CELL WALL
Chemical composition and Functions

Table of Content

Introduction

Functions

→ Provides support

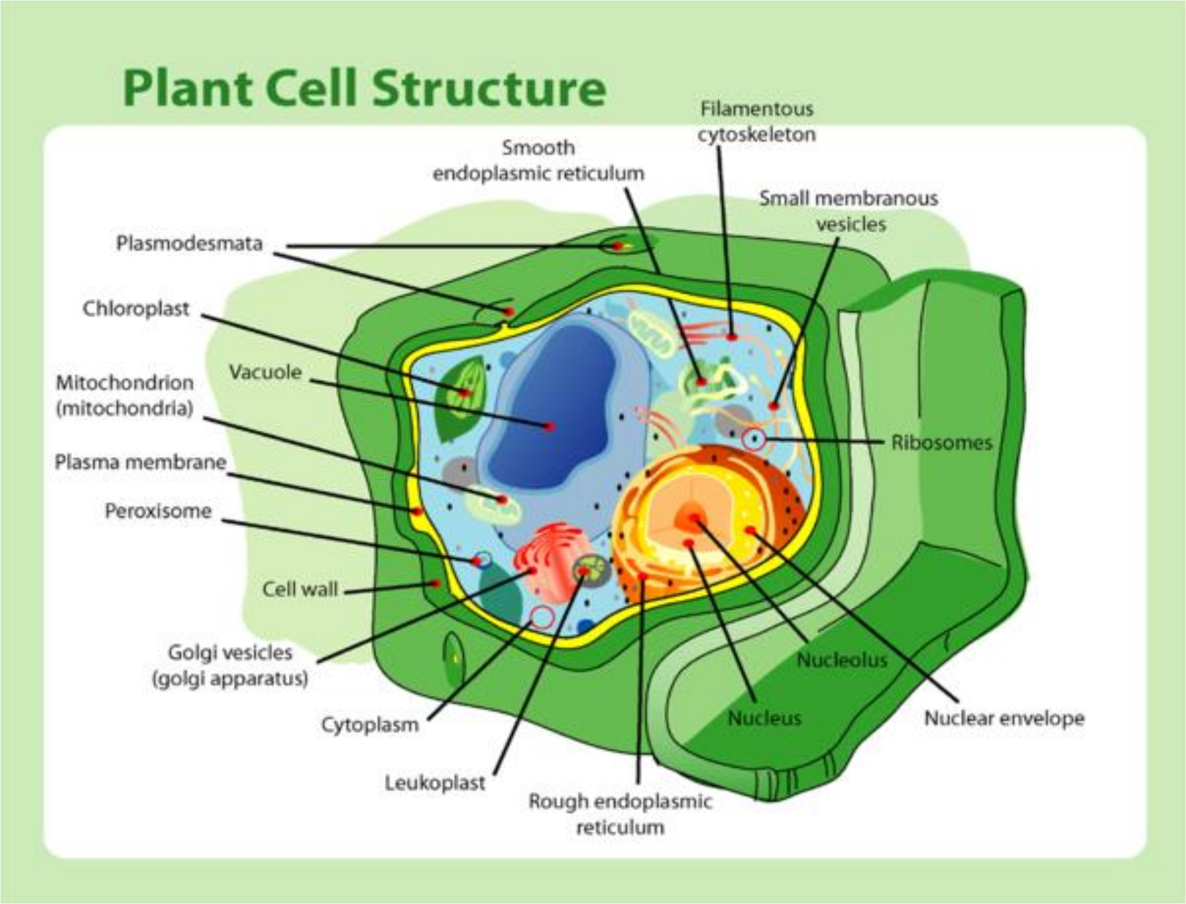
→ Gives shape

→ The gatekeeper

→ Protection of internal structures

→ Prevent loss of water

Architecture



http://study.com/cimages/multimages/16/Plant_cell_structure.png

Introduction

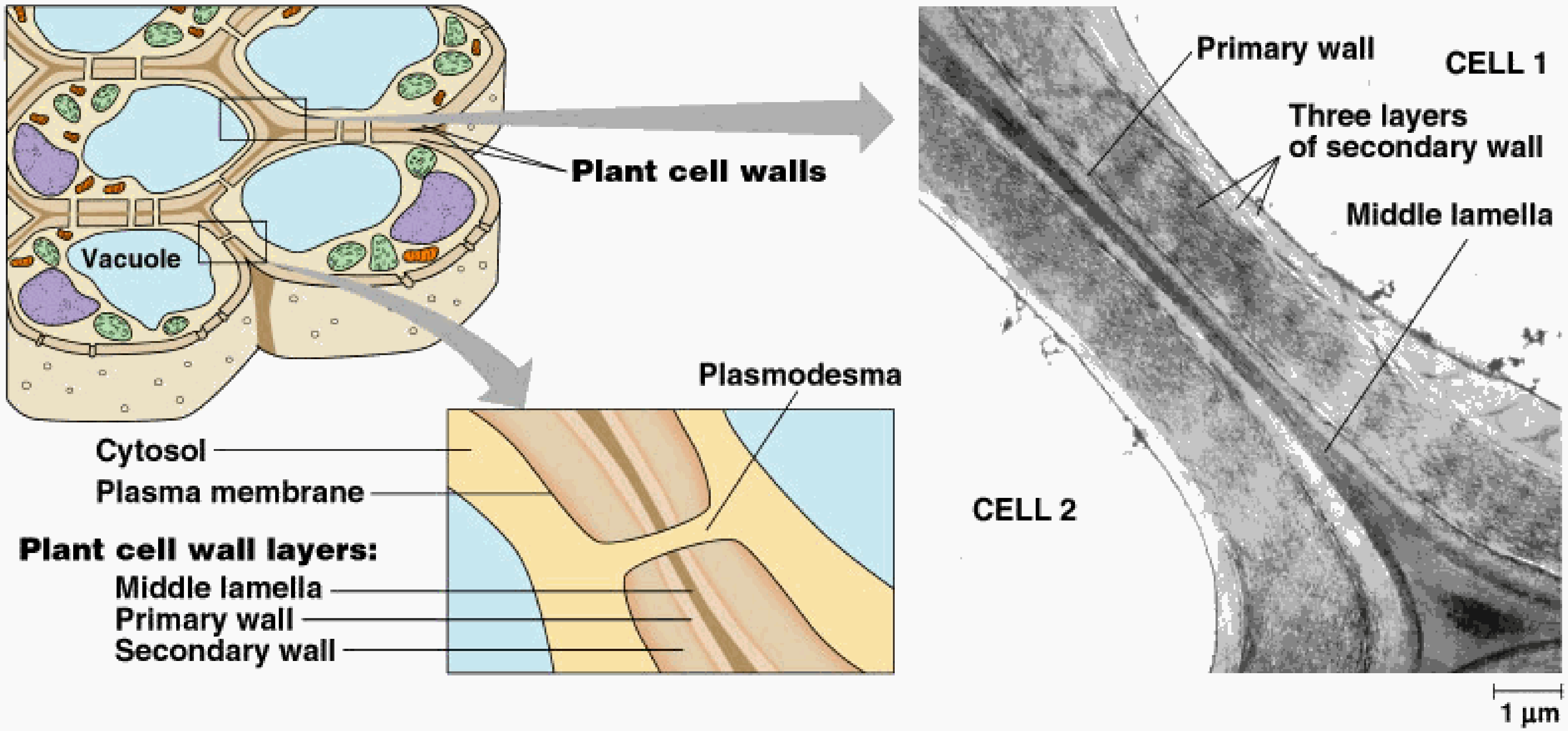
Composition

- ❖ Cellulose, Pectin, hemiocellulose
- ❖ Callose, structural proteins

➢ Layers

- ❖ Primary cell wall
- ❖ Secondary cell wall
- ❖ Middle lamella (pectin-rich)

Introduction



http://www.cbv.ns.ca/bec/science/cell/page_17-2.gif

Formation

Cell plate devolopment

❖ Fusion of golgi vesicles

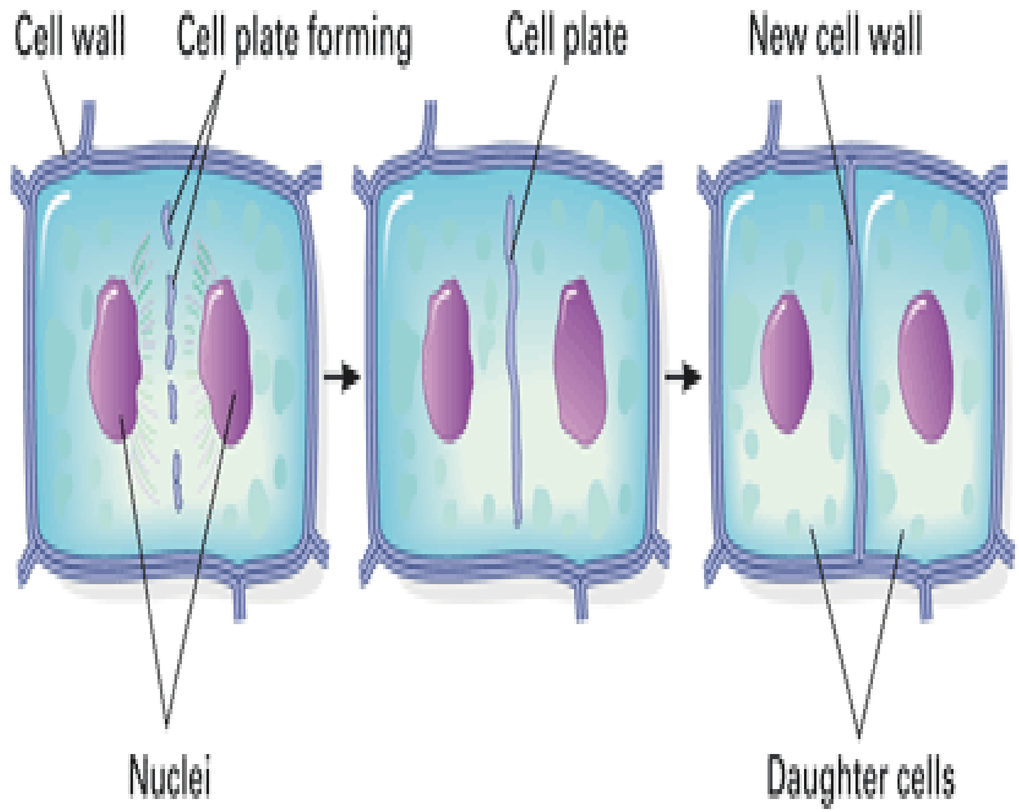
❖ Tubulo-vesicle network (TVN)

❖ Tubolar Network (TN) is formed

❖ Planar fenestrated sheet formed

❖ Proteins involved

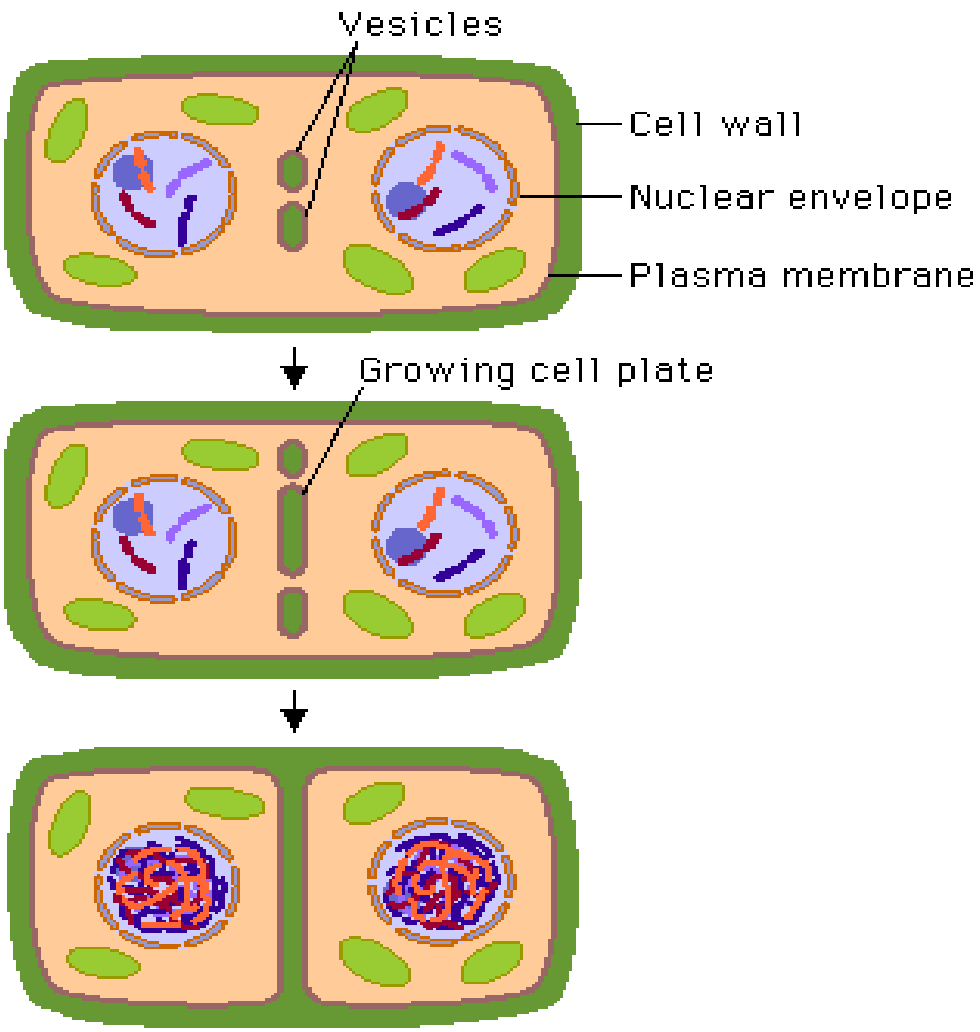
- Vesicle-Associated Membrane Protein (VAMP)
- Soluble *N*-ethylmaleimide-sensitive factor protein attachment protein receptor (SNARE)
- Clathrin-coated vesicles
- Dynamin related proteins



https://strangbiology0910.wikispaces.com/file/view/0909.gif/95226622/09-09.gif

Formation

- ➢ Cell plate assembly matrix (CPAM)
- ➢ Deposition of polysaccharides and
- ➢ Abundance of callose, later replaced by cellulose
- ➢ Plasmodesmata develop through open fenestrae
- ➢ Cell wall fuses with parental cell wall



http://www.phschool.com/science/biology_place/biocoach/mitosisisg/images/mitcytpl.gif

Callose

Synthesized at the plasma membrane

Synthesized by callose synthase

(1,3)-ß-glucan

Apears at TVN, TN and PFS stages

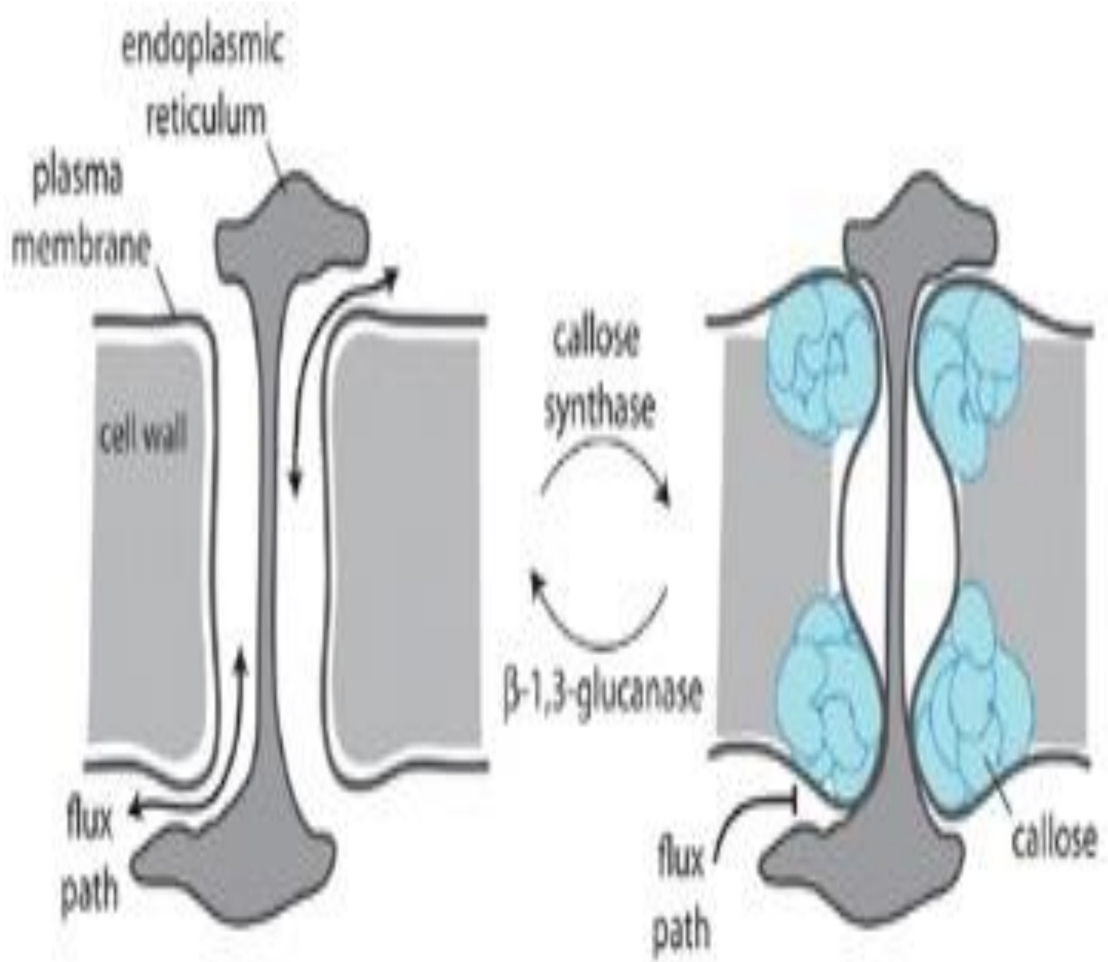
Formation of membrane network triggers

induction of callose accumulation

High calcium concentration

Callose accumulation is transient

Remove after establishment of cell wall



http://www.frontiersin.org/files/Articles/19755/fpls-03-00030-HTML/image_m/fpls-03-00030-g002.jpg

Cellulose

Synthesized at the plasma membrane

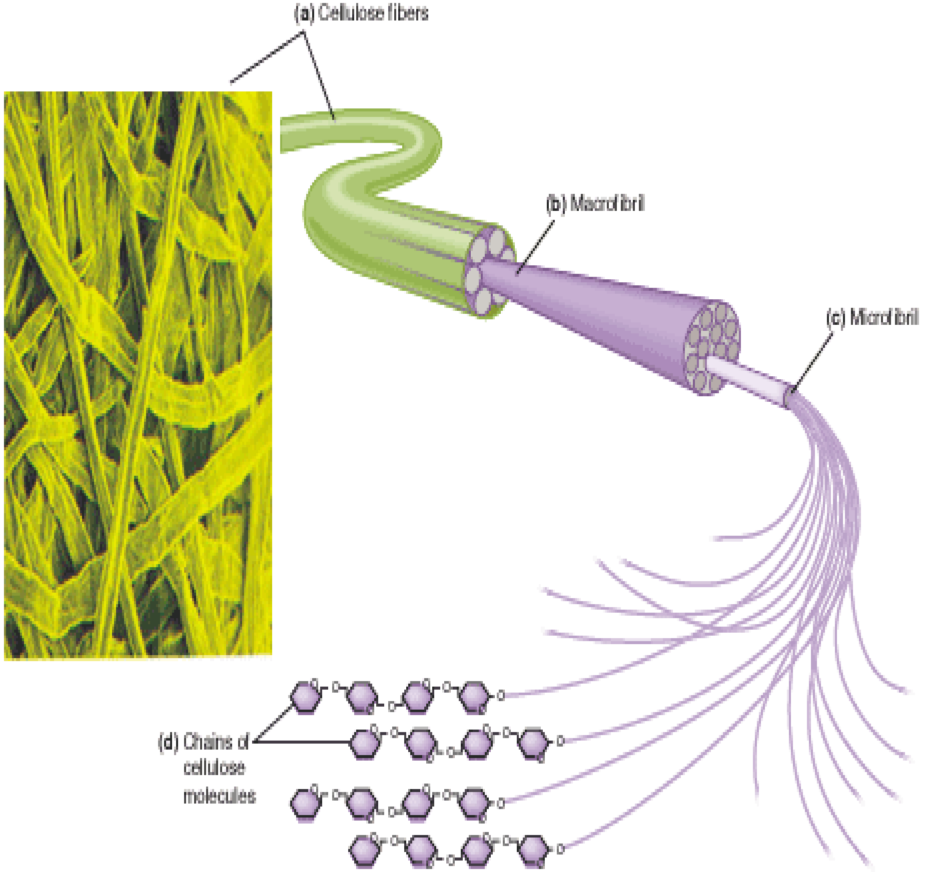
Synthesized by Cellulose synthase

A (1,4)-ß-linked glucan

Major component of parental cell wall

Minor concentration in cell plate

Replaces callose from the TN stage



http://alevelnotes.com/content_images/i18_image001.gif

Hemicellulose

Synthesized at the Golgi apparatus

Includes xyloglucans---crosslink cellulose mycrofibrils

Xyloglucans transported through TGN

Detected at the TVN satge

Abundant in the new cell wall

Structural proteins

Physcial properties of the cell wall

Glycine, proline and hydroxy-proline

rich glycoproteins

Extensins support the cell plate

Pectin

Pectin **cell-cell adhesion**

Synthesized in the Golgi apparatus

Forms a matrix embedding cellulose

and hemicellulose

Transported trough secretory

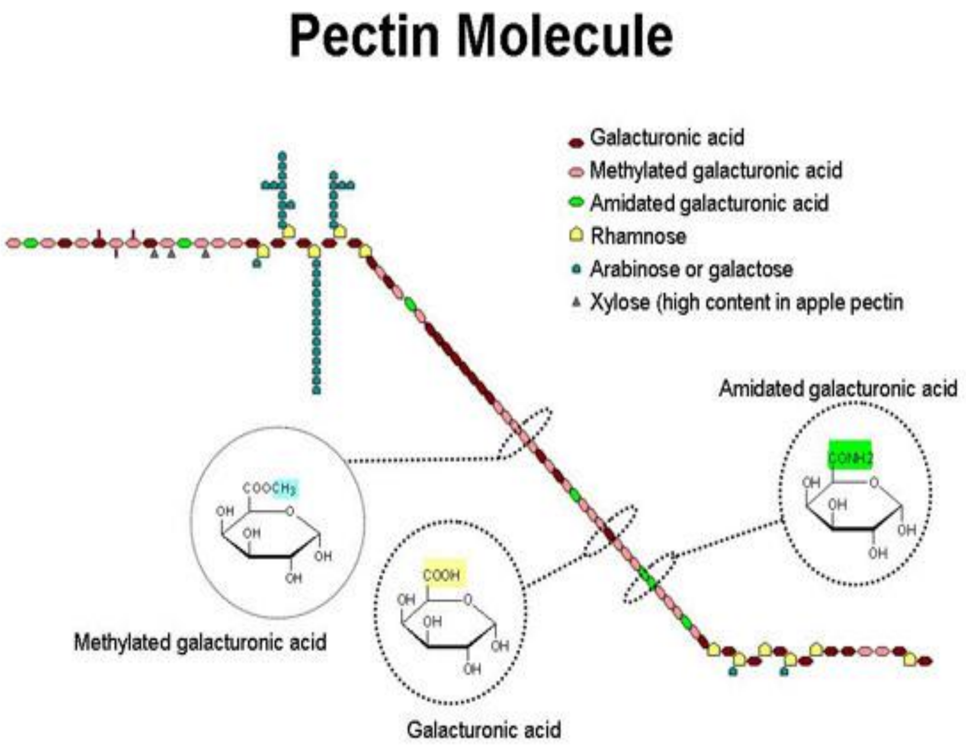
Vesicles

Promotes cell to cell adhesion

50% cell wall in *Arabidopsis thaliana*

Delivery of pectin through actin

cytoskeleton



https://cdavies.files.wordpress.com/2007/04/pectin-pix-little.jpg

Inhibitors

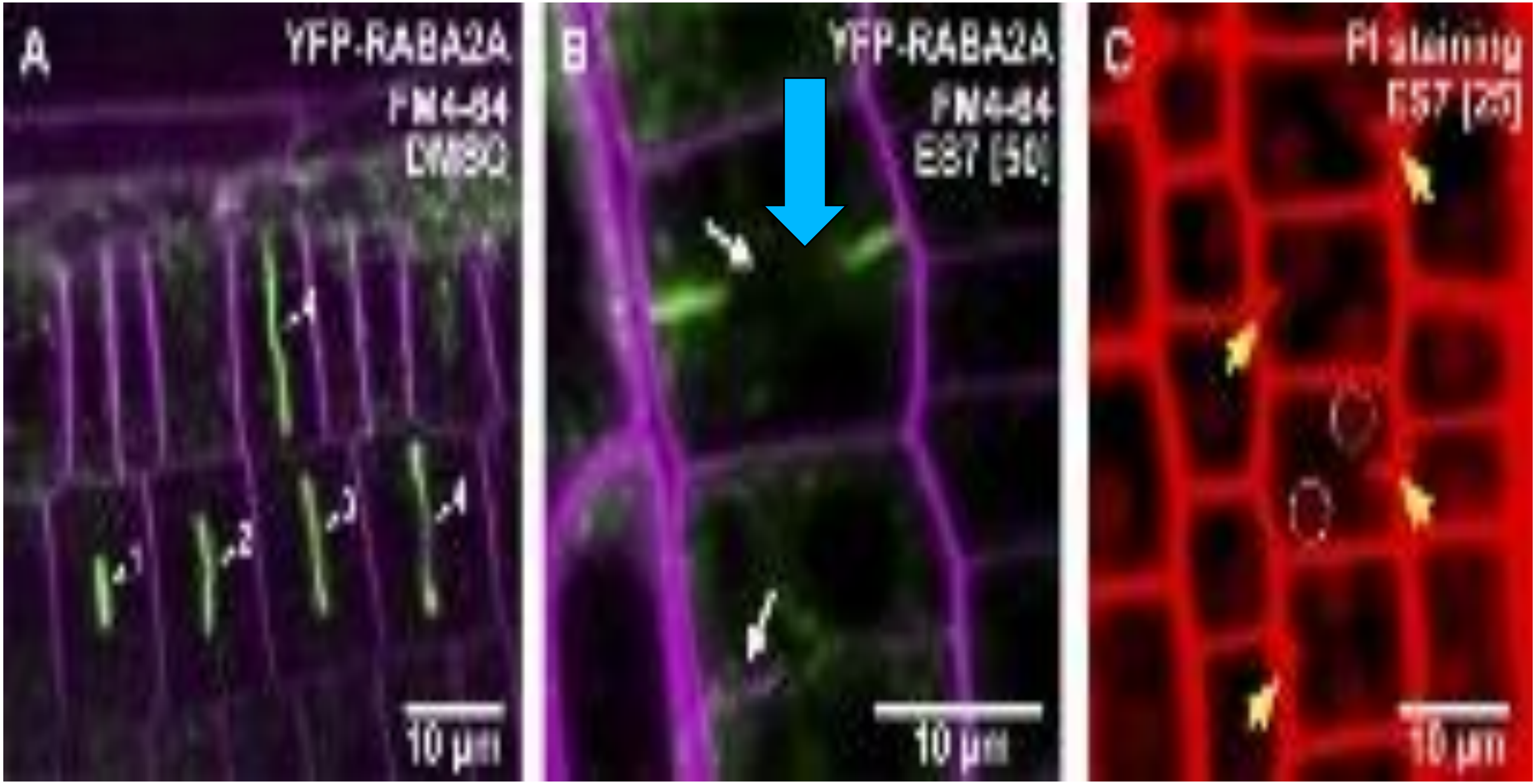
- ❑ Endosidin 7 (ESD 7)
- ➢ Specific inhibitor to callose synthase
- ➢ ES7 inhibits later stages of cell plate maturation
- ➢ Induces cell plate gaps

- ✓ No effects with Dimethyl sulfoxide (DMSO)
- ✓ Cellulose is however not inhibited by ES7

Eunsook Park et al., Plant Physiol. 2015 May 29; 168(1):378.

Inhibitors

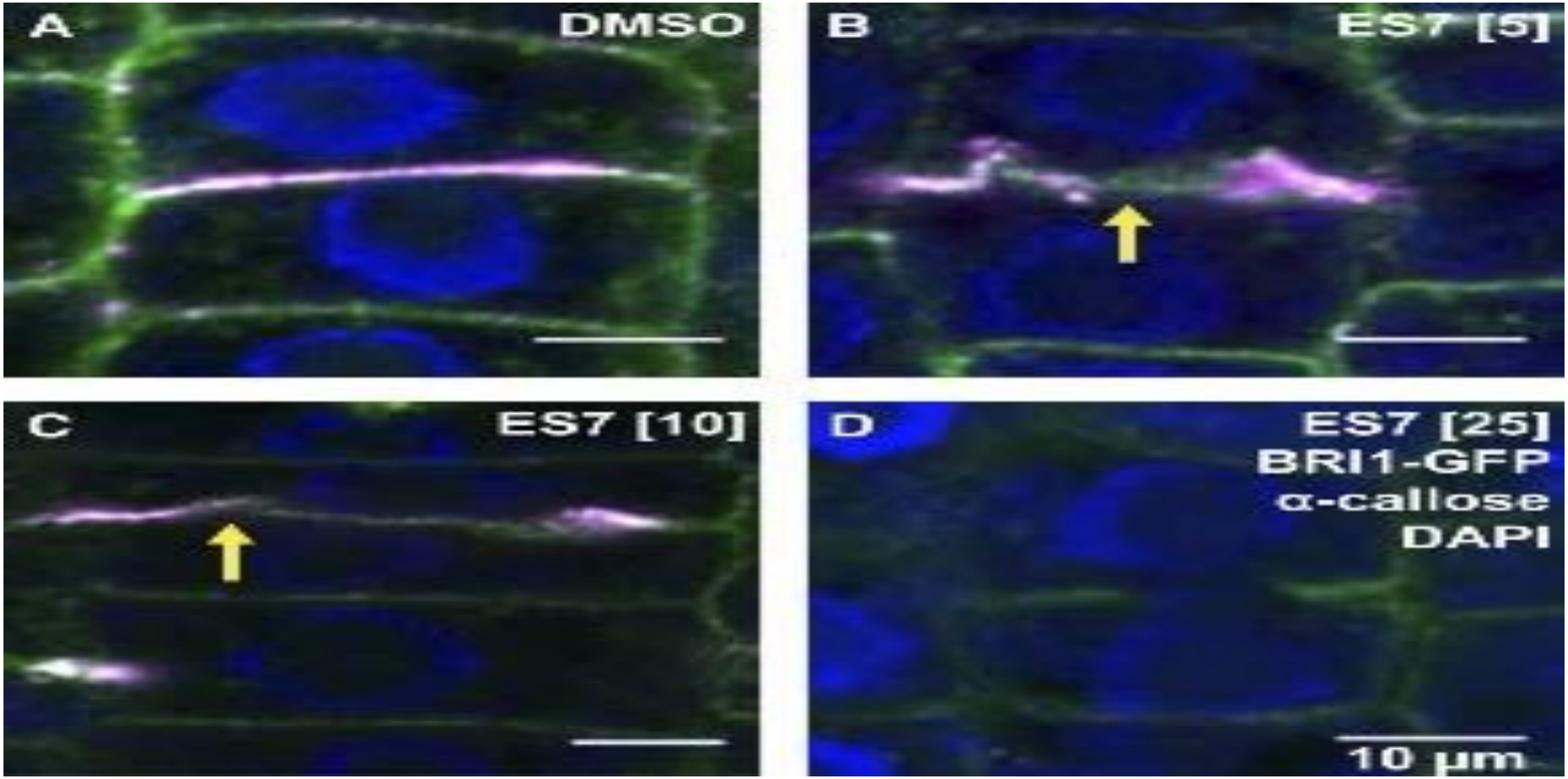
Effects of ES7 on callose



Eunsook Park et al., Plant Physiol. 2015 May 29; 168(1):378.

Inbibitors

ES7 effects on callose synthase is concentration dependant

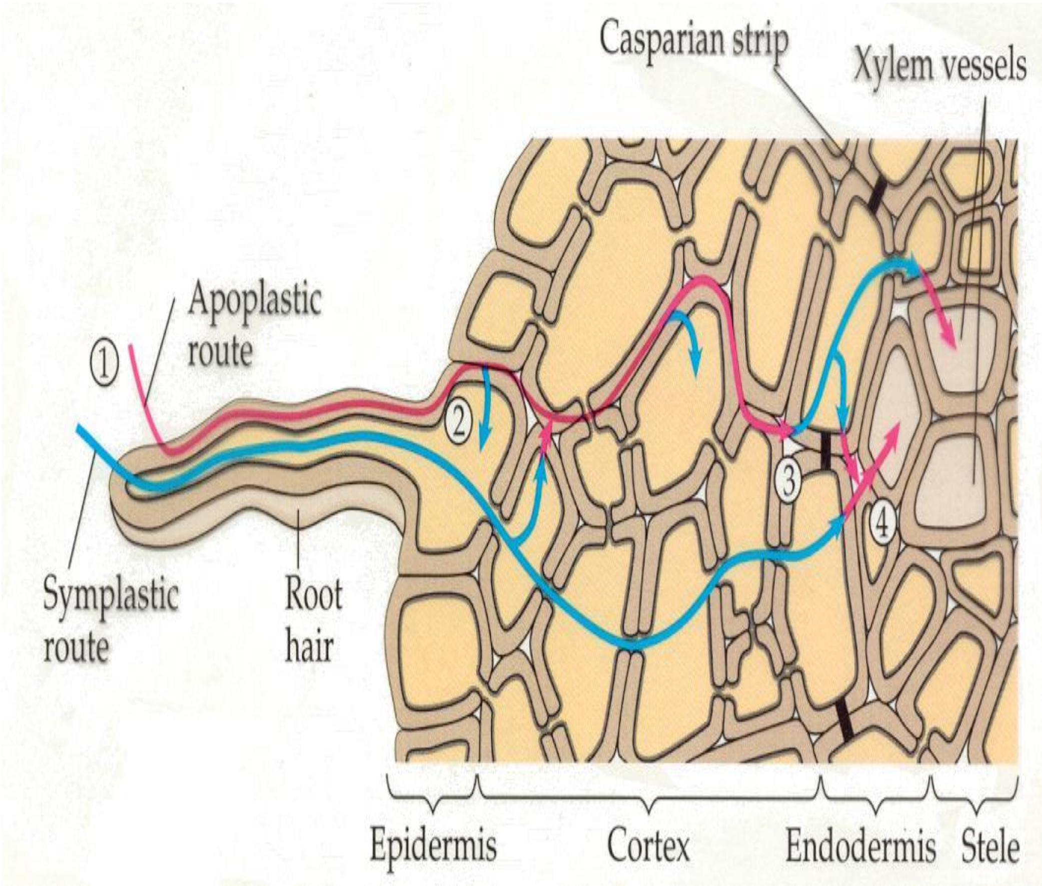


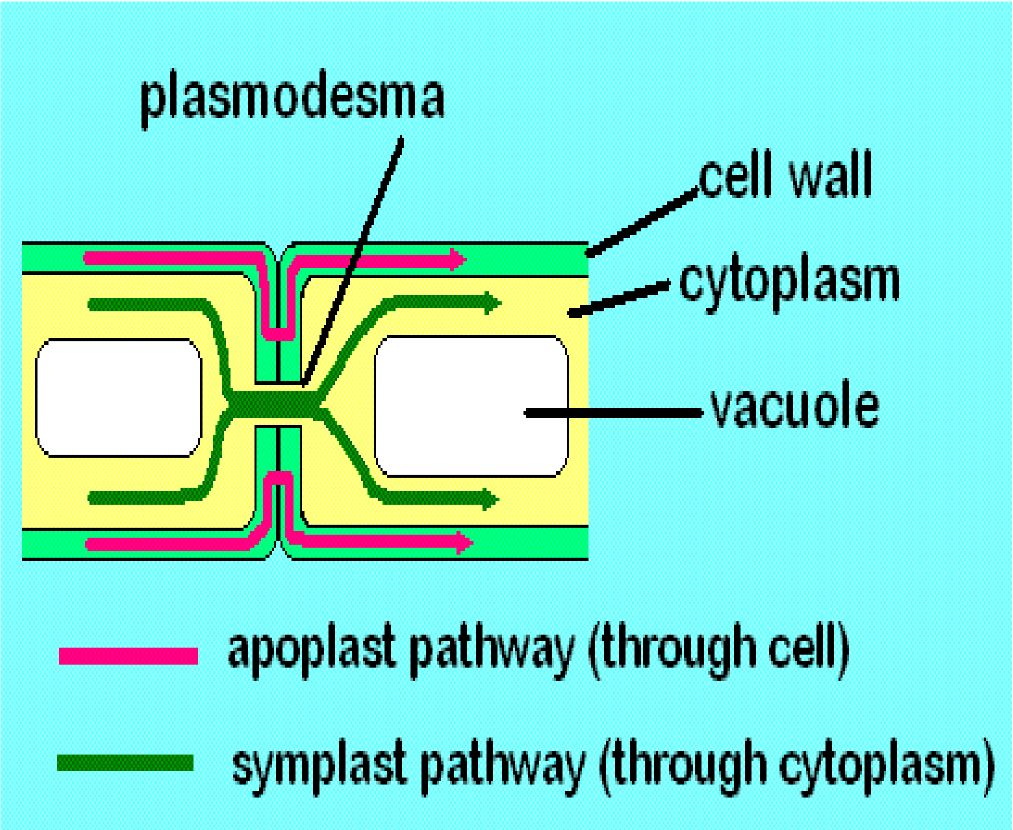
Eunsook Park et al., Plant Physiol. 2015 May 29; 168(1):378

Apoplastic signals

Diffusion barrier

Modulate water and solute uptake





https://upload.wikimedia.org/wikibooks/en/0/00/Waterpathwaysthroughrootcells.gif

Modification

Root pathogens attack cell walls

Formation of haustorium

Breaking of cell wall barrier

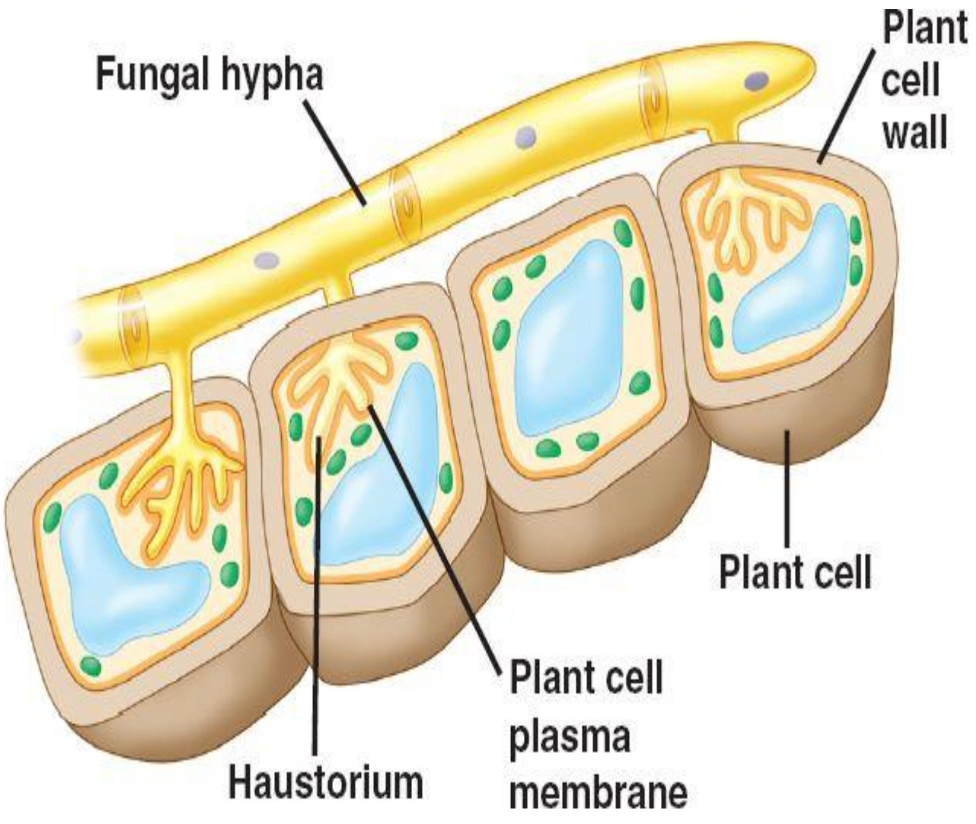
Xylem bridge connection

Plant cell wall degrading enzymes (PCWDEs) are secreted

Pectin degrading enzymes eg PME

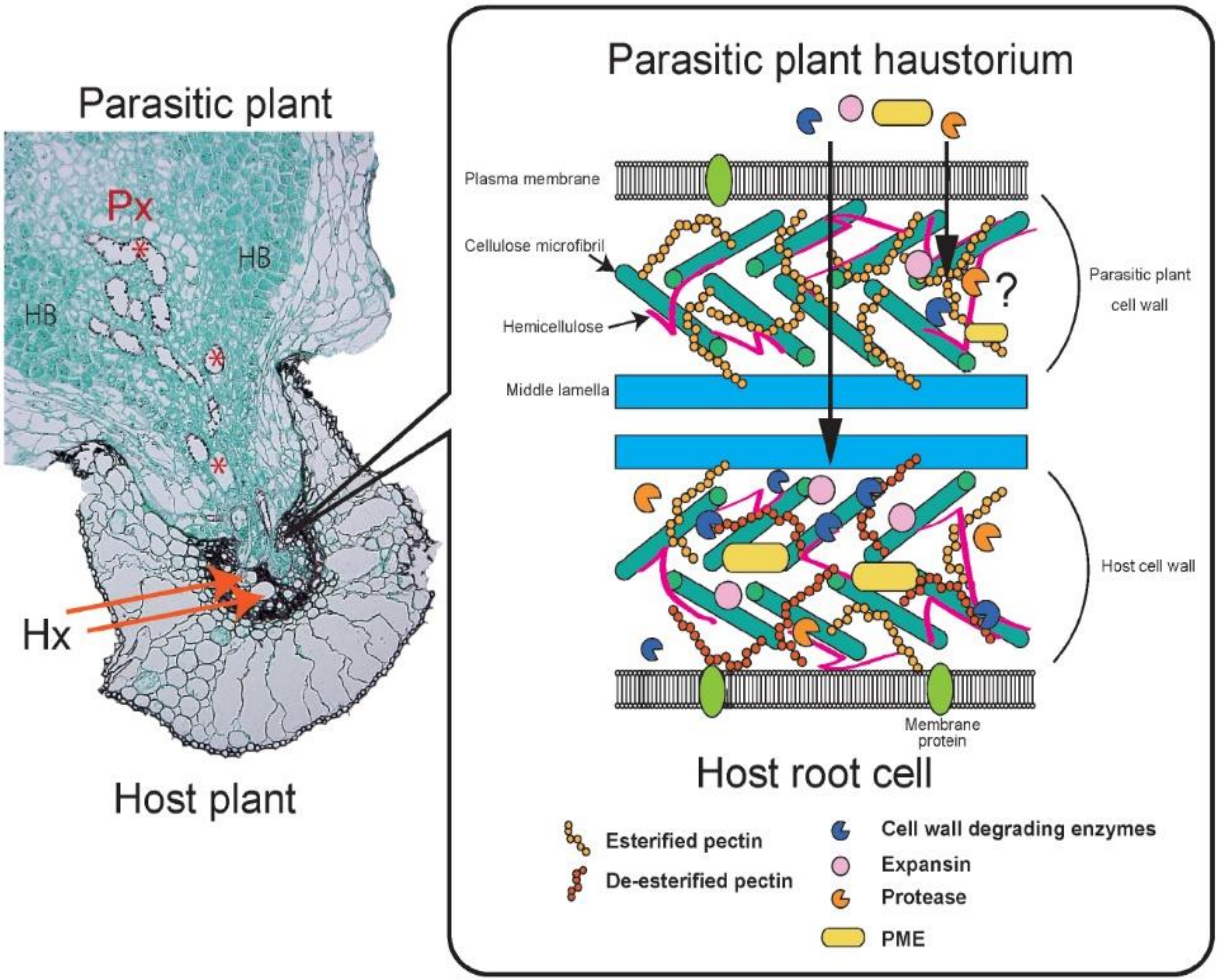
Pectin methylesterase

Degardation of pectin layer--→ access for cellulase and xylanases



http://bio1903.nicerweb.com/Locked/media/ch31/31_04SpecializedHyphaeB.jpg

Modification



Px→ Parasitic xylem cells

Hx→ Host xylem cells

HB→ Hyaline bodies

Mitsumasu et al. (2015) Apoplastic interactions between plants and plant root intruders

Host response

Callose deposition restricts growth in nematode cyst.

