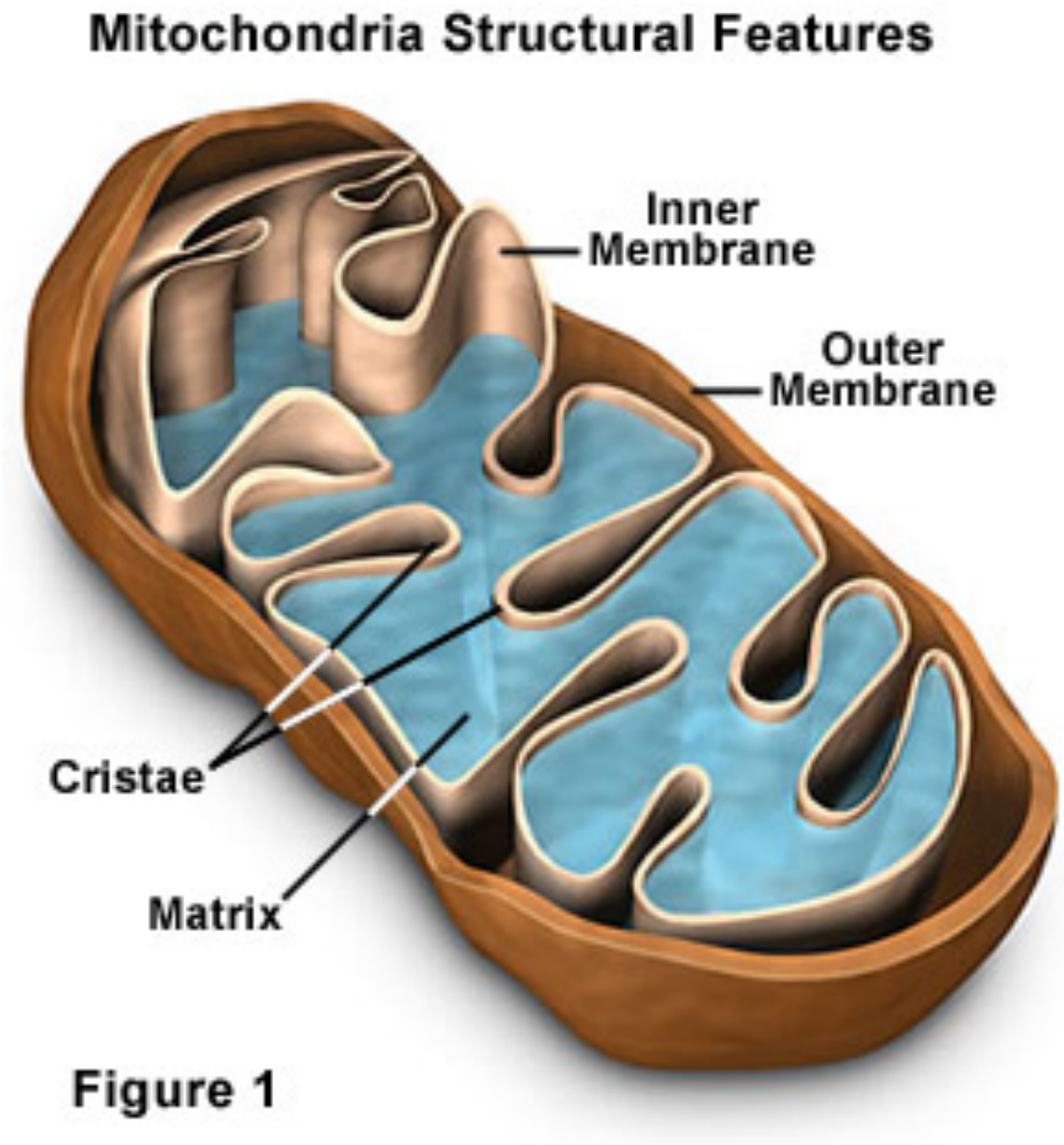

Mitochondria Structural Features
Inner Membrane
Outer Membrane
Cristae
Matrix

Figure 1

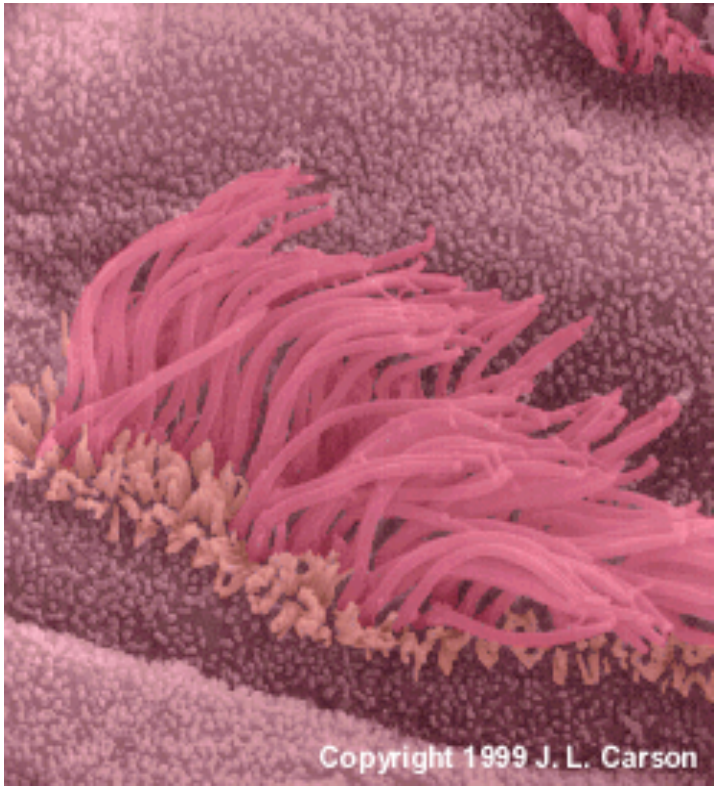
Cilia and Flagella

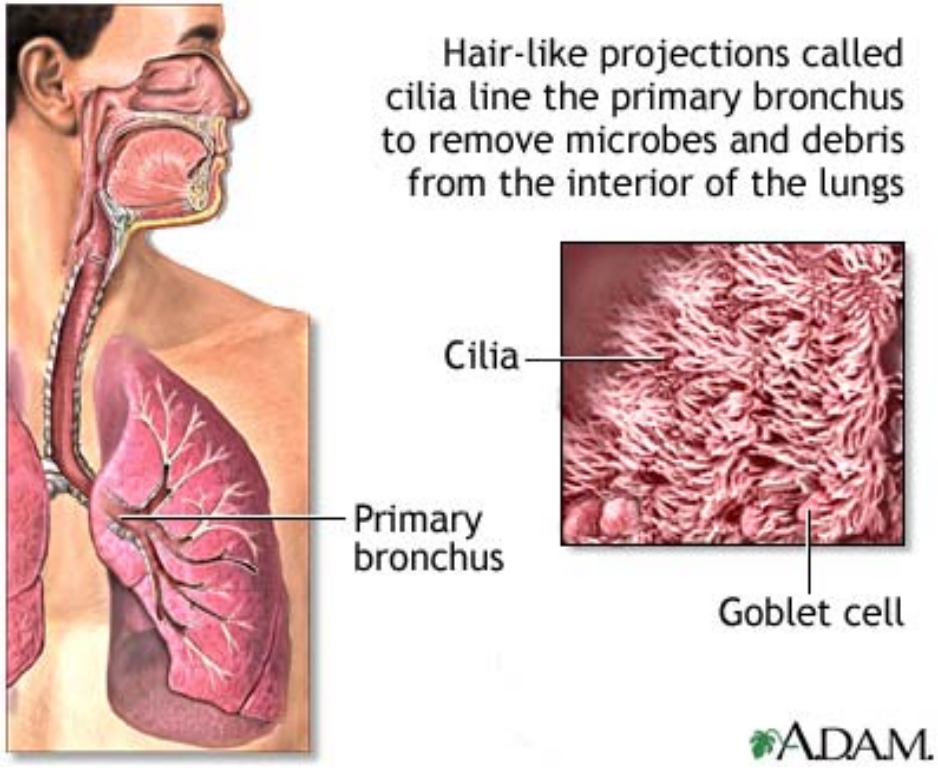
- Cilia and flagella are motile cellular appendages found in most microorganisms and animals, but not in higher plants.
- For single-celled eukaryotes, cilia and flagella are essential for the locomotion of individual organisms.

