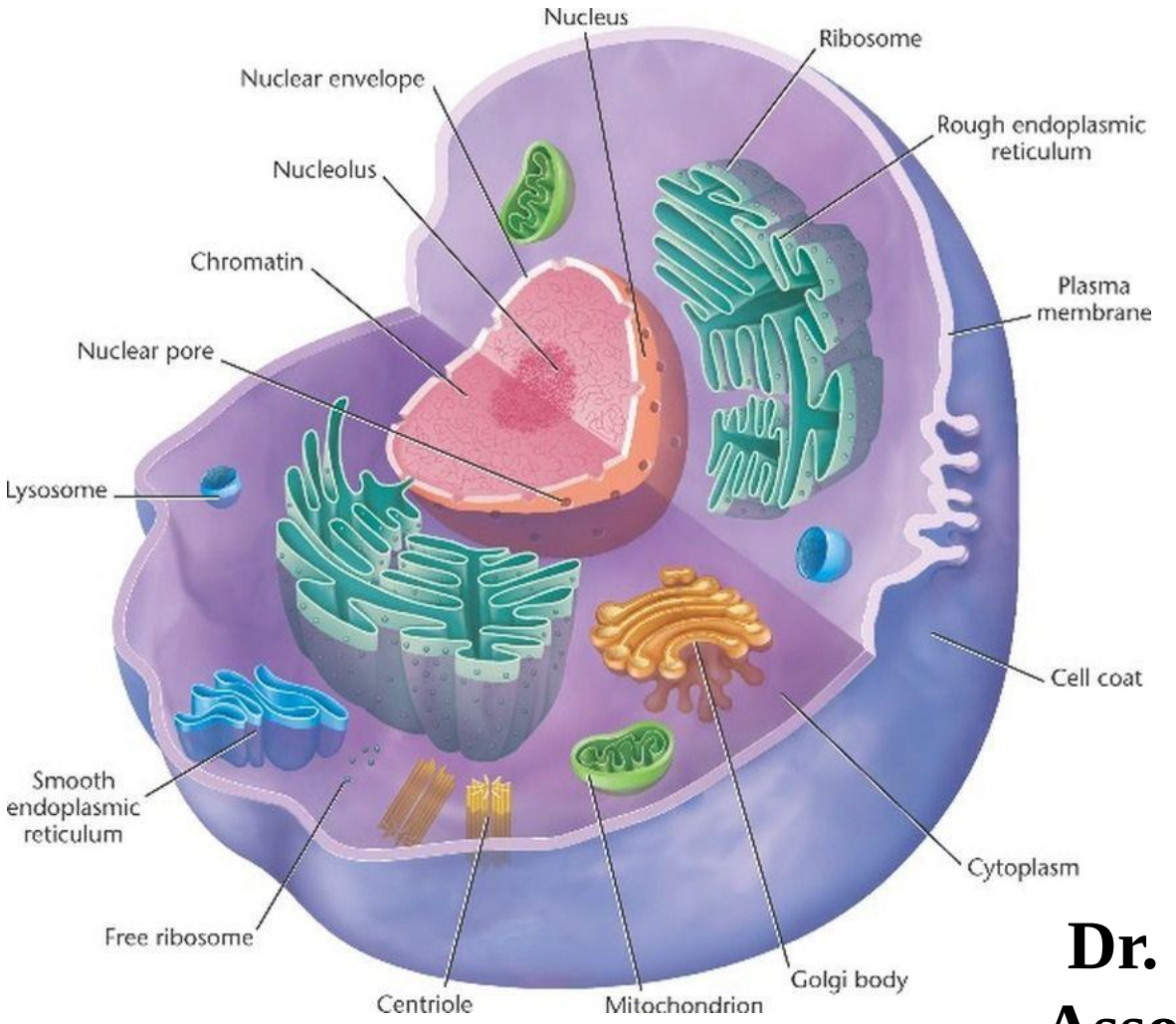
Cell physiology



Dr. Jayamala A K
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