Callose deposition within plasmodesmata reduces callose degradation in *arabidopsis thaliana*

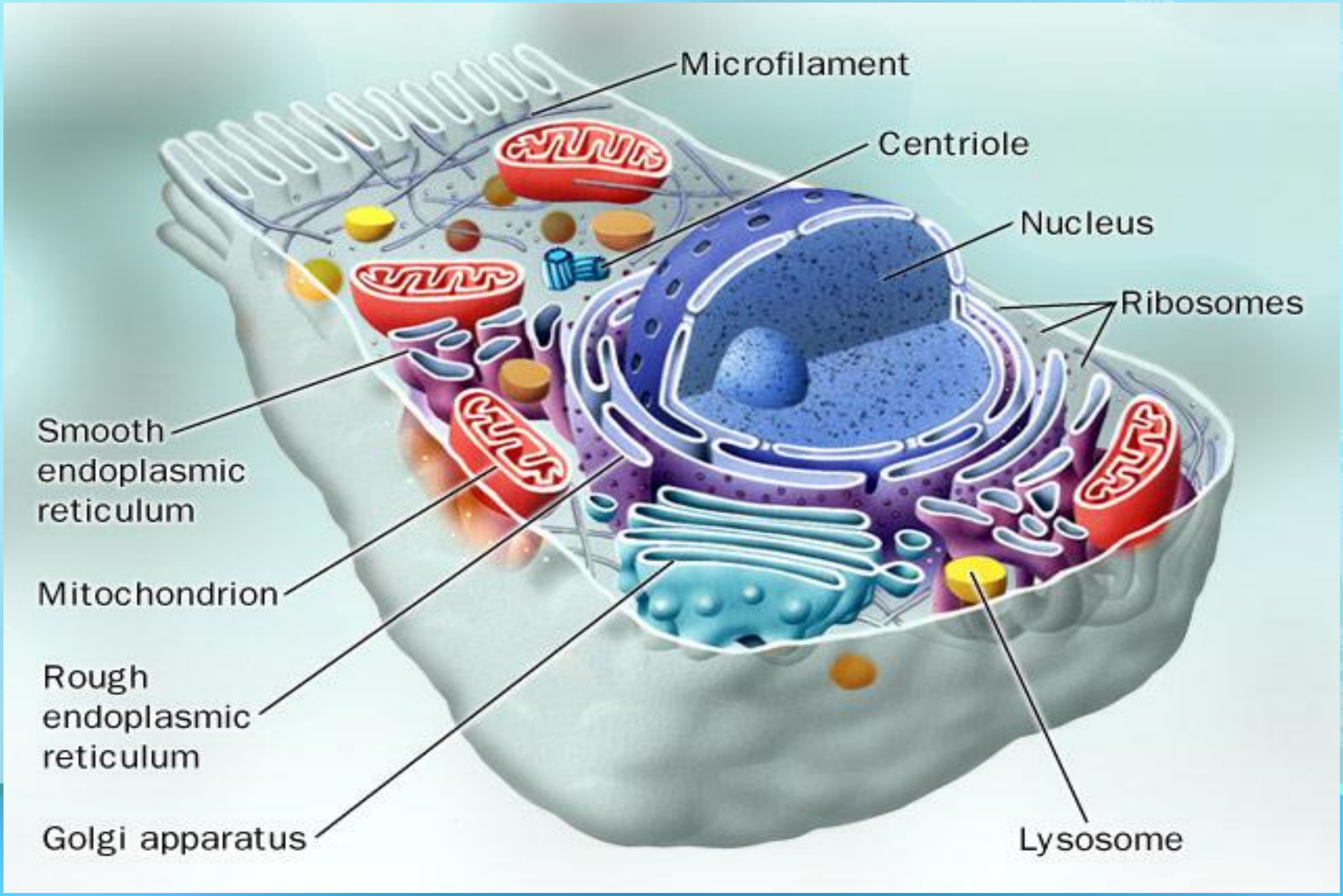
Current Knowledge

In vivo imaging of polysaccharides

THE CELL

Dr.K.Kalimuthu
Assistant Professor
Department of Botany
Government Arts College
Coimbatore

Basic Structure of a Cell



Review Facts About Living Things

What Are the Main Characteristics of organisms?

1. Made of CELLS
2. Require ENERGY (food)
3. REPRODUCE (species)
4. Maintain HOMEOSTASIS
5. ORGANIZED
6. RESPOND to environment
7. GROW and DEVELOP
8. EXCHANGE materials with surroundings (water, wastes, gases)

LEVELS OF ORGANIZATION

Nonliving Levels:

1. ATOM (element)
2. MOLECULE (compounds like carbohydrates & proteins)
3. ORGANELLES (nucleus, ER, Golgi …)

LEVELS OF ORGANIZATION

Living Levels:

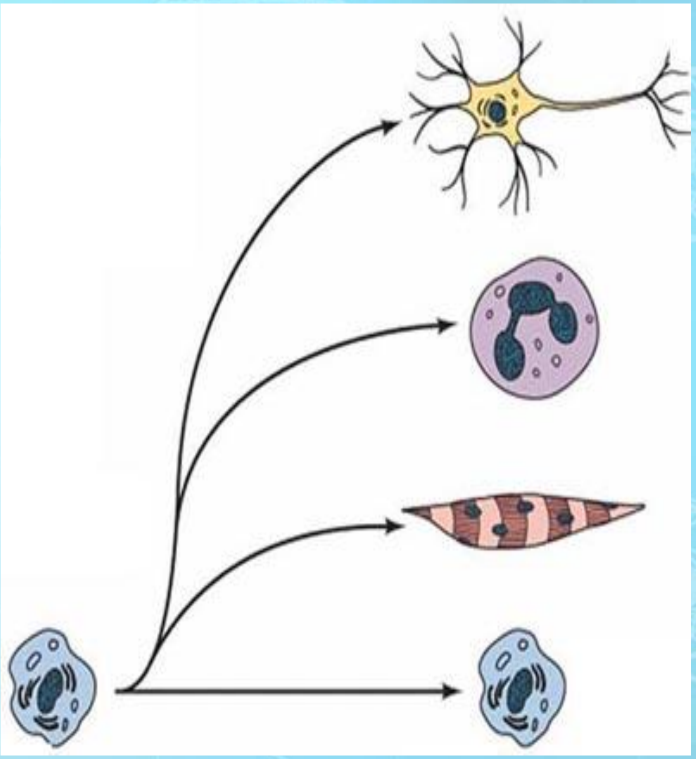
1. CELL (makes up ALL organisms)
2. TISSUE (cells working together
3. ORGAN (heart, brain, stomach …)
4. ORGAN SYSTEMS (respiratory, circulatory …)
5. ORGANISM

LEVELS OF ORGANIZATION

Living Levels continued:

1. POPULATION (one species in an area)
2. COMMUNITY (several populations in an area
3. ECOSYSTEM (forest, prairie …)
4. BIOME (Tundra, Tropical Rain forest…)
5. BIOSPHERE (all living and nonliving things on Earth)

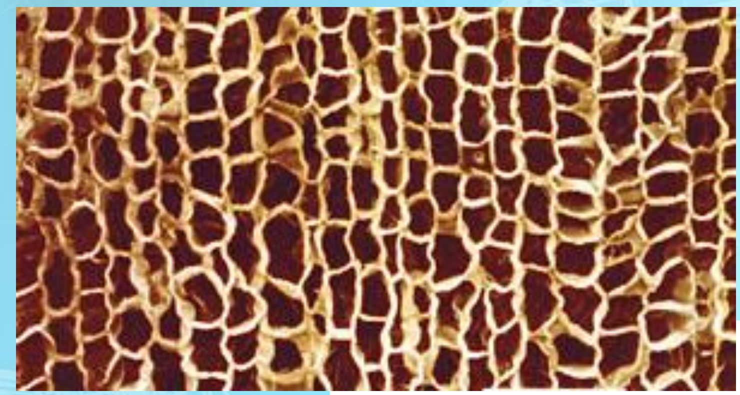
History of Cells & the Cell Theory



Cell Specialization

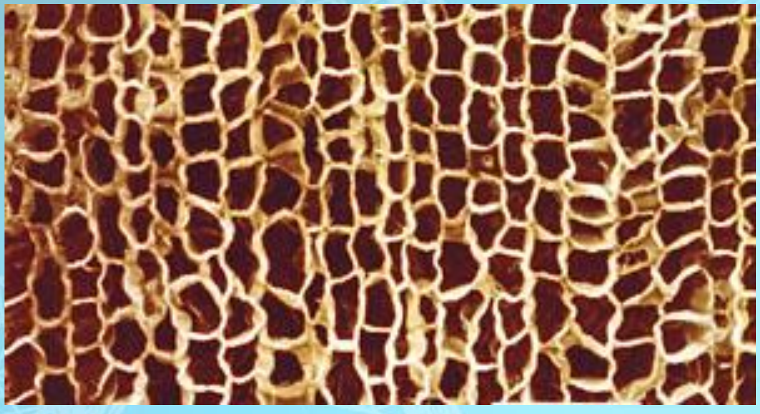
First to View Cells

- In 1665, Robert Hooke used a microscope to examine a thin slice of cork (dead plant cell walls)
- What he saw looked like small boxes



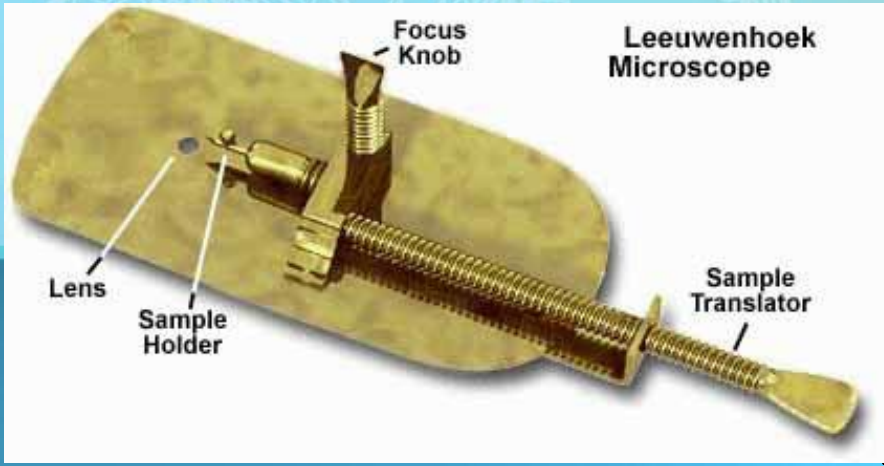
First to View Cells

- Hooke is responsible for **naming cells**
- Hooke called them "CELLS" because they looked like the **small rooms that monks lived in** called Cells



Anton van Leeuwenhoek

- In 1673, Leeuwenhoek (a Dutch microscope maker), was first to view organism (living things)
- Leeuwenhoek used a simple, handheld microscope to view pond water & scrapings from his teeth



Beginning of the Cell Theory

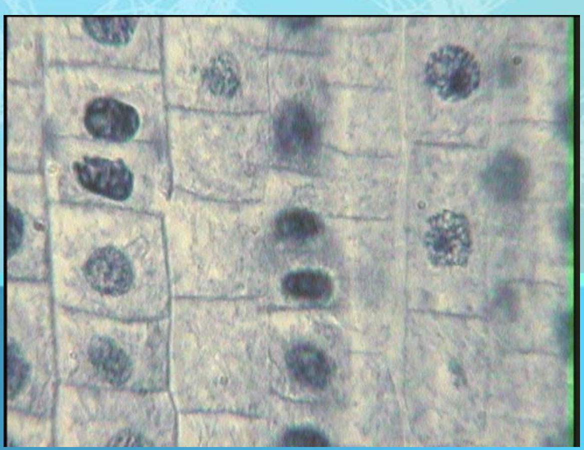
- In 1838, a German botanist named Matthias Schleiden concluded that all plants were made of cells
- Schleiden is a cofounder of the cell theory

Beginning of the Cell Theory

- In 1839, a German zoologist named Theodore Schwann concluded that all animals were made of cells
- Schwann also cofounded the cell theory

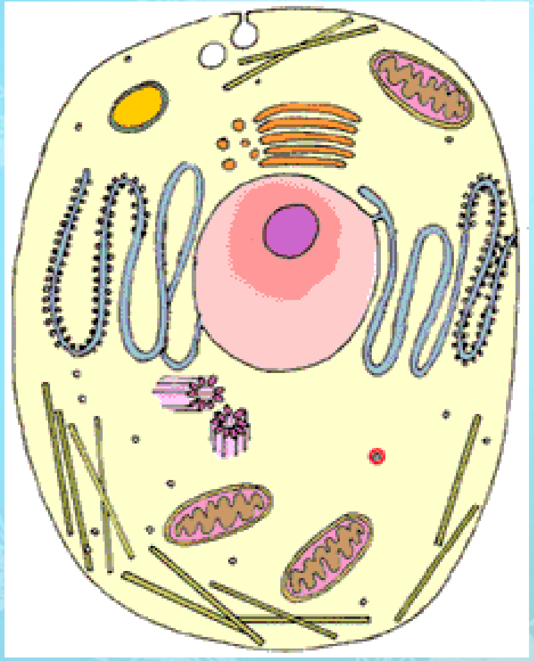
Beginning of the Cell Theory

- In 1855, a German medical doctor named Rudolph Virchow observed, under the microscope, cells dividing
- He reasoned that all cells come from other pre-existing cells by cell division

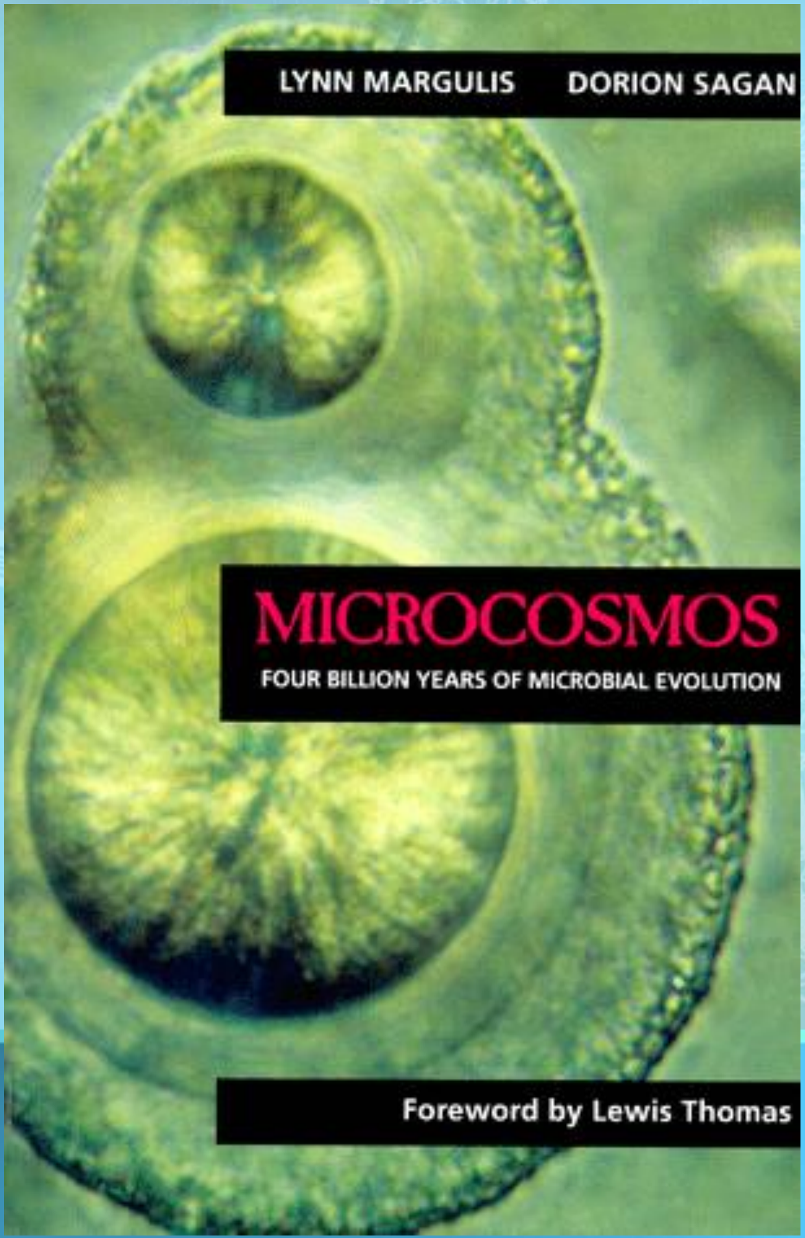


CELL THEORY

- All living things are made of cells
- Cells are the basic unit of structure and function in an organism (basic unit of life)
- Cells come from the reproduction of existing cells (cell division)



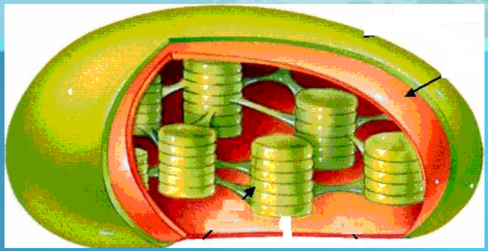
Discoveries *Since* the Cell Theory

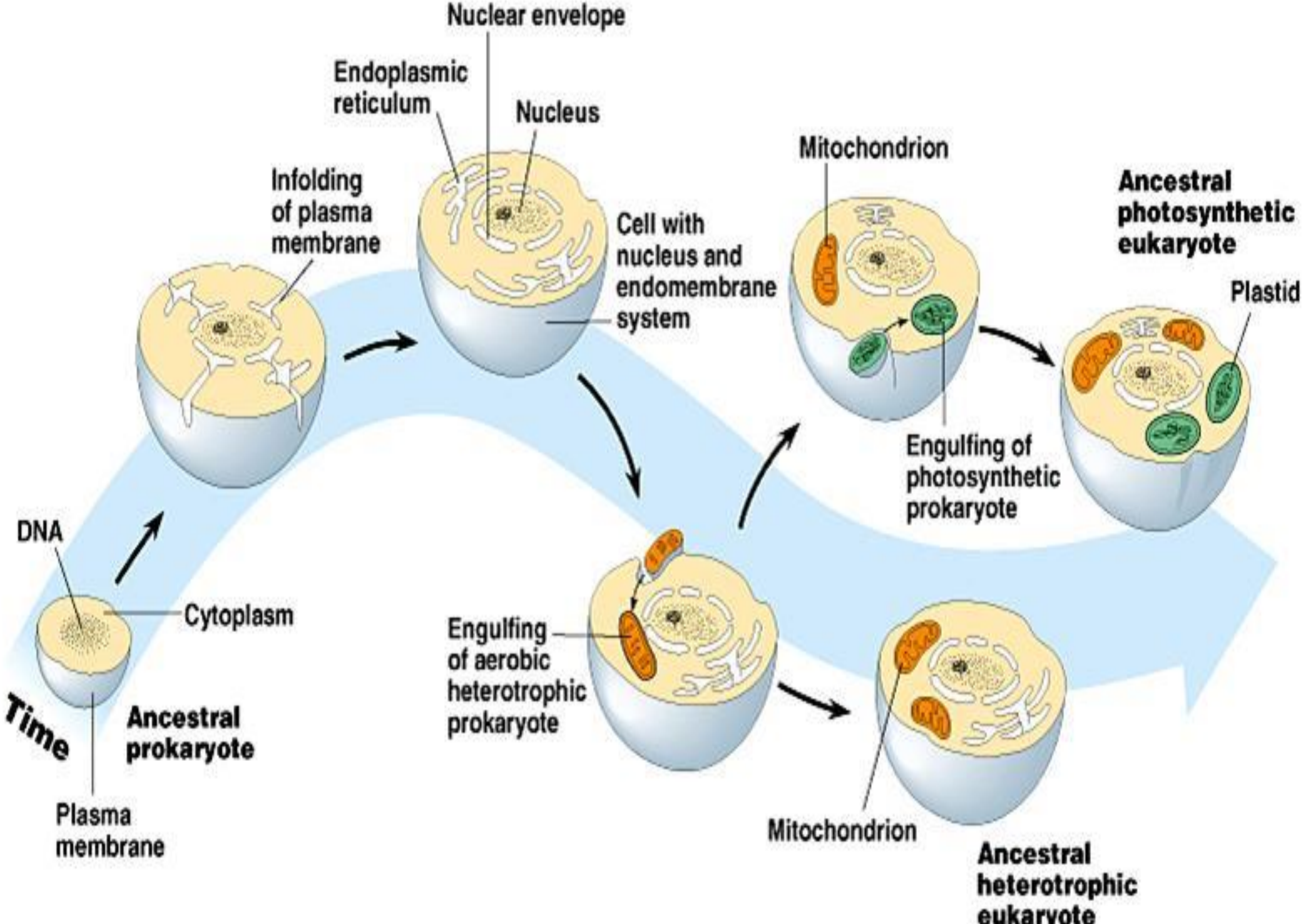


ENDOSYMBIOTIC THEORY

- In 1970, American biologist, Lynn Margulis, provided evidence that some organelles within cells were at one time free living cells themselves

- Supporting evidence included organelles with their own DNA
- Chloroplast and Mitochondria

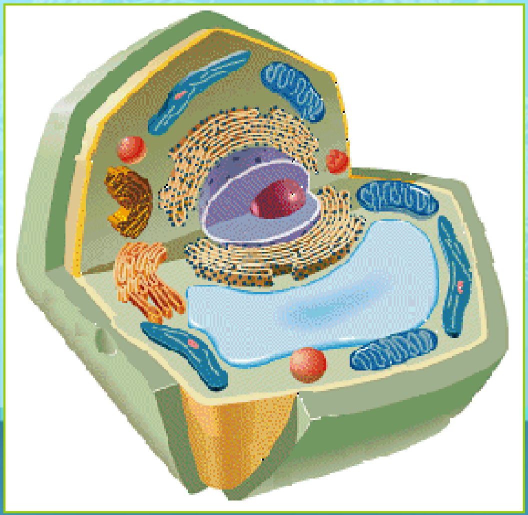


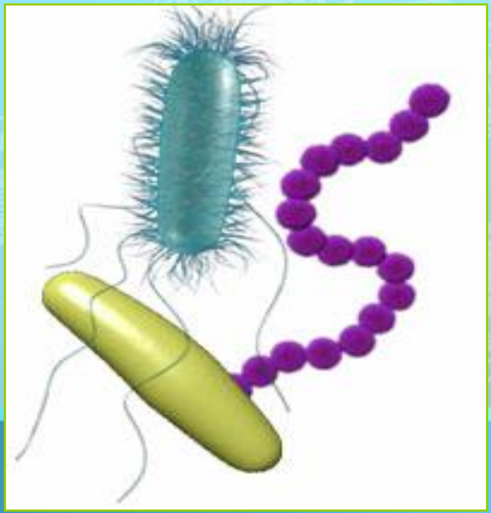

Nuclear envelope
Endoplasmic reticulum
Nucleus
Infolding of plasma membrane
Cell with nucleus and endomembrane system
Mitochondrion
Ancestral photosynthetic eukaryote
Plastid
Engulfing of photosynthetic prokaryote
DNA
Cytoplasm
Engulfing of aerobic heterotrophic prokaryote
Time
Ancestral prokaryote
Plasma membrane
Mitochondrion
Ancestral heterotrophic eukaryote

Cell Size and Types

- Cells, the basic units of organisms, can only be observed under microscope
- Three Basic types of cells include:


Animal Cell


Plant Cell

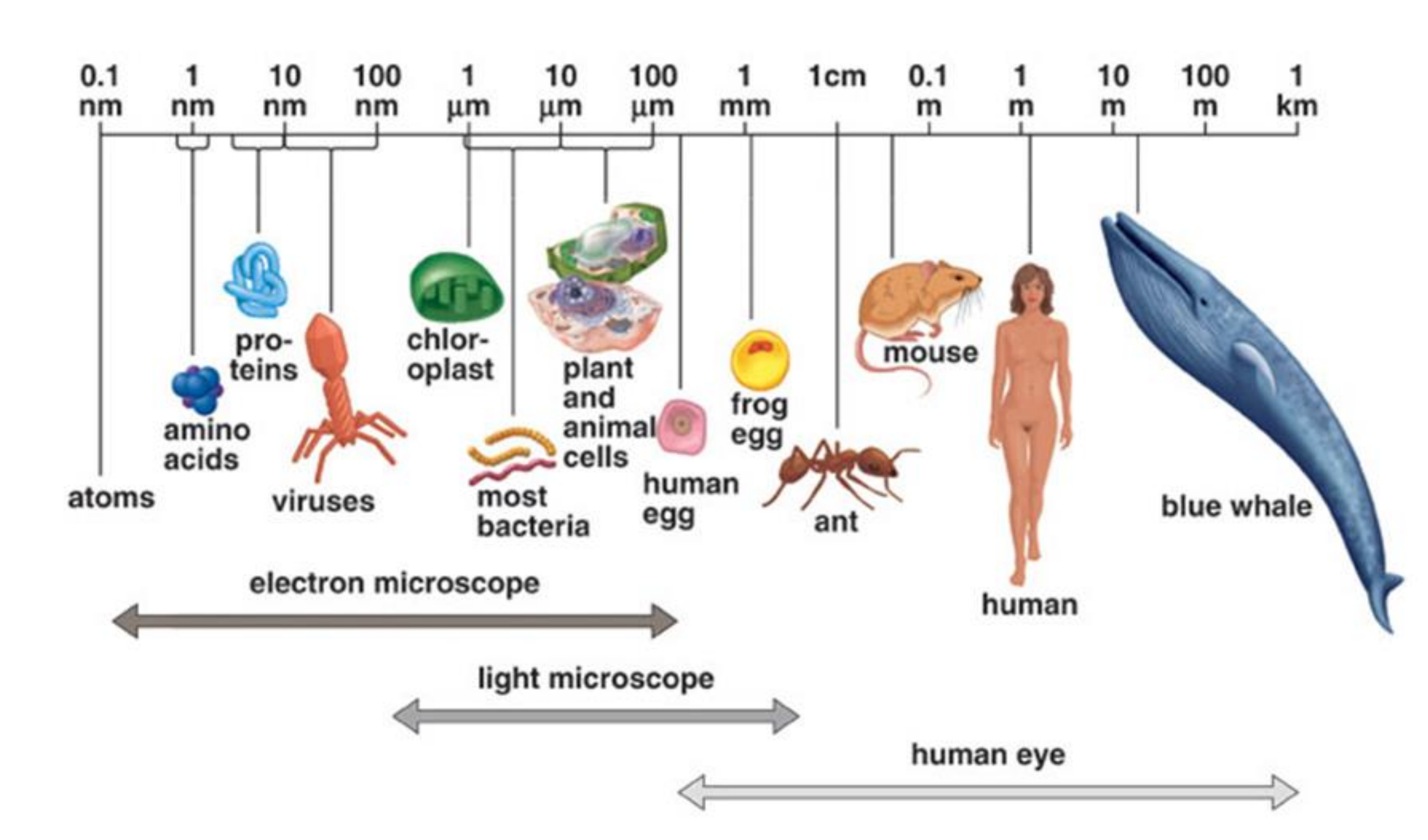

Bacterial Cell

Number of Cells

Although ALL living things are made of cells, organisms may be:

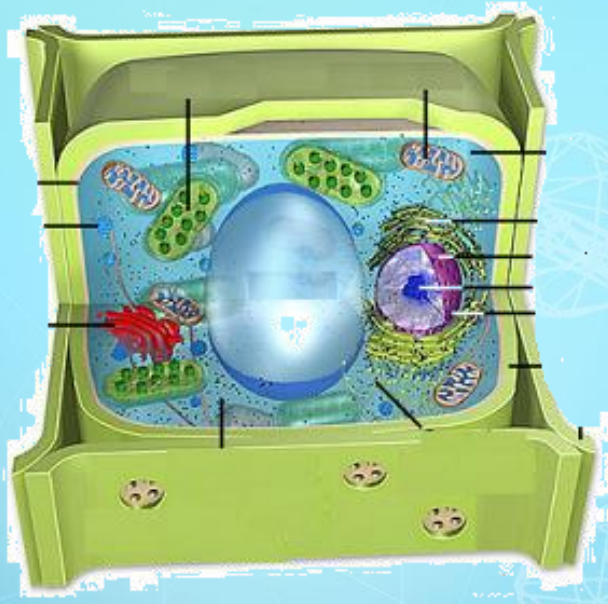
- *Unicellular* – composed of one cell
- *Multicellular*- composed of many cells that may organize into tissues, etc.

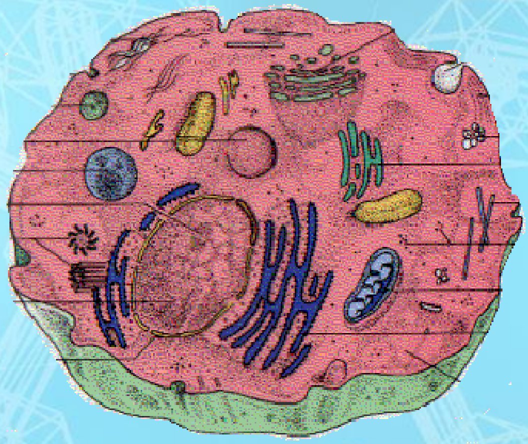
CELL SIZE



Typical cells range from 5 – 50 micrometers (microns) in diameter

Which Cell Type is Larger?





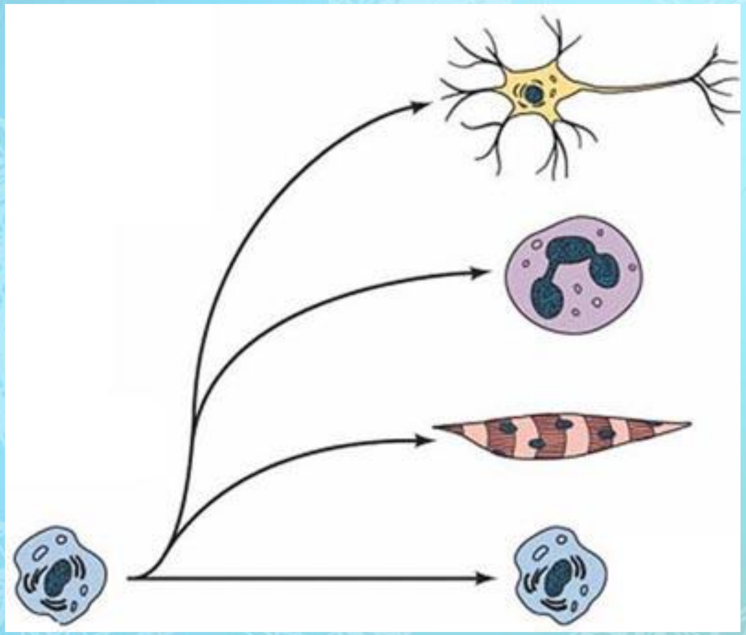
Plant cell > Animal cell > bacteria

How Big is a Micron (μ) ?

1 cm = 10,000 microns   1" = 25,000 microns

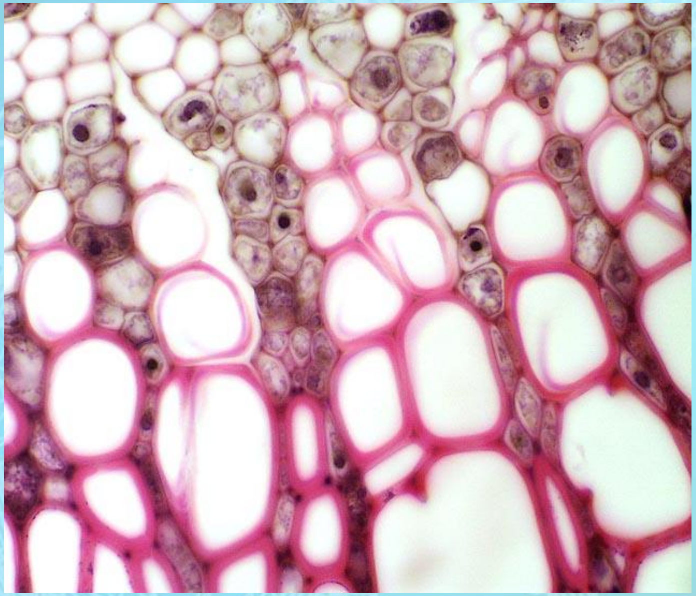
Cell Specialization

- Cells in a multi-cellular organism become specialized by turning different genes on and off
- This is known as DIFFERENTIATION



Specialized Plant cells

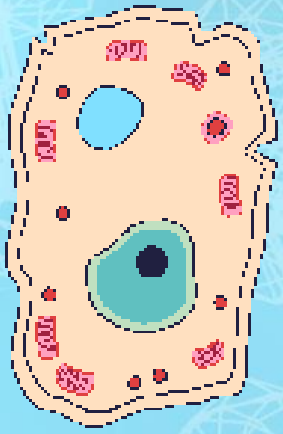
Guard Cells



Xylem cells

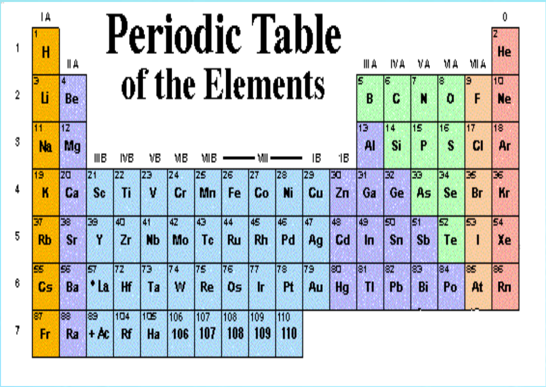
Pollen

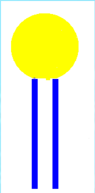
Organization Levels of Life

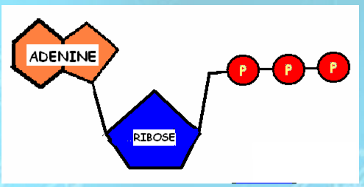


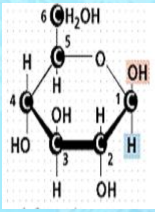
Atoms to Organisms

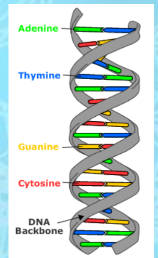
Nonliving Levels

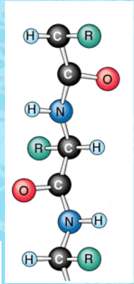


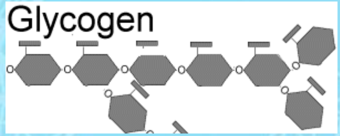


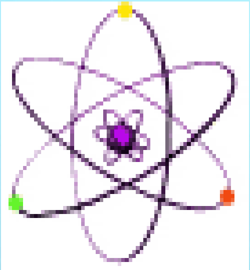


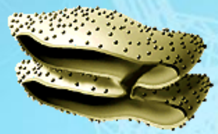


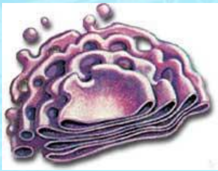


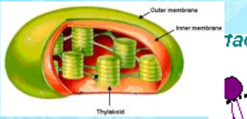


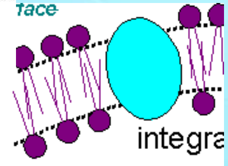


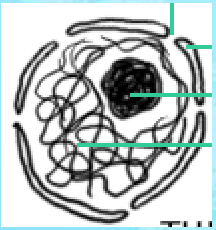


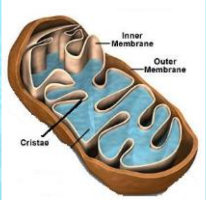






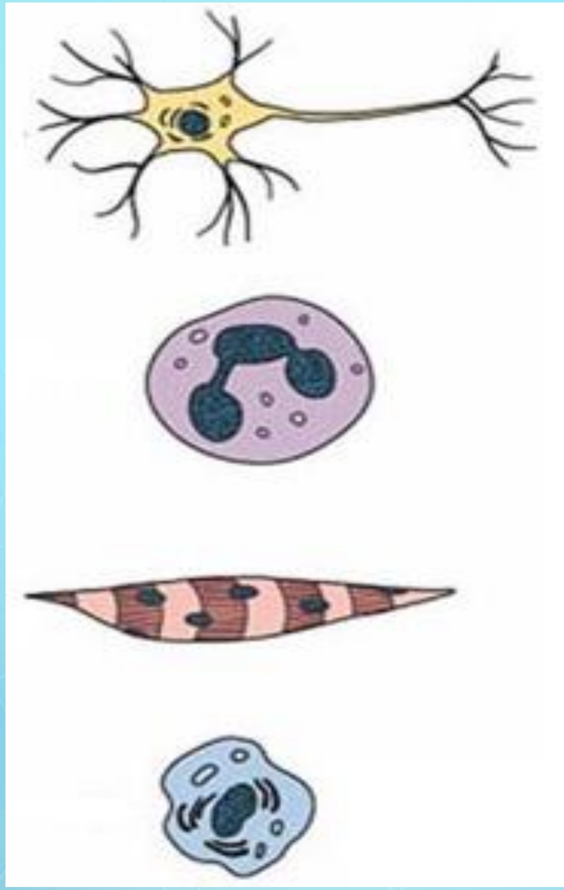






ATOMS → MOLECULES → ORGANELLES

Living Levels



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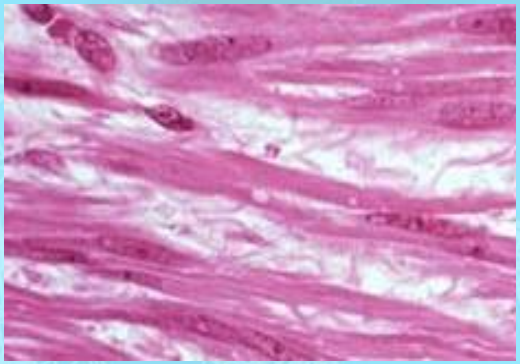
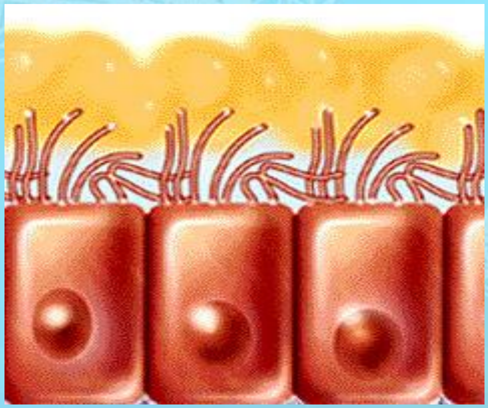
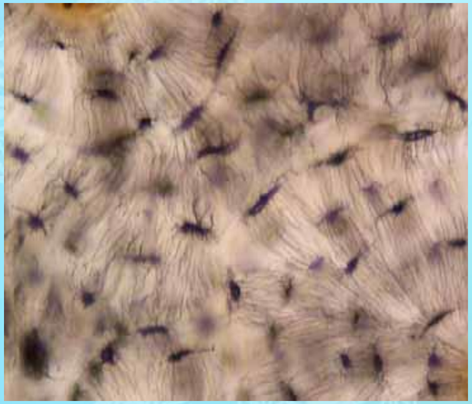