Cilia

- In multicellular organisms, cilia function to move fluid or materials past an immobile cell as well as moving a cell or group of cells.
- cilia are usually shorter and occur together in much greater numbers than flagella, which are often solitary.
- movement of cilia is often described as whip-like, or compared to the breast stroke in swimming.
- Adjacent cilia move almost simultaneously (but not quite), so that in groups of cilia, wave-like patterns of motion occur

Cilia

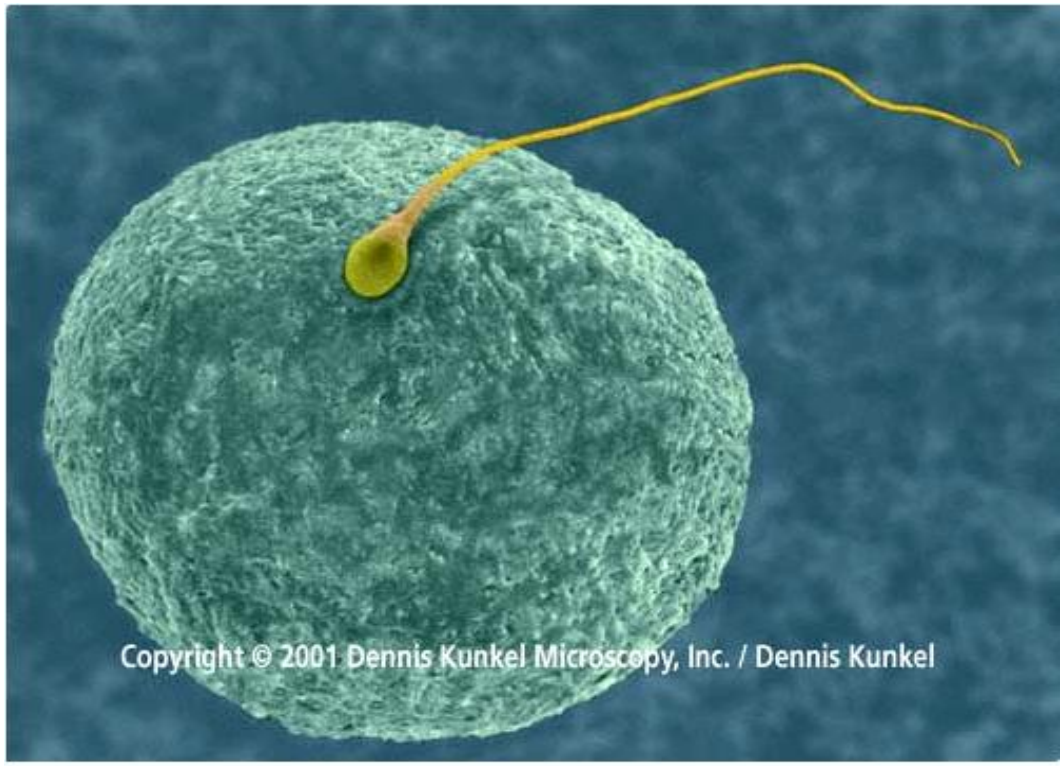

Copyright 1999 J. L. Carson


Hair-like projections called cilia line the primary bronchus to remove microbes and debris from the interior of the lungs
Cilia
Primary bronchus
Goblet cell
A.D.A.M.

Flagella

- Flagella are found primarily on gametes, but create the water currents necessary for respiration and circulation in some invertebrates such as sponges.
- Flagella exhibit a smooth, independent undulatory type of movement in eukaryotes.

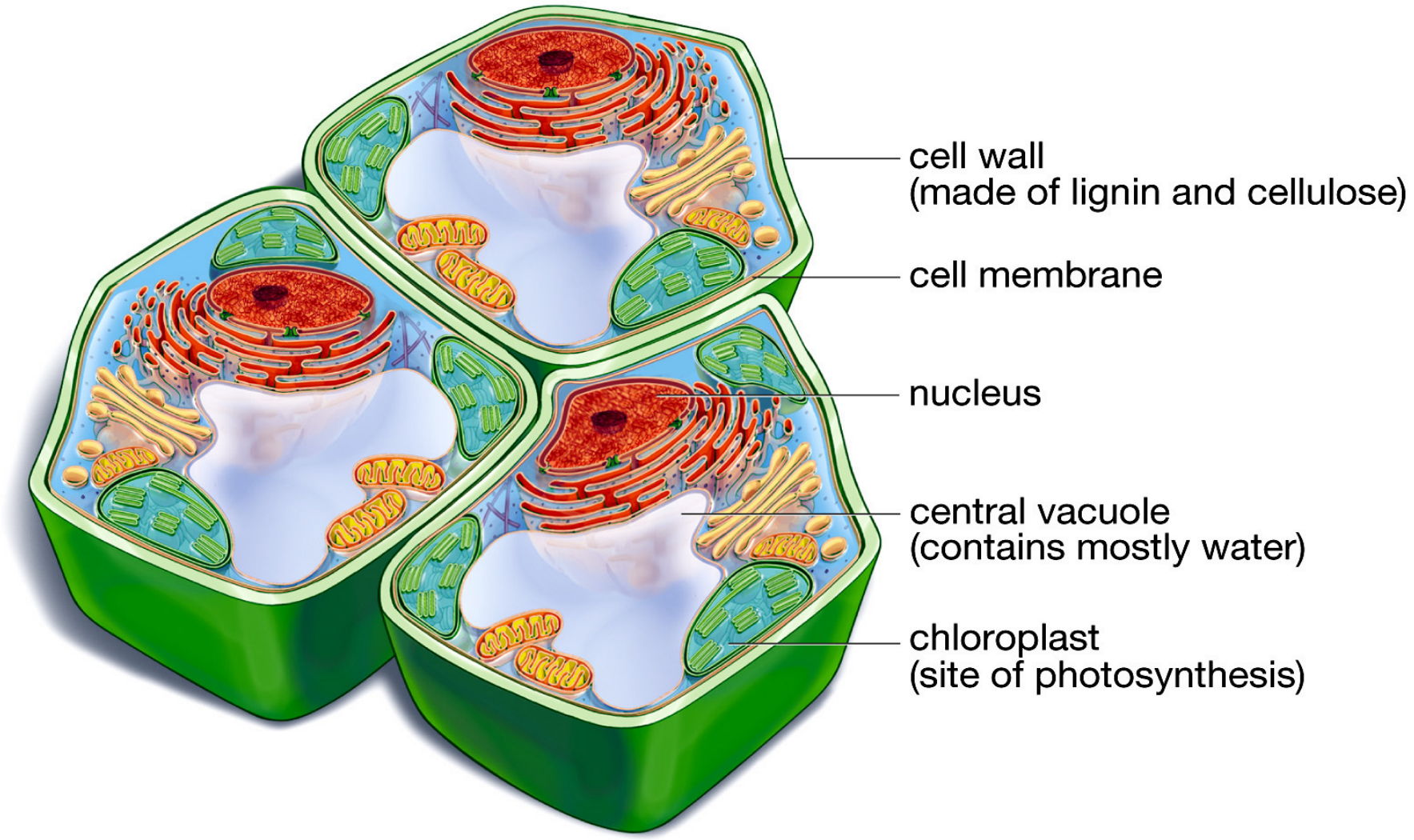
Flagella…think sperm!



Caption: Human egg (oocyte) and sperm (spermatozoon).
File Name: 97990A
Category: Medical
Type of Image: SEM
Magnification: egg x260, sperm x560 (Based on an image size of 1 inch in the narrow dimension)

Plant cells

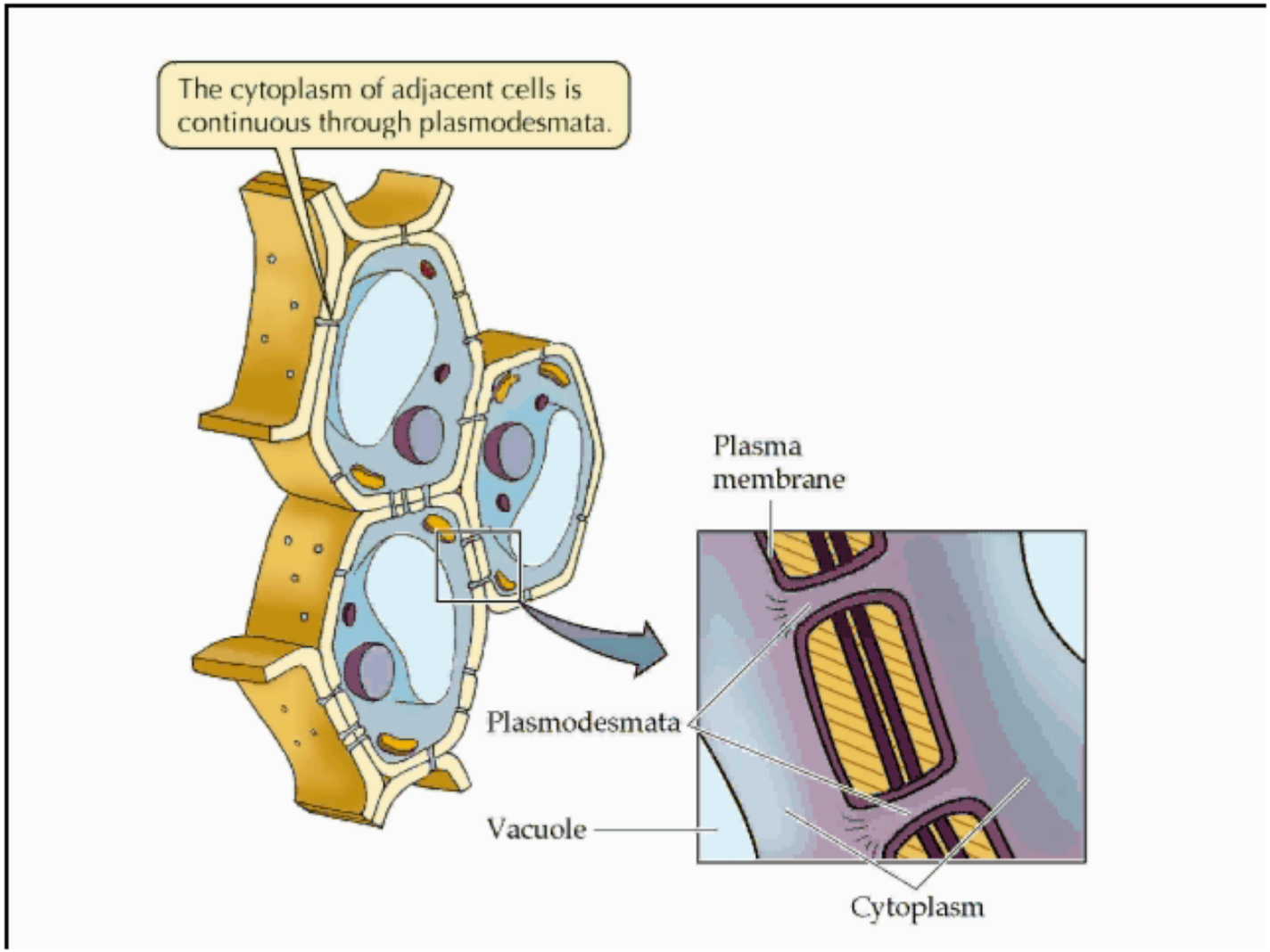
- The basic plant cell has a similar construction to the animal cell, but does not have lysosomes, cilia, or flagella.
- It does have additional structures, including a rigid cell wall, central vacuole, plasmodesmata, and chloroplasts.