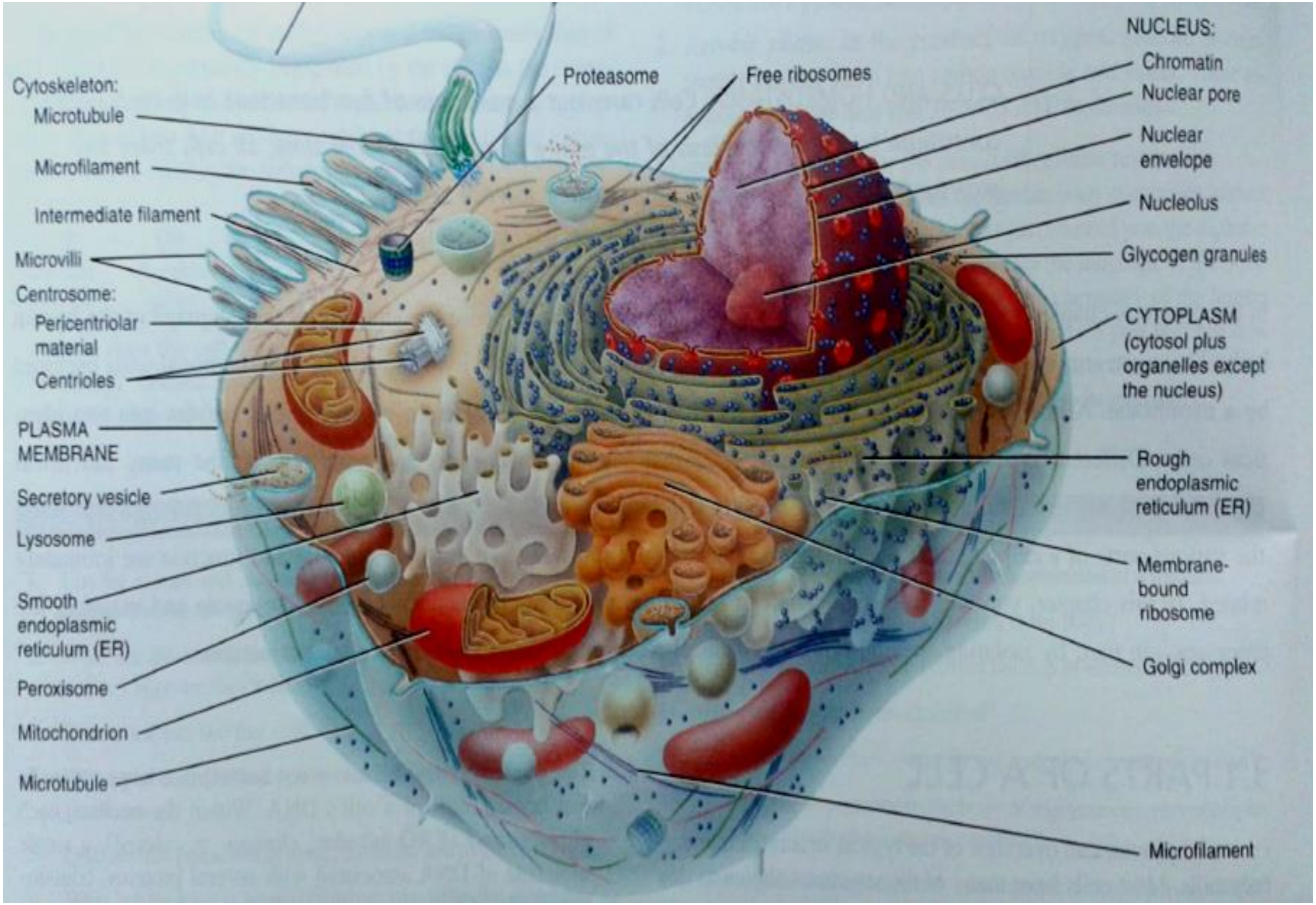
SVMCH & RC

Scheme

- Organelles
- Functions of organelles
- **Cytoskeleton**
- **Intercellular junctions**
- Applied aspect