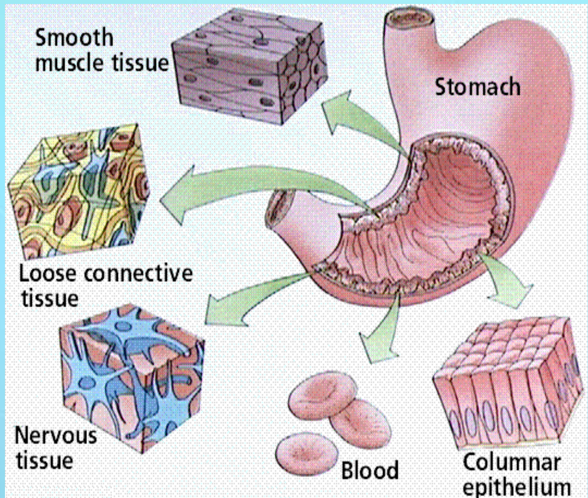


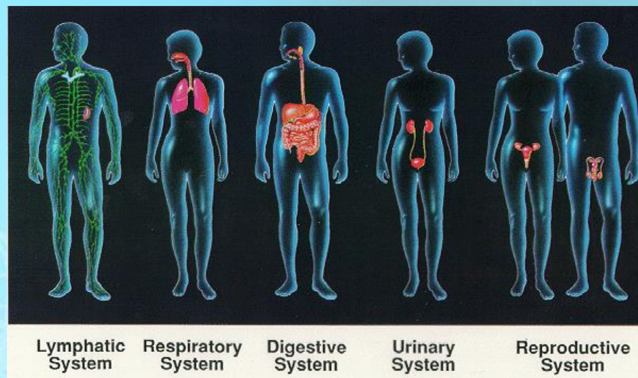
CELLS – life starts here

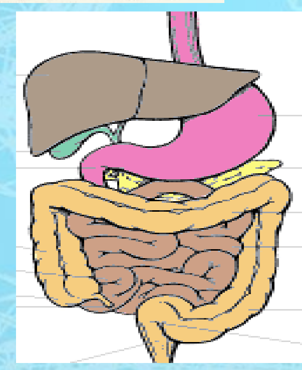
→

TISSUES – Similar cells working together

More Living Levels





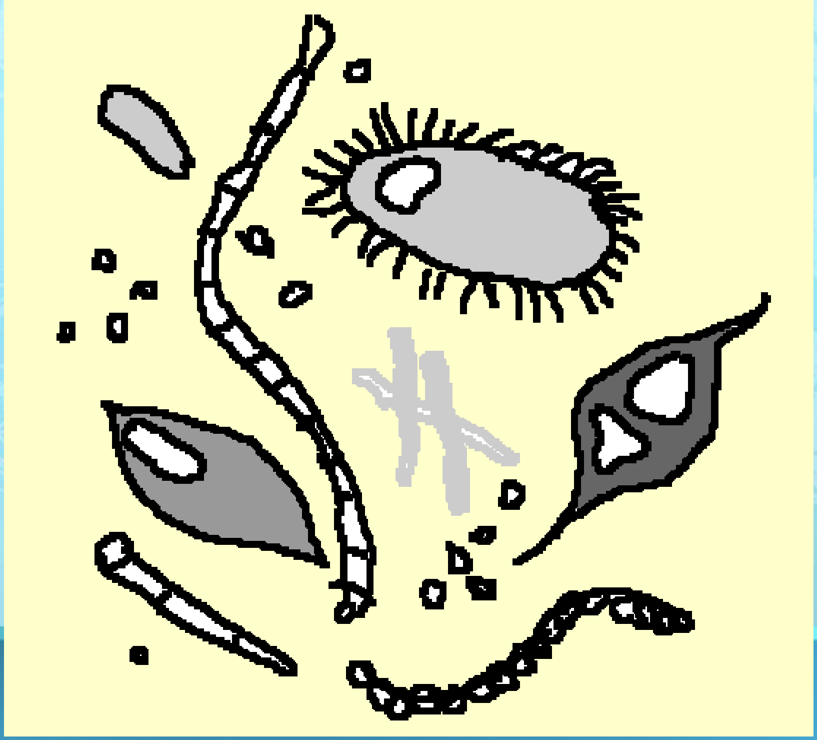


ORGANS → ORGAN SYSTEMS → ORGANISM

Different tissues working together

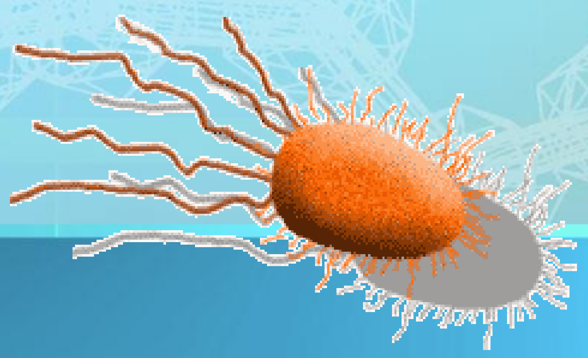
Different organs working together

Simple or Complex Cells



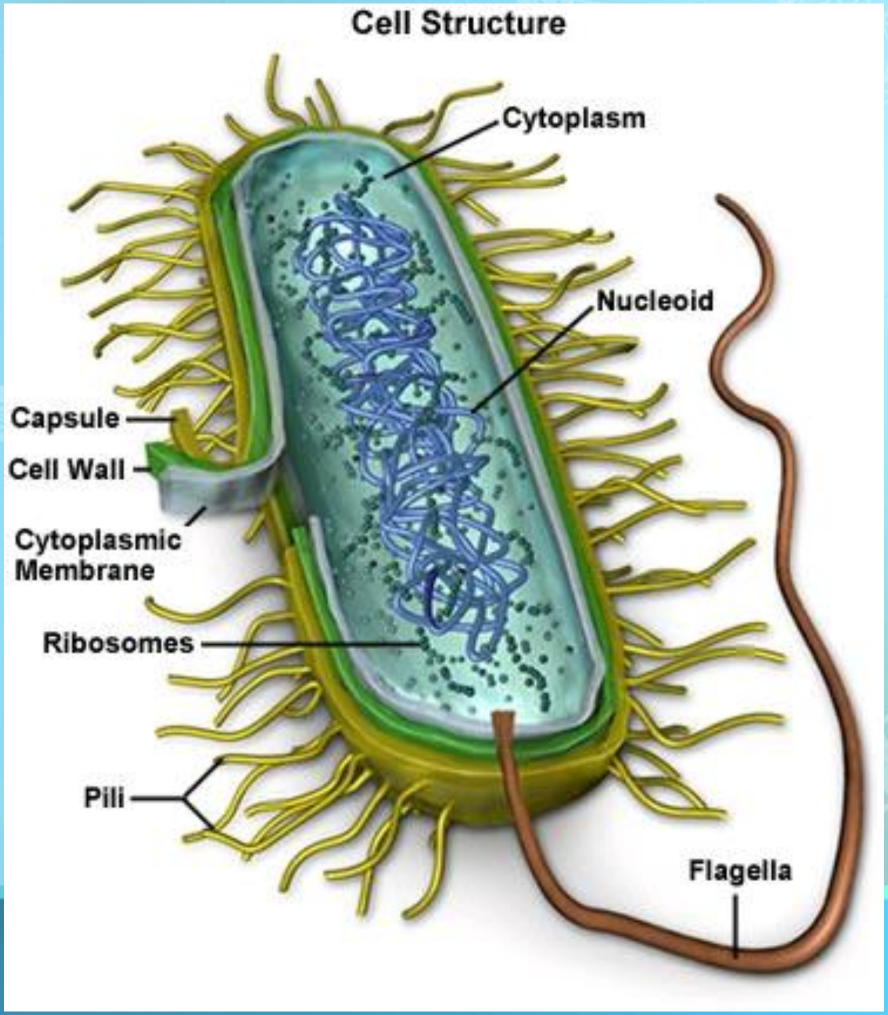
Prokaryotes – The first Cells

- Cells that lack a nucleus or membrane-bound organelles
- Includes bacteria
- Simplest type of cell
- Single, circular chromosome



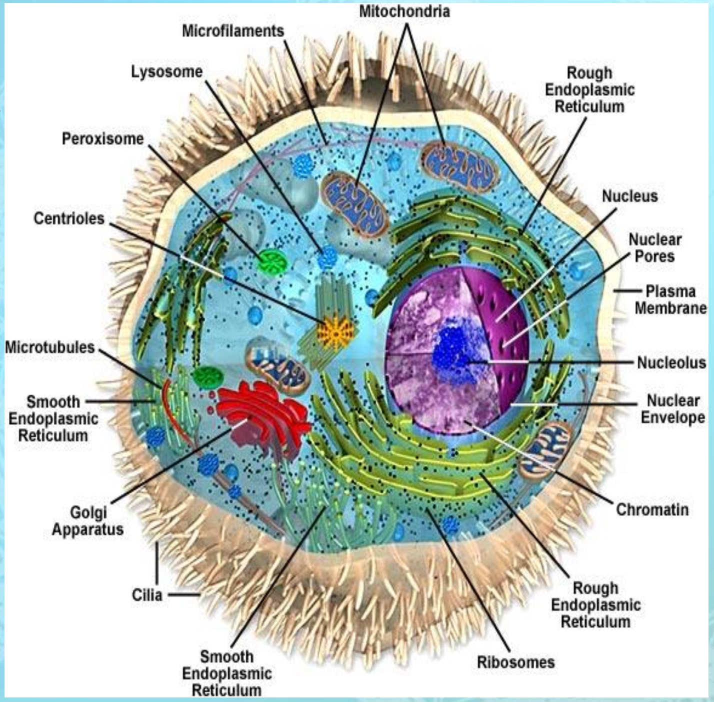
Prokaryotes

- Nucleoid region (center) contains the DNA
- Surrounded by cell membrane & cell wall (peptidoglycan)
- Contain ribosomes (no membrane) in their cytoplasm to make proteins



Eukaryotes

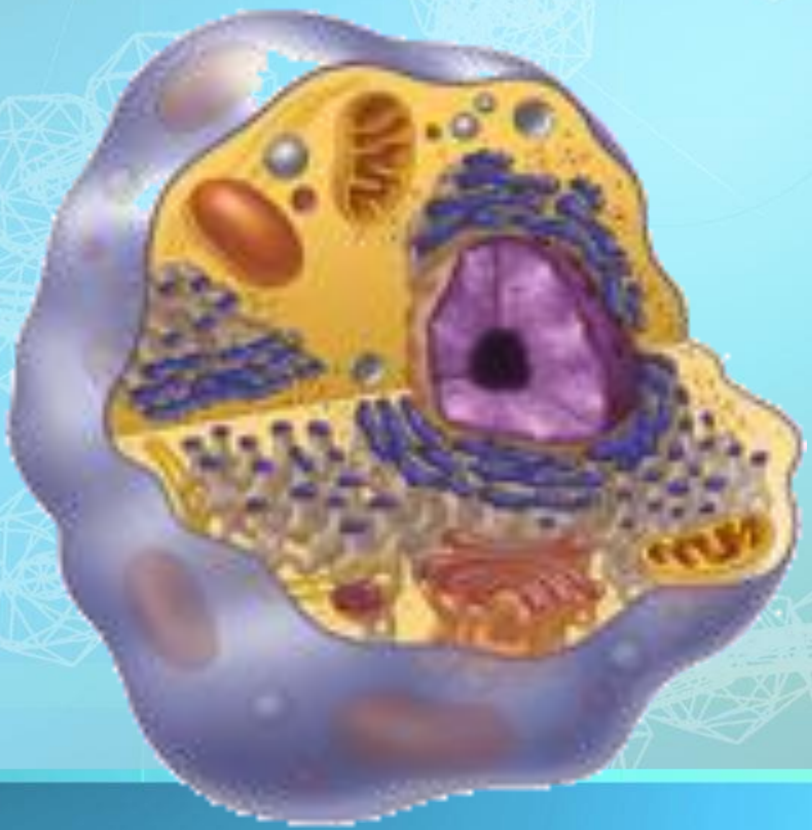
- Cells that HAVE a nucleus and membrane-bound organelles
- Includes protists, fungi, plants, and animals
- More complex type of cells



Eukaryotic Cell

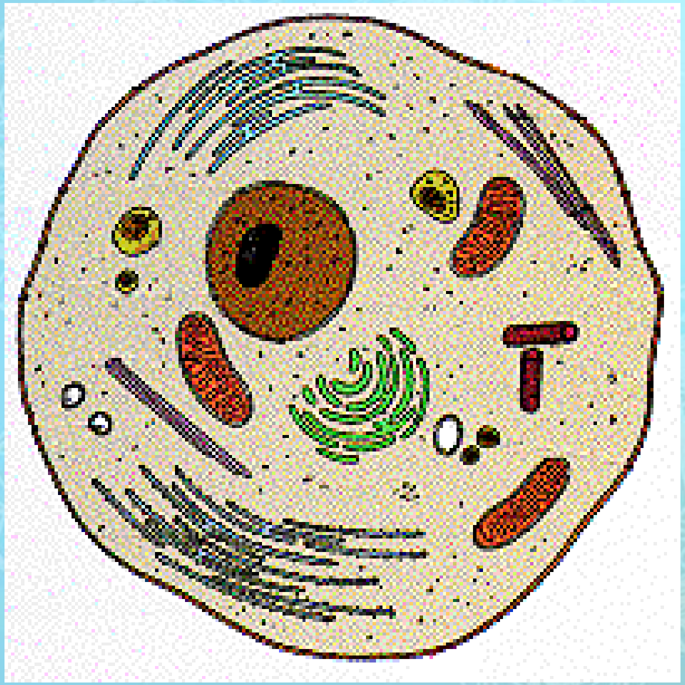
Contain 3 basic cell structures:

- Nucleus
- Cell Membrane
- Cytoplasm with organelles



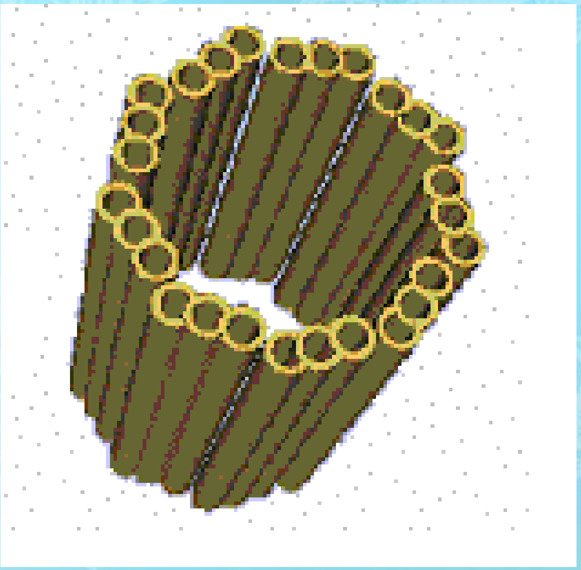
Two Main Types of Eukaryotic Cells

Plant Cell



Animal Cell

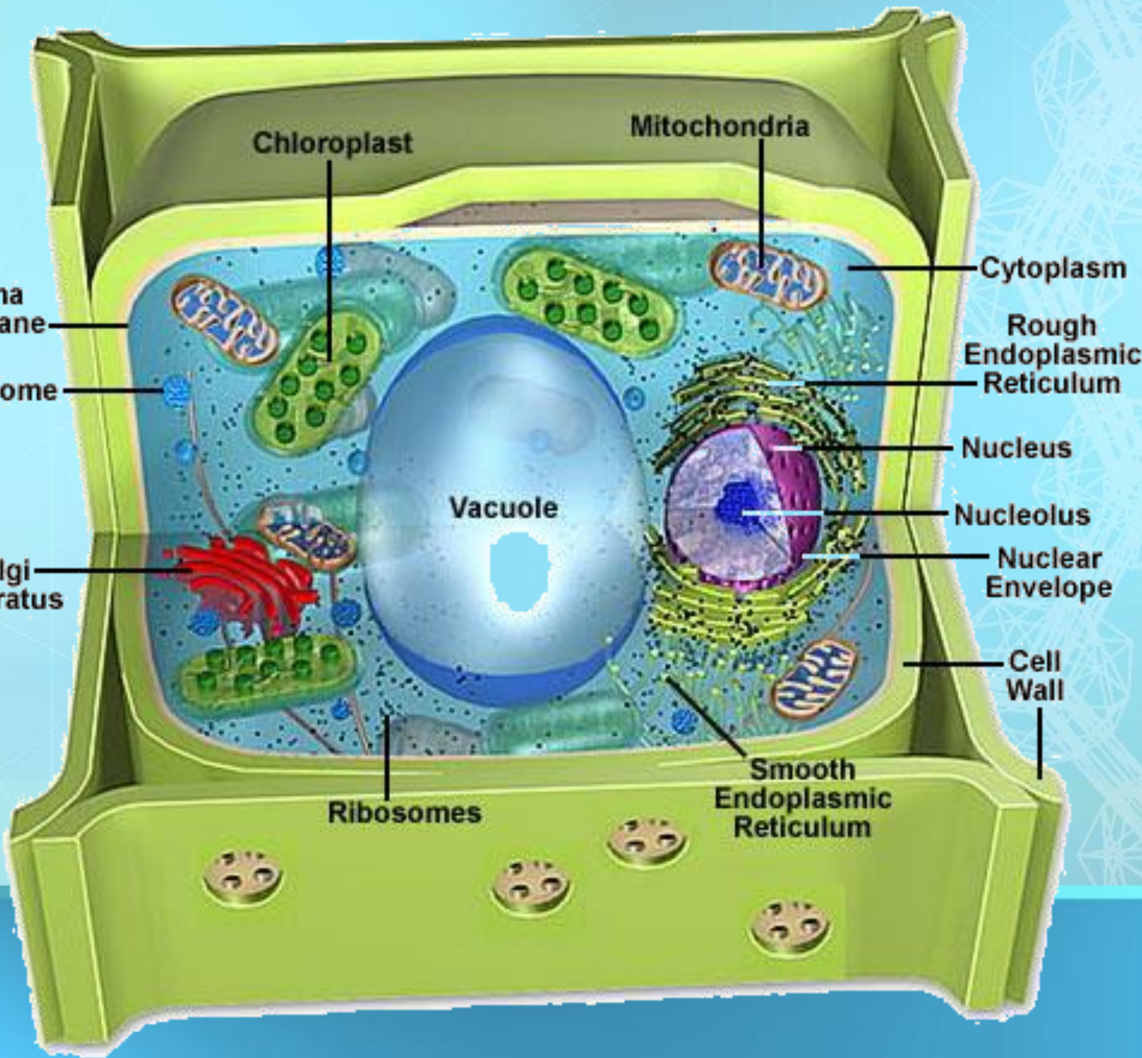
Organelles



Organelles

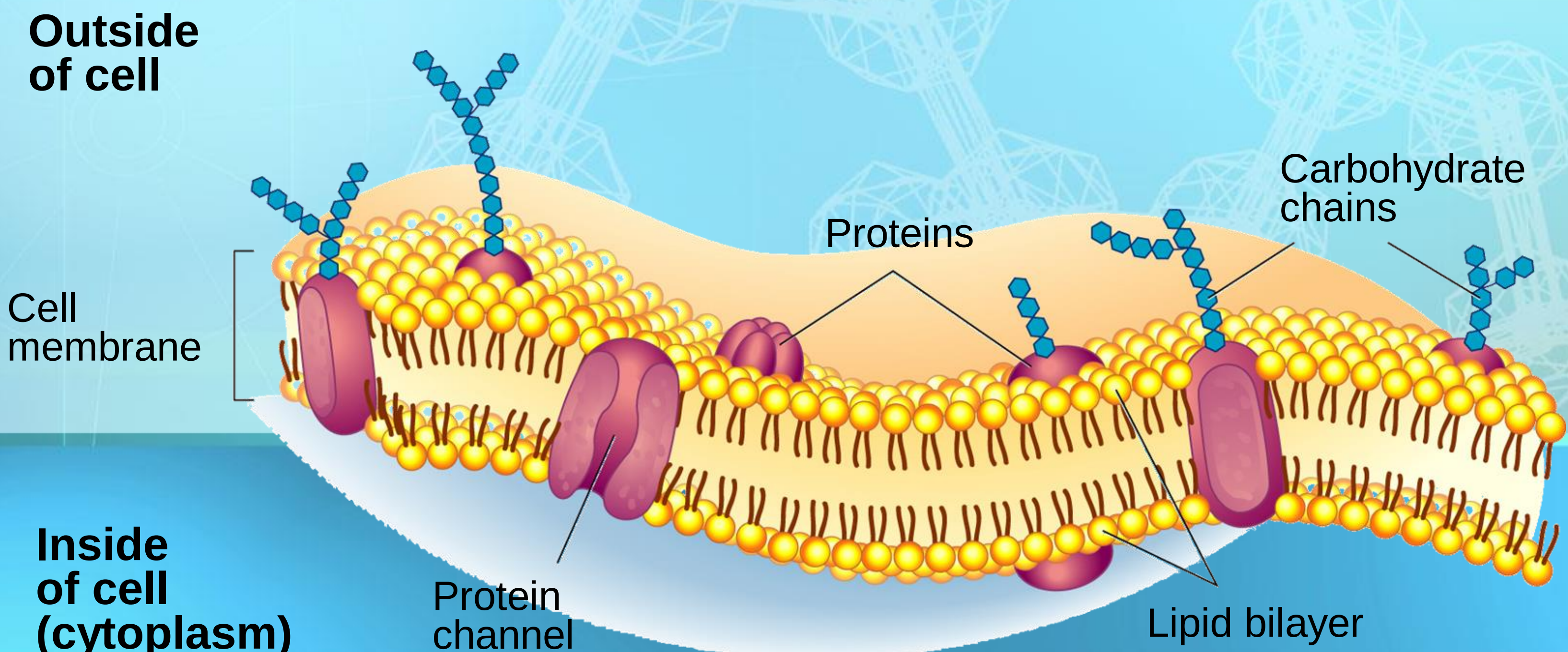
- Very small (Microscopic)
- Perform various functions for a cell
- Found in the cytoplasm
- May or may not be membrane-bound

Plant Cell Organelles



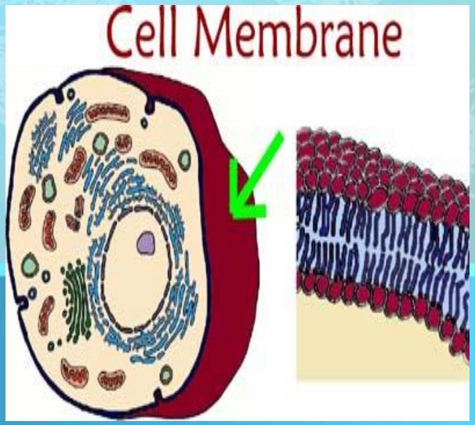
Cell or Plasma Membrane

- Composed of double layer of phospholipids and proteins
- Surrounds outside of ALL cells
- Controls what enters or leaves the cell
- Living layer

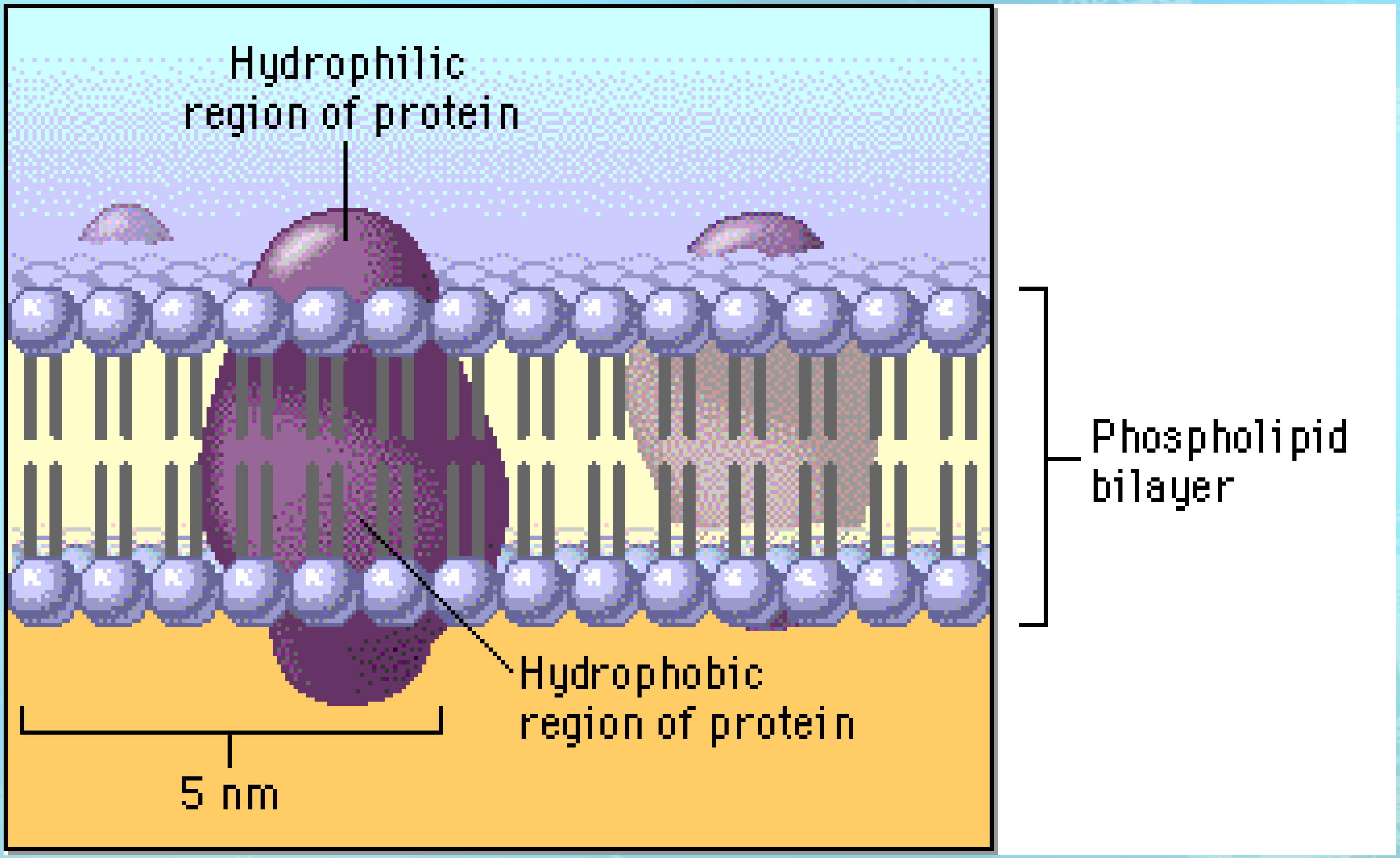


Phospholipids

- Heads contain glycerol & phosphate and are hydrophilic (attract water)
- Tails are made of fatty acids and are hydrophobic (repel water)
- Make up a bilayer where tails point inward toward each other
- Can move laterally to allow small molecules (O_2, CO_2, & H_2O to enter)



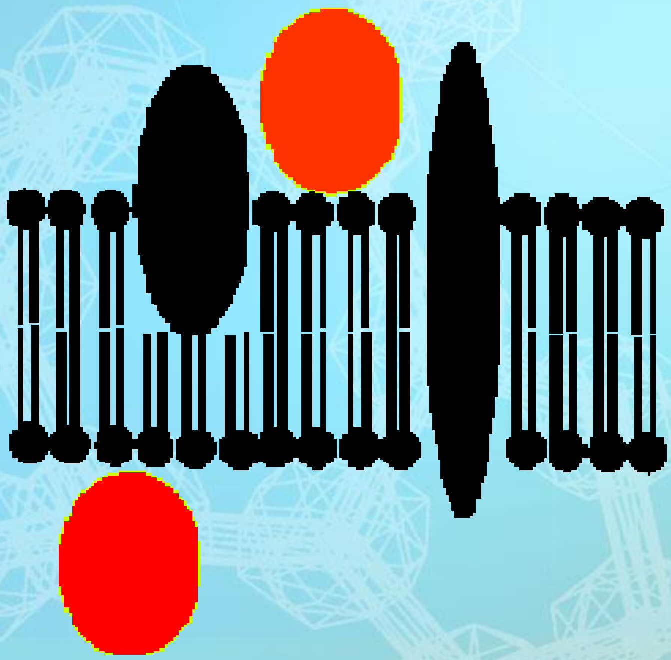
The Cell Membrane is Fluid



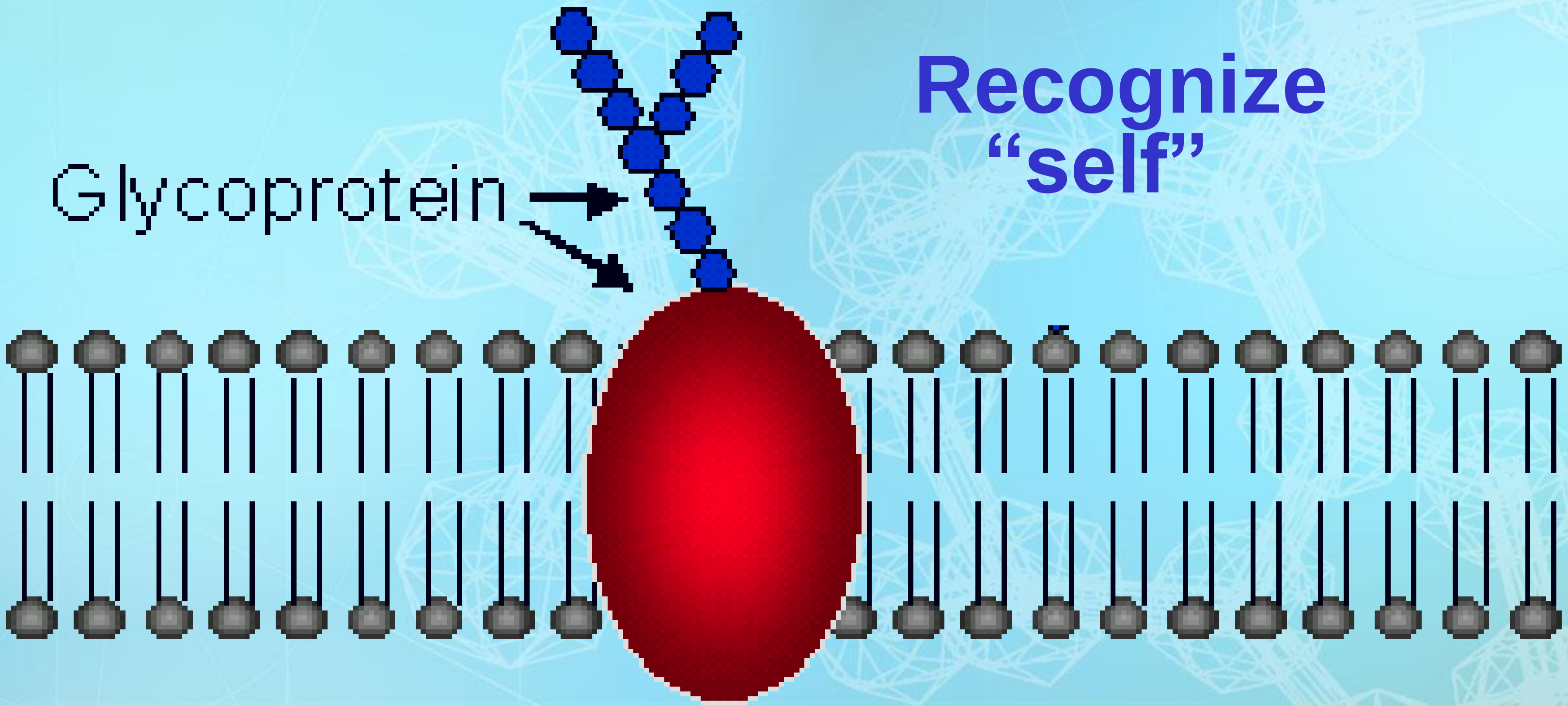
Molecules in cell membranes are constantly moving and changing

Cell Membrane Proteins

- Proteins help move large molecules or aid in cell recognition
- Peripheral proteins are attached on the surface (inner or outer)
- Integral proteins are embedded completely through the membrane



GLYCOPROTEINS

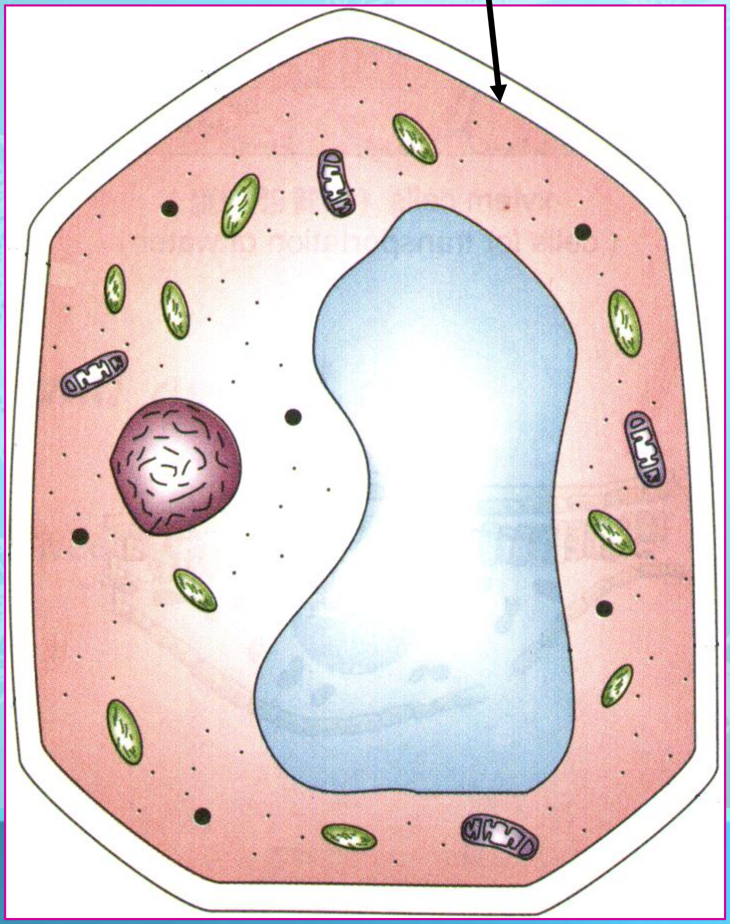


Recognize "self"

Glycoproteins have carbohydrate tails to act as markers for cell recognition

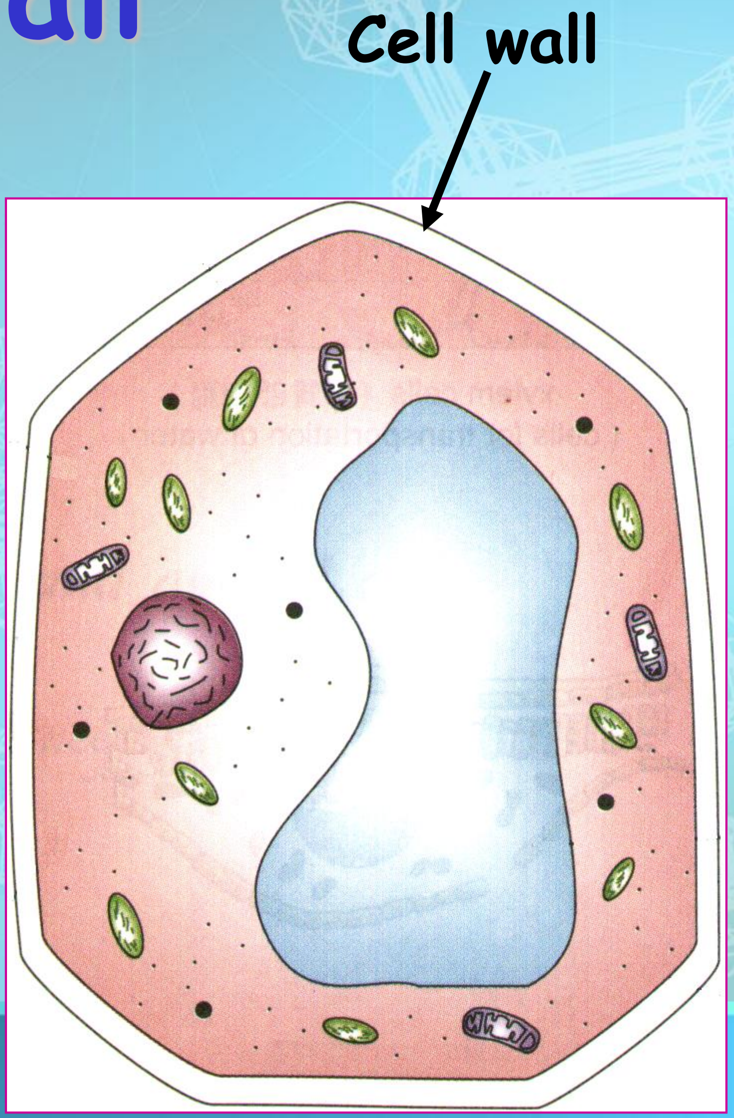
Cell Membrane in Plants

- Lies immediately against the cell wall in plant cells
- Pushes out against the cell wall to maintain cell shape



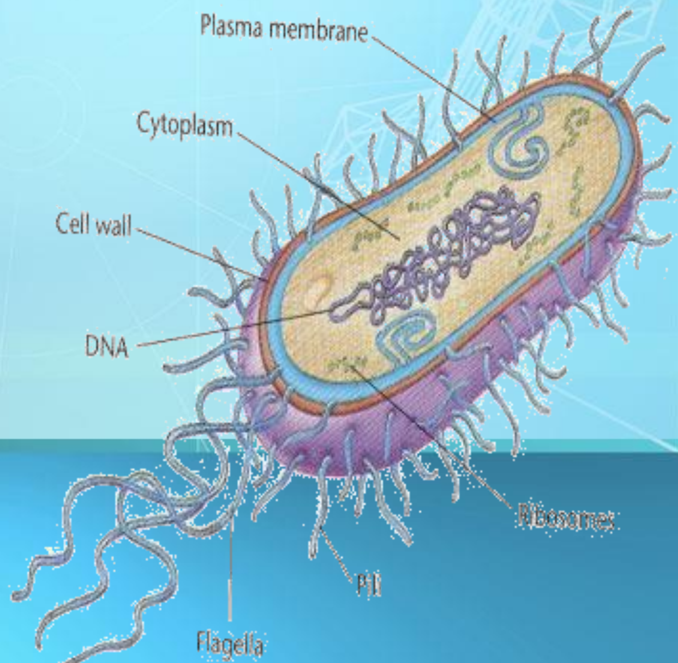
Cell Wall

- Nonliving layer
- Found in plants, fungi, & bacteria
- Made of cellulose in plants
- Made of peptidoglycan in bacteria
- Made of chitin in Fungi



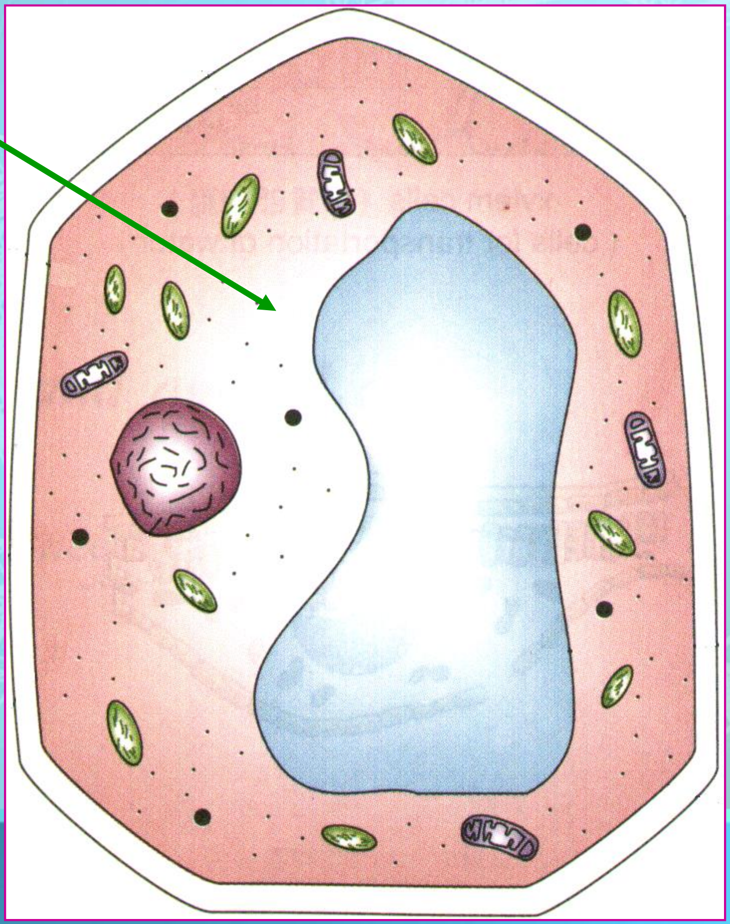
Cell Wall

- **Supports** and **protects** cell
- Found **outside of the cell membrane**



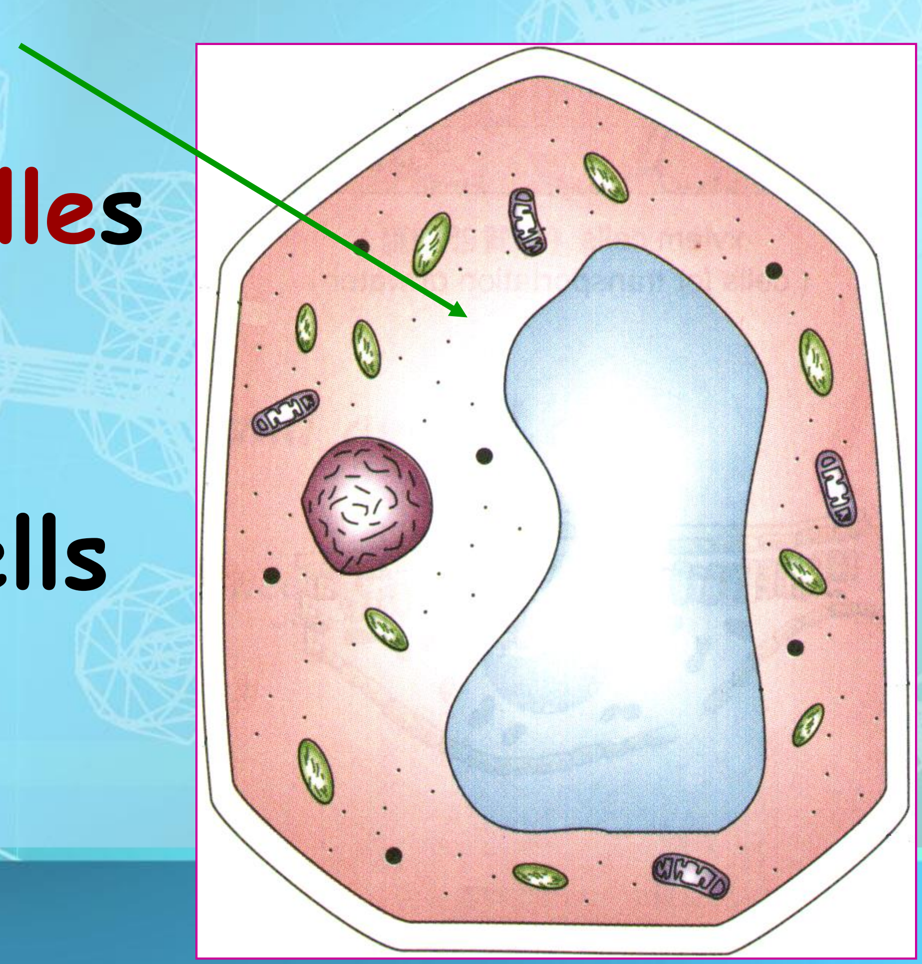
Cytoplasm of a Cell

- Jelly-like substance enclosed by cell membrane
- Provides a medium for chemical reactions to take place



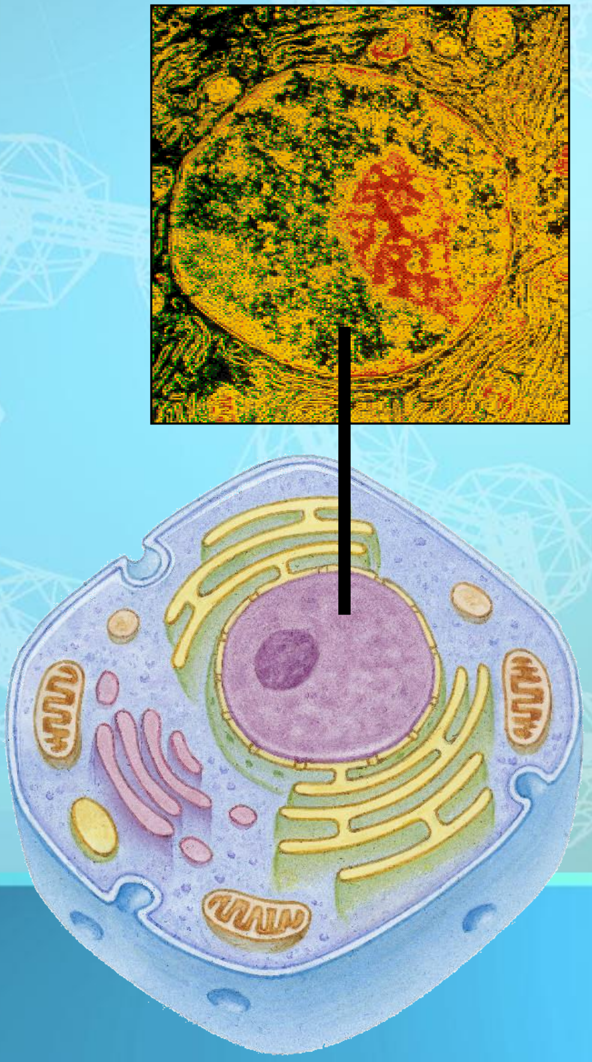
More on Cytoplasm

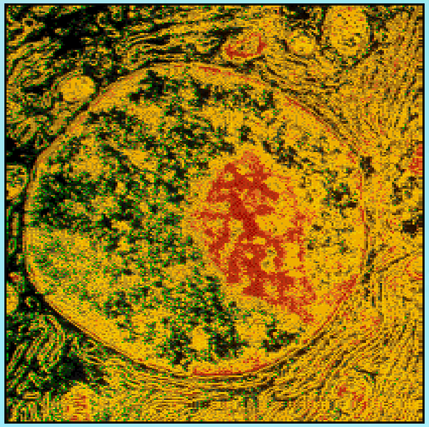
- Contains organelles to carry out specific jobs
- Found in ALL cells