The plant cell wall

- Protects the intracellular contents
- Lends structure and rigidity to the plant
- Provides a porous medium for the circulation and distribution of water, minerals, and other nutrients
- Mainly composed of cellulose - a polysaccharide.

Plasmodesmata



Chloroplast

- These organelles are the site of photosynthesis in plants and other photosynthesizing organisms.
  - Convert energy from sun into consumable energy (ATP)
- Chloroplasts have a double membrane.
  - On the average, the chloroplast density on the surface of a leaf is about one-half million per square millimeter.
- Like the mitochondrion, the chloroplast is different from most other organelles because it has its own DNA and reproduces independently of the cell in which it is found; an apparent case of endosymbiosis .

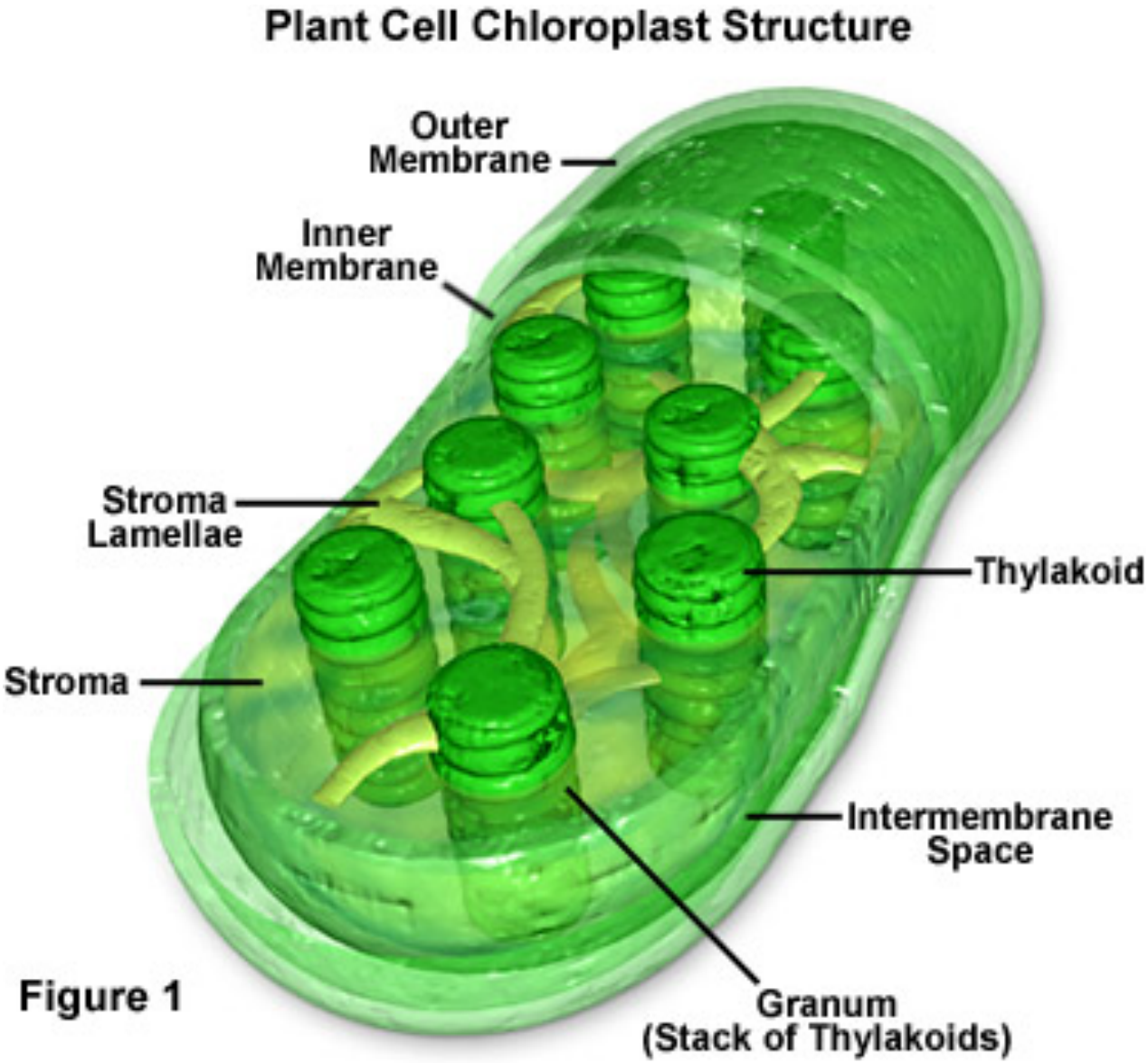

Plant Cell Chloroplast Structure
Outer Membrane
Inner Membrane
Stroma Lamellae
Thylakoid
Stroma
Intermembrane Space
Granum (Stack of Thylakoids)

Figure 1

Central Vacuole

- Many plant cells have a large, single **central vacuole** that typically takes up most of the room in the cell (80 percent or more).

- The central vacuole is a membrane-bound sac that stores compounds, helps in plant growth, and plays an important structural role for the plant.