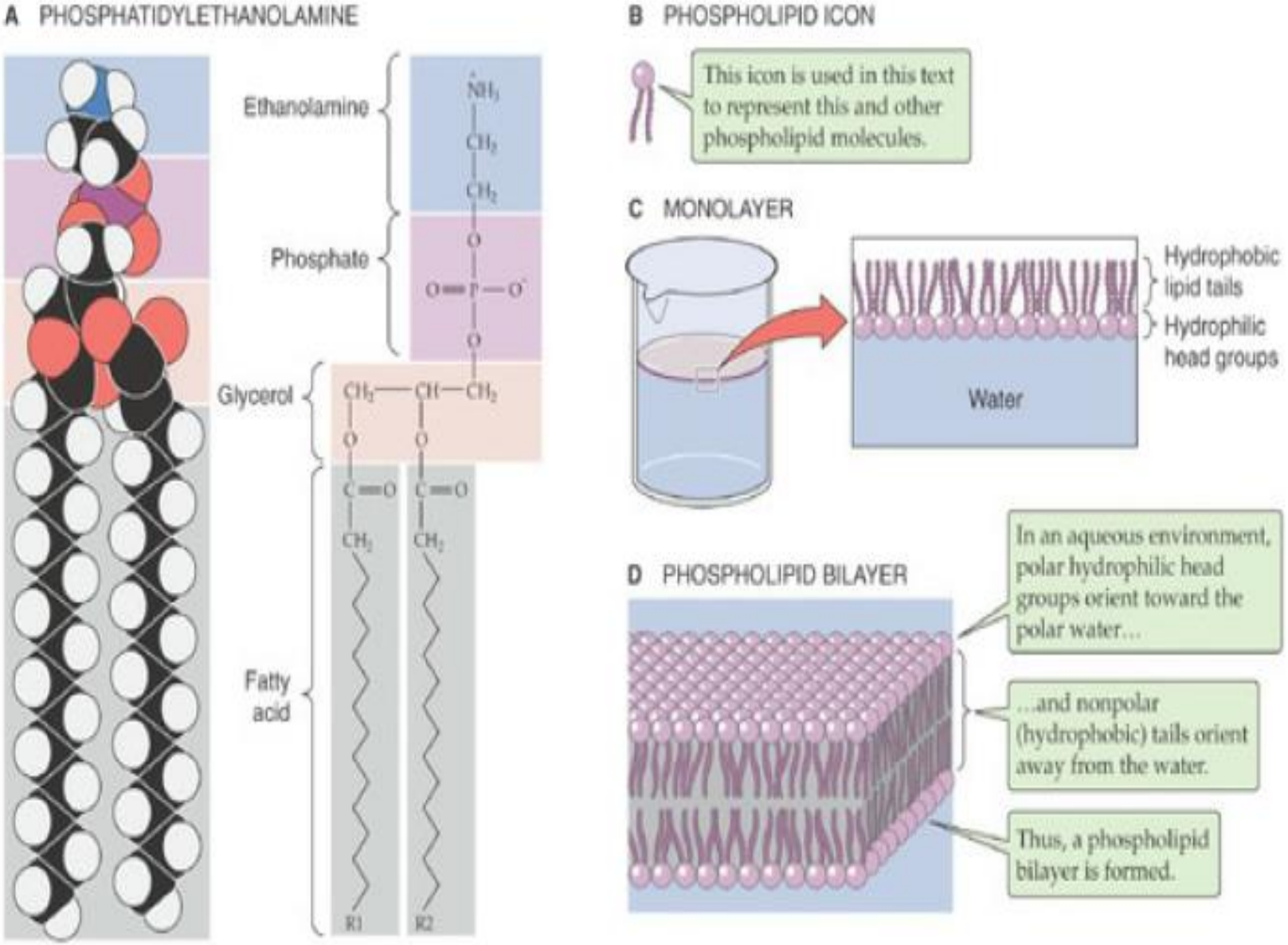

Cytoskeleton:
Microtubule
Microfilament
Intermediate filament
Microvilli
Centrosome:
Pericentriolar material
Centrioles
PLASMA MEMBRANE
Secretory vesicle
Lysosome
Smooth endoplasmic reticulum (ER)
Peroxisome
Mitochondrion
Microtubule
Proteasome
Free ribosomes
NUCLEUS:
Chromatin
Nuclear pore
Nuclear envelope
Nucleolus
Glycogen granules
CYTOPLASM (cytosol plus organelles except the nucleus)
Rough endoplasmic reticulum (ER)
Membrane-bound ribosome
Golgi complex
Microfilament