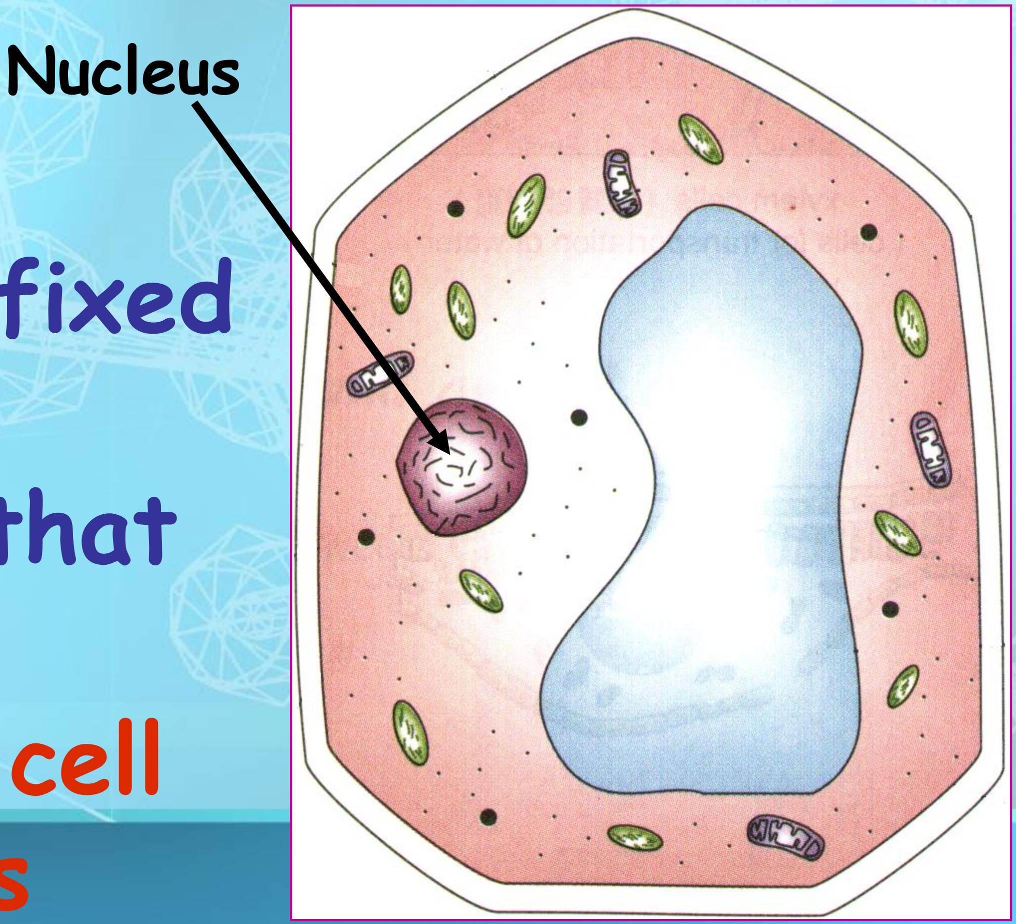
The Control Organelle - Nucleus

- Controls the normal activities of the cell
- Contains the DNA in chromosomes
- Bounded by a **nuclear envelope** (membrane) with pores
- Usually the **largest** organelle





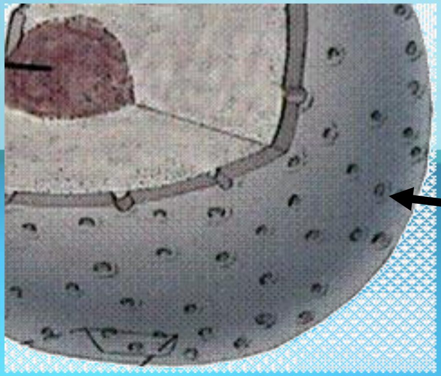
More on the Nucleus



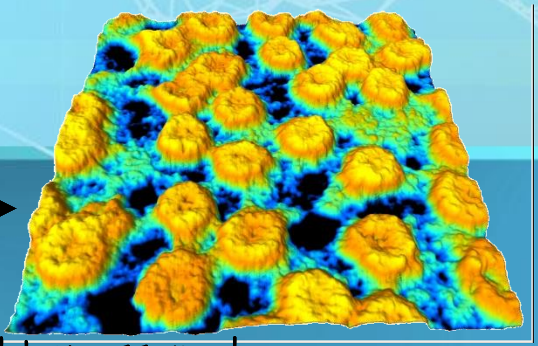
- Each cell has fixed number of chromosomes that carry genes
- Genes control cell characteristics

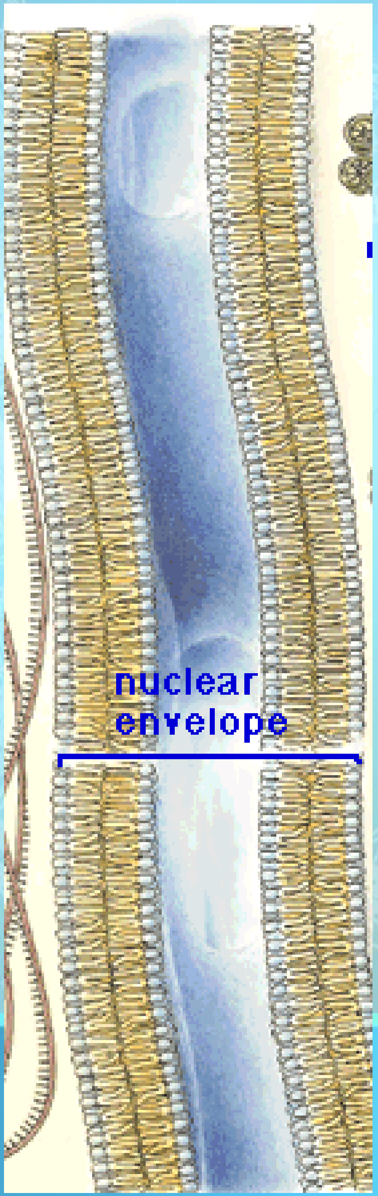
Nuclear Envelope

- Double membrane surrounding nucleus
- Also called nuclear membrane
- Contains nuclear pores for materials to enter & leave nucleus
- Connected to the rough ER



Nuclear pores





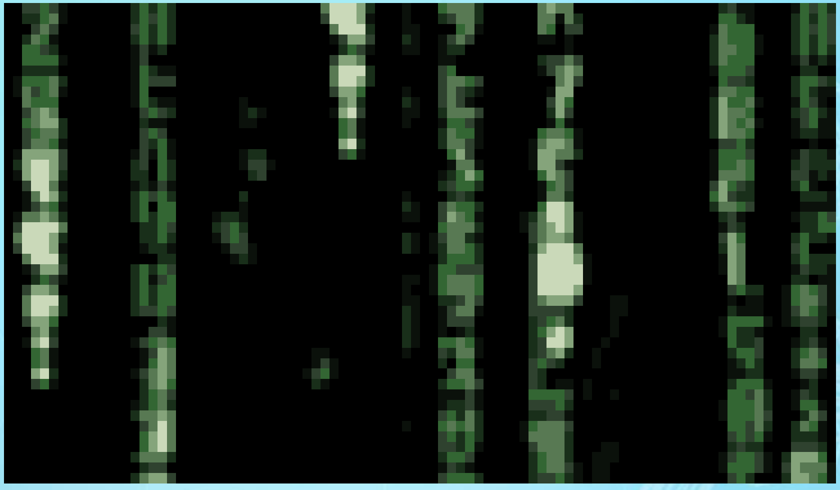
Inside the Nucleus -

The genetic material (DNA) is found

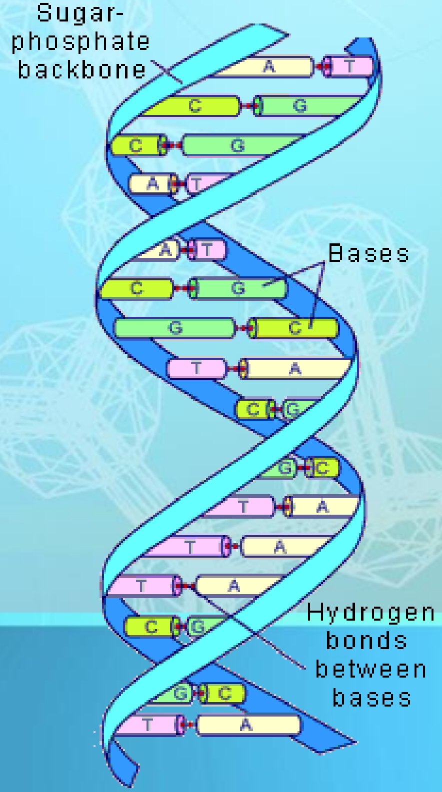
DNA is spread out
And appears as
CHROMATIN
in non-dividing cells

DNA is condensed &
wrapped around proteins
forming
as CHROMOSOMES
in dividing cells

What Does DNA do?



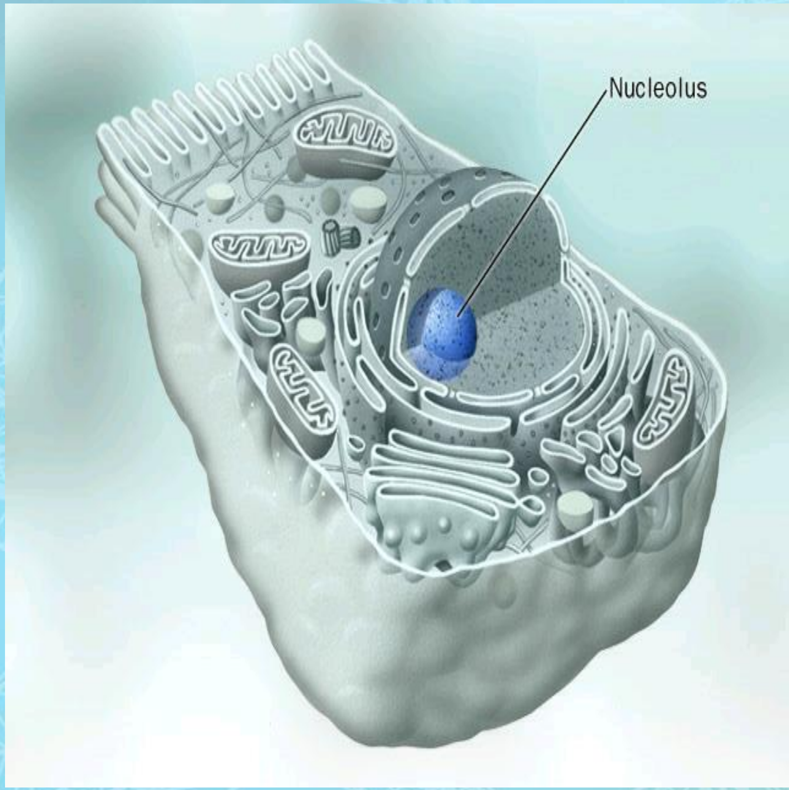
DNA is the **hereditary material** of the cell

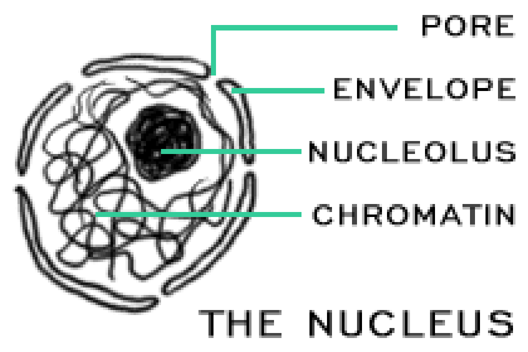


Genes that make up the DNA molecule code for different **proteins**

Nucleolus

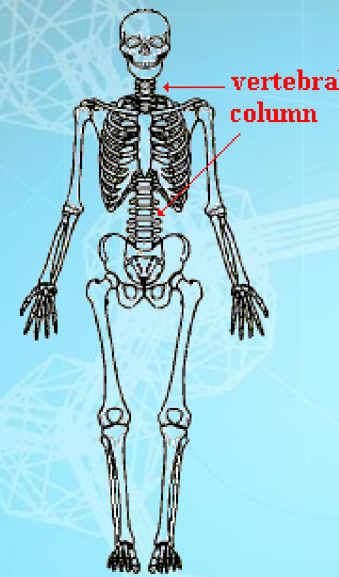
- Inside nucleus
- Cell may have 1 to 3 nucleoli
- Disappears when cell divides
- Makes ribosomes that make proteins

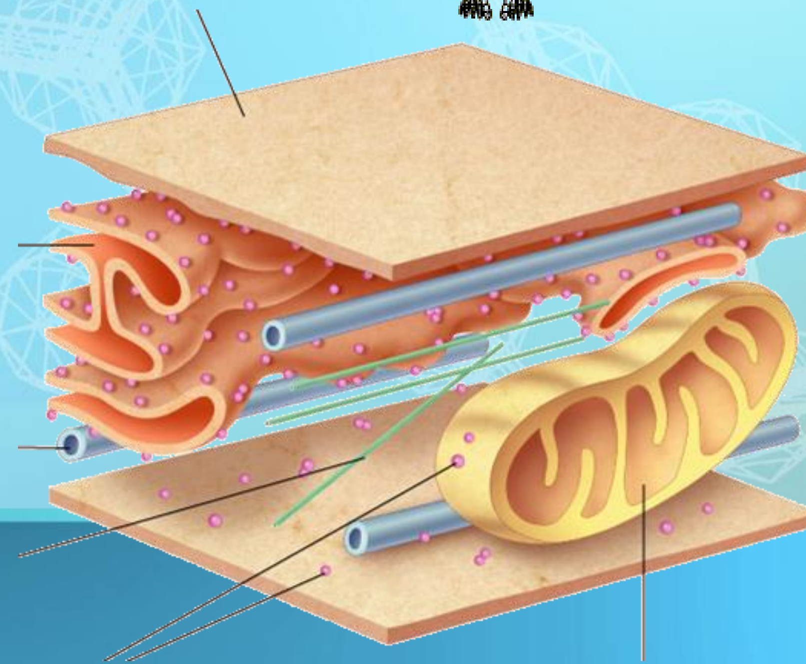




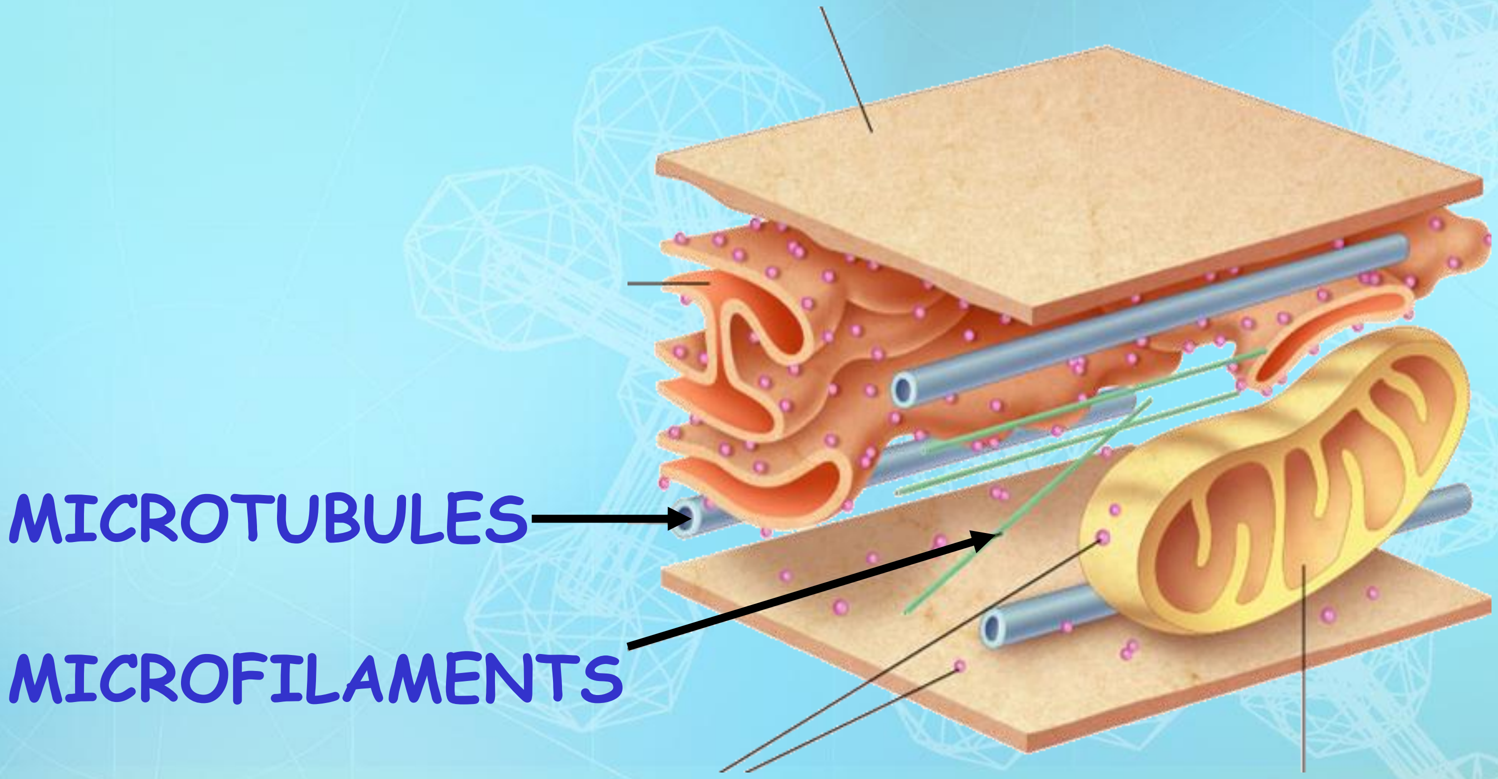
Cytoskeleton

- Helps cell maintain cell shape
- Also help move organelles around
- Made of proteins
- Microfilaments are threadlike & made of ACTIN
- Microtubules are tubelike & made of TUBULIN

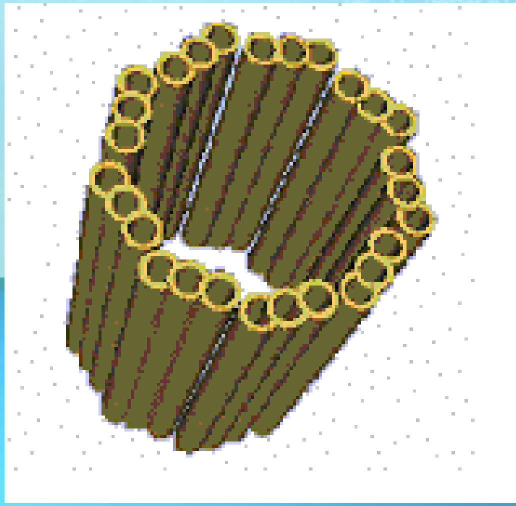




Cytoskeleton



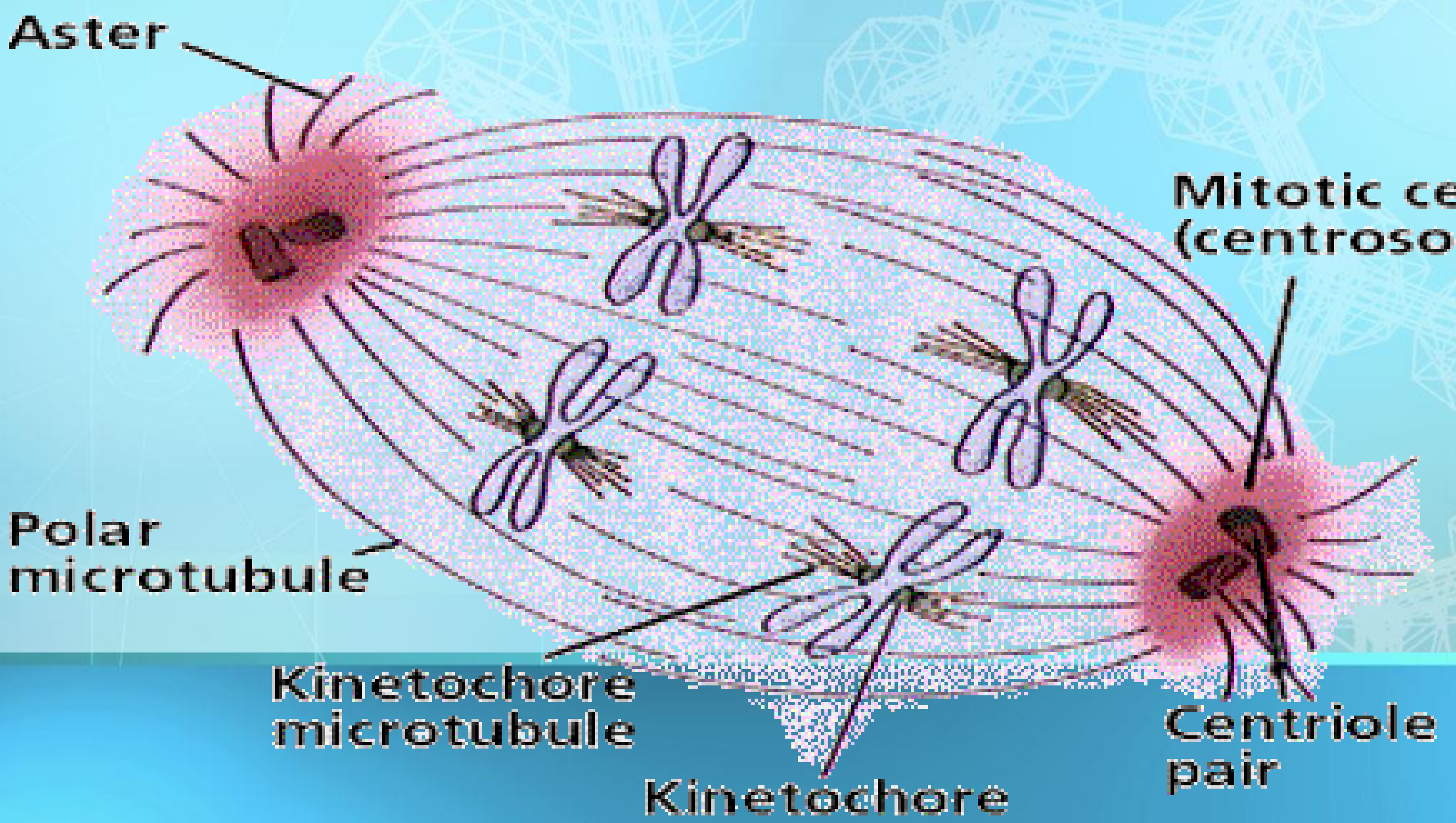
Centrioles



- Found only in animal cells
- Paired structures near nucleus
- Made of bundle of microtubules
- Appear during cell division forming mitotic spindle
- Help to pull chromosome pairs apart to opposite ends of the cell

Centrioles & the Mitotic Spindle

Made of MICROTUBULES (Tubulin)



Mitochondrion (plural = mitochondria)

- “Powerhouse” of the cell
- Generate cellular energy (ATP)
- More active cells like muscle cells have MORE mitochondria
- Both plants & animal cells have mitochondria
- Site of CELLULAR RESPIRATION (burning glucose)

MITOCHONDRIA

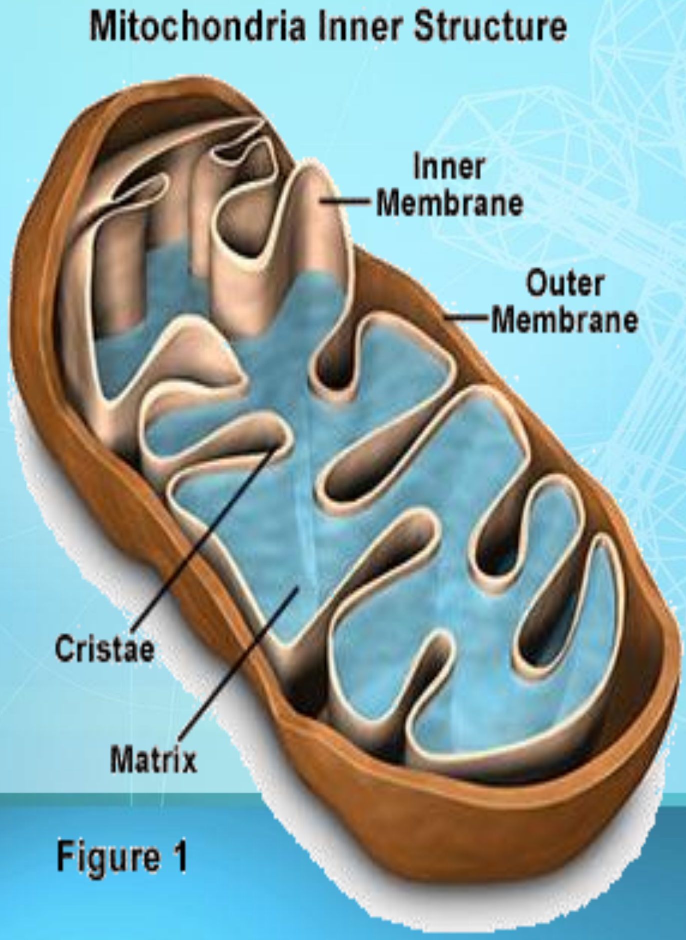


Figure 1

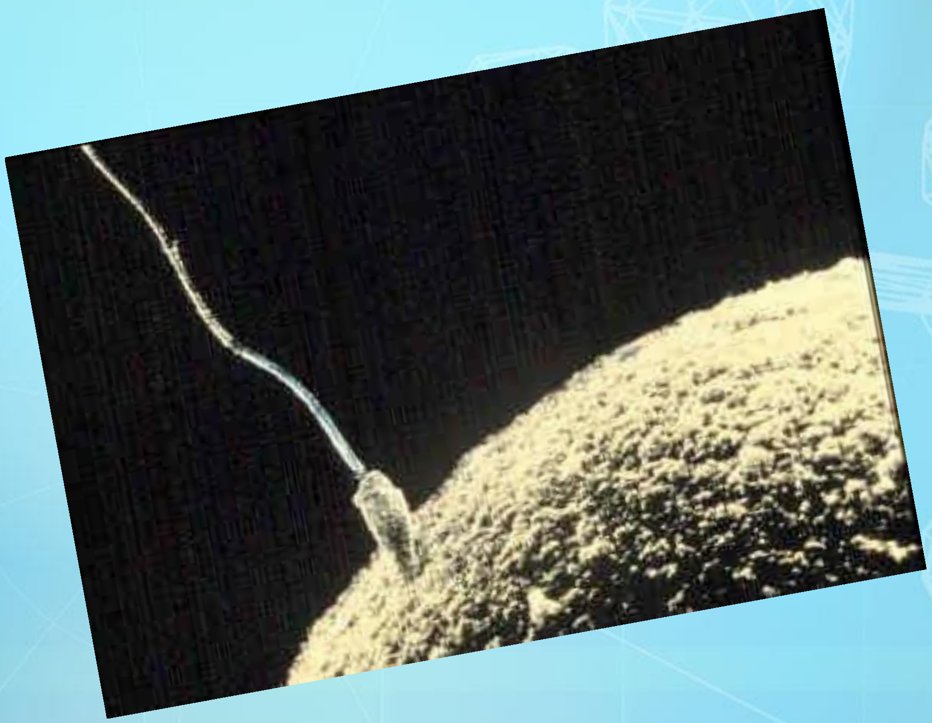
Surrounded by a DOUBLE membrane

Has its own DNA

Folded inner membrane called CRISTAE (increases surface area for more chemical Reactions)

Interior called MATRIX

Interesting Fact ---



- Mitochondria Come from cytoplasm in the EGG cell during fertilization

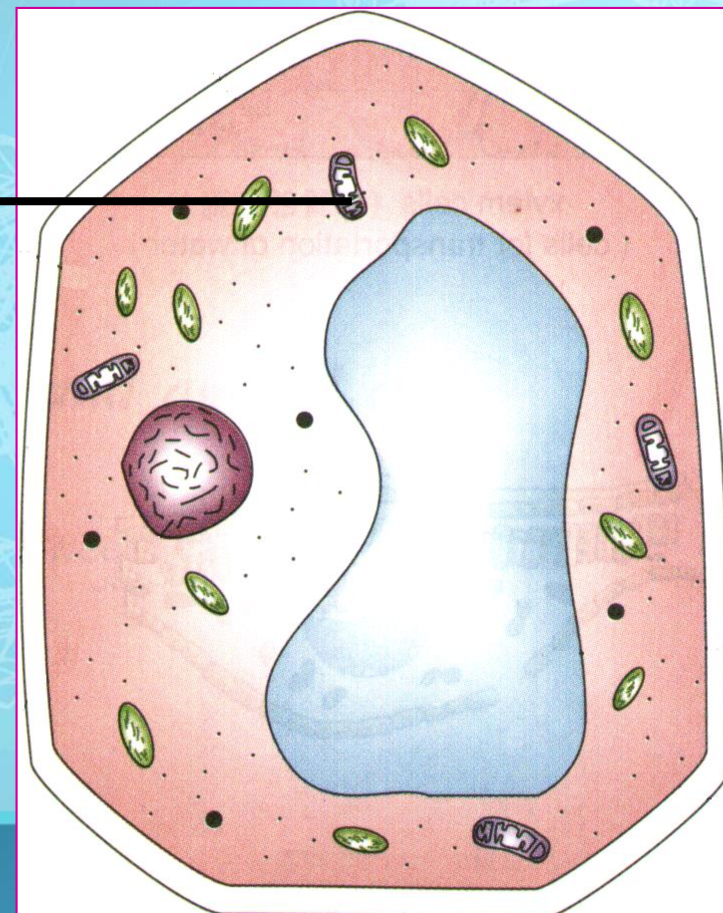
Therefore …

- You inherit your mitochondria from your mother!

Cell Powerhouse

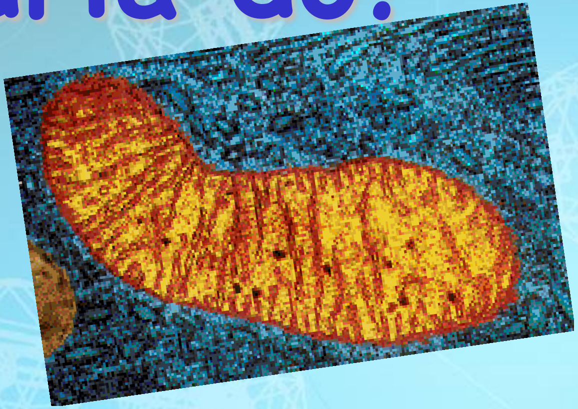
Mitochondrion
(mitochondria)

Rod shape

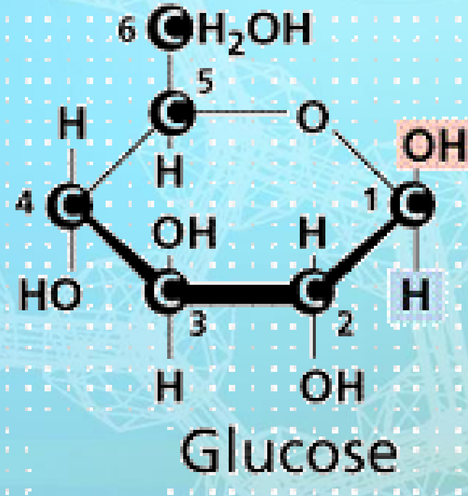


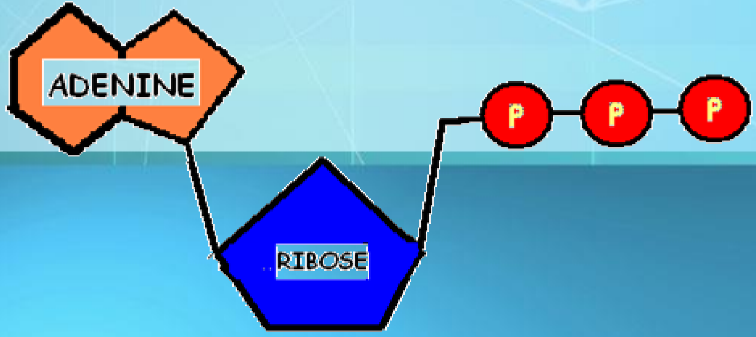
What do mitochondria do?

"Power plant" of the cell



Burns glucose to release energy (ATP)

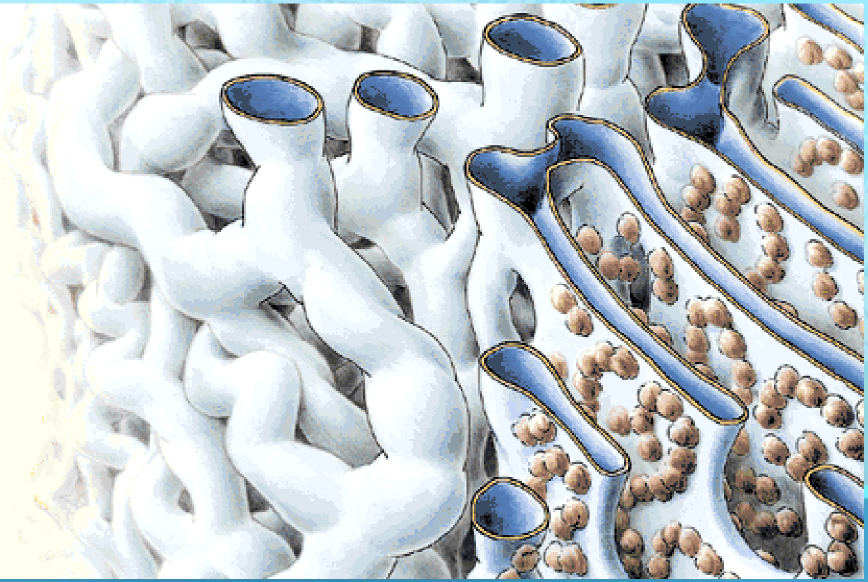




Stores energy as ATP

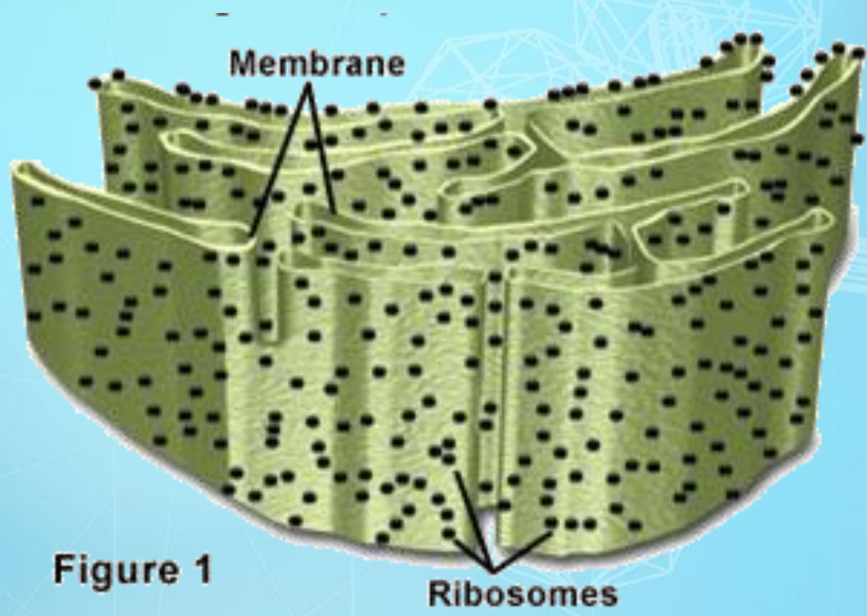
Endoplasmic Reticulum - ER

- Network of **hollow membrane tubules**
- Connects to **nuclear envelope & cell membrane**
- Functions in **Synthesis** of cell products & **Transport**



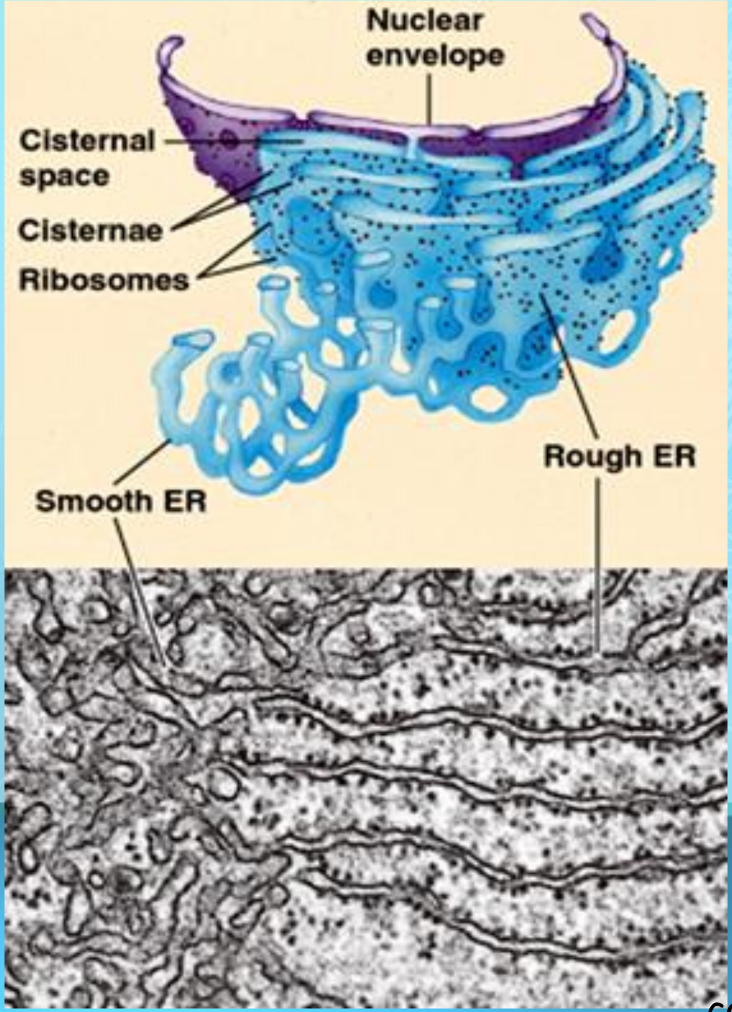
Two kinds of ER ---ROUGH & SMOOTH

Rough Endoplasmic Reticulum (Rough ER)



- Has ribosomes on its surface
- Makes membrane proteins and proteins for EXPORT out of cell

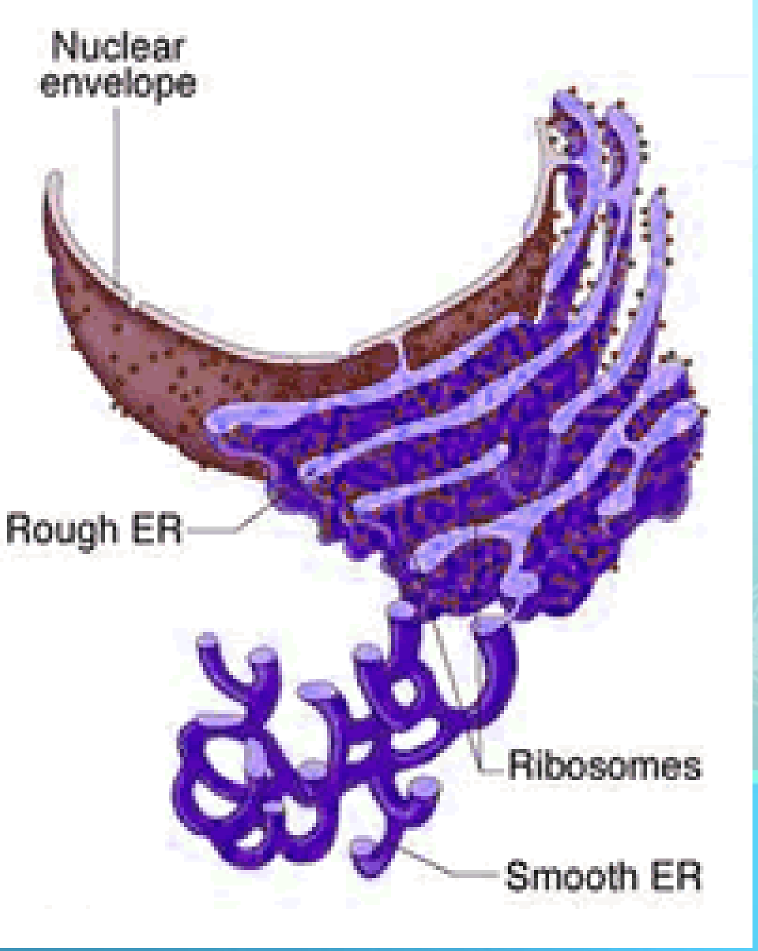
Rough Endoplasmic Reticulum (Rough ER)



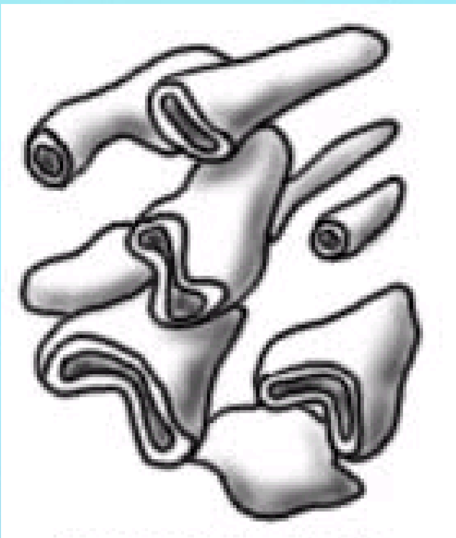
- Proteins are made by ribosomes on ER surface
- They are then threaded into the interior of the Rough ER to be modified and transported