Plant Cell Central Vacuole

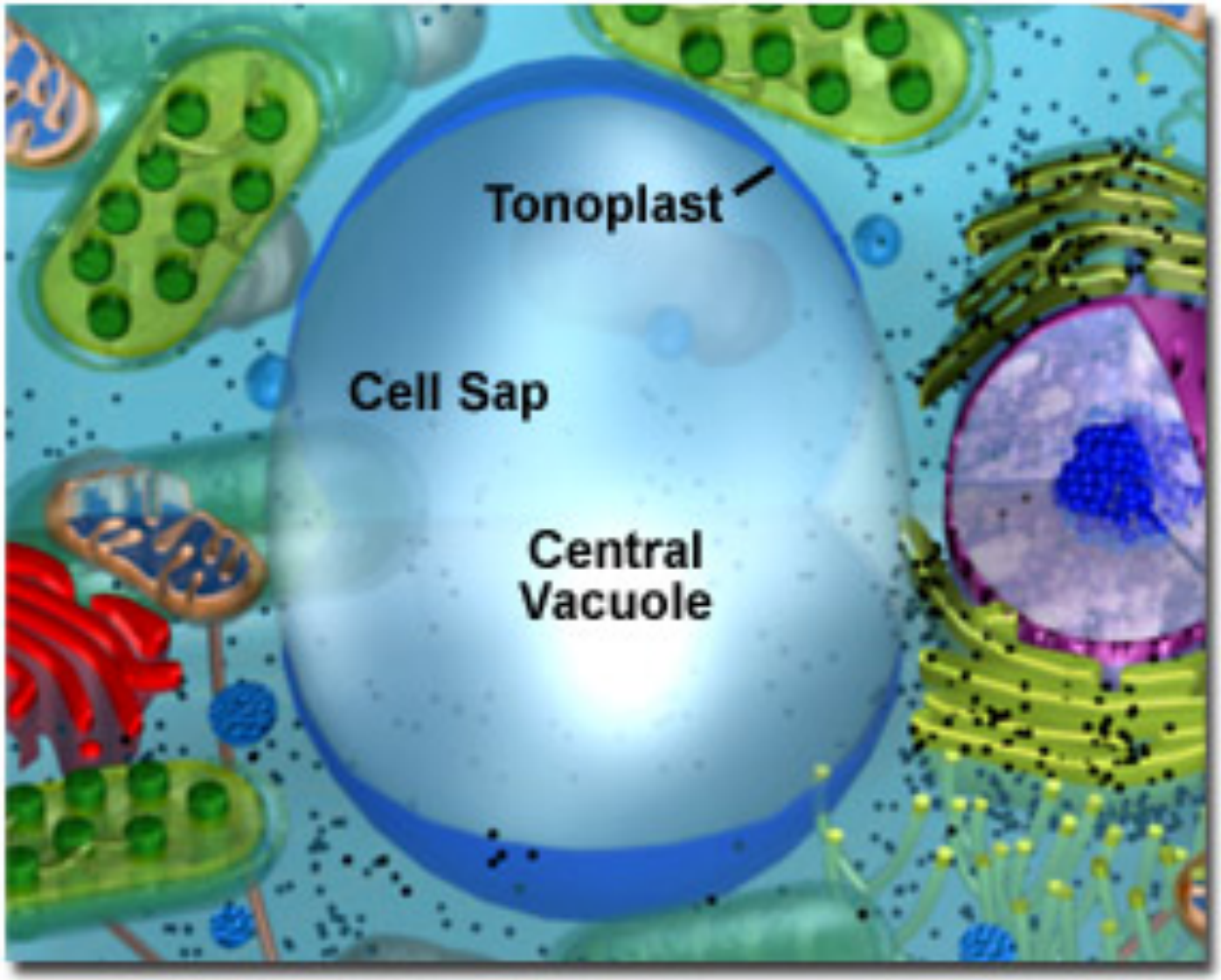
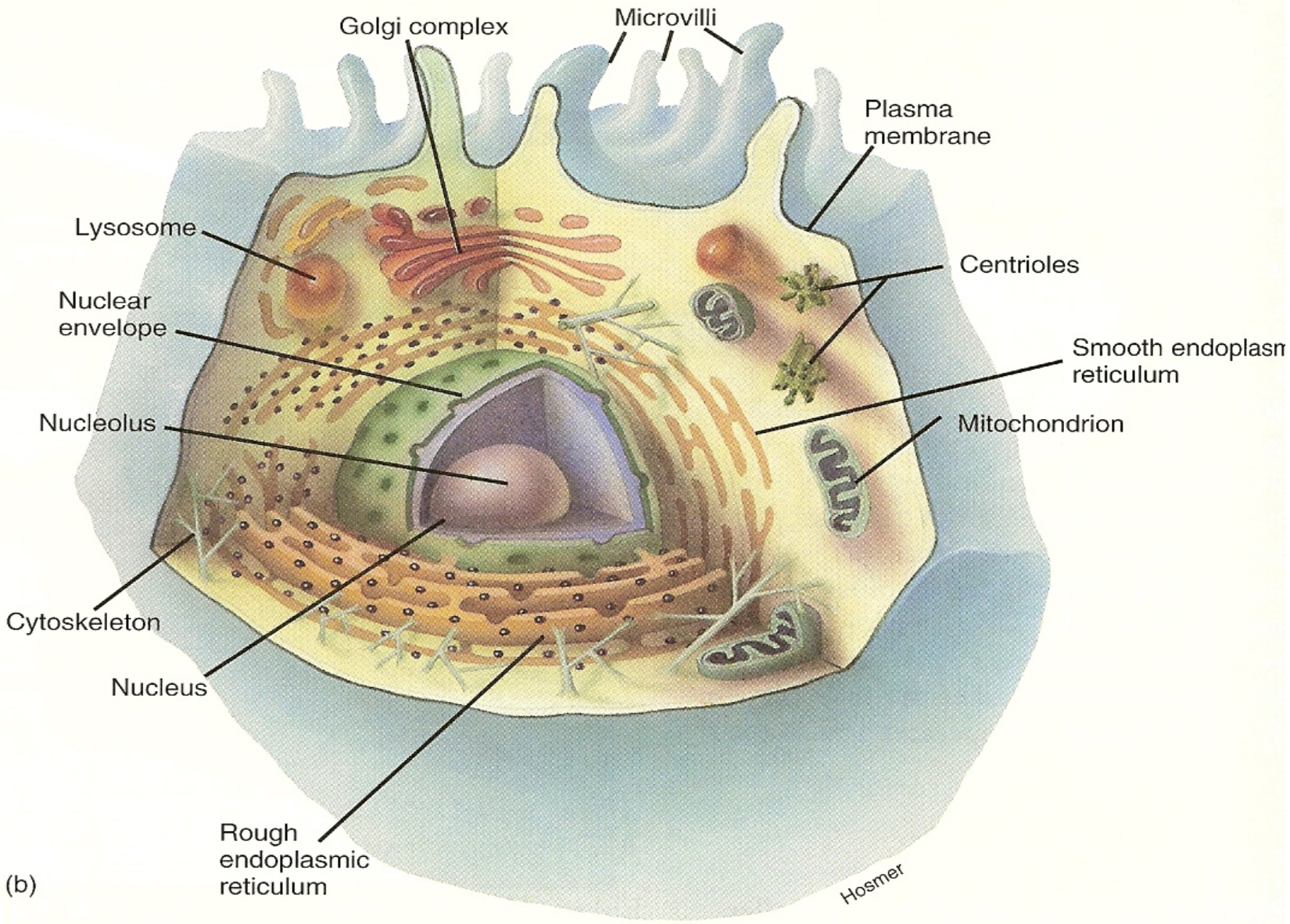
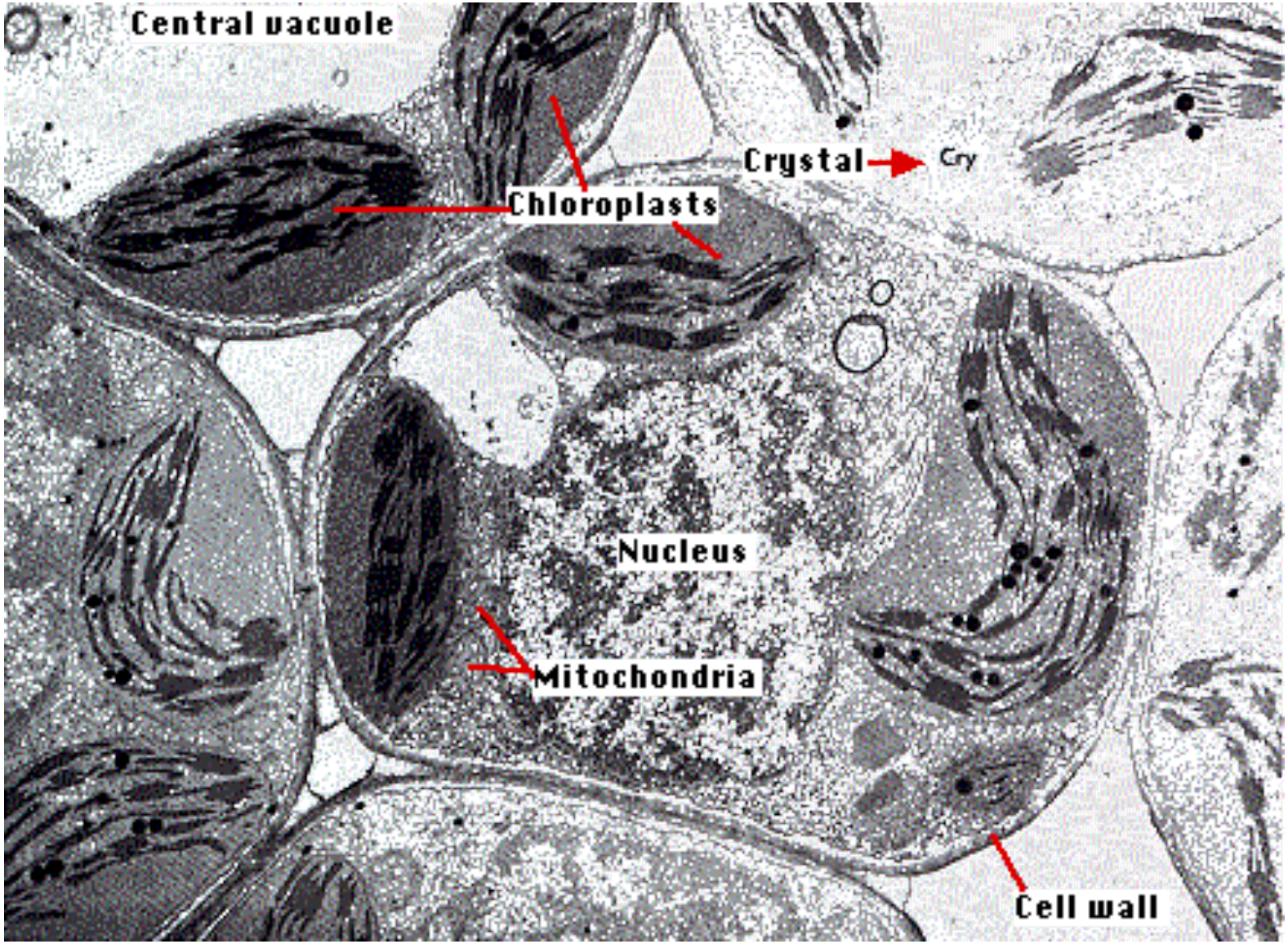