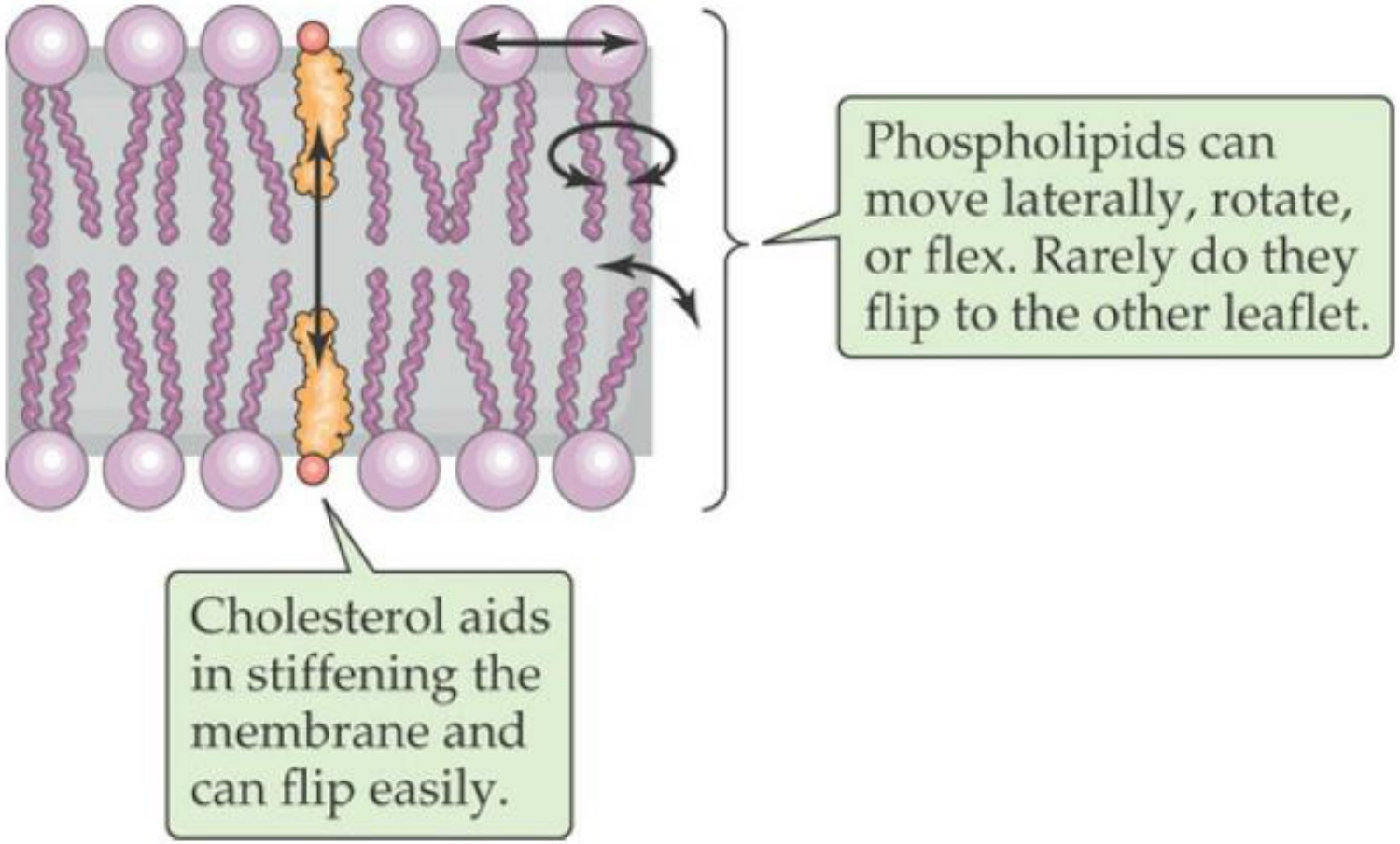
Cell membrane

Garth Nicolson
(1943-)

Saymour Singer
(1924 – 2017)

- Fluid mosaic model explained by singer and Nicolson
- Thin layer of membrane covering cytoplasm and nucleus.
- 7-10nm in thickness
- Composition: proteins (55%), lipids(42%), carbohydrates(3%)
- Made up of 2 layers of lipids.
- Mainly made up of phospholipids, cholesterol.
- Hydrophilic and hydrophobic ends


A PHOSPHATIDYLETHANOLAMINE
Ethanolamine
Phosphate
Glycerol
Fatty acid
R1
R2
B PHOSPHOLIPID ICON
This icon is used in this text to represent this and other phospholipid molecules.
C MONOLAYER
Hydrophobic lipid tails
Hydrophilic head groups
Water
D PHOSPHOLIPID BILAYER
In an aqueous environment, polar hydrophilic head groups orient toward the polar water…
…and nonpolar (hydrophobic) tails orient away from the water.
Thus, a phospholipid bilayer is formed.