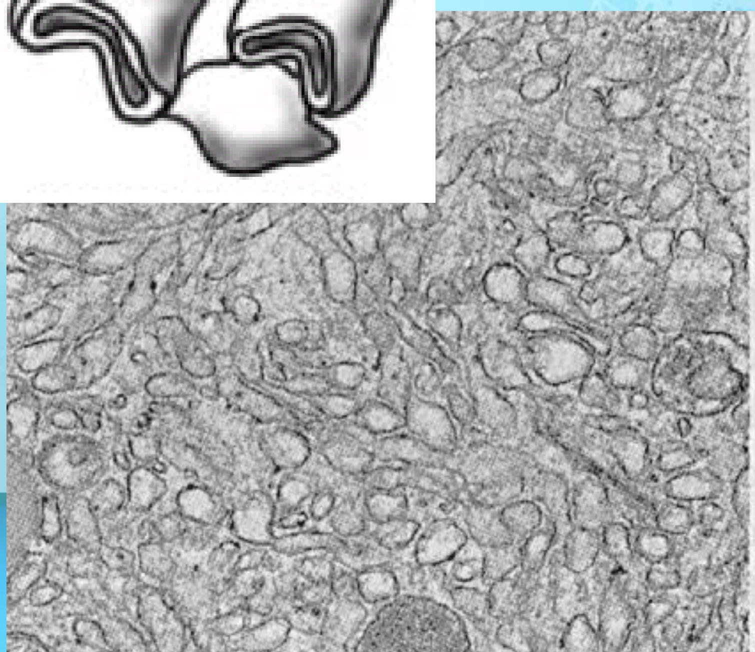
Smooth Endoplasmic Reticulum

- *Smooth ER* lacks ribosomes on its surface
- Is attached to the ends of rough ER
- Makes cell products that are USED INSIDE the cell



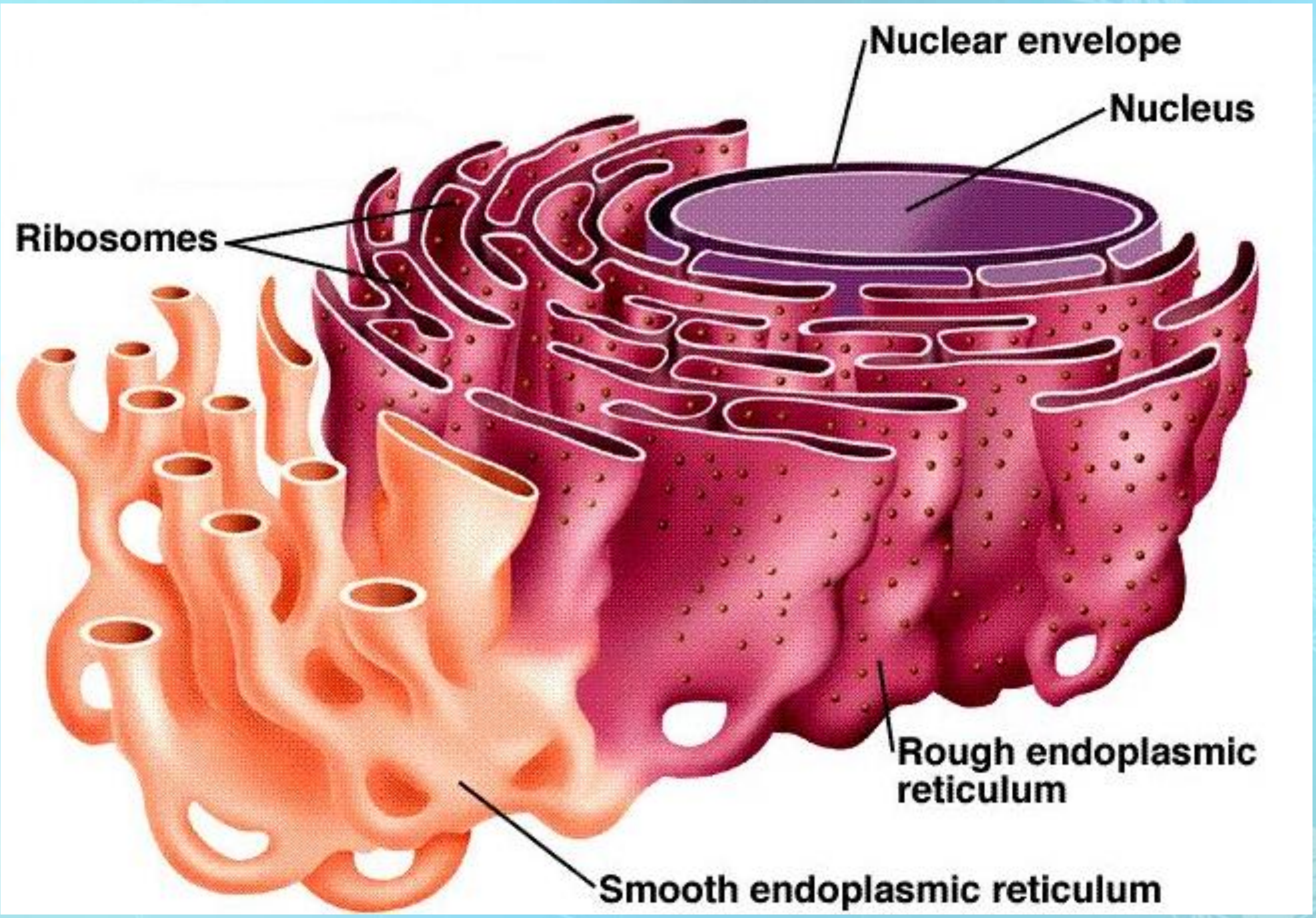
Functions of the Smooth ER





- Makes membrane lipids (steroids)
- Regulates calcium (muscle cells)
- Destroys toxic substances (Liver)

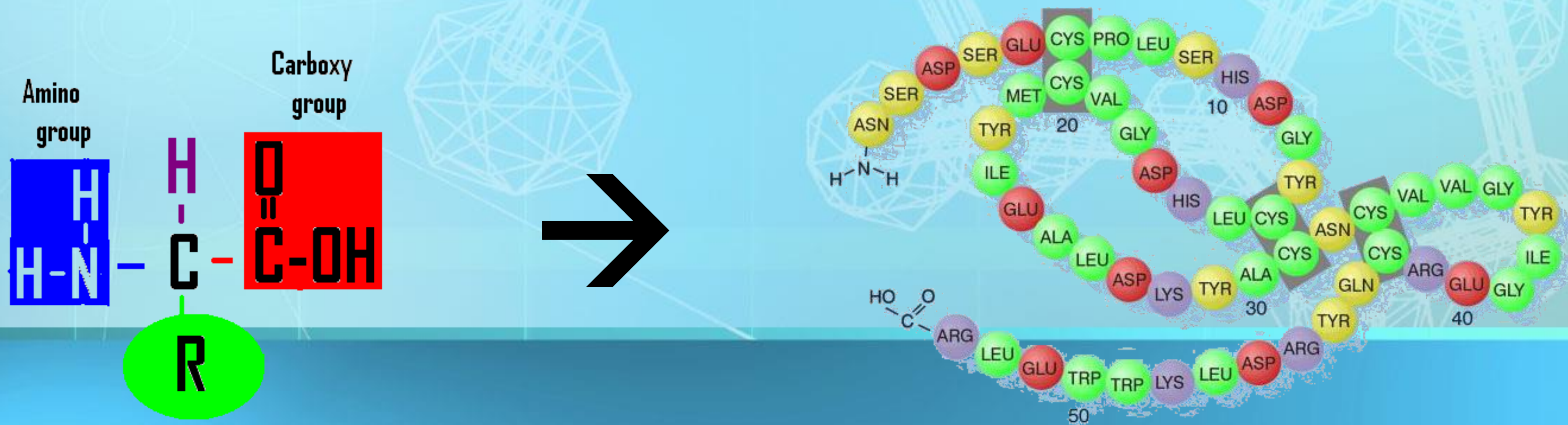
Endomembrane System



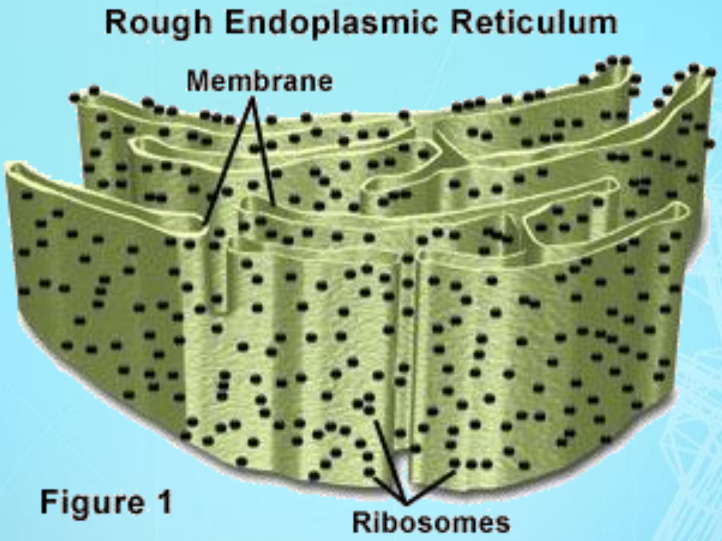
Includes nuclear membrane connected to ER connected to cell membrane (transport)

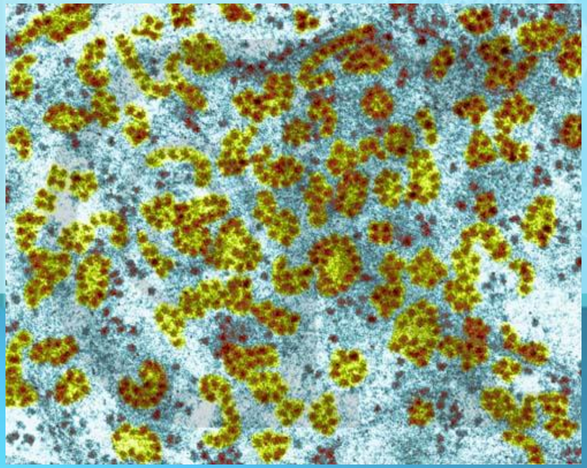
Ribosomes

- Made of PROTEINS and rRNA
- "Protein factories" for cell
- Join amino acids to make proteins
- Process called protein synthesis



Ribosomes





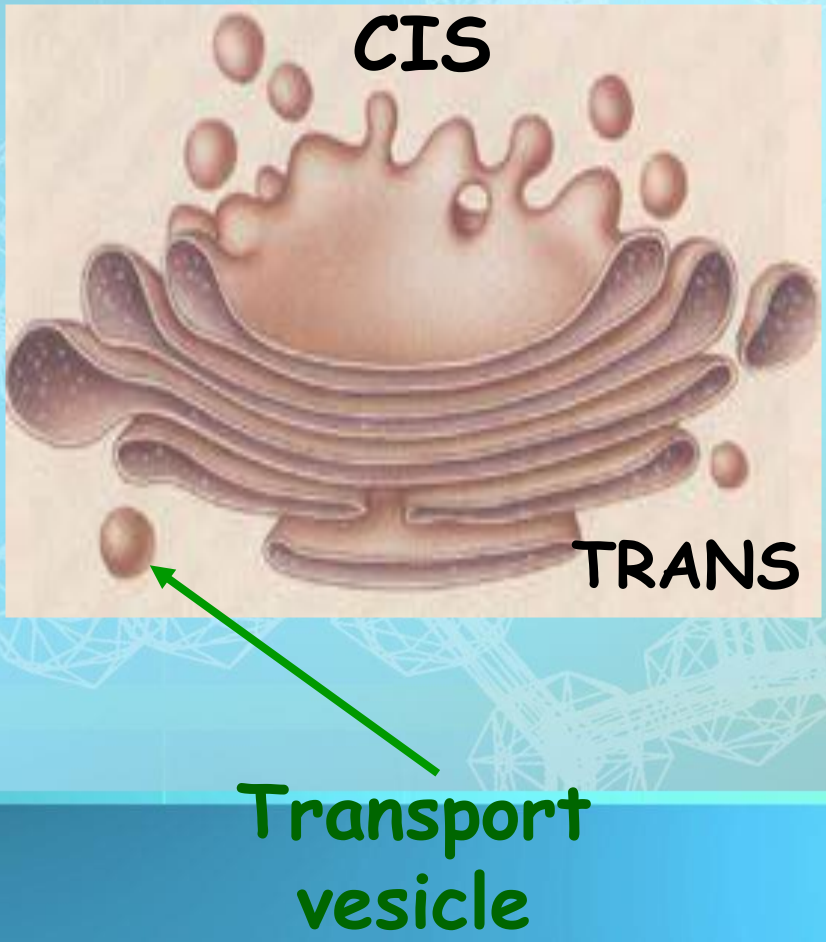
Can be attached to Rough ER

OR

Be free (unattached) in the **cytoplasm**

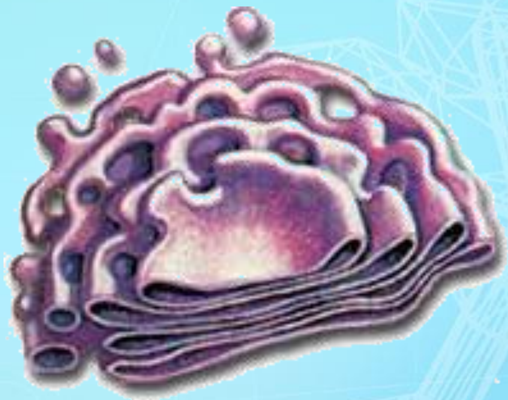
Golgi Bodies

- Stacks of flattened sacs
- Have a shipping side (trans face) and receiving side (cis face)
- Receive proteins made by ER
- Transport vesicles with modified proteins pinch off the ends

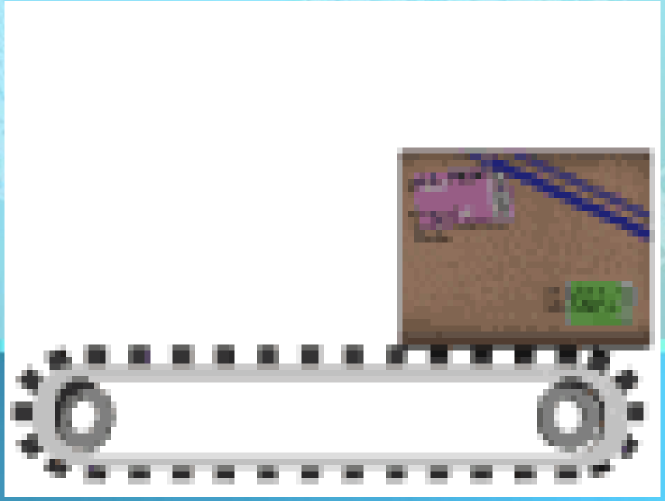


Golgi Bodies

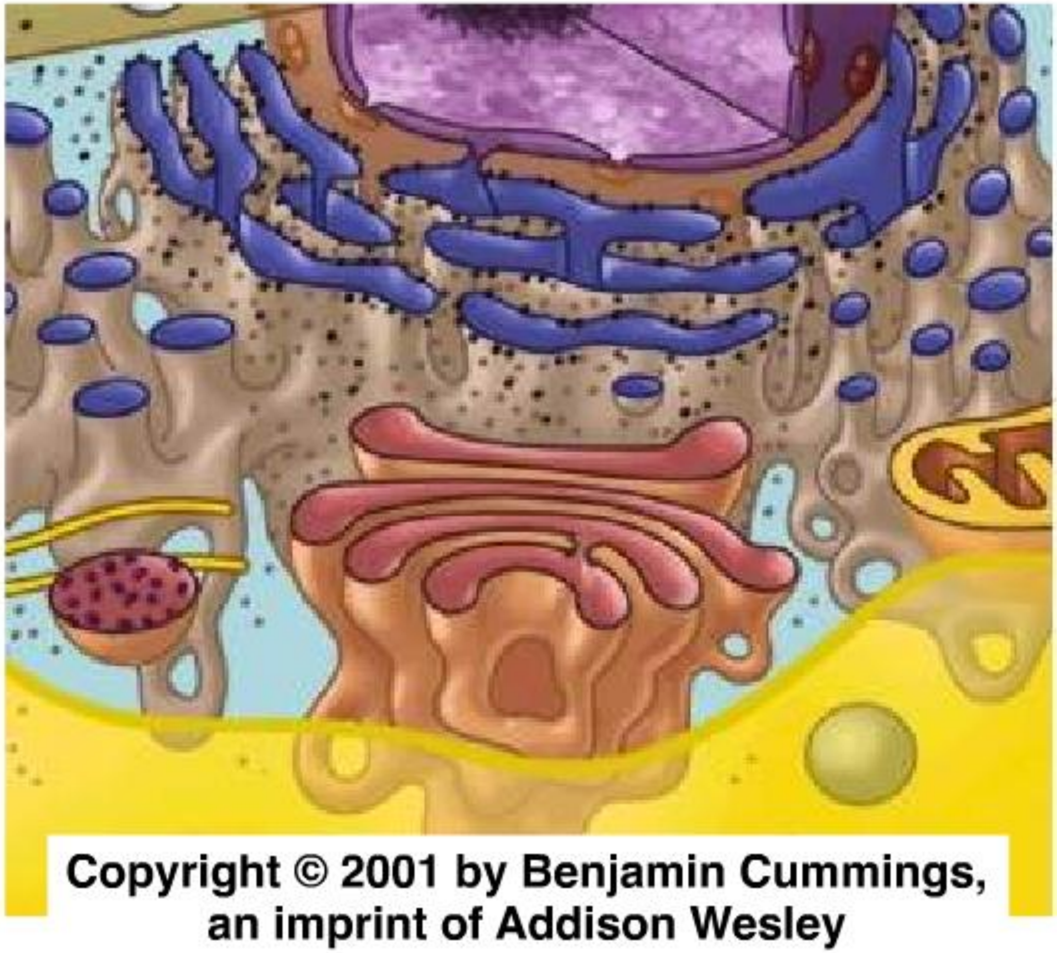
Look like a stack of pancakes



Modify, sort, & package molecules from ER for storage OR transport out of cell



Golgi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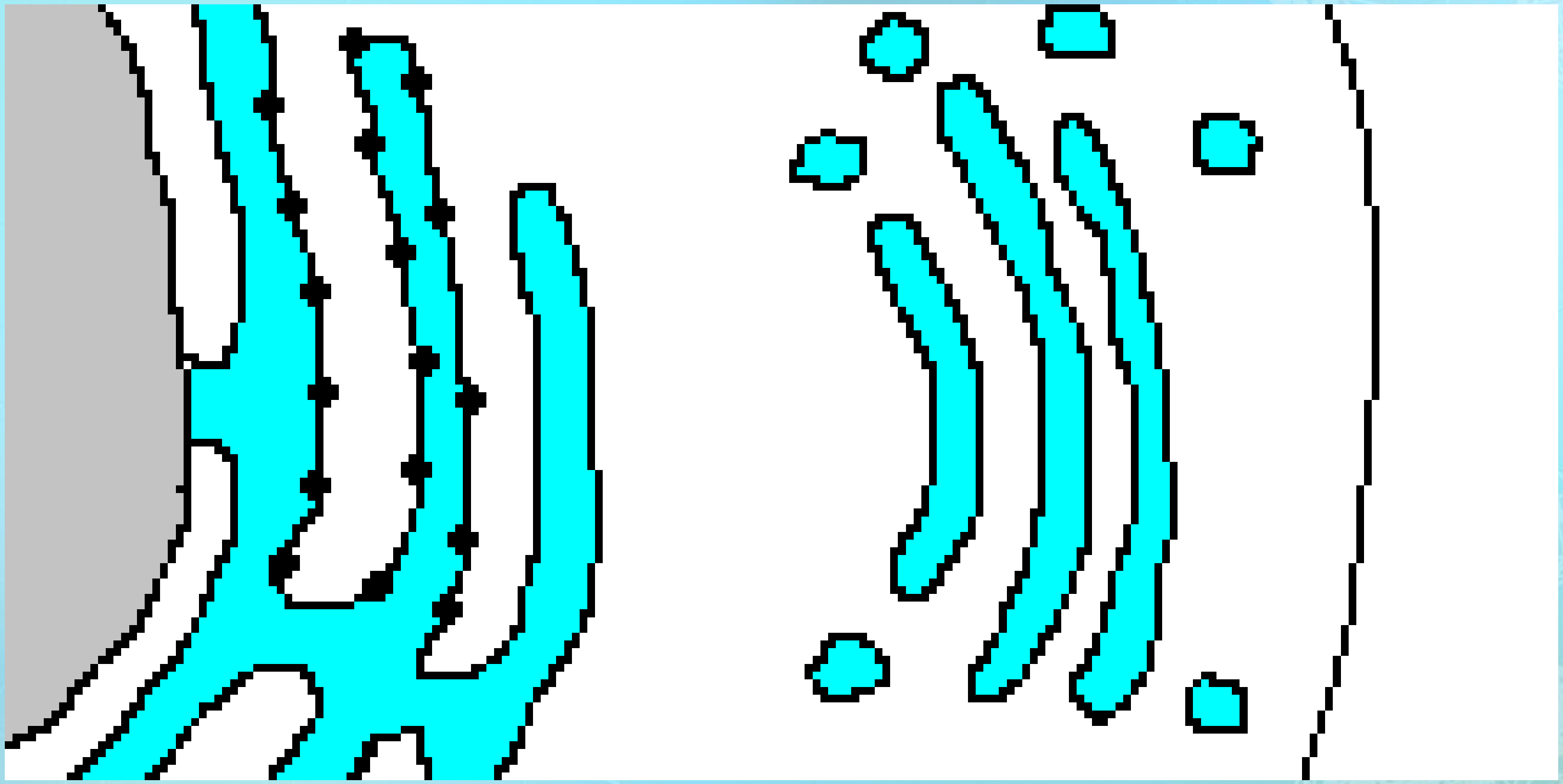
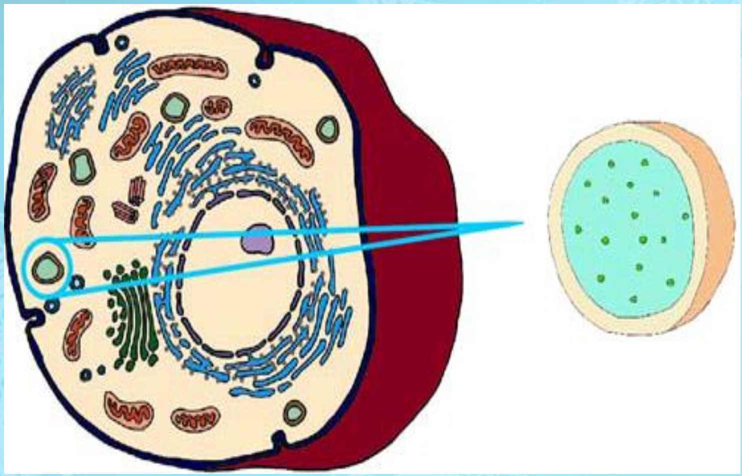
Golgi Animation

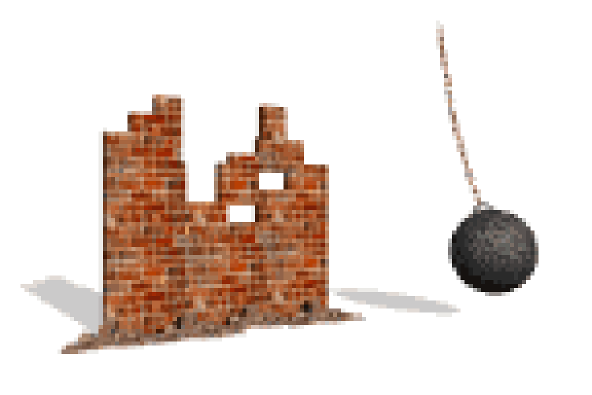


Materials are transported from Rough ER to Golgi to the cell membrane by VESICLES

Lysosomes

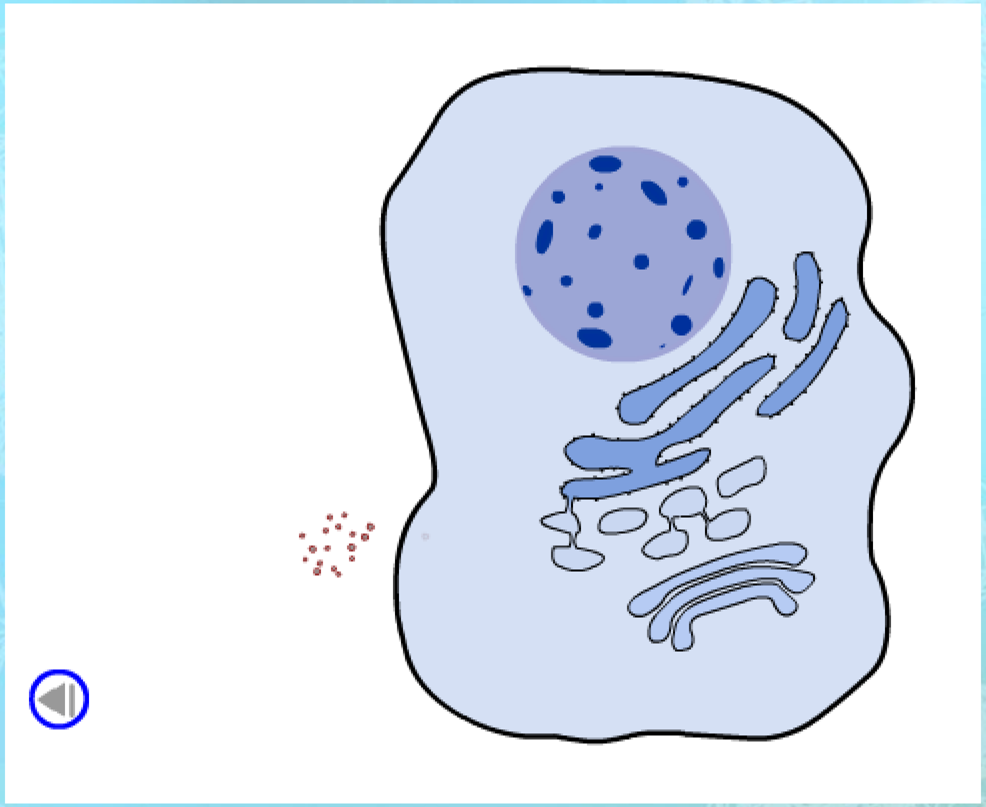
- Contain digestive enzymes
- Break down food, bacteria, and worn out cell parts for cells
- Programmed for cell death (AUTOLYSIS)
- Lyse (break open) & release enzymes to break down & recycle cell parts)





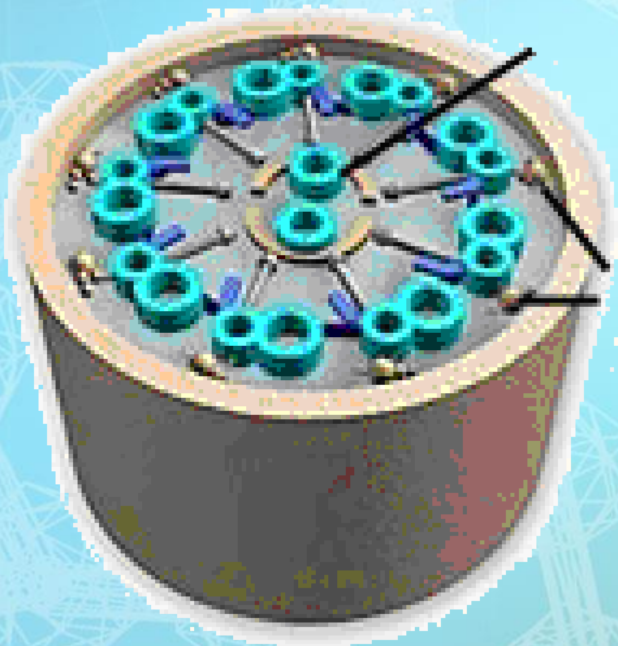
Lysosome Digestion

- Cells take in food by **phagocytosis**
- Lysosomes **digest** the food & get **rid of wastes**



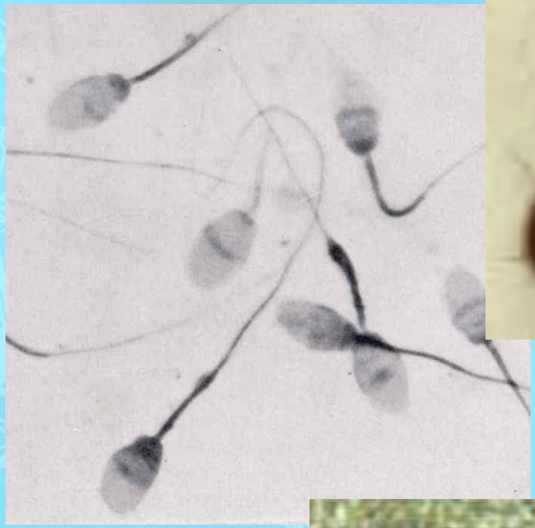
Cilia & Flagella

- Made of protein tubes called microtubules
- Microtubules arranged (9 + 2 arrangement)
- Function in moving cells, in moving fluids, or in small particles across the cell surface

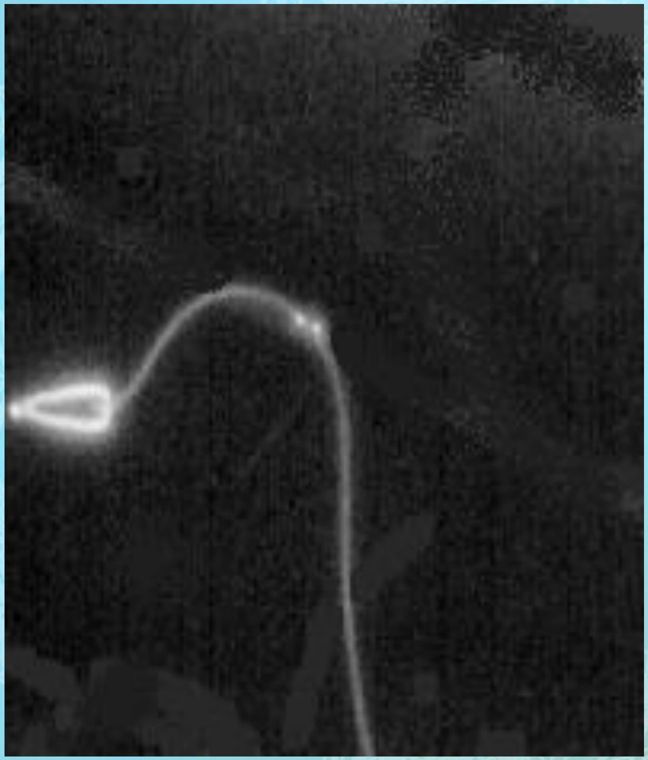


Cilia & Flagella

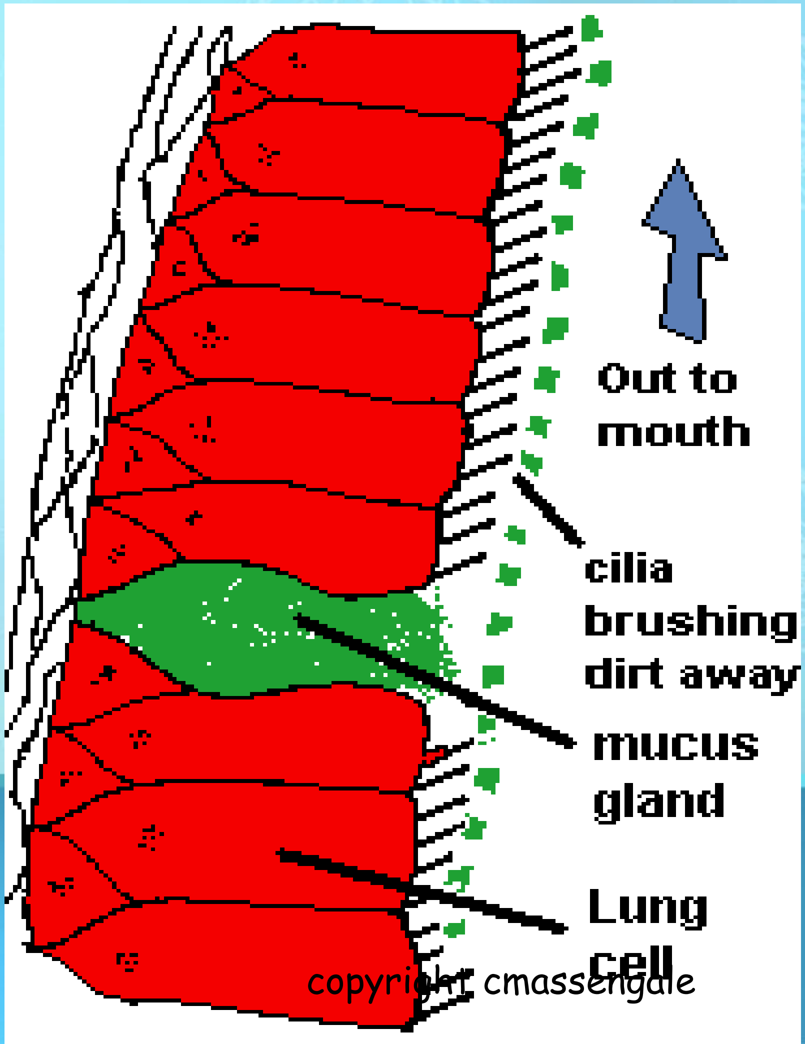
- **Cilia** are shorter and more numerous on cells
- **Flagella** are longer and fewer (usually 1-3) on cells



Cell Movement with Cilia & Flagella

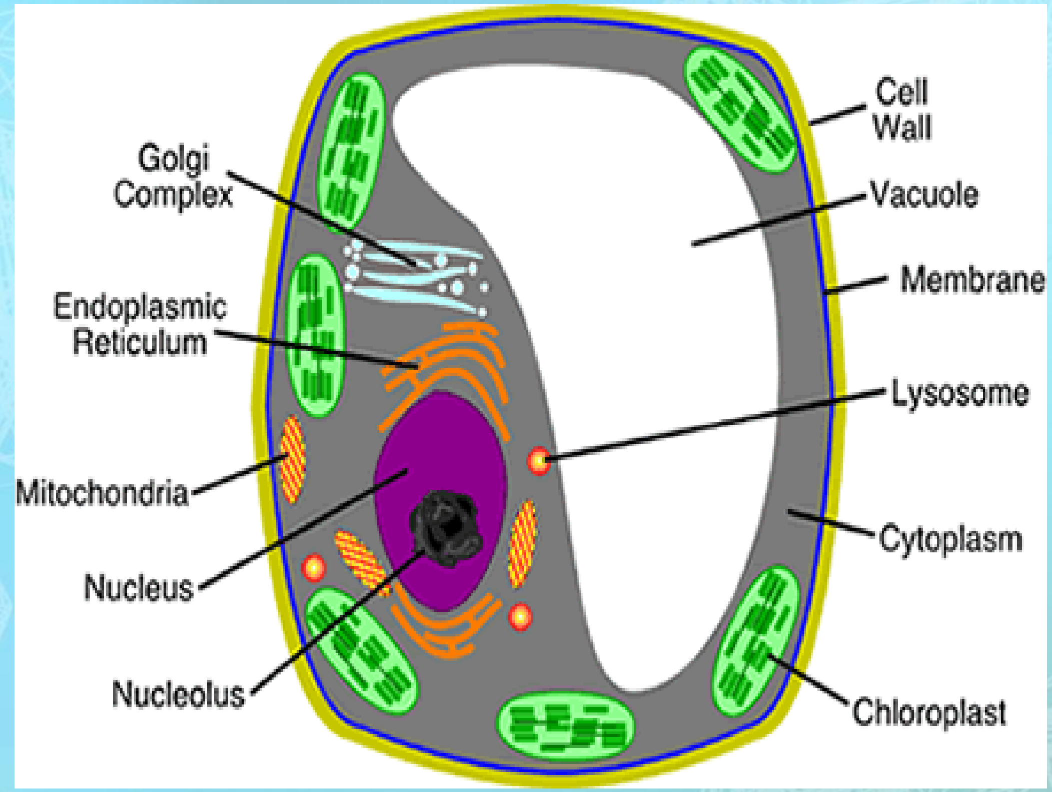


Cilia Moving Away Dust Particles from the Lungs
Respiratory System



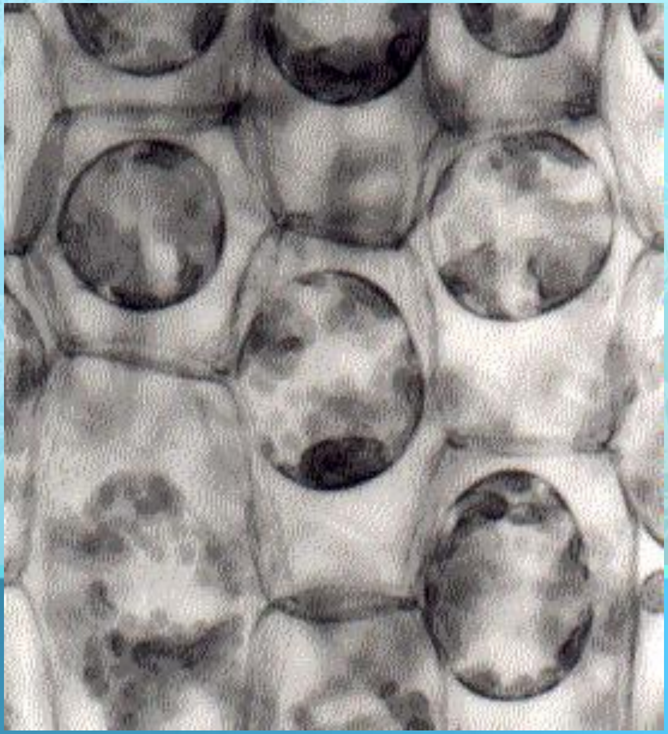
Vacuoles

- **Fluid filled** sacks for **storage**
- **Small or absent** in *animal* cells
- *Plant* cells have a **large Central Vacuole**
- **No vacuoles** in *bacterial* cells



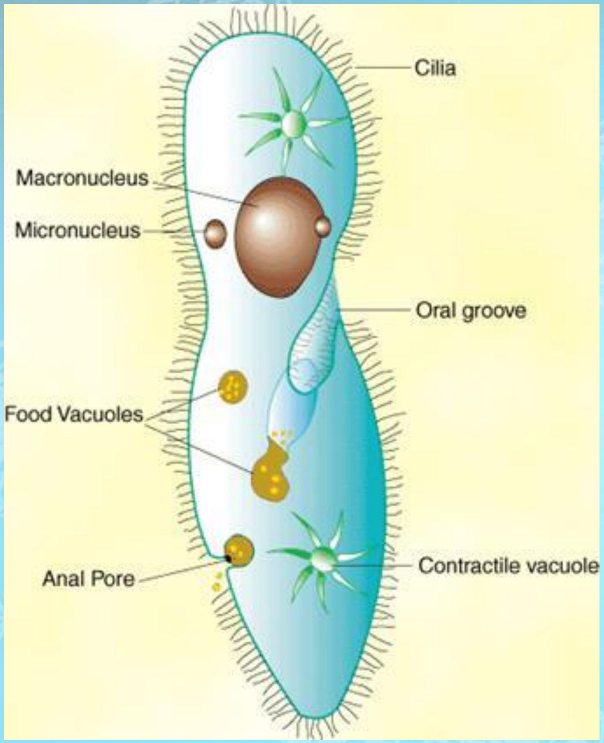
Vacuoles

- In plants, they store Cell Sap
- Includes storage of sugars, proteins, minerals, lipids, wastes, salts, water, and enzymes

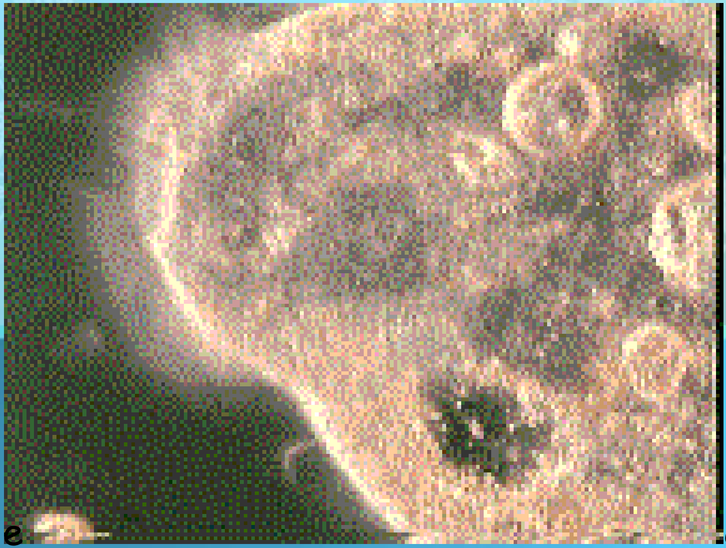


Contractile Vacuole

- Found in unicellular protists like **paramecia**
- **Regulate water** intake by **pumping out excess** (homeostasis)
- Keeps the cell from lysing (bursting)

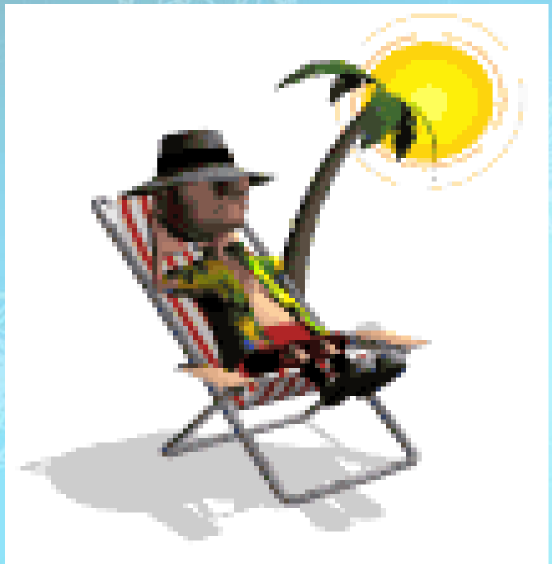


Contractile vacuole animation ↗



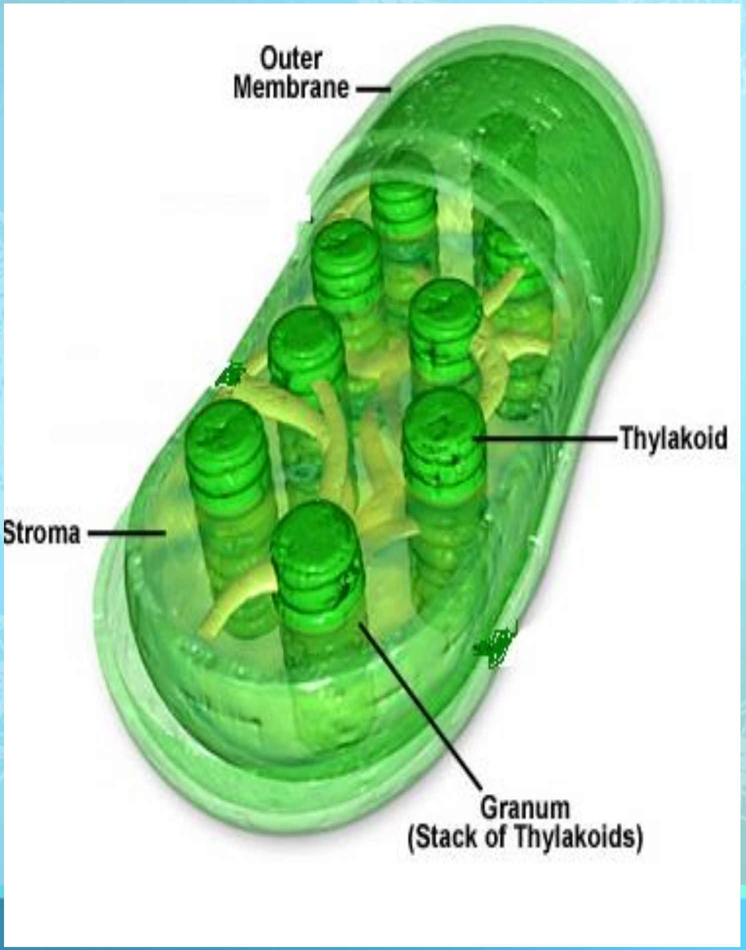
Chloroplasts

- Found only in producers (organisms containing chlorophyll)
- Use energy from sunlight to make own food (glucose)
- Energy from sun stored in the Chemical Bonds of Sugars



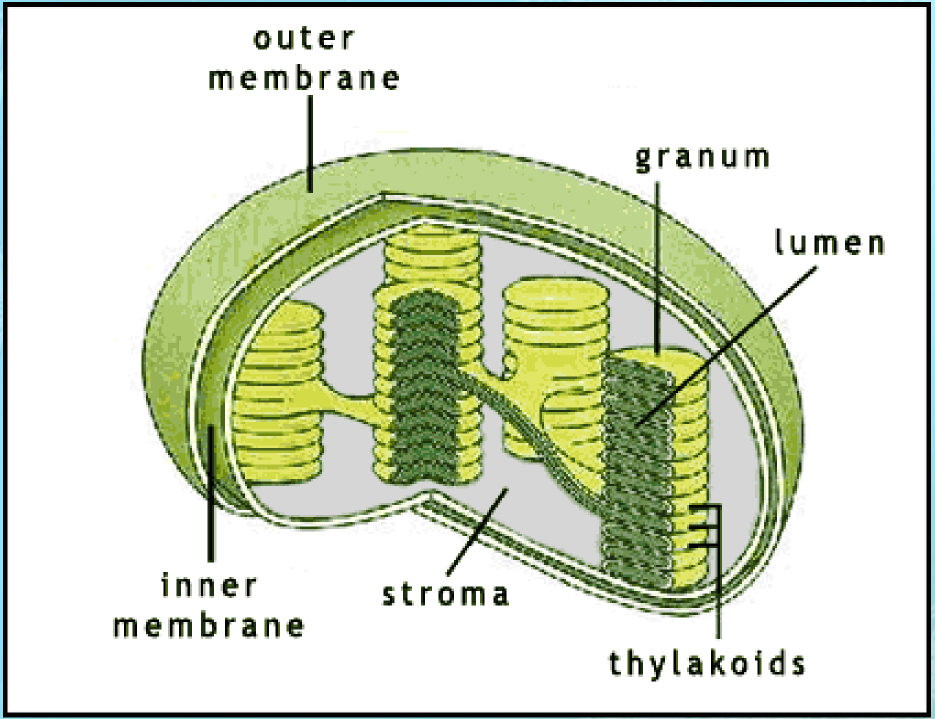
Chloroplasts

- Surrounded by DOUBLE membrane
- Outer membrane smooth
- Inner membrane modified into sacs called Thylakoids
- Thylakoids in stacks called Grana & interconnected
- Stroma – gel like material surrounding thylakoids



Chloroplasts

- Contains its own DNA
- Contains enzymes & pigments for Photosynthesis
- Never in animal or bacterial cells
- Photosynthesis – food making process



Cell Size

Question:

Are the cells in an elephant bigger, smaller, or about the same size as those in a mouse?