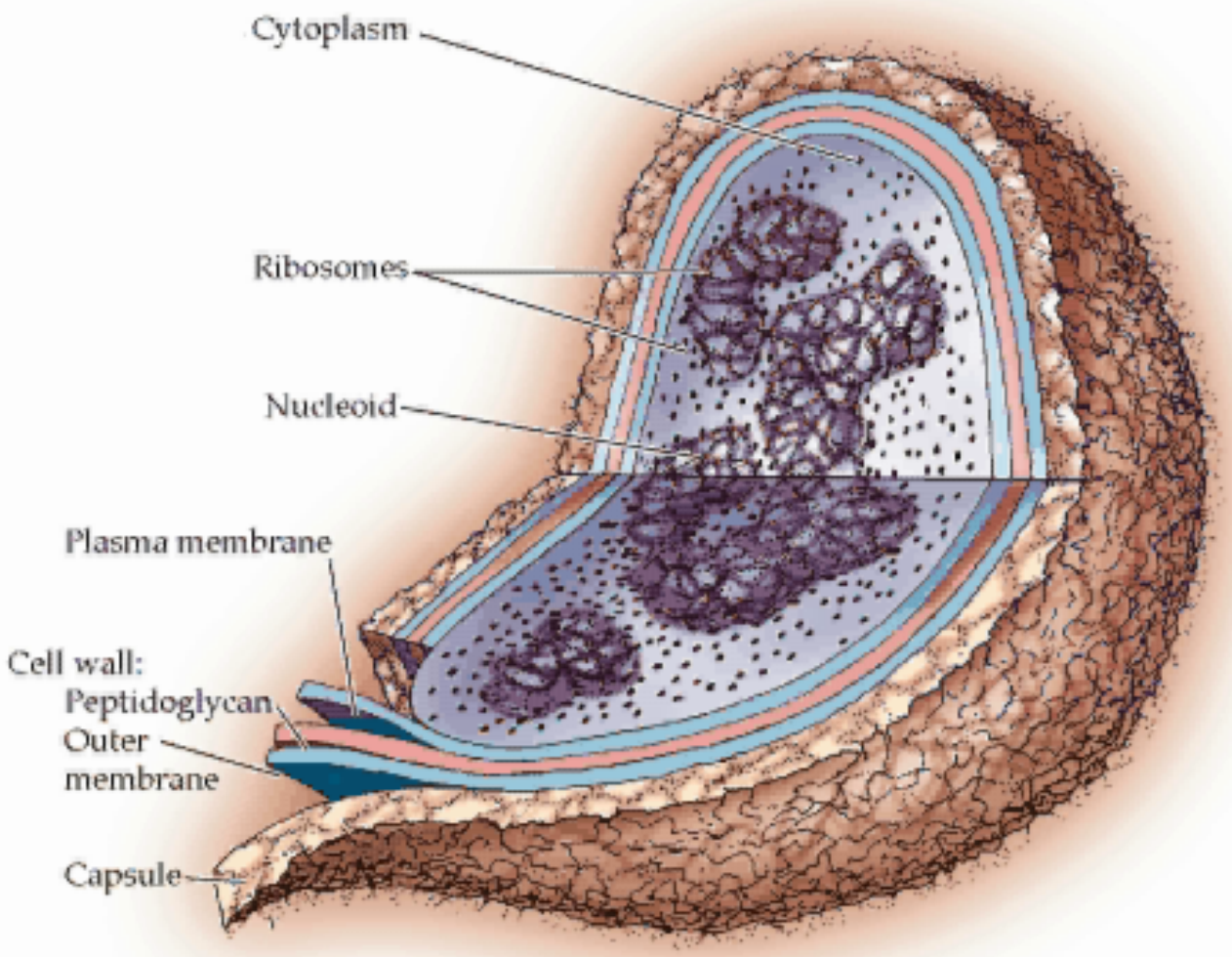
Figure 1

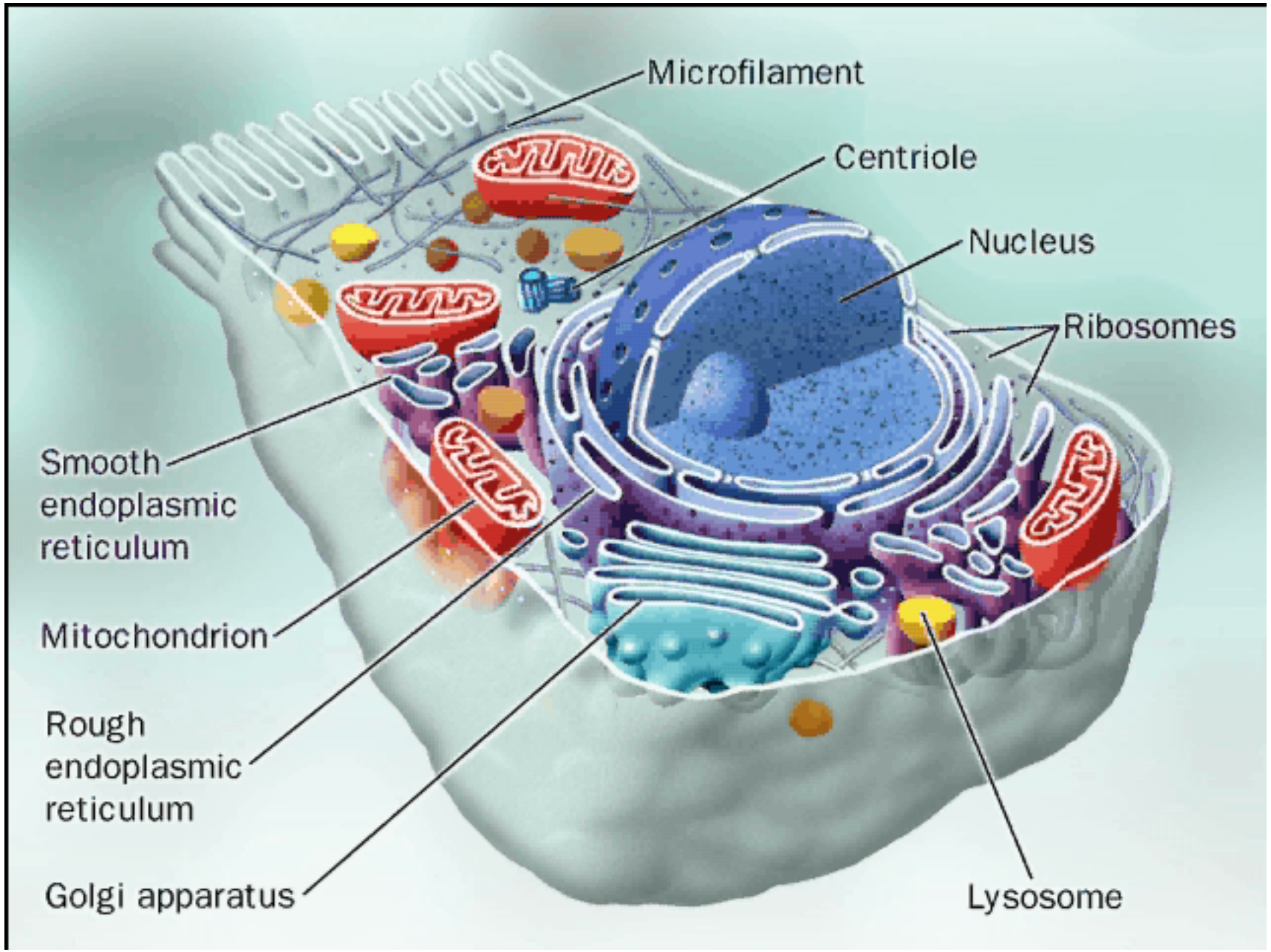
What kind of cell is it?