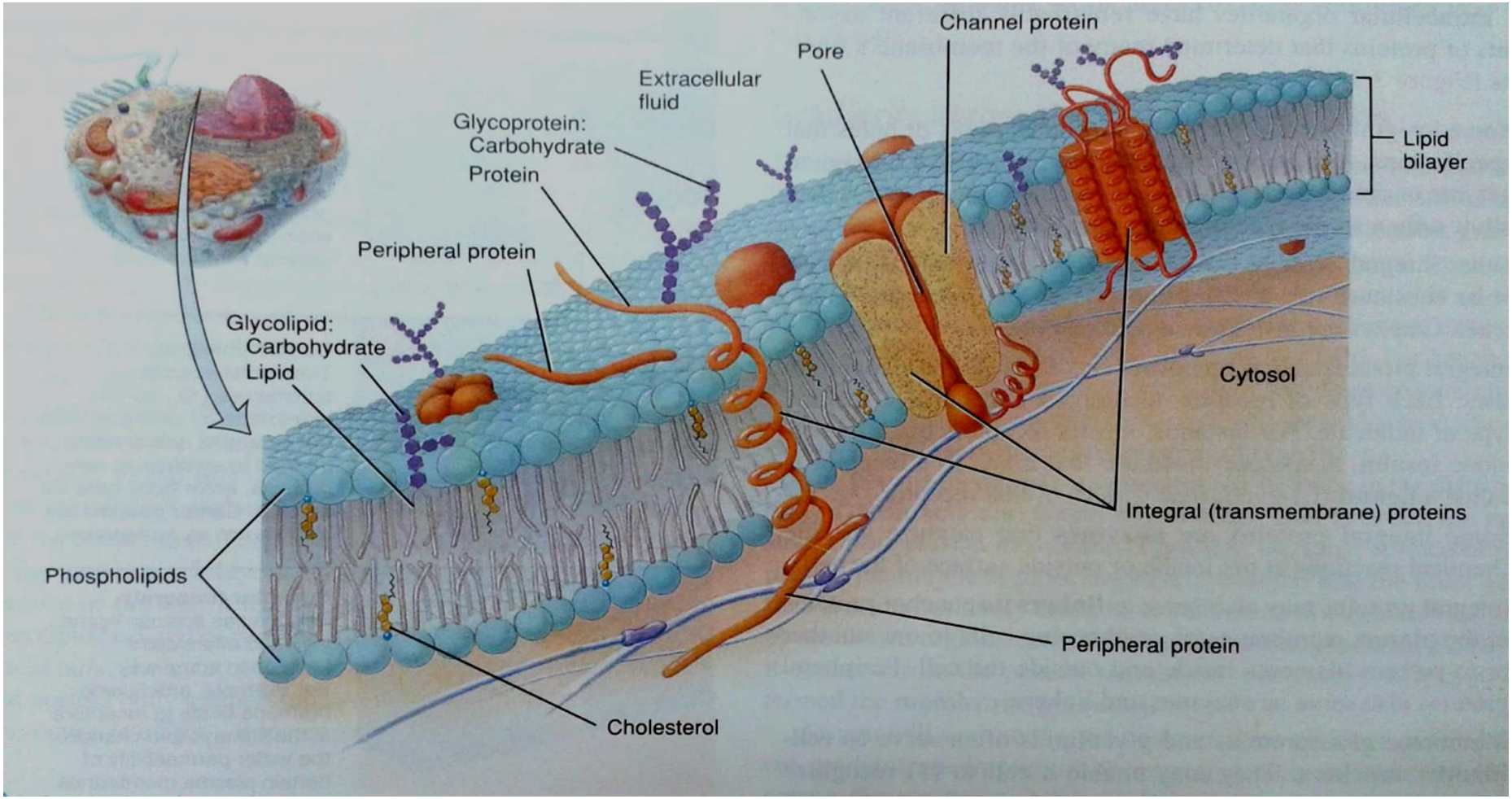

Phospholipids can move laterally, rotate, or flex. Rarely do they flip to the other leaflet.
Cholesterol aids in stiffening the membrane and can flip easily.

Functions of lipids

- Cholesterol present in cell membrane provides stability
- Selectively permeable (fat soluble substances can pass easily through the membrane)

- Proteins and carbohydrates attach to the lipids on the cell membrane.