Factors Affecting Cell Size

- Surface area (plasma membrane surface) is determined by multiplying length times width (L x W)
- Volume of a cell is determined by multiplying length times width times height (L x W x H)
- Therefore, Volume increases FASTER than the surface area

Cell Size

- When the surface area is no longer great enough to get rid of all the wastes and to get in enough food and water, **then the cell must divide**
- **Therefore, the cells of an organism are close in size**

Cell Size

Question:

Are the cells in an elephant bigger, smaller, or about the same size as those in a mouse?

About the same size, but …

The elephant has MANY MORE cells than a mouse!

THANK YOU

Prokaryotes & Eukaryotes

PROKARYOTES *Vs* EUKARYOTES

What are Prokaryotes & Eukaryotes?

- Two fundamental or basic classes of cells
- Distinguished by their size and internal structures
- Existence of two classes of cells without any intermediate type represents one of the most fundamental evolutionary separations in the living world
- Prokaryotes more primitive to eukaryotes
- Share many common characteristics
- Shared properties reflect the fact that eukaryotic cells most certainly evolved from prokaryotic ancestors

Prokaryotes & Eukaryotes Similarities

PROKARYOTES *Vs* EUKARYOTES

Similarities between Prokaryotes and Eukaryotes:

- Cellular contents limited by plasma membrane
- Plasma membrane composed of lipid bilayer with intermittent proteins
- DNA is the genetic information carrier in both the groups
- Chemical composition of nucleic acids (DNA and RNA) and their organization are similar in both groups
- Process of transcription, translation and DNA replication occurs in both prokaryotes and eukaryotes

PROKARYOTES *Vs* EUKARYOTES

Similarities between Prokaryotes and Eukaryotes:

- Both groups processes regulation of expression of genetic information
- mRNA acts as the intermediate molecule between genetic information and their expression (as proteins) in both groups
- Proteins are the expression of genetic information in both groups
- All the 20 protein coding amino acids are similar
- All the 61 codons are similar in both groups

PROKARYOTES *Vs* EUKARYOTES

Similarities between Prokaryotes and Eukaryotes:

- All the tree stop codons (UAA, UAG, UGA) are similar in both groups
- Structure of tRNA is similar in both groups
- Metabolic pathways such as glycolysis and TCA cycle are similar in both prokaryotes and eukaryotes
- Metabolic pathways are multi-step processes each step catalyzed by specialized proteins called enzymes
- ATP is the energy currency in both prokaryotes and eukaryotes

PROKARYOTES *Vs* EUKARYOTES

Similarities between Prokaryotes and Eukaryotes:

- ATP is produced by the use of proton (H+) gradient
- Photosynthesis is similar in both prokaryotes (blue green algae) and eukaryotes (plants)
- Photosynthesis consists of two process
    1. Light dependent 'light reaction'
    2. Light independent 'dark reaction'
- Proteasomes are with similar structure and working in both groups

These are the similarities between prokaryotes and eukaryotes

Prokaryotes & Eukaryotes Differences

PROKARYOTES *Vs* EUKARYOTES

Difference between Prokaryotes and Eukaryotes:

- Overall biological process, events and organization are similar in both prokaryotes and eukaryotes
- However each component and their interactions to each other vary in both groups.
- Major differences between Prokaryotes and Eukaryotes are summarized as follows

PROKARYOTES *Vs* EUKARYOTES

Difference between Prokaryotes and Eukaryotes:

Sl. No.	Prokaryotes	Eukaryotes
1	'pro' = pre, 'karyon'= nucleus	'eu' = true, 'karyo' = nucleus
2	Originated about 3.5 billion years ago	Originated about 1.2 billion years ago
3	Primitive forms	Advanced forms
4	Usually unicellular organization	Usually multicellular organization
5	Incipient nucleus, true nucleus absent	True nucleus present
6	Small cell size, usually 1 – 10 µm	Larger cell size, usually 5 – 100 µm, sometimes very large and macroscopic

PROKARYOTES *Vs* EUKARYOTES

Difference between Prokaryotes and Eukaryotes:

Sl. No.	Prokaryotes	Eukaryotes
7	Membrane bounded organelles such as nucleus, mitochondria, Golgi bodies, chloroplasts, lysosome, peroxisomes, ER etc. are absent	Membrane bounded organelles present. Majority of organelles have single or double membrane system
8	Genetic material consists of single chromosome	Genetic materials usually consists of more than one chromosomes
9	Genetic material is freely distributed in the central portion of the cell (nucleoplasm)	Genetic material is located in the nucleus
10	Chromosome with covalently closed circular DNA (ccc DNA)	Chromosome with linear DNA

PROKARYOTES *Vs* EUKARYOTES

Difference between Prokaryotes and Eukaryotes:

Sl. No.	Prokaryotes	Eukaryotes
11	Cell division by fission or budding, Mitosis and Meiosis completely absent	Cell division by mitosis and meiosis
12	Nucleolus absent	A well-developed nucleolus present
13	Ribosome 70S type	Ribosome 80S type
14	Two subunits of ribosomes are 50S large subunit and 30S small subunit	Two subunits of ribosome are 60S larger subunit and 40S smaller subunit
15	DNA is naked, not associated with histone proteins	DNA is wrapped around histone proteins

PROKARYOTES *Vs* EUKARYOTES

Difference between Prokaryotes and Eukaryotes:

Sl. No.	Prokaryotes	Eukaryotes
15	Endoplasmic reticulum absent and hence protein synthesizing ribosome freely distributed in the cytoplasm	Endoplasmic reticulum present, protein synthesizing ribosome usually attached to endoplasmic reticulum
16	Internal membrane system scarce. If present, associated with respiration and photosynthesis	Internal membrane system well developed. Cell organelles are surrounded by single or double membranes
17	Flagella with simple organization	Flagella (if present) is very complex with 9 + 2 arrangement of microtubules
18	Microtubules absent in flagella	Microtubules present in flagella

PROKARYOTES *Vs* EUKARYOTES

Difference between Prokaryotes and Eukaryotes:

Sl. No.	Prokaryotes	Eukaryotes
19	Flagella extracellular and not enclosed by cell surface membrane	Flagella intracellular and surrounded by cell surface membrane
20	Cell wall is composed of muco-polysaccharides	Cell wall (if present) composed of cellulose (in plants) and chitin (in fungi). Cell wall absent in animal cells
21	Organisms haploid, contain only a single copy of genome	Organisms usually diploid very rarely polyploids, contains two copies of genome, one from each parent
22	Plasmid (extra-chromosomal genetic materials) usually present	Plasmids absent, however mitochondria and chloroplasts are autonomous with its own genetic materials

PROKARYOTES *Vs* EUKARYOTES

Difference between Prokaryotes and Eukaryotes:

Sl. No.	Prokaryotes	Eukaryotes
23	Cytoskeleton system absent	Cytoskeleton system well developed
24	Sexual reproduction absent	Sexual reproduction present
25	Processes like transformation conjugation and, transduction present for genetic material exchange	All such processes completely absent, and genetic exchange occurs through sexual reproduction
26	Respiration is by mesosomes	Respiration is by mitochondria
27	Chloroplasts and mitochondria absent	Chloroplasts and mitochondria present, both are double membrane bounded and autonomous with its own genetic materials

PROKARYOTES *Vs* EUKARYOTES

Difference between Prokaryotes and Eukaryotes:

Sl. No.	Prokaryotes	Eukaryotes
28	Photosynthesis takes place in the membrane system of cytoplasm	Photosynthesis takes place in chloroplast. Chloroplasts contains membrane stacks into lamella or stroma
29	Nitrogen fixing capacity is present in some forms	Nitrogen fixing capacity is completely absent. None of the eukaryotic cells is known to processes nitrogen fixing ability both in plants and animals
30	Endocytosis and phagocytosis completely absent	Endocytosis and phagocytosis is present in some animals cells
31	Cytoplasmic movement (cyclosis) absent	Cyclosis present

PROKARYOTES *Vs* EUKARYOTES

Difference between Prokaryotes and Eukaryotes:

Sl. No.	Prokaryotes	Eukaryotes
32	Well-developed intracellular and extracellular communication system absent	Communication system is well developed and advanced
33	Cell cycle duration about 20 – 60 minutes	Highly varies, rapidly dividing cells the cell cycle is ~ 24 hours
34	Regulatory mechanisms of DNA relatively simple	Regulatory mechanism highly complex
35	Transcription and translation are continuous process and occurs simultaneously in the cytoplasm	They are separate processes, transcription occurs in the nucleus whereas translation occurs in the cytoplasm

Membrane structure and Functions

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Assistant Professor
Department of Botany
Government Arts College
Coimbatore

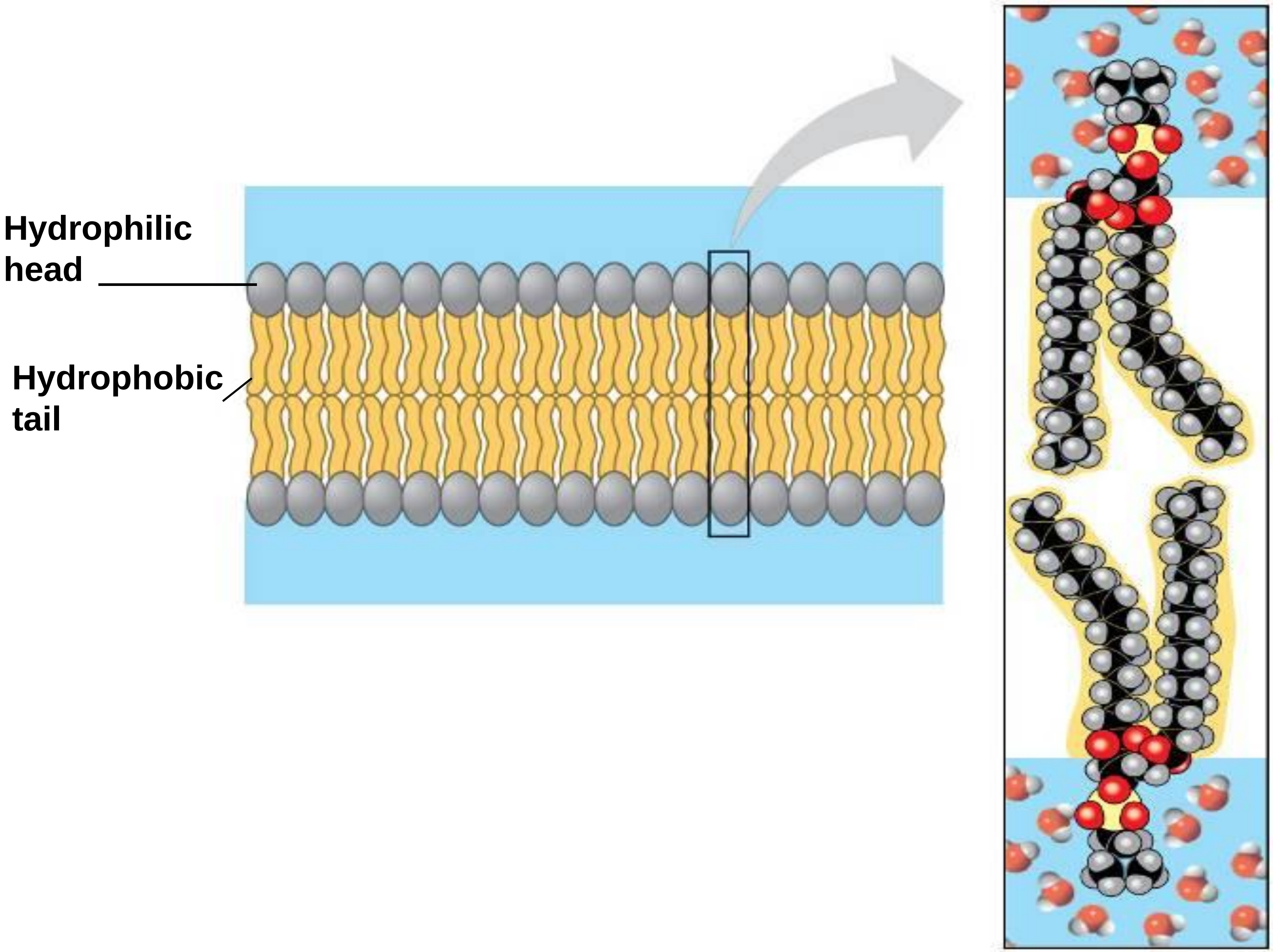
Overview

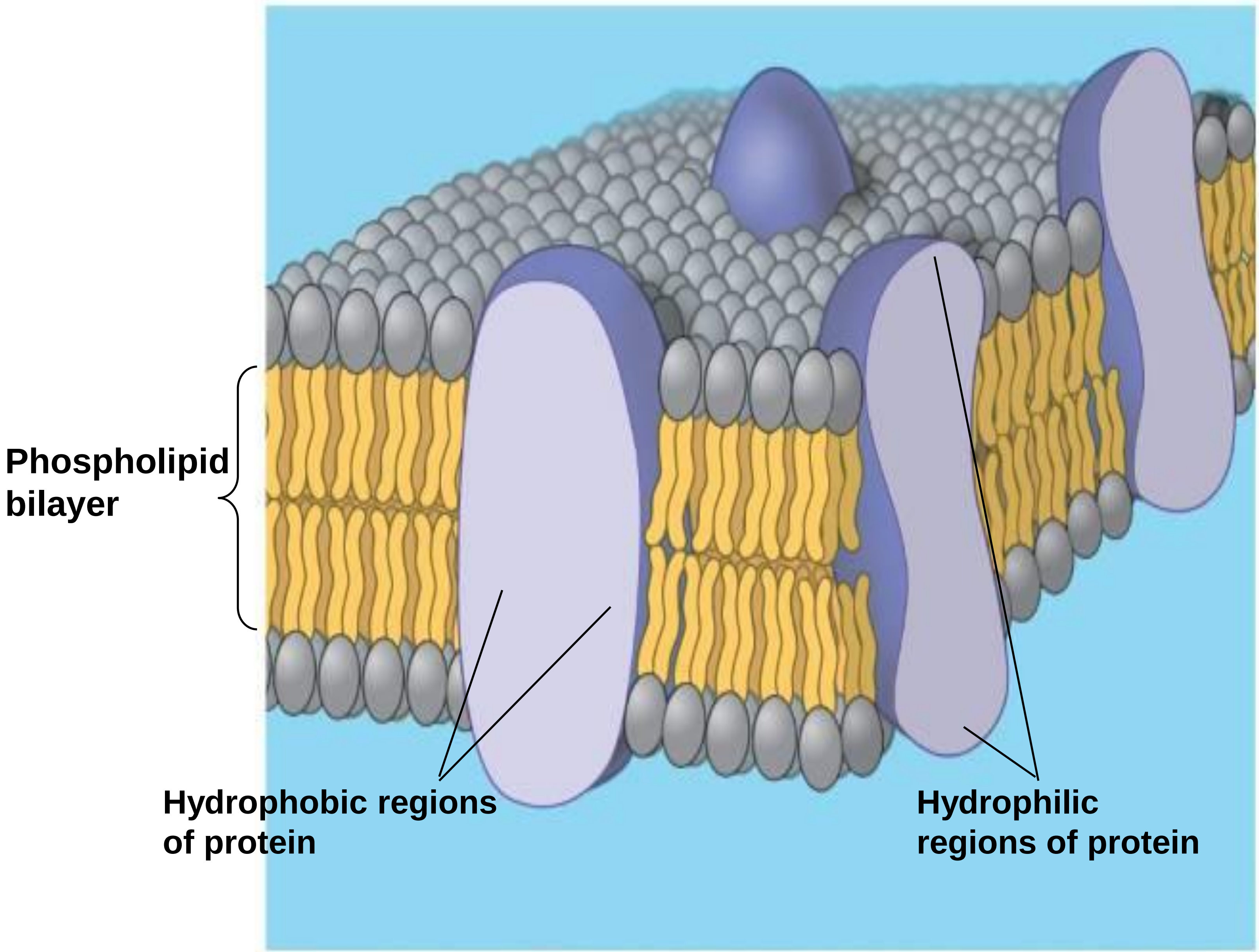
- The plasma membrane is the boundary that separates the living cell from its surroundings

- The plasma membrane exhibits **selective permeability**, allowing some substances to cross it more easily than others

Cellular membranes are fluid mosaics of lipids and proteins

- Phospholipids are the most abundant lipid in the plasma membrane
- Phospholipids are **amphipathic molecules**, containing hydrophobic and hydrophilic regions
- The **fluid mosaic model** states that a membrane is a fluid structure with a “mosaic” of various proteins embedded in it


Hydrophilic head
Hydrophobic tail


Phospholipid bilayer
Hydrophobic regions of protein
Hydrophilic regions of protein

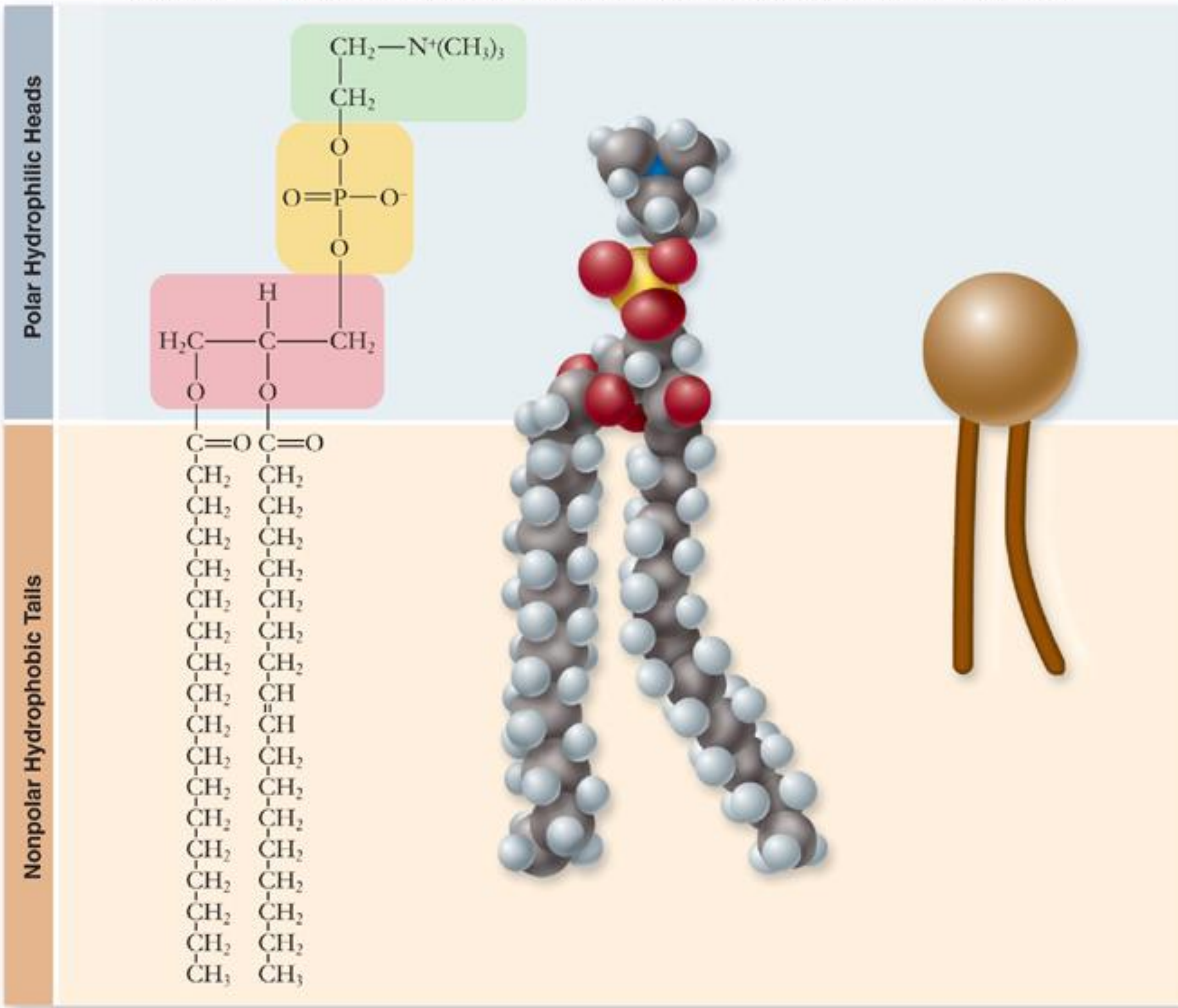
- In 1935, Hugh Davson and James Danielli proposed a sandwich model in which the phospholipid bilayer lies between two layers of globular proteins
- Later studies found problems with this model, particularly the placement of membrane proteins, which have hydrophilic and hydrophobic regions
- In 1972, S. J. Singer and G. Nicolson proposed that the membrane is a mosaic of proteins dispersed within the bilayer, with only the hydrophilic regions exposed to water

Membrane Structure

The **fluid mosaic model** of membrane structure contends that membranes consist of:

-**phospholipids** arranged in a bilayer

-**globular proteins** inserted in the lipid bilayer

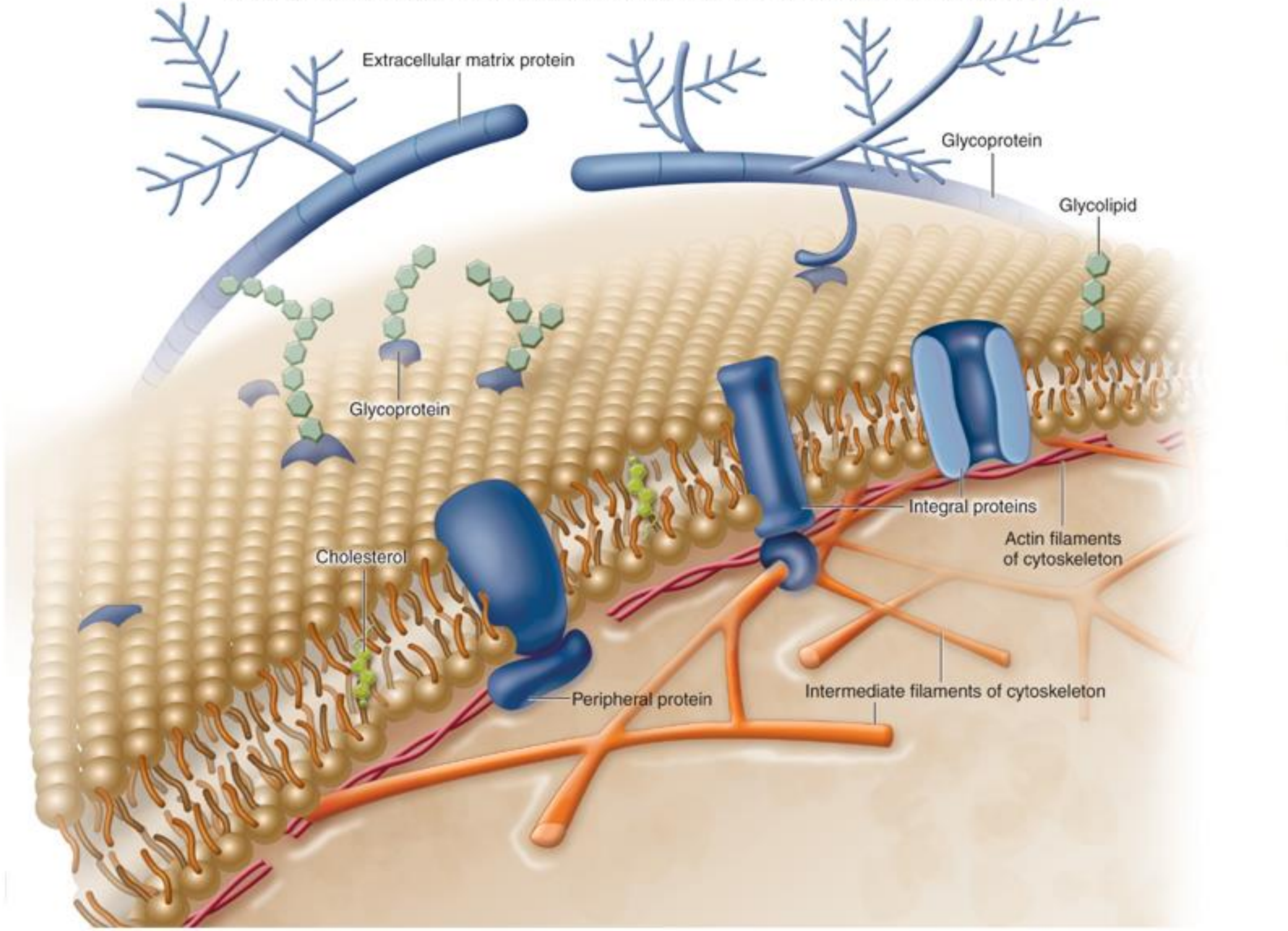


a. Formula *b.* Space-filling model *c.* Icon

Membrane Structure

Cellular membranes have 4 components:

1. phospholipid bilayer
2. transmembrane proteins
3. interior protein network
4. cell surface markers


Extracellular matrix protein
Glycoprotein
Glycolipid
Glycoprotein
Integral proteins
Actin filaments
of cytoskeleton
Cholesterol
Peripheral protein
Intermediate filaments of cytoskeleton

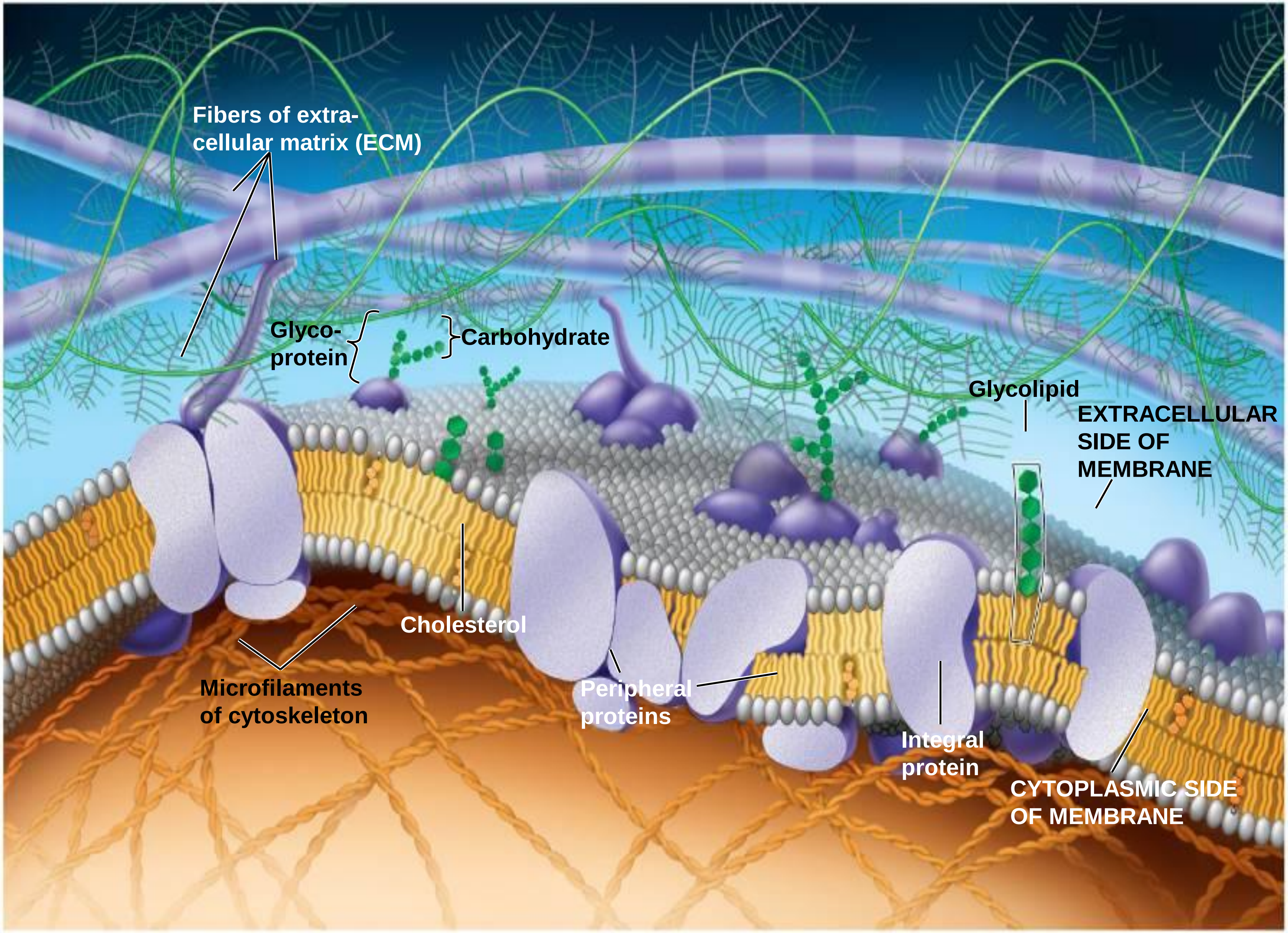
Membrane Structure

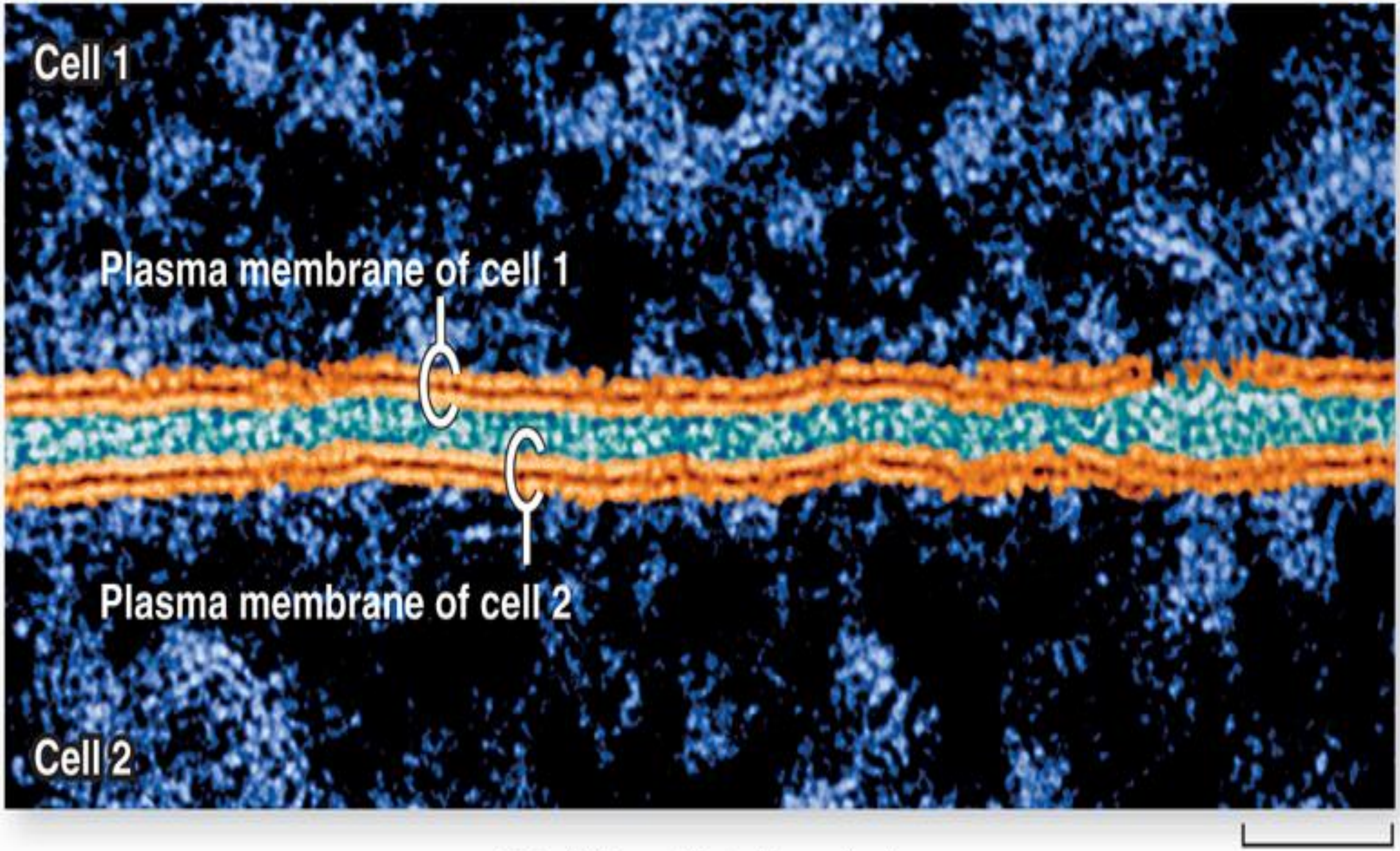
Membrane structure is visible using an electron microscope.

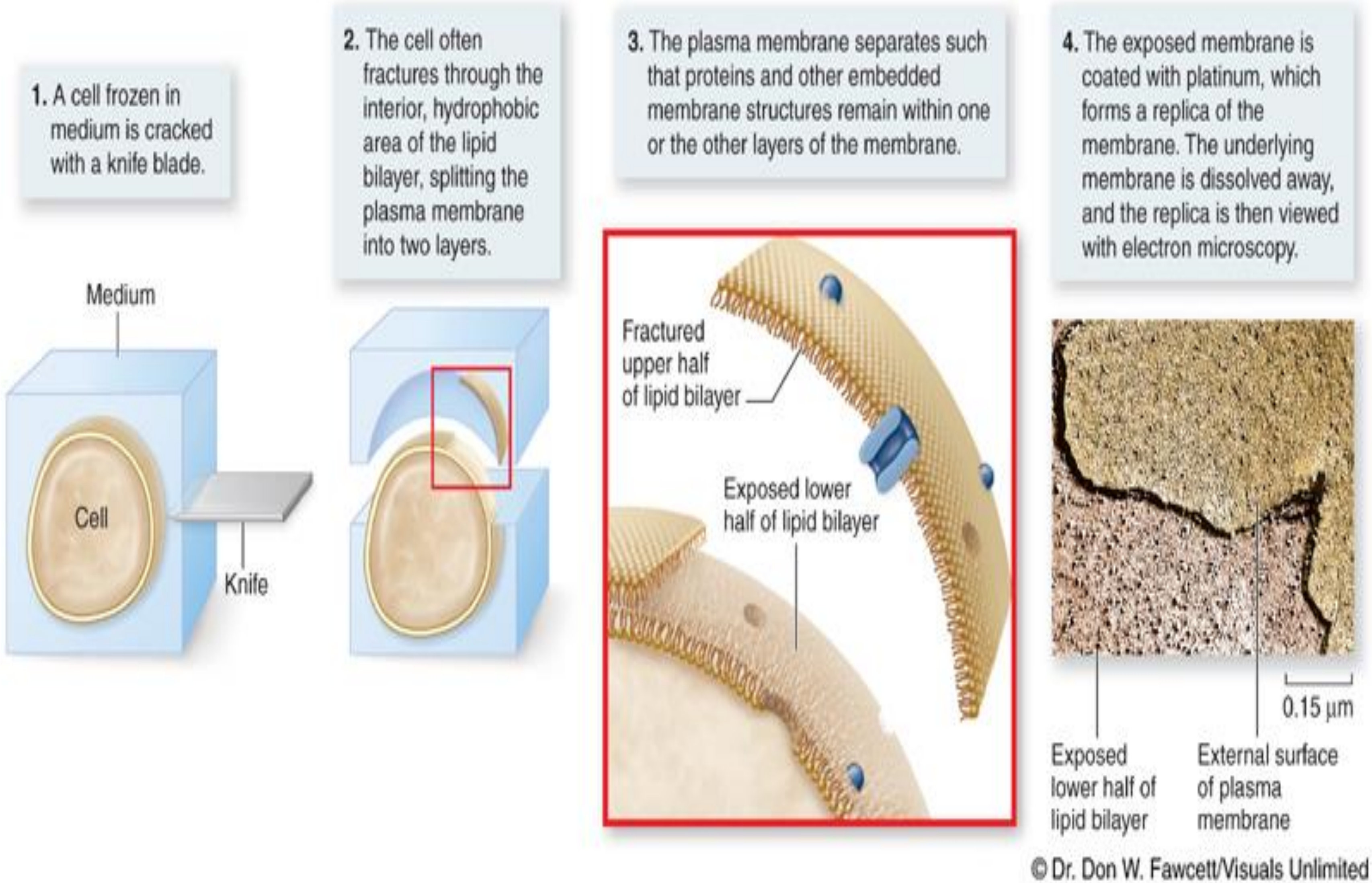
Transmission electron microscopes (TEM) can show the 2 layers of a membrane.

Freeze-fracturing techniques separate the layers and reveal membrane proteins.

- **Peripheral proteins** are bound to the surface of the membrane
- **Integral proteins** penetrate the hydrophobic core
- Integral proteins that span the membrane are called transmembrane proteins
- The hydrophobic regions of an integral protein consist of one or more stretches of nonpolar amino acids, often coiled into alpha helices


Fibers of extra-
cellular matrix (ECM)
Glyco-
protein
Carbohydrate
Glycolipid
EXTRACELLULAR
SIDE OF
MEMBRANE
Cholesterol
Microfilaments
of cytoskeleton
Peripheral
proteins
Integral
protein
CYTOPLASMIC SIDE
OF MEMBRANE


Cell 1
Plasma membrane of cell 1
Plasma membrane of cell 2
Cell 2



1. A cell frozen in medium is cracked with a knife blade.
2. The cell often fractures through the interior, hydrophobic area of the lipid bilayer, splitting the plasma membrane into two layers.
3. The plasma membrane separates such that proteins and other embedded membrane structures remain within one or the other layers of the membrane.
4. The exposed membrane is coated with platinum, which forms a replica of the membrane. The underlying membrane is dissolved away, and the replica is then viewed with electron microscopy.
Medium
Cell
Knife
Fractured upper half of lipid bilayer
Exposed lower half of lipid bilayer
0.15 µm
Exposed lower half of lipid bilayer
External surface of plasma membrane
© Dr. Don W. Fawcett/Visuals Unlimited

Phospholipids

Phospholipid structure consists of

-**glycerol** – a 3-carbon polyalcohol acting as a backbone for the phospholipid

-2 **fatty acids** attached to the glycerol

-**phosphate group** attached to the glycerol

Phospholipids

The fatty acids are nonpolar chains of carbon and hydrogen.

-Their nonpolar nature makes them **hydrophobic** (“water-fearing”).