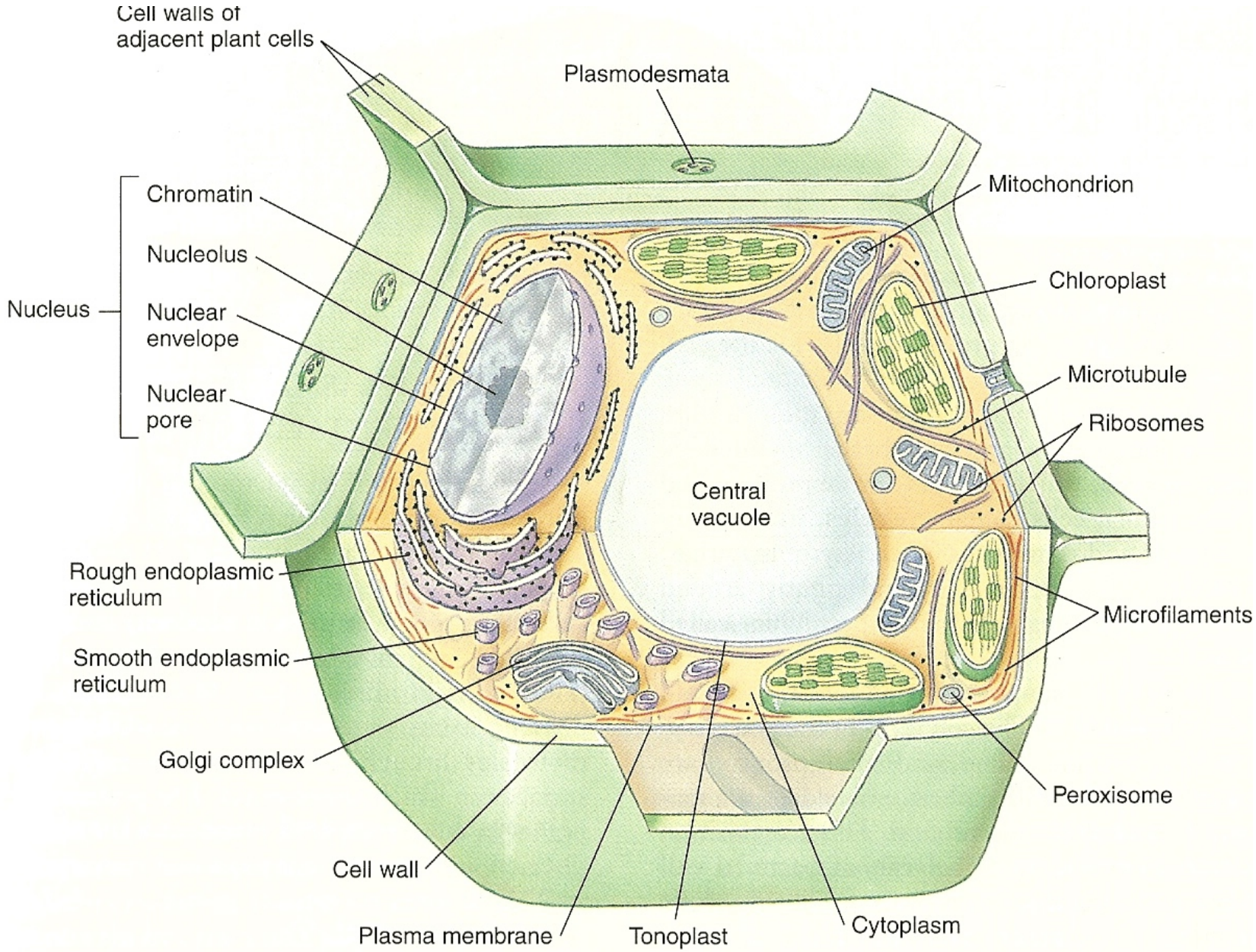
How do you know that?


Golgi complex
Microvilli
Plasma membrane
Lysosome
Centrioles
Nuclear envelope
Smooth endoplasm reticulum
Nucleolus
Mitochondrion
Cytoskeleton
Nucleus
Rough endoplasmic reticulum
(b)
Hosmer