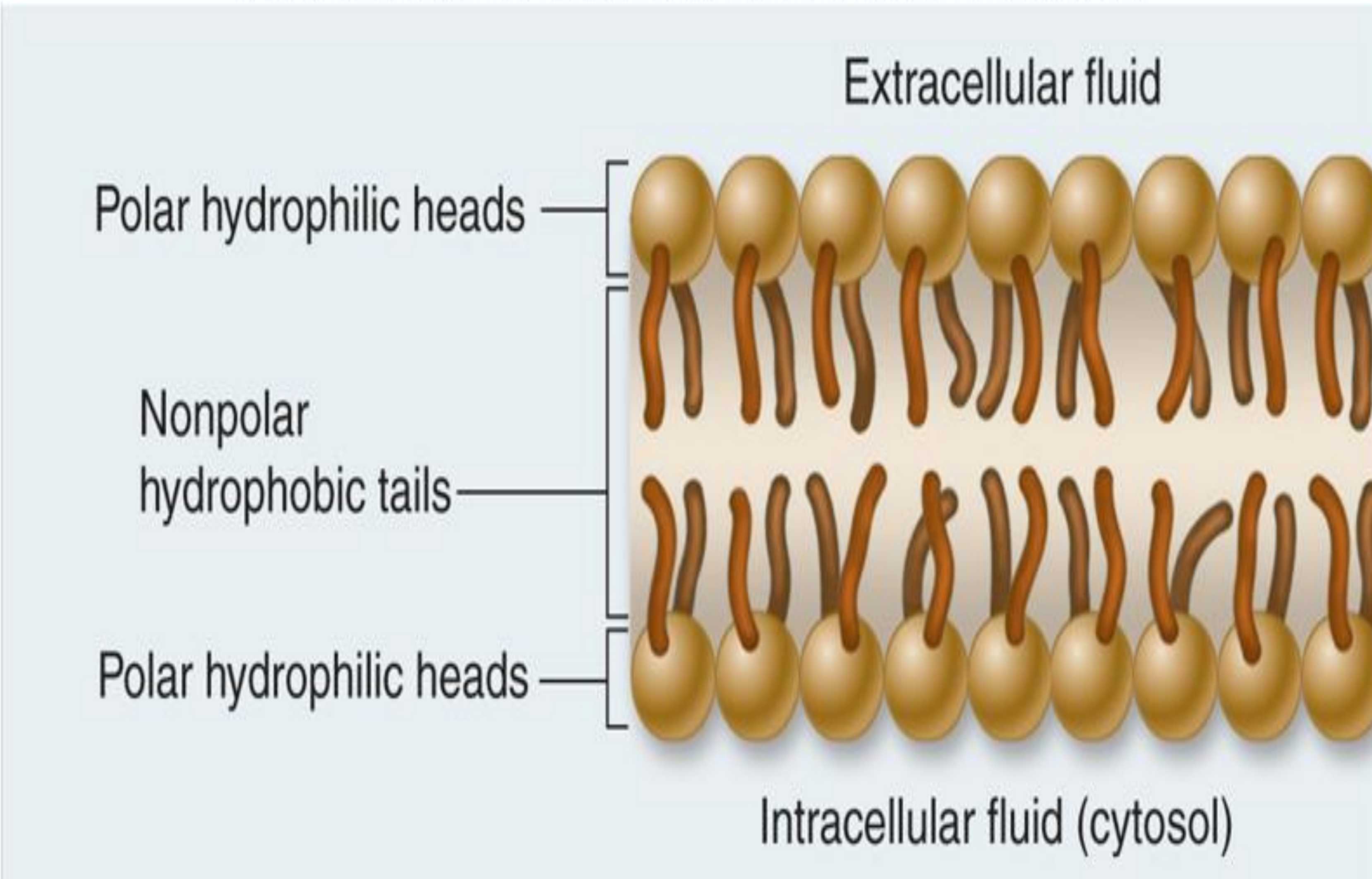
The phosphate group is polar and **hydrophilic** (“water-loving”).

Phospholipids

The partially hydrophilic, partially hydrophobic phospholipid spontaneously forms a bilayer:

-fatty acids are on the inside

-phosphate groups are on both surfaces of the bilayer


Extracellular fluid
Polar hydrophilic heads
Nonpolar hydrophobic tails
Polar hydrophilic heads
Intracellular fluid (cytosol)

Phospholipids

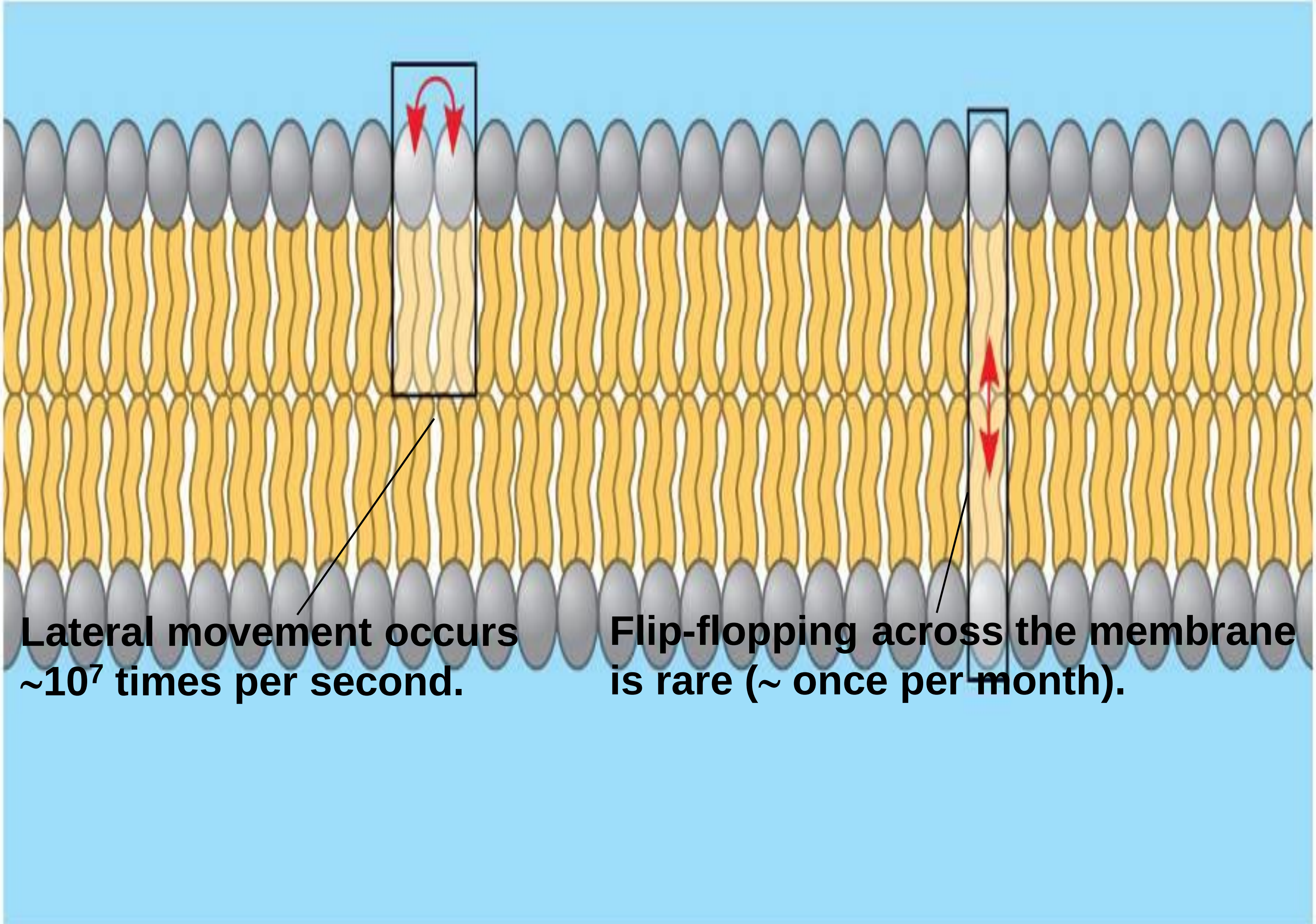
Phospholipid bilayers are fluid.

- -hydrogen bonding of water holds the 2 layers together
- -individual phospholipids and unanchored proteins can move through the membrane
- -saturated fatty acids make the membrane less fluid than unsaturated fatty acids
- -warm temperatures make the membrane more fluid than cold temperatures

The Fluidity of Membranes

- Phospholipids in the plasma membrane can move within the bilayer
- Most of the lipids, and some proteins, drift laterally
- Rarely does a molecule flip-flop transversely across the membrane

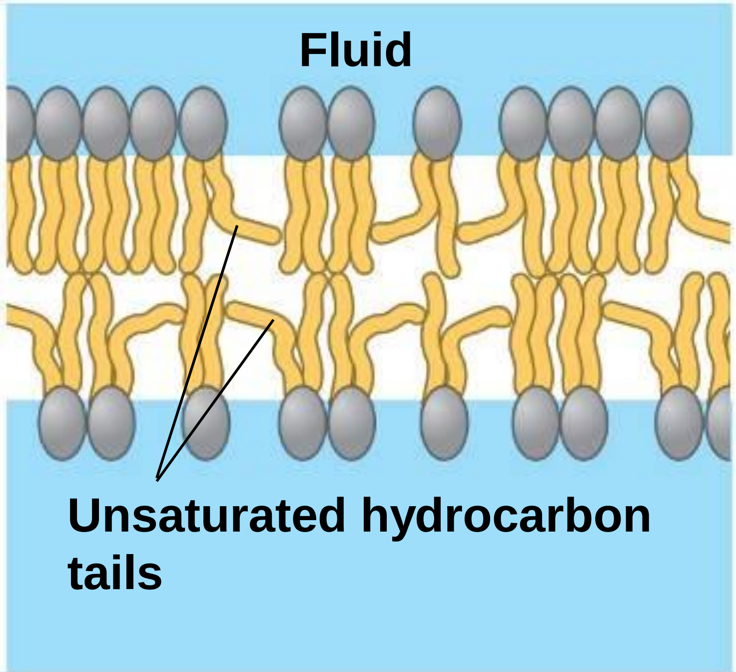
Figure 7.6


Lateral movement occurs ~10^7 times per second.
Flip-flopping across the membrane is rare (~ once per month).

- As temperatures cool, membranes switch from a fluid state to a solid state
- The temperature at which a membrane solidifies depends on the types of lipids
- Membranes rich in unsaturated fatty acids are more fluid than those rich in saturated fatty acids
- Membranes must be fluid to work properly; they are usually about as fluid as salad oil

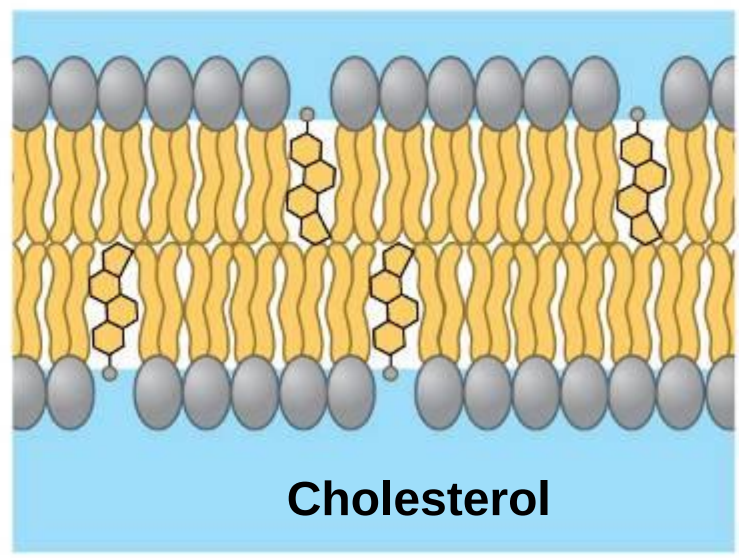
- The steroid cholesterol has different effects on membrane fluidity at different temperatures
- At warm temperatures (such as 37°C), cholesterol restrains movement of phospholipids
- At cool temperatures, it maintains fluidity by preventing tight packing

Figure 7.8



(a) Unsaturated versus saturated hydrocarbon tails

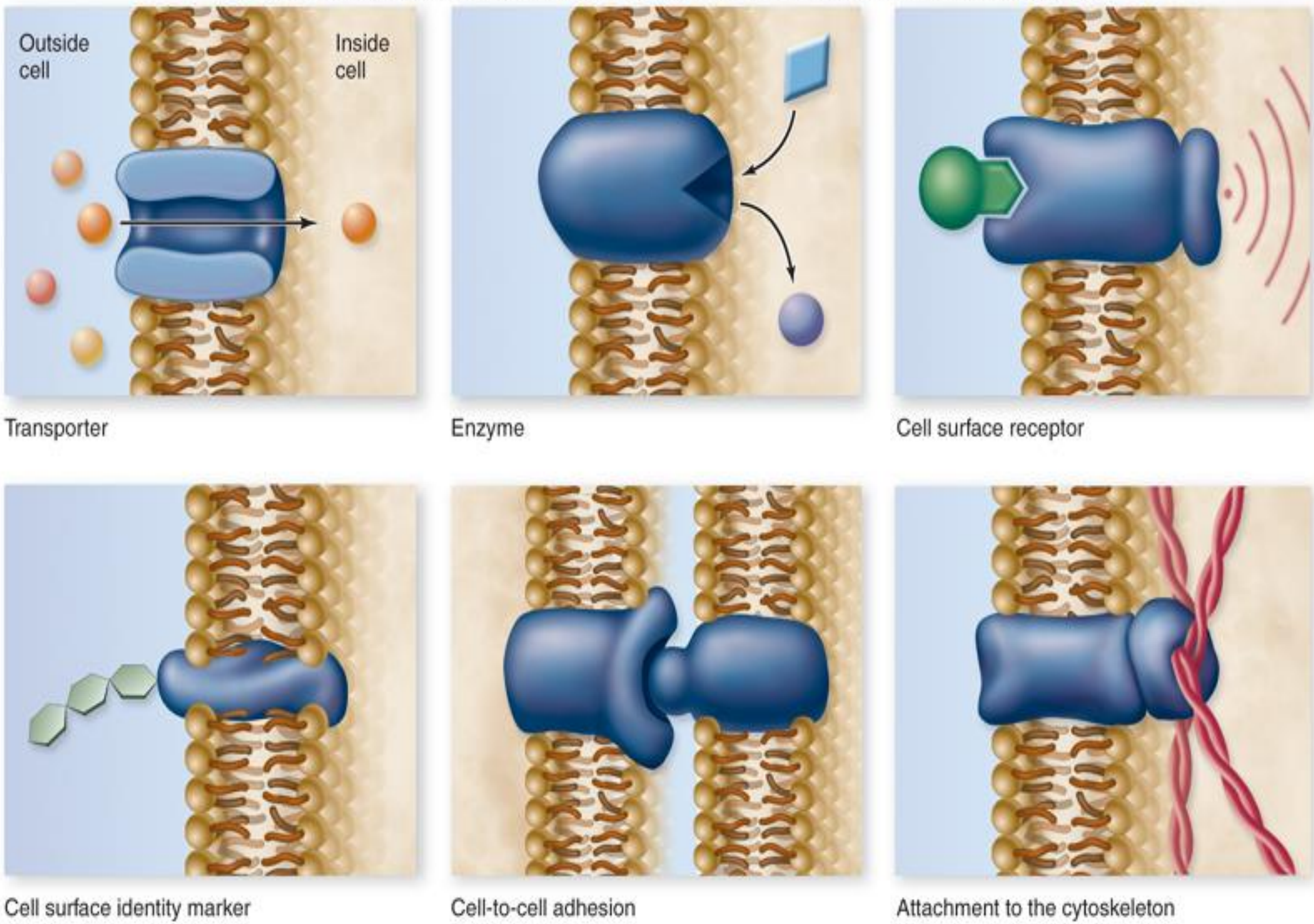
(b) Cholesterol within the animal cell membrane



Membrane Proteins

Membrane proteins have various functions:

1. transporters
2. enzymes
3. cell surface receptors
4. cell surface identity markers
5. cell-to-cell adhesion proteins
6. attachments to the cytoskeleton


Outside cell
Inside cell
Transporter
Enzyme
Cell surface receptor
Cell surface identity marker
Cell-to-cell adhesion
Attachment to the cytoskeleton

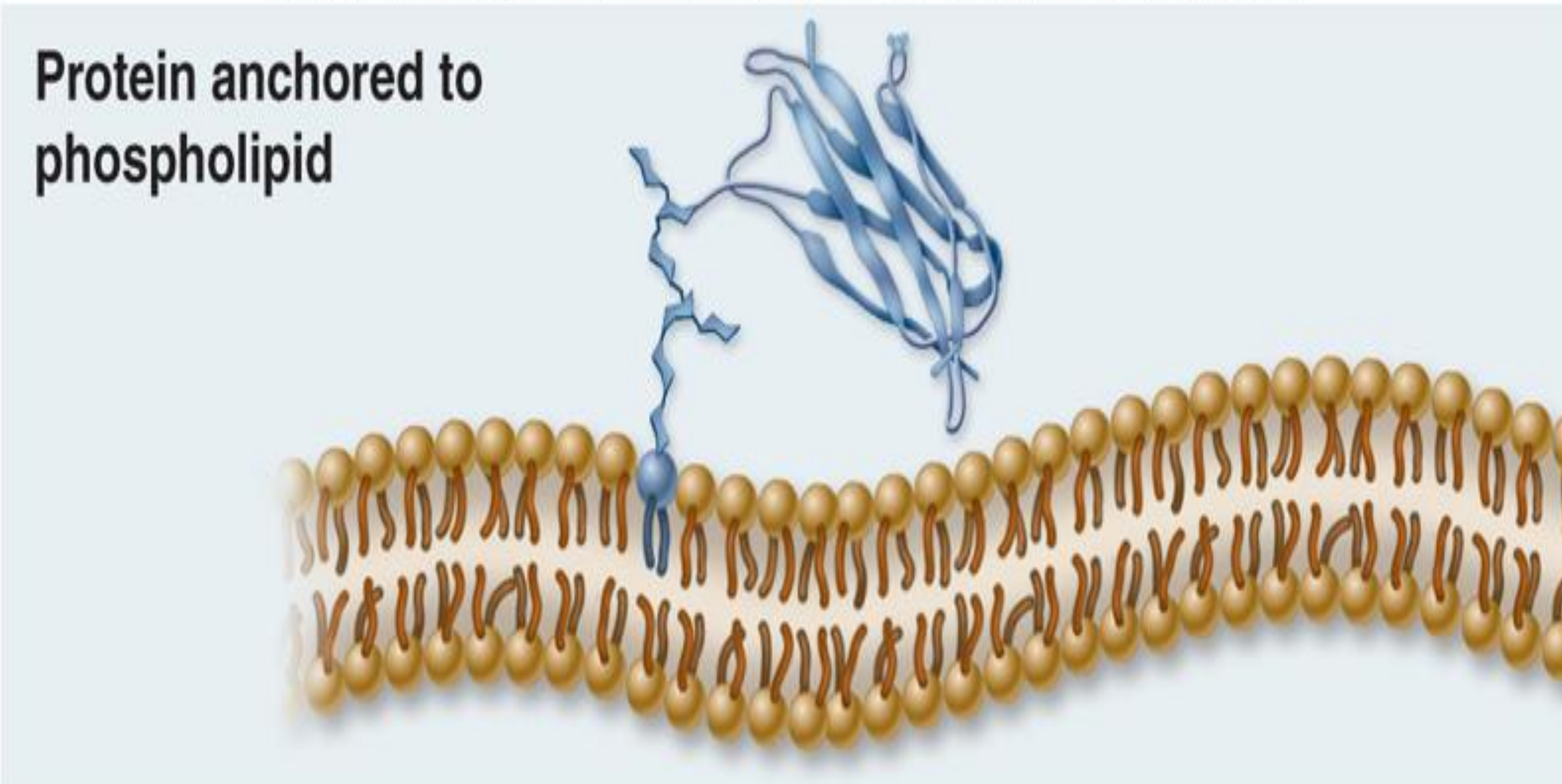
Membrane Proteins

Peripheral membrane proteins

-anchored to a phospholipid in one layer of the membrane

-possess nonpolar regions that are inserted in the lipid bilayer

-are free to move throughout one layer of the bilayer


Protein anchored to phospholipid

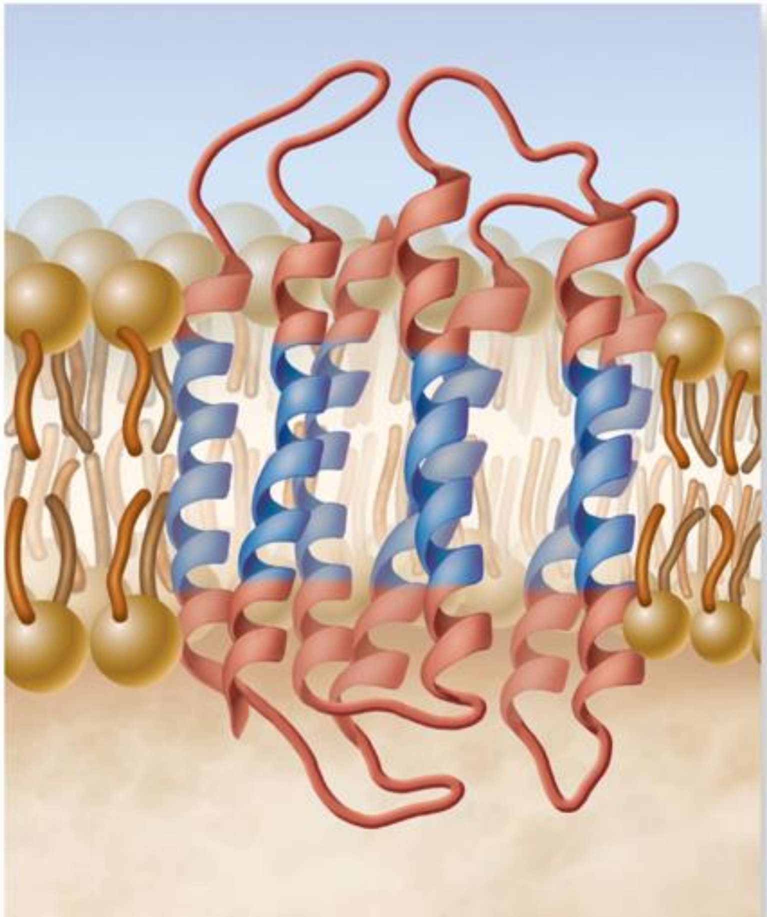
Membrane Proteins

Integral membrane proteins

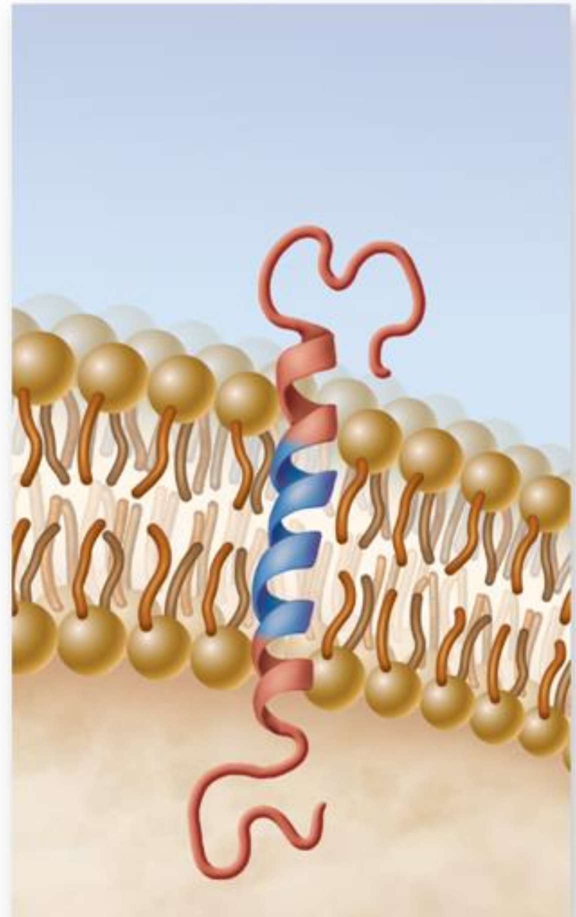
-span the lipid bilayer (transmembrane proteins)

-nonpolar regions of the protein are embedded in the interior of the bilayer

-polar regions of the protein protrude from both sides of the bilayer



a.



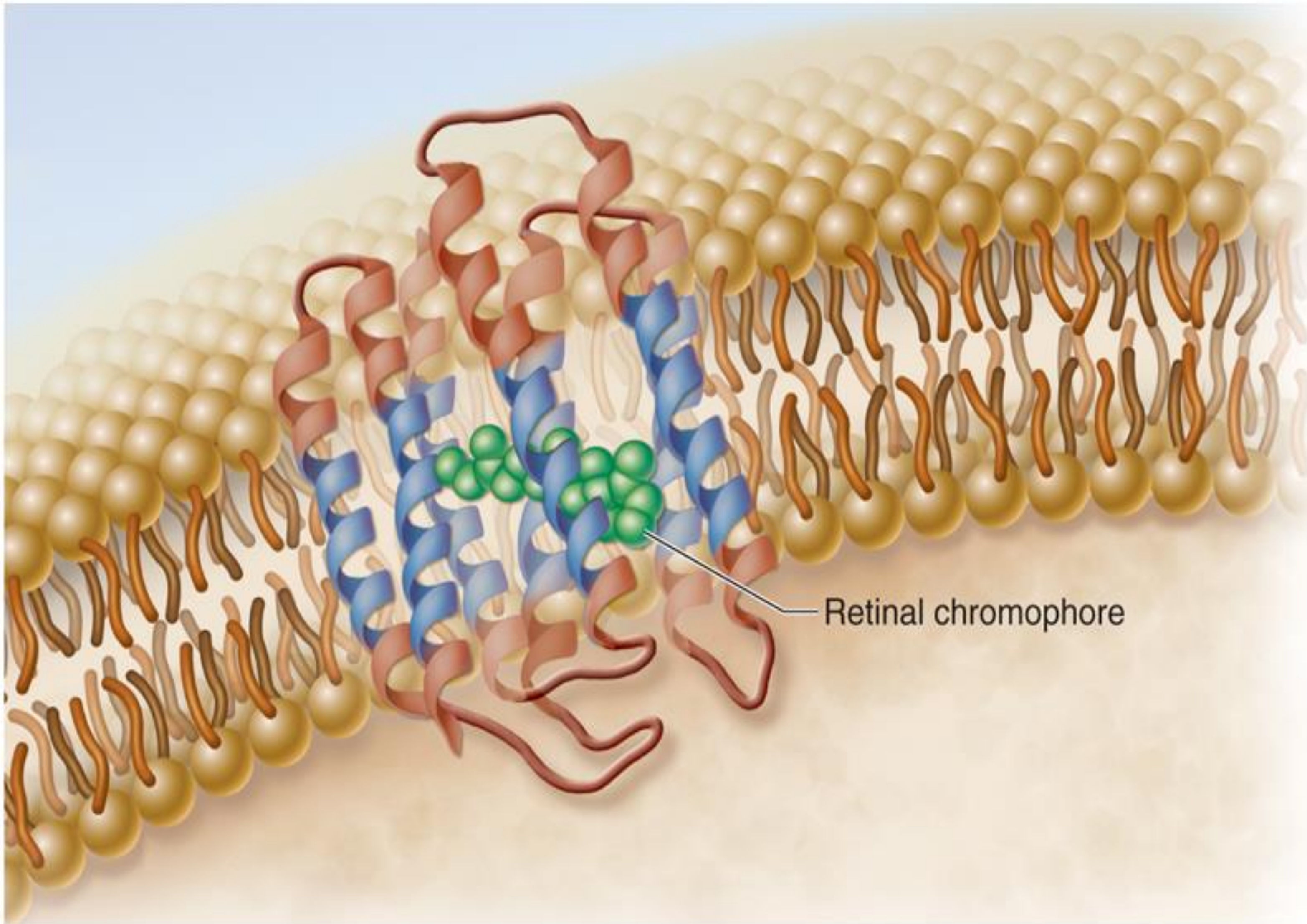
b.

Membrane Proteins

Integral proteins possess at least one **transmembrane domain**

-region of the protein containing hydrophobic amino acids

-spans the lipid bilayer

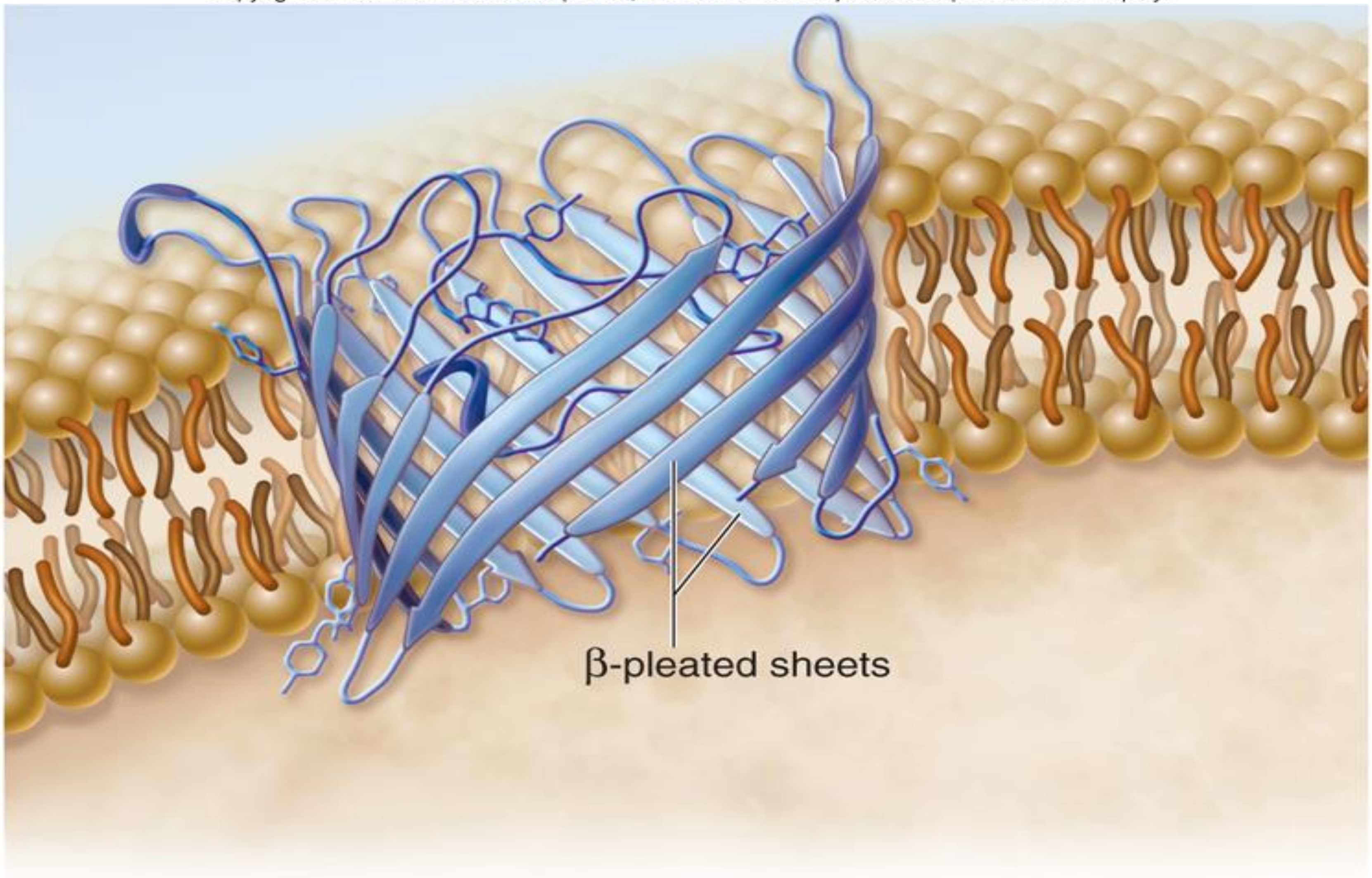

Retinal chromophore

Membrane Proteins

Extensive nonpolar regions within a transmembrane protein can create a pore through the membrane.

-β sheets in the protein secondary structure form a cylinder called a **β-barrel**

-β-barrel interior is polar and allows water and small polar molecules to pass through the membrane


β-pleated sheets

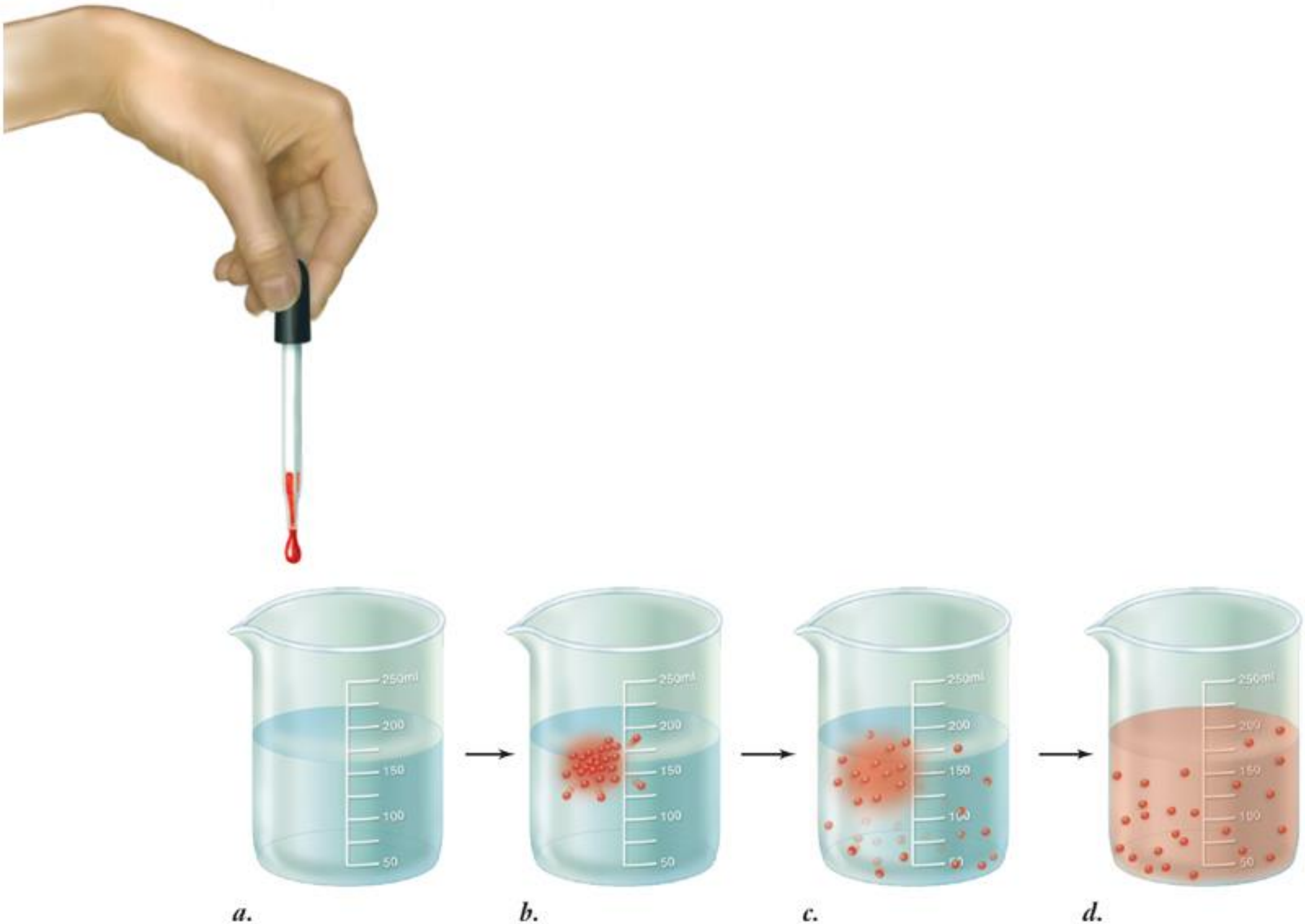
Passive Transport

Passive transport is movement of molecules through the membrane in which

-no energy is required

-molecules move in response to a **concentration gradient**

Diffusion is movement of molecules from high concentration to low concentration


250ml
200
150
100
50
a.
b.
c.
d.

Passive Transport

Selective permeability: integral membrane proteins allow the cell to be selective about what passes through the membrane.

Channel proteins have a polar interior allowing polar molecules to pass through.

Carrier proteins bind to a specific molecule to facilitate its passage.

Passive Transport

Channel proteins include:

-**ion channels** allow the passage of ions (charged atoms or molecules) which are associated with water

-**gated channels** are opened or closed in response to a stimulus

-the stimulus may be chemical or electrical

Passive Transport

Carrier proteins bind to the molecule that they transport across the membrane.

Facilitated diffusion is movement of a molecule from high to low concentration with the help of a carrier protein.

-is specific

-is passive

-saturates when all carriers are occupied

Passive Transport

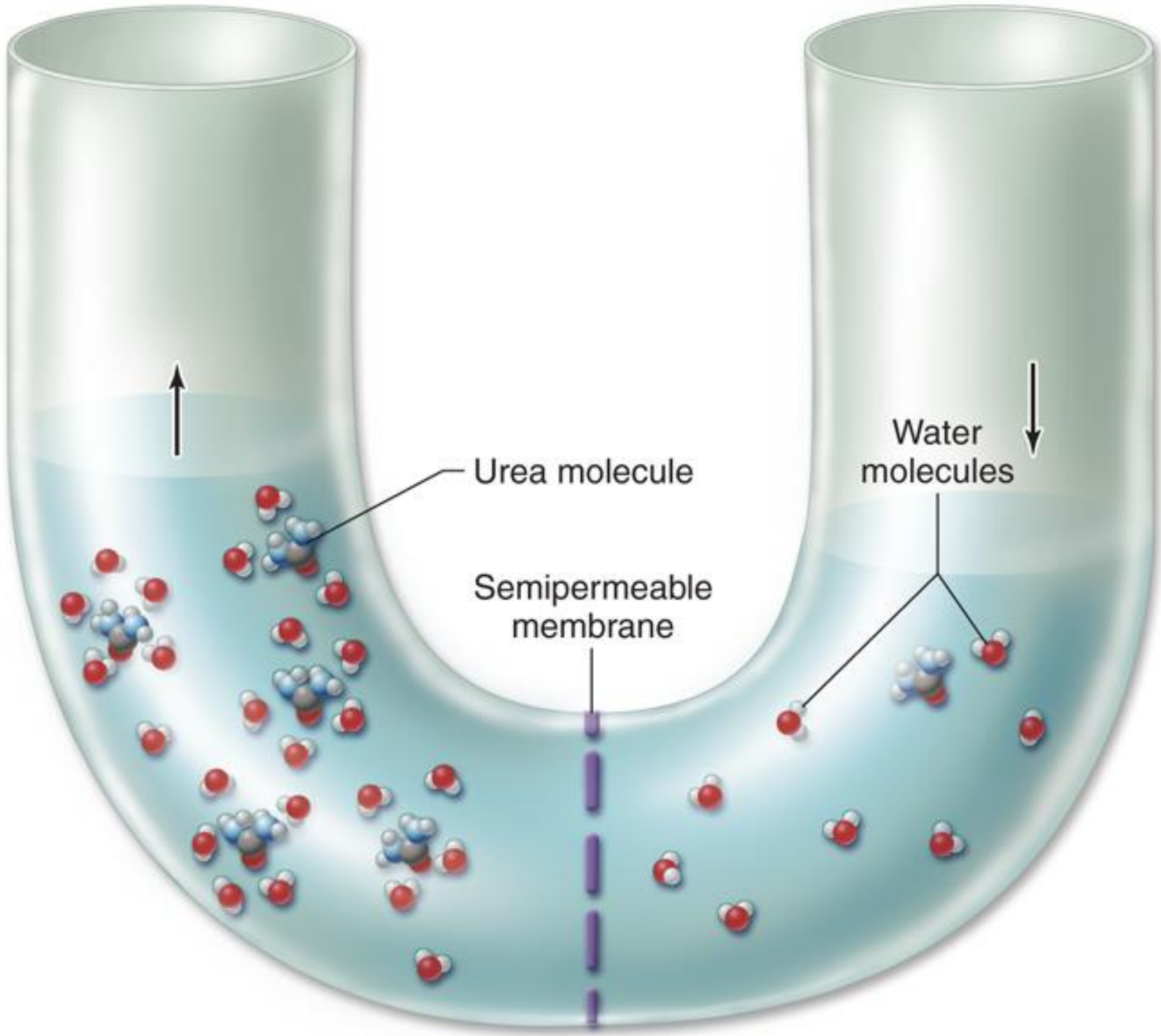
In an aqueous solution

-water is the **solvent**

-dissolved substances are the **solutes**

Osmosis is the movement of *water* from an area of high to low concentration of *water*

-movement of water toward an area of high *solute* concentration


Urea molecule
Water
molecules
Semipermeable
membrane

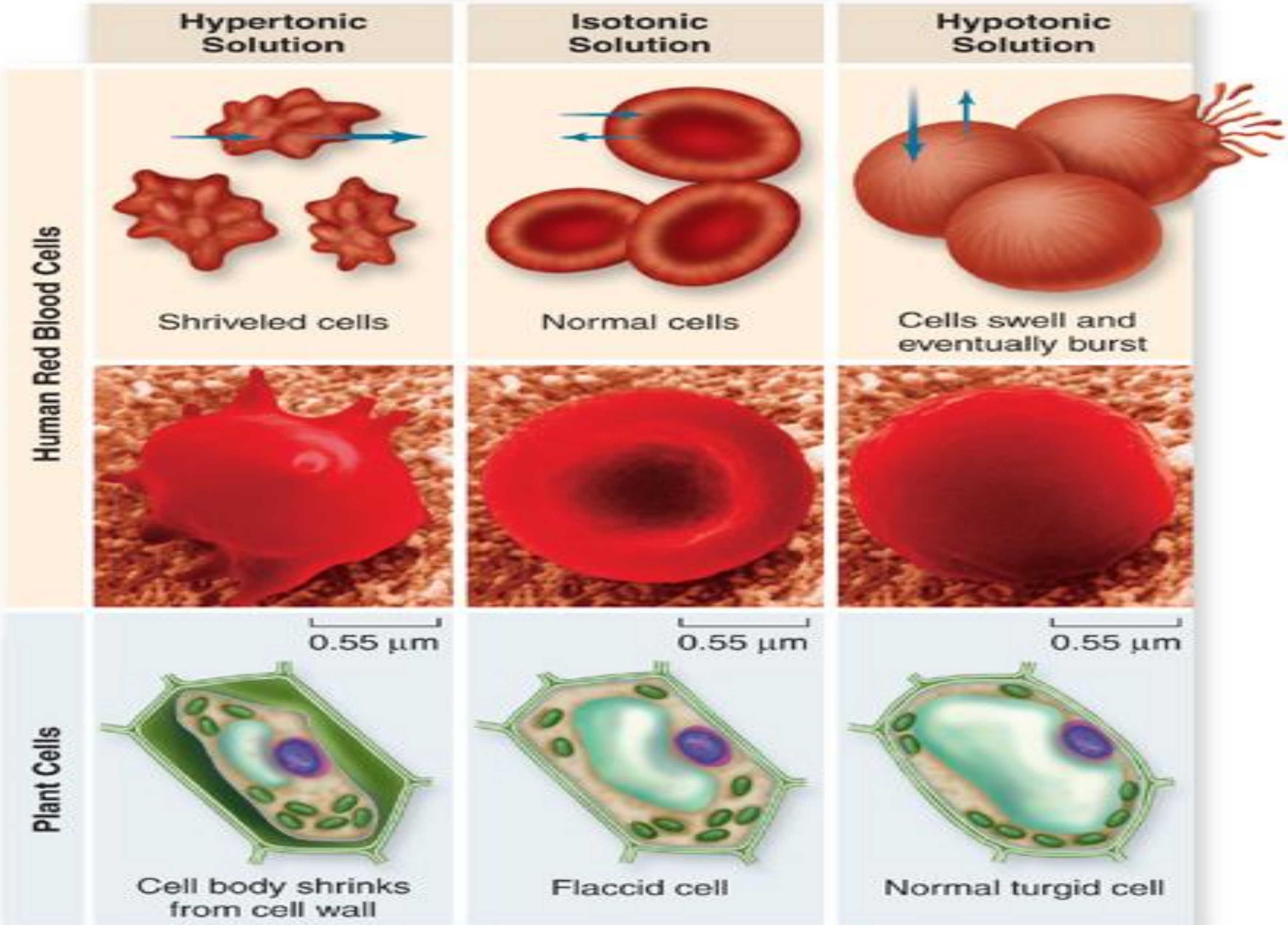
Passive Transport

When 2 solutions have different osmotic concentrations

-the **hypertonic solution** has a higher solute concentration

-the **hypotonic solution** has a lower solute concentration

Osmosis moves water through **aquaporins** toward the hypertonic solution.