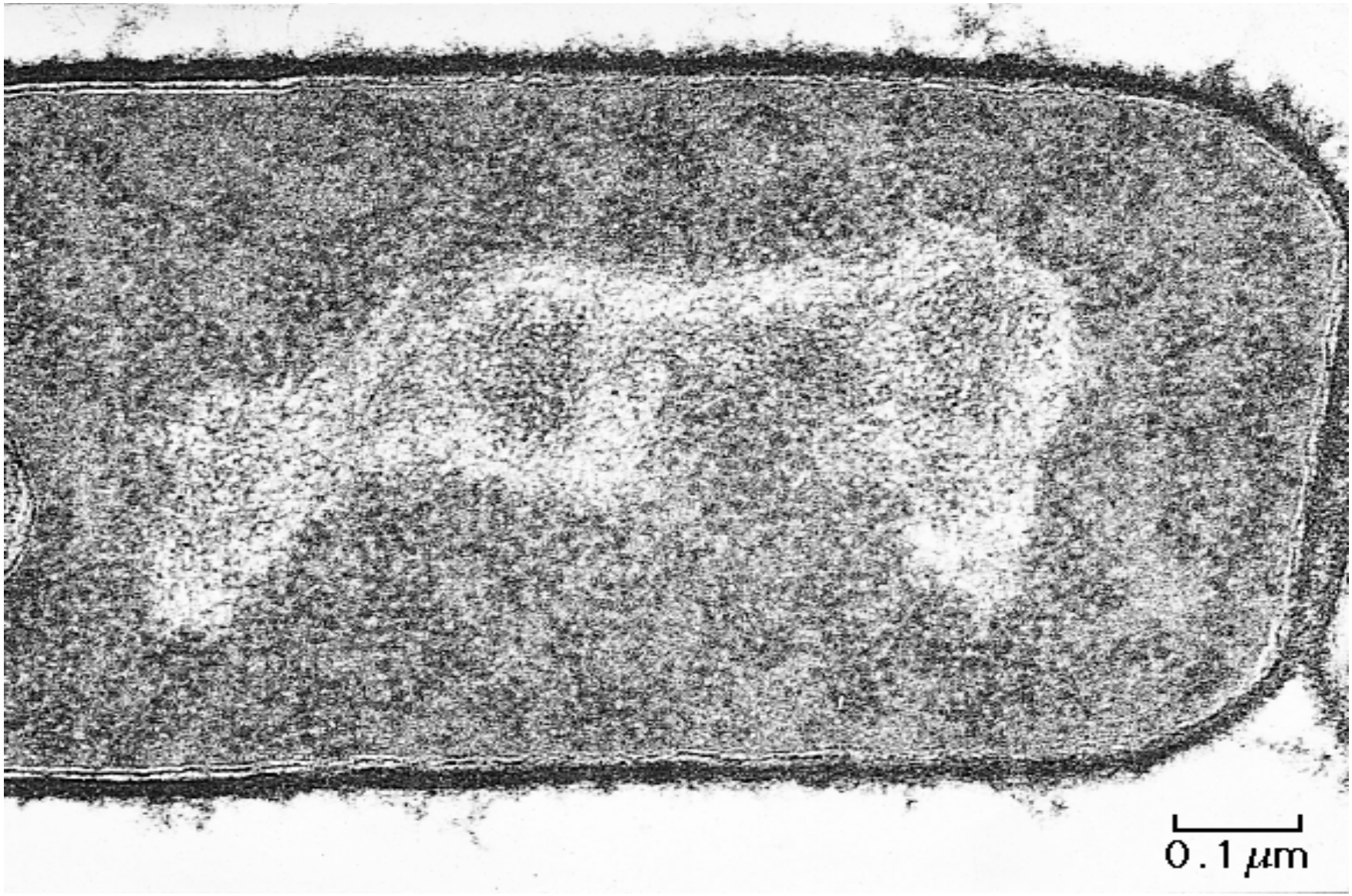

Central vacuole
Crystal
Cry
Chloroplasts
Nucleus
Mitochondria
Cell wall

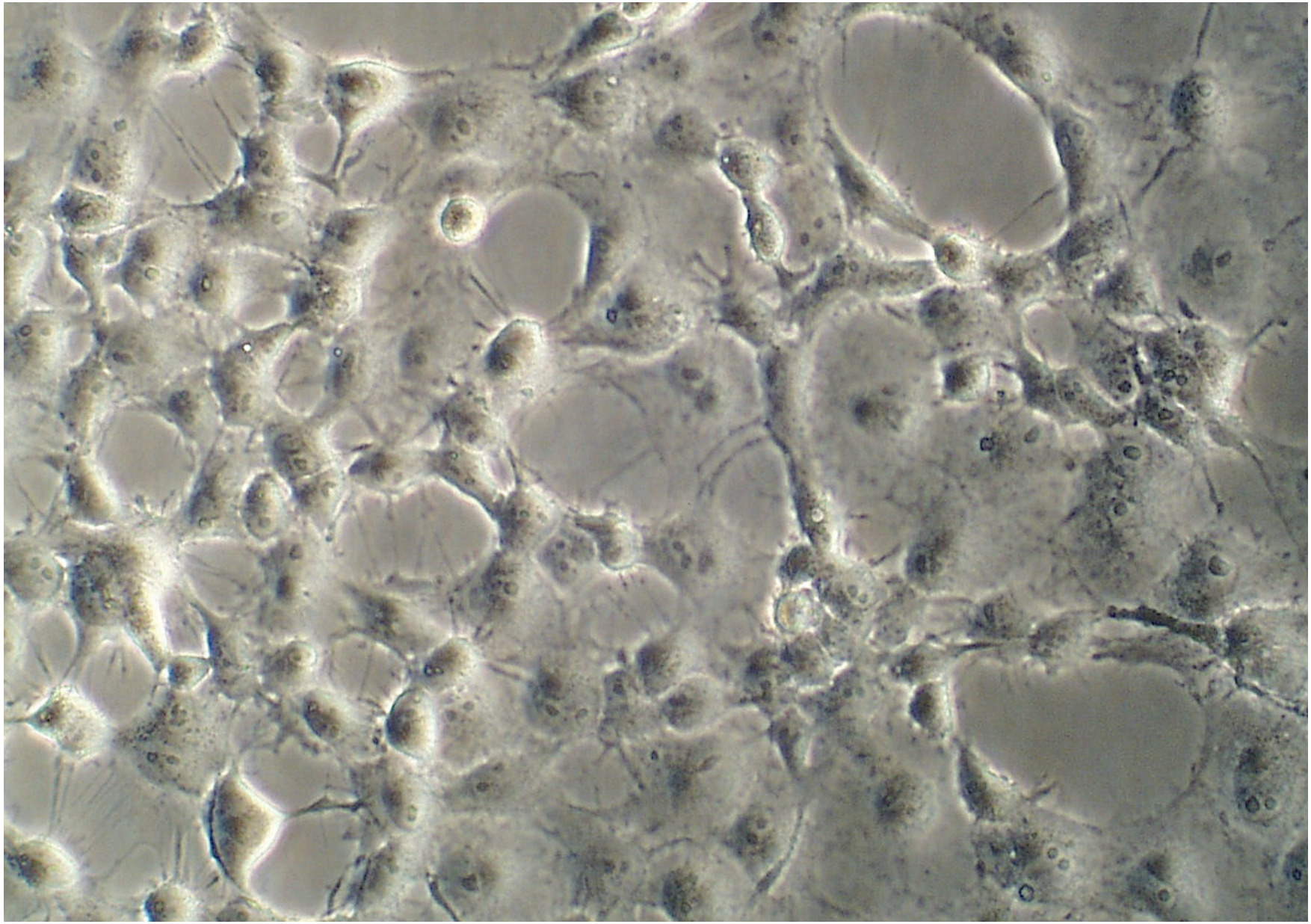

Cytoplasm
Ribosomes
Nucleoid
Plasma membrane
Cell wall:
Peptidoglycan
Outer membrane
Capsule

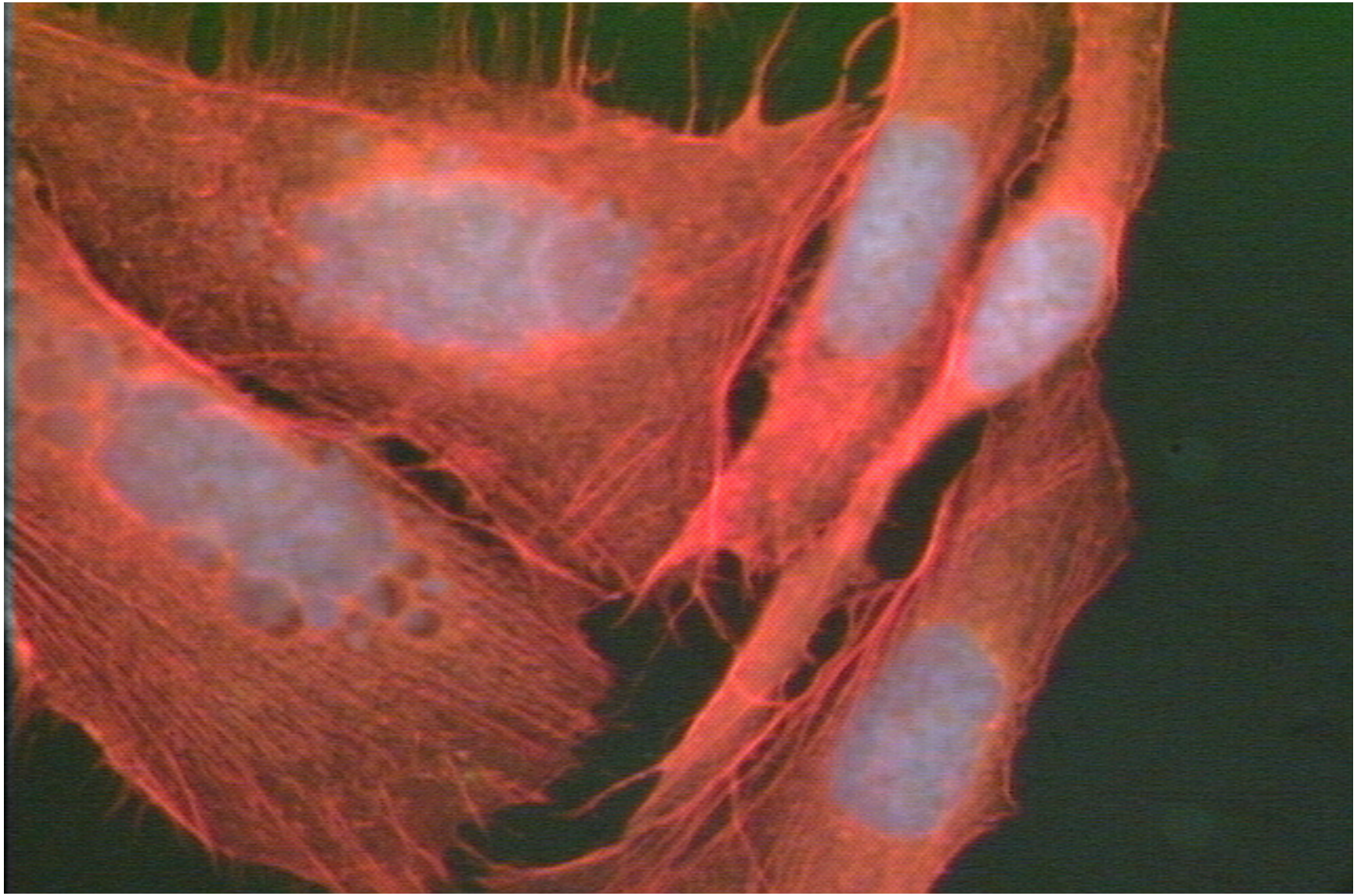

Microfilament
Centriole
Nucleus
Ribosomes
Smooth endoplasmic reticulum
Mitochondrion
Rough endoplasmic reticulum
Golgi apparatus
Lysosome

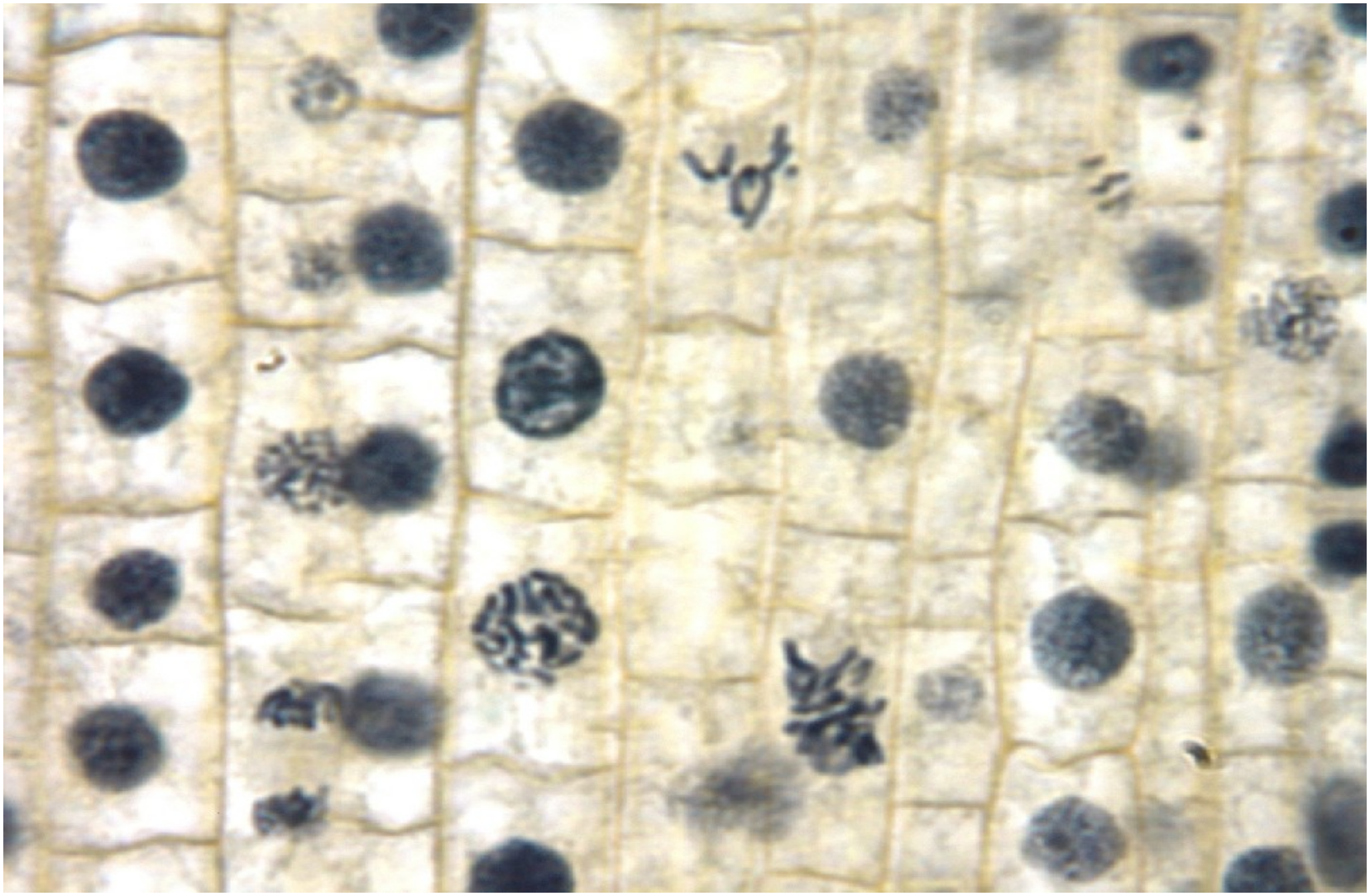

Cell walls of adjacent plant cells
Plasmodesmata
Mitochondrion
Chromatin
Nucleolus
Nucleus
Nuclear envelope
Nuclear pore
Chloroplast
Microtubule
Ribosomes
Central vacuole
Rough endoplasmic reticulum
Microfilaments
Smooth endoplasmic reticulum
Golgi complex
Peroxisome
Cell wall
Plasma membrane
Tonoplast
Cytoplasm