© Dr. David M. Phillips/Visuals Unlimited

Passive Transport

Organisms can maintain osmotic balance in different ways.

1. Some cells use **extrusion** in which water is ejected through contractile vacuoles.

2. **Isosmotic regulation** involves keeping cells isotonic with their environment.

3. Plant cells use **turgor pressure** to push the cell membrane against the cell wall and keep the cell rigid.

Active Transport

Active transport

-requires energy – ATP is used directly or indirectly to fuel active transport

-moves substances from low to high concentration

-requires the use of carrier proteins

Active Transport

Carrier proteins used in active transport include:

-**uniporters** – move one molecule at a time

-**symporters** – move two molecules in the same direction

-**antiporters** – move two molecules in opposite directions

Active Transport

Sodium-potassium (Na^+-K^+) pump

-an active transport mechanism

-uses an antiporter to move 3 Na^+ out of the cell and 2 K^+ into the cell

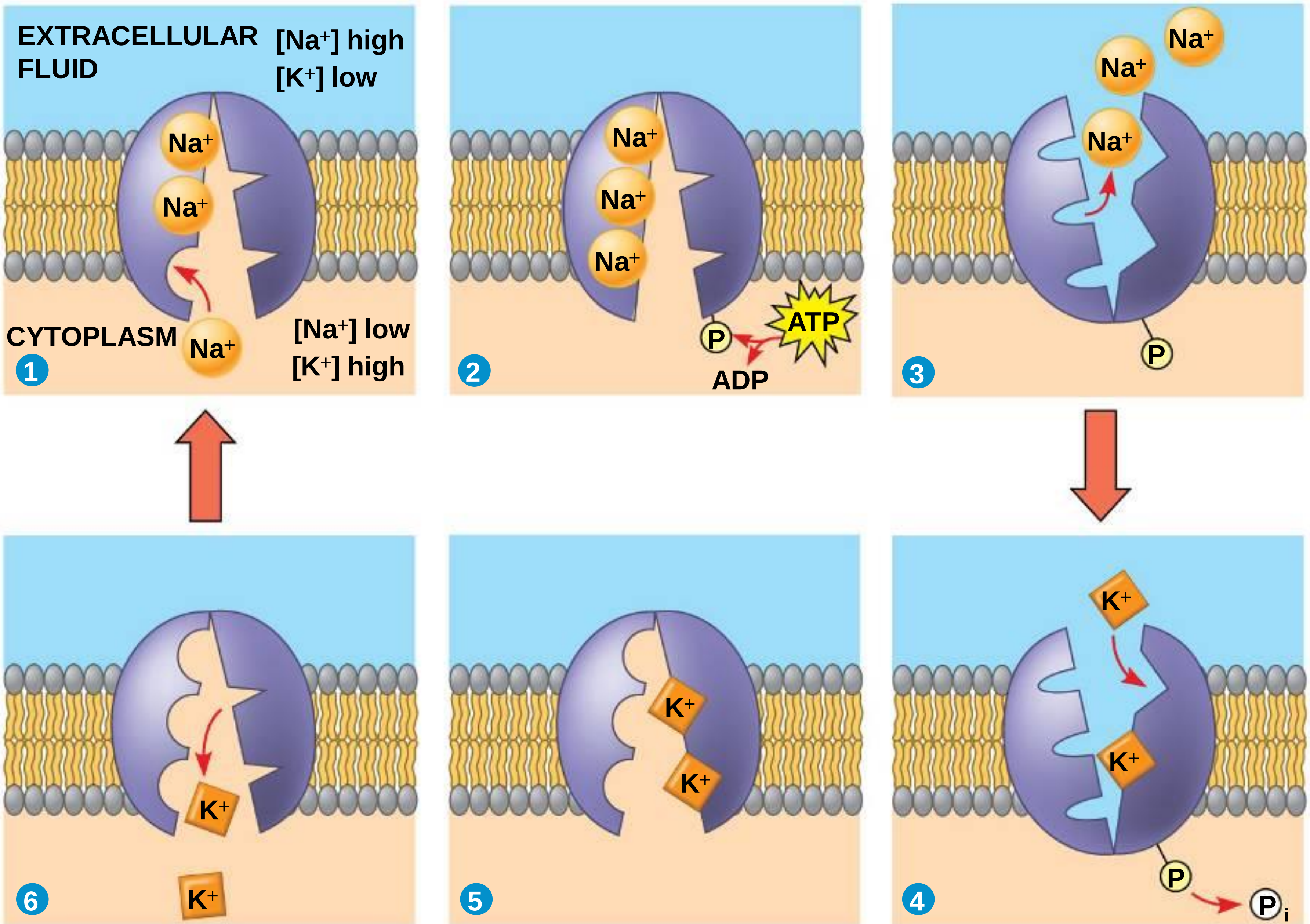
-ATP energy is used to change the conformation of the carrier protein

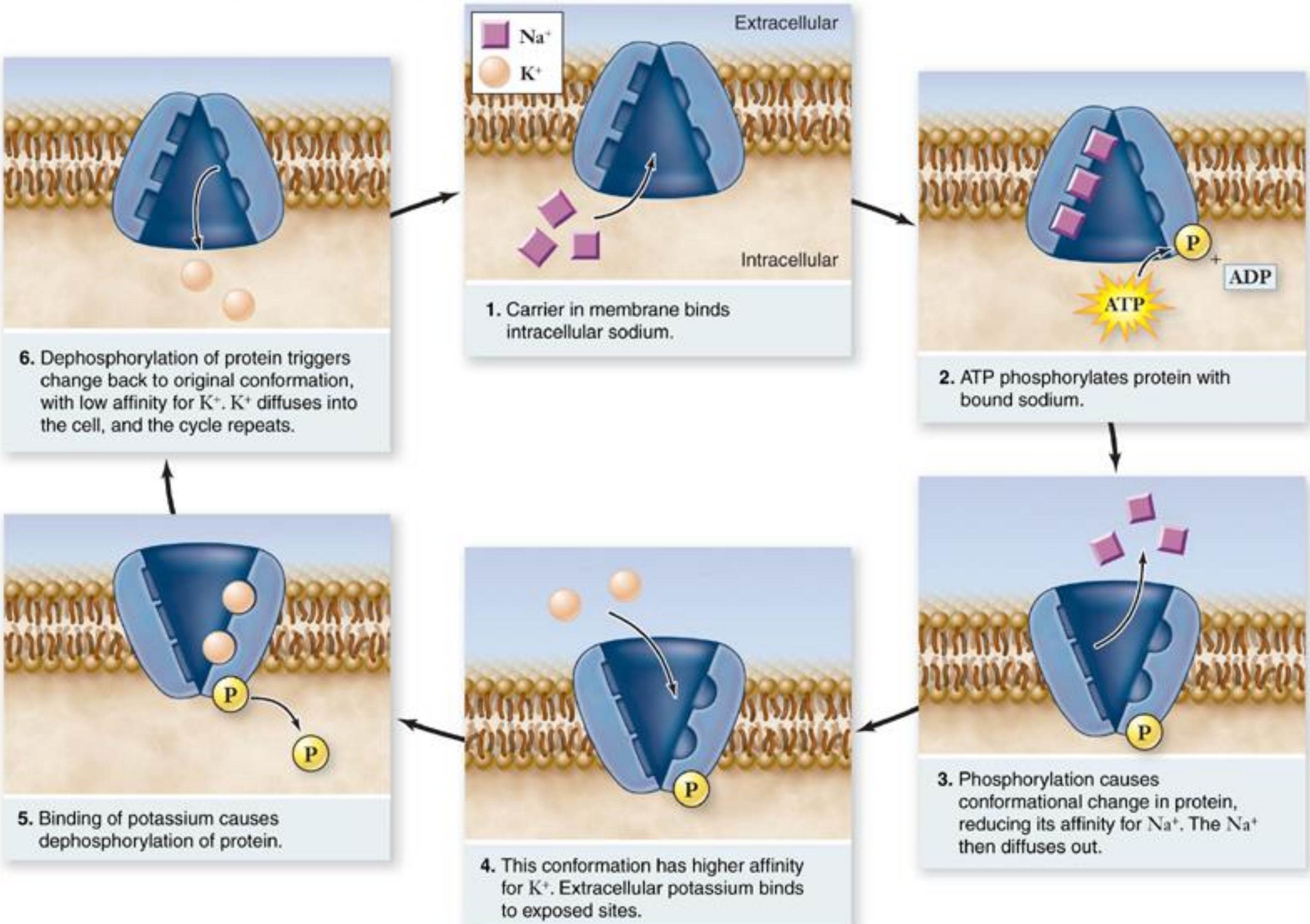
-the affinity of the carrier protein for either Na^+ or K^+ changes so the ions can be carried across the membrane

- Active transport allows cells to maintain concentration gradients that differ from their surroundings

- The sodium-potassium pump is one type of active transport system

Figure 7.18-6


EXTRACELLULAR FLUID
[Na+] high
[K+] low
CYTOPLASM
[Na+] low
[K+] high
Na+
Na+
Na+
1
Na+
Na+
Na+
P
ATP
ADP
2
Na+
Na+
Na+
P
3
K+
K+
P
P
i
4
K+
K+
5
K+
K+
6


Na+
K+
Extracellular
Intracellular
1. Carrier in membrane binds intracellular sodium.
ATP
P
+
ADP
2. ATP phosphorylates protein with bound sodium.
P
3. Phosphorylation causes conformational change in protein, reducing its affinity for Na+. The Na+ then diffuses out.
P
4. This conformation has higher affinity for K+. Extracellular potassium binds to exposed sites.
P
P
5. Binding of potassium causes dephosphorylation of protein.
6. Dephosphorylation of protein triggers change back to original conformation, with low affinity for K+. K+ diffuses into the cell, and the cycle repeats.

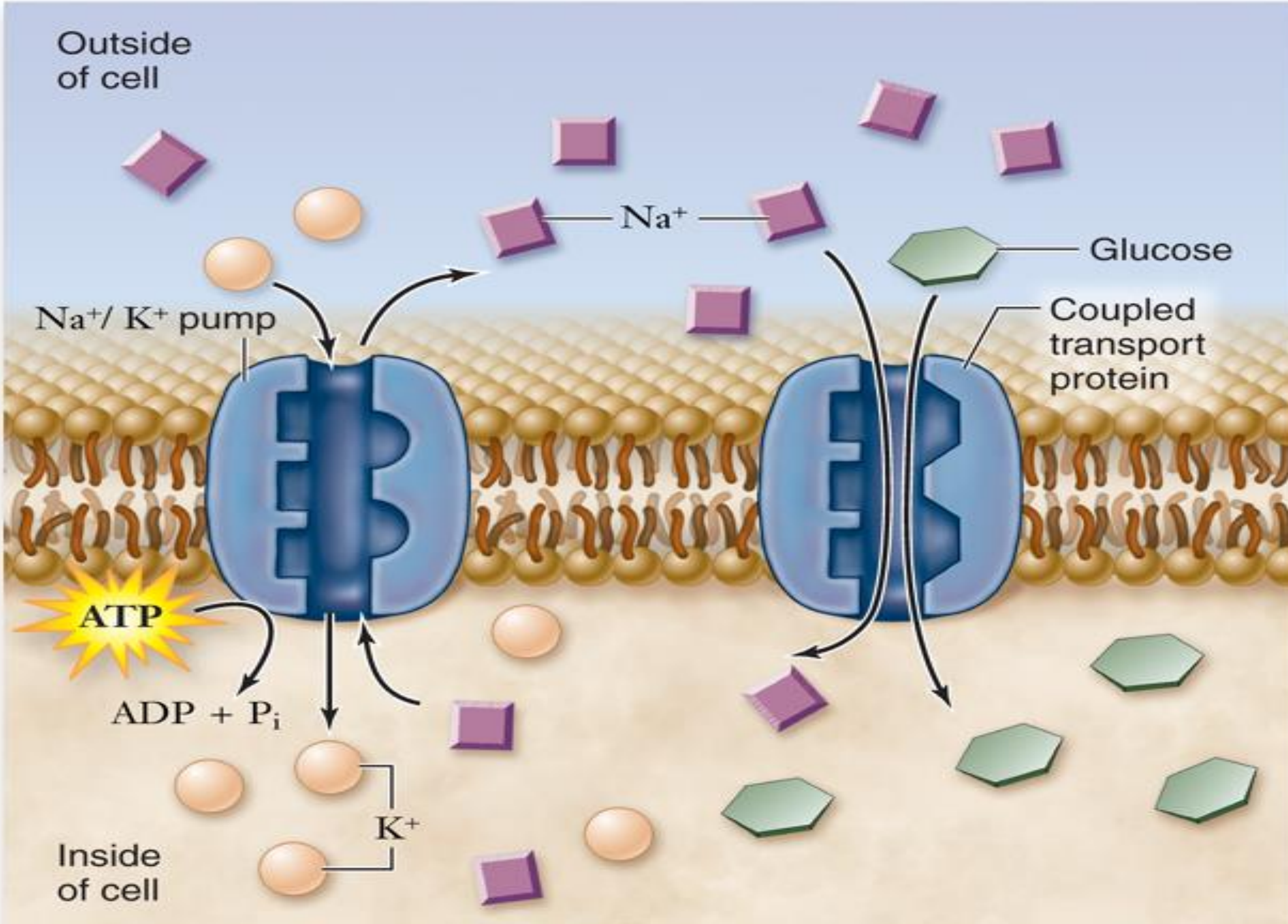
Active Transport

Coupled transport

-uses the energy released when a molecule moves by diffusion to supply energy to active transport of a different molecule

-a symporter is used

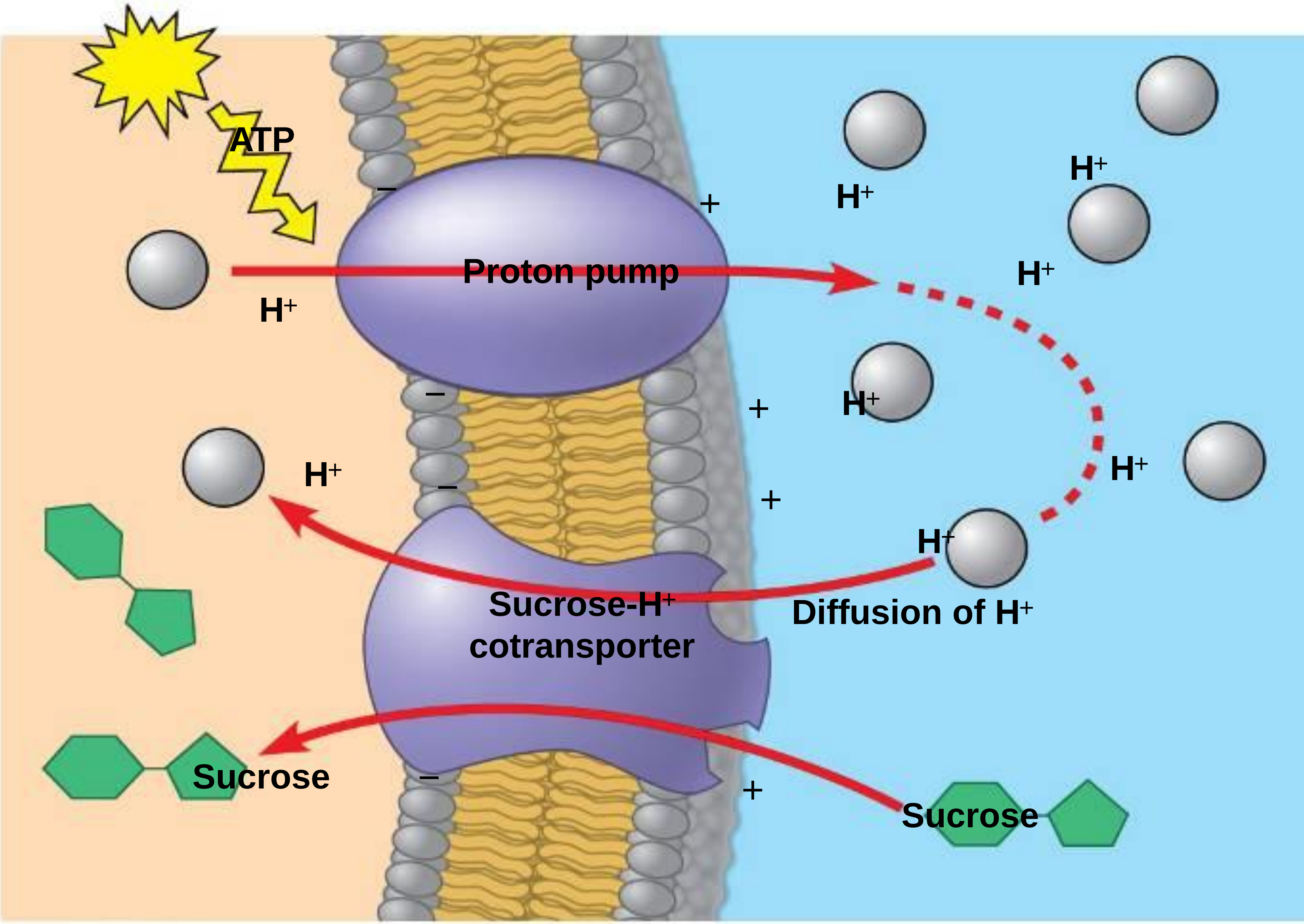
-glucose-Na^+ symporter captures the energy from Na^+ diffusion to move glucose against a concentration gradient


Outside of cell
Na+
Glucose
Na+/ K+ pump
Coupled transport protein
ATP
ADP + Pi
K+
Inside of cell

Cotransport: Coupled Transport by a Membrane Protein

- **Cotransport** occurs when active transport of a solute indirectly drives transport of other solutes
- Plants commonly use the gradient of hydrogen ions generated by proton pumps to drive active transport of nutrients into the cell

Figure 7.21


ATP
Proton pump
H+
H+
H+
H+
H+
H+
H+
H+
Sucrose-H+
cotransporter
Diffusion of H+
Sucrose
Sucrose
–
+

Bulk Transport

Bulk transport of substances is accomplished by

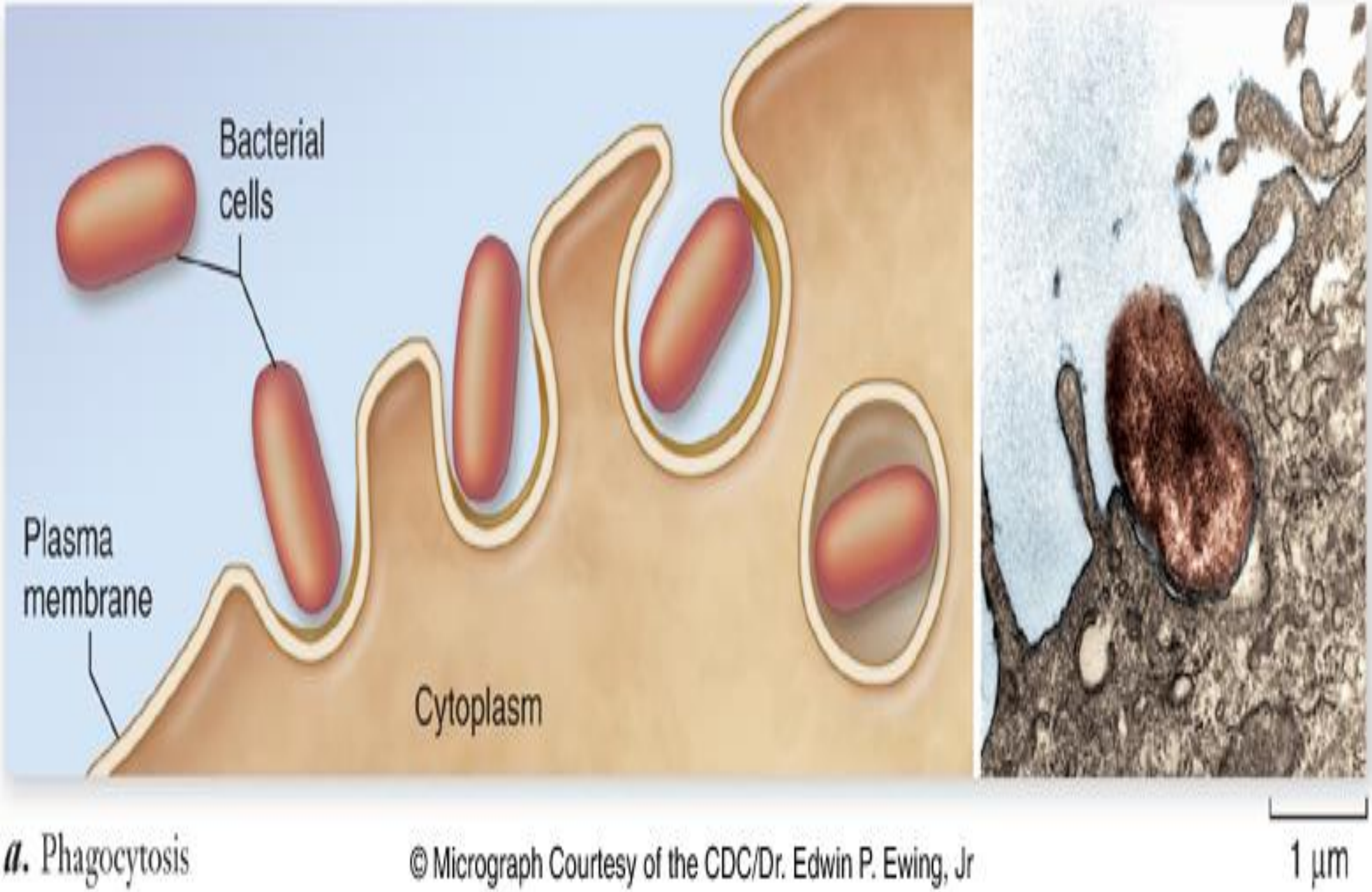
1. **endocytosis** – movement of substances into the cell

2. **exocytosis** – movement of materials out of the cell

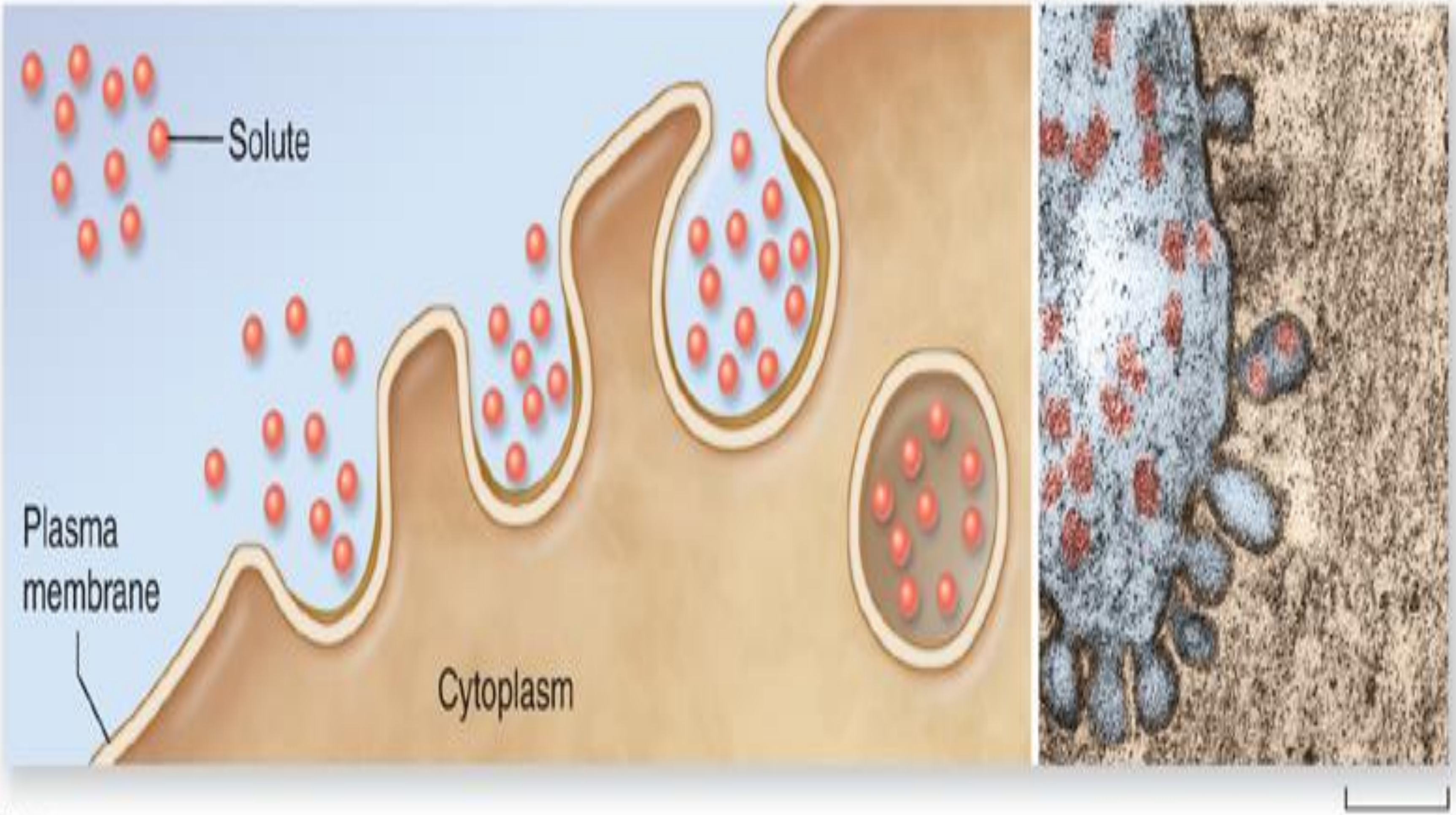
Bulk Transport

Endocytosis occurs when the plasma membrane envelops food particles and liquids.

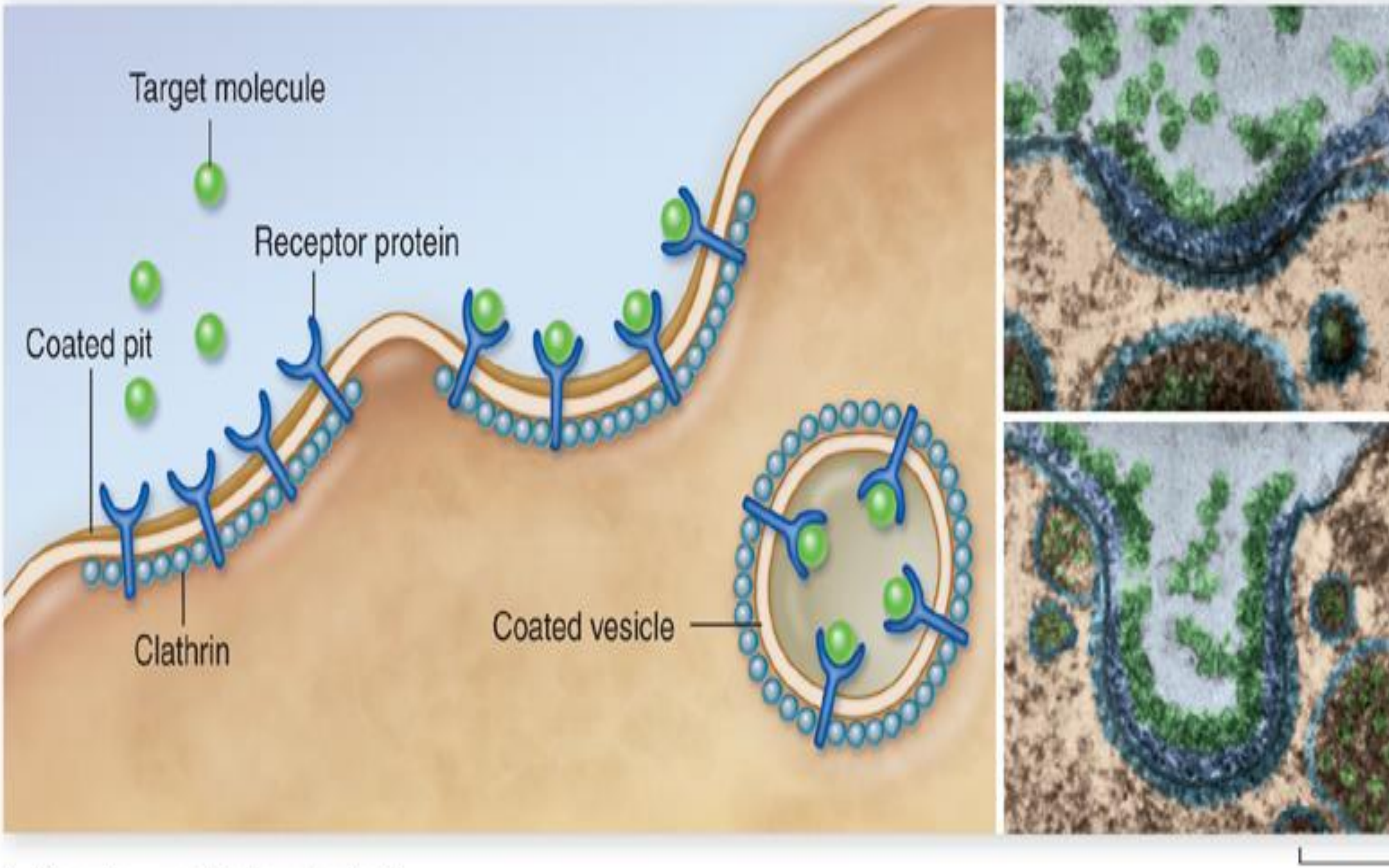
1. **phagocytosis** – the cell takes in particulate matter
2. **pinocytosis** – the cell takes in only fluid
3. **receptor-mediated endocytosis** – specific molecules are taken in after they bind to a receptor



a. Phagocytosis



b. Pinocytosis



c. Receptor-mediated endocytosis

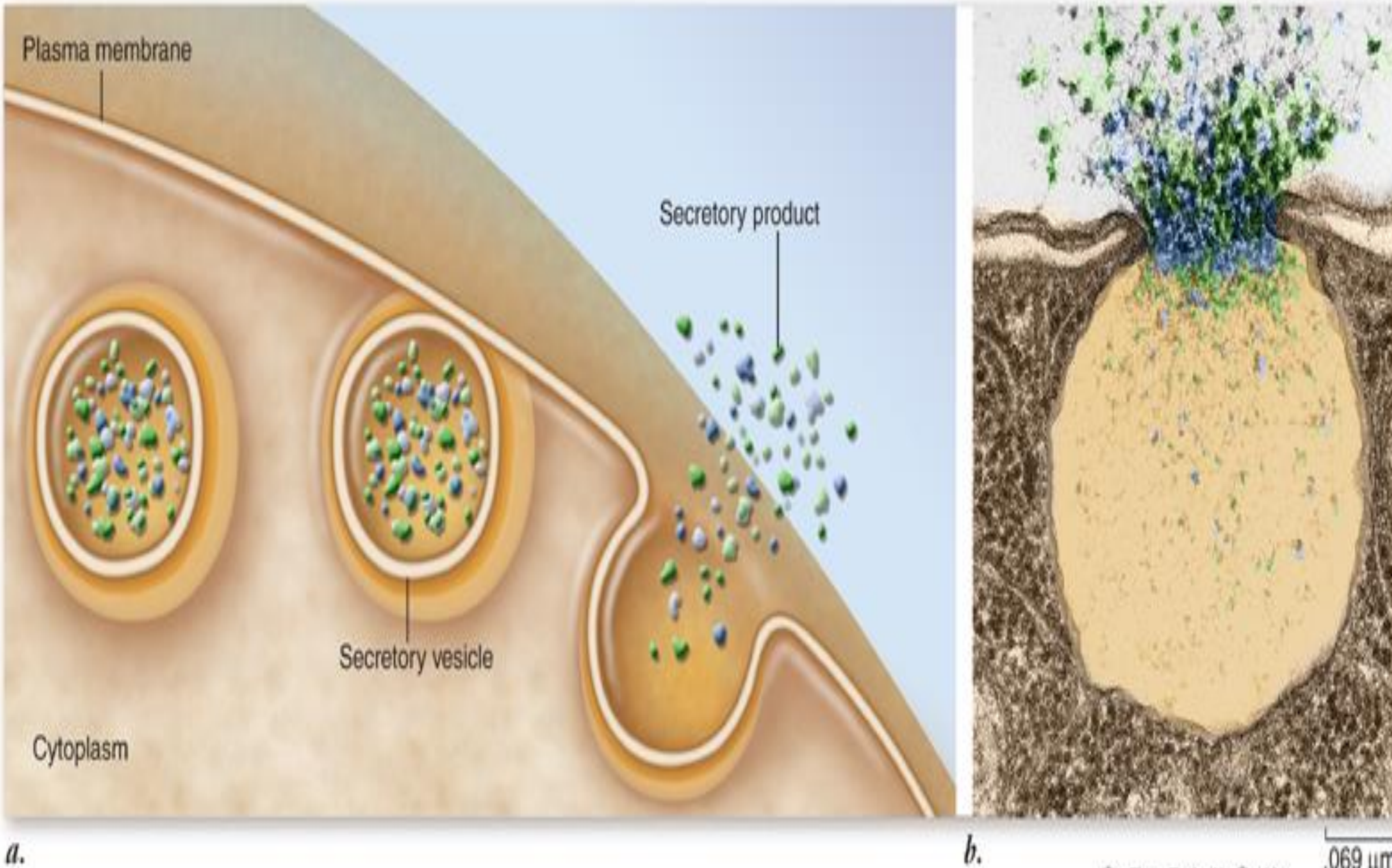
Bulk Transport

Exocytosis occurs when material is discharged from the cell.

-vesicles in the cytoplasm fuse with the cell membrane and release their contents to the exterior of the cell

-used in plants to export cell wall material

-used in animals to secrete hormones, neurotransmitters, digestive enzymes


Plasma membrane
Secretory product
Secretory vesicle
Cytoplasm
a.
b.
.069 µm

The History of Cells and Cell Theory

Dr.K.Kalimuthu

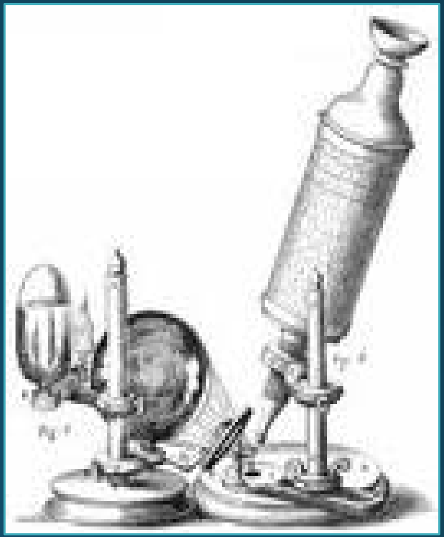
History of the Cell

- Around the year 1590, two Dutch lens makers by the name of **Hans and Zacharias Janssen invented the first compound microscope** when they put two of their lenses together in a tube.
- In 1665, an English scientist, **Robert Hooke discovered and came up with the name "cells"** while looking through a microscope at a piece of cork.
- Supposedly, the cork (which was made of dead oak tree tissues) reminded him of the small rooms that the monks lived in at the monasteries.

History of the Cell

- Zacharias Jansen

- Robert Hooke



- Hooke's cells

History of the Cell

- Not long after Hooke (around 1683), a Dutch amateur scientist by the name of **Anton Van Leeuwenhoek observed some of the first living cells** under a simple (1 lens) microscope.
- He named these small organisms "animalcules".
- It is now believed that some of the living cells he saw were actually protozoa.

The Development of Cell Theory

- In 1838 and 1839, a German botanist by the name of **Matthias Schleiden** and German zoologist by the name of **Theodore Schwann** viewed plants and animals under a microscope and discovered that **plants and animals are both made of cells**.
- In 1855 a Prussian (modern day German) physician by the name of **Rudolph Virchow** collaborated his ideas with the other two scientists and they developed the **Cell Theory.**

Cell Theory

- The **ideas of these three men led to the creation** of the **cell theory**. These are **the three main principles of cell theory.**
- **1. All living organisms are made up of cells.**
- **2. Cells are the most basic unit of life.**
- **3. Cells only come from the division of pre-existing cells.** In other words, spontaneous generation of cells does not occur.

Microscope Technology

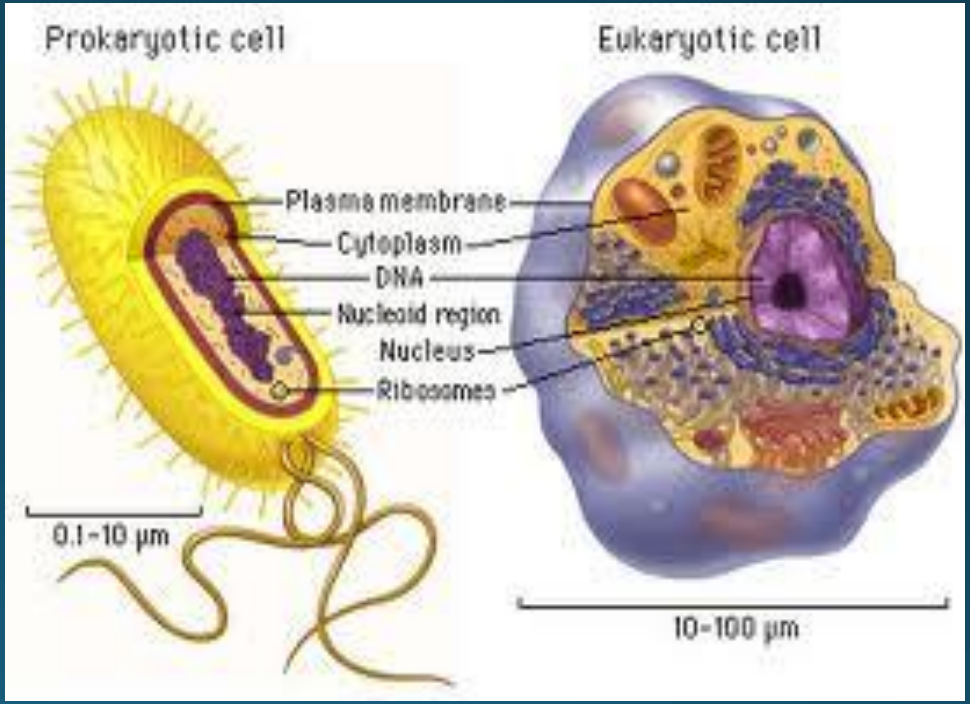
- The discovery of cells would not have been possible without the invention of the microscope.
- **Compound light microscopes use glass lenses** just like the early microscopes Robert Hooke used.
- **Modern compound light microscopes use electricity, a source of light, and can magnify images up to 1000x w/out blurring**.

Modern Microscopes

- Modern microscopes like the **transmission electron microscope (TEM)** and the **scanning electron microscope (SEM)** can **magnify specimens up to 500,000x**.
- **One disadvantage** to using these microscopes is that the **specimens must be dead.**

Basic types of Cells

- Cells come in a variety of shapes and sizes, but all cells share some basic characteristics.
- **One thing that all cells have in common is a plasma (cell) membrane.**
- The cell membrane is a **boundary which allows things into and out of the cell.**

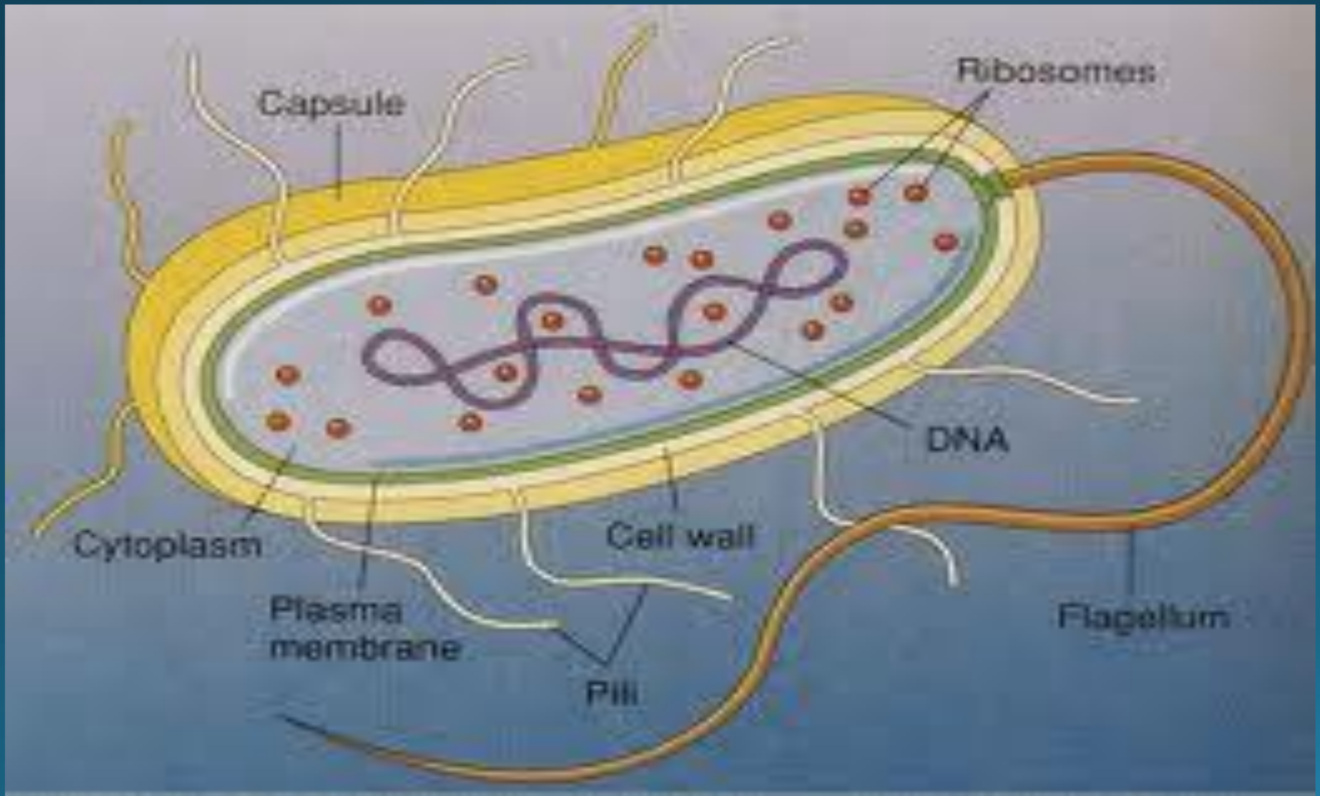


Differences in Cell Types

- All cells fall into one of two categories.
- **Eukaryotes** – Cells with a **membrane-bound nucleus** and **membrane-bound organelles**.
- **Prokaryotes** – Cells **without a membrane-bound nucleus** and **membrane-bound organelles**.
- A **nucleus** is the central organelle of a cell that **contains the genetic material (DNA).**
- **Organelles are like organs for the cell**. They are special structures that **perform vital functions** necessary to the cell.

Prokaryotic Cells

- **Prokaryotic** cell – **Unicellular** organisms like **bacteria**. Notice the DNA is not found in a nucleus and **organelles are absent (except ribosomes).**



Eukaryotic Cells

- **<u>Eukaryotic</u>** cells have a **<u>membrane-bound nucleus</u>** and **<u>membrane-bound organelles</u>**. **<u>Animals, plants, protists</u>** (like paramecium and amoeba), and **<u>fungi</u>** are all eukaryotic organisms.