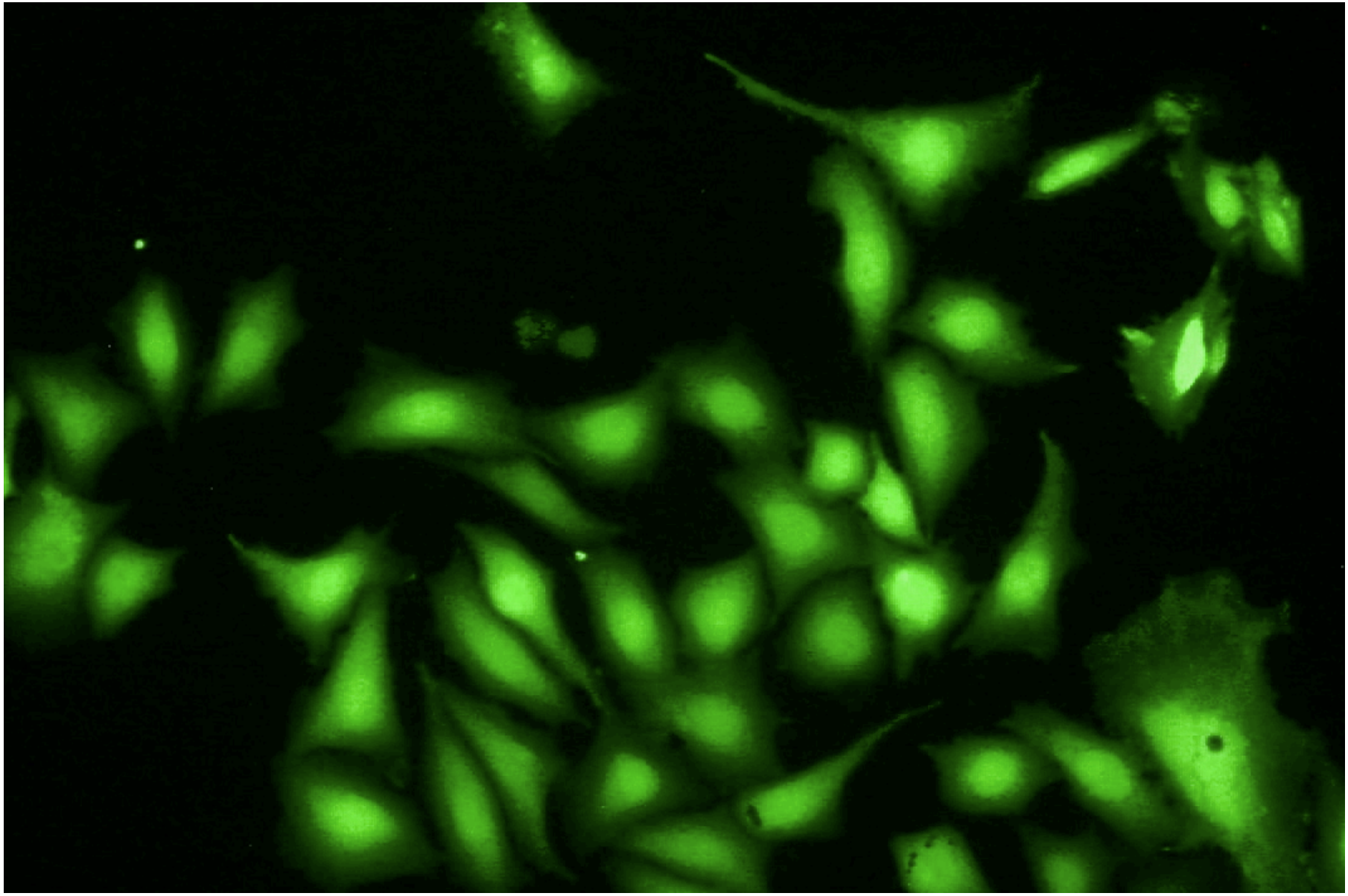
(b)

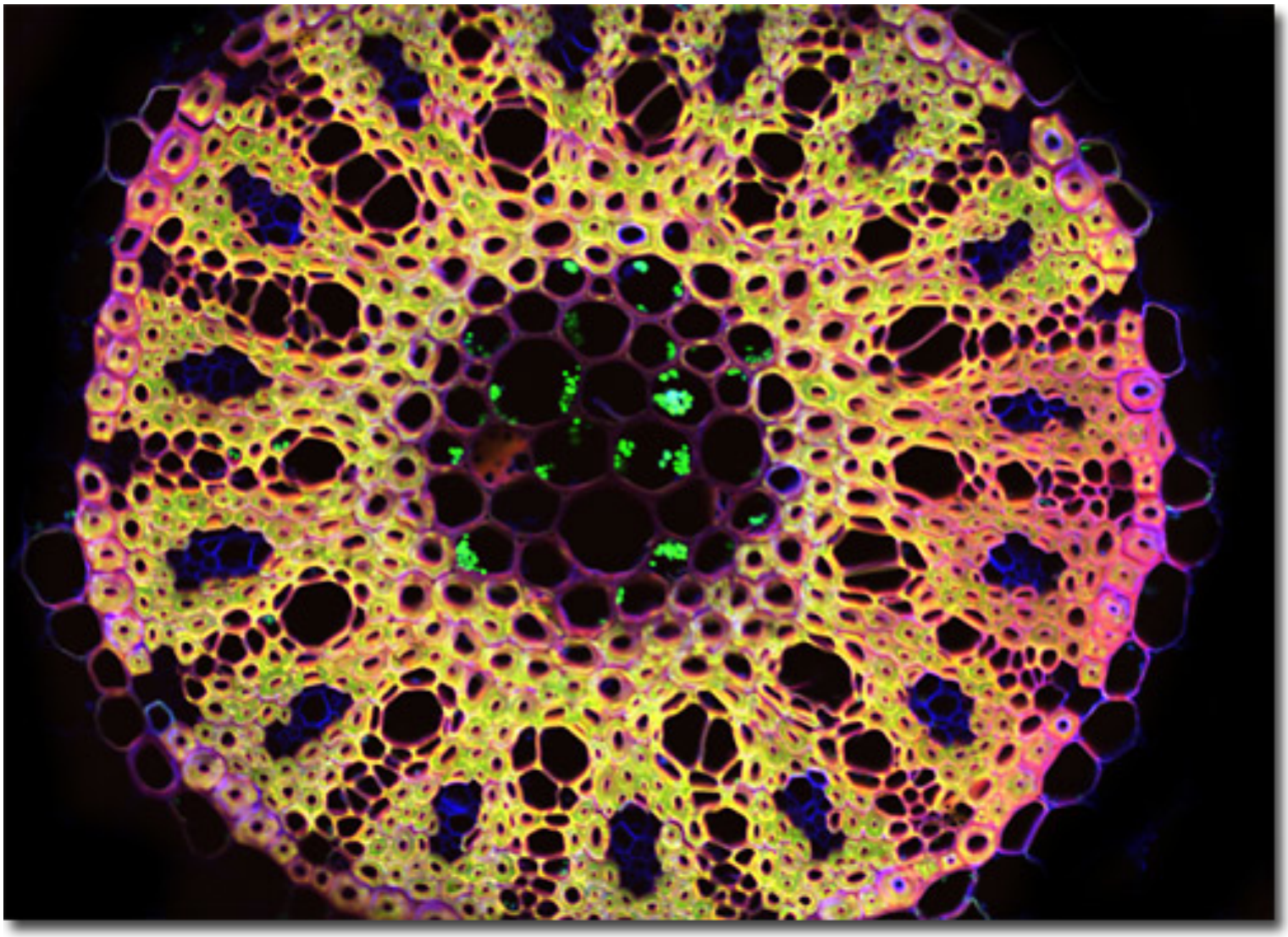

0.1 μm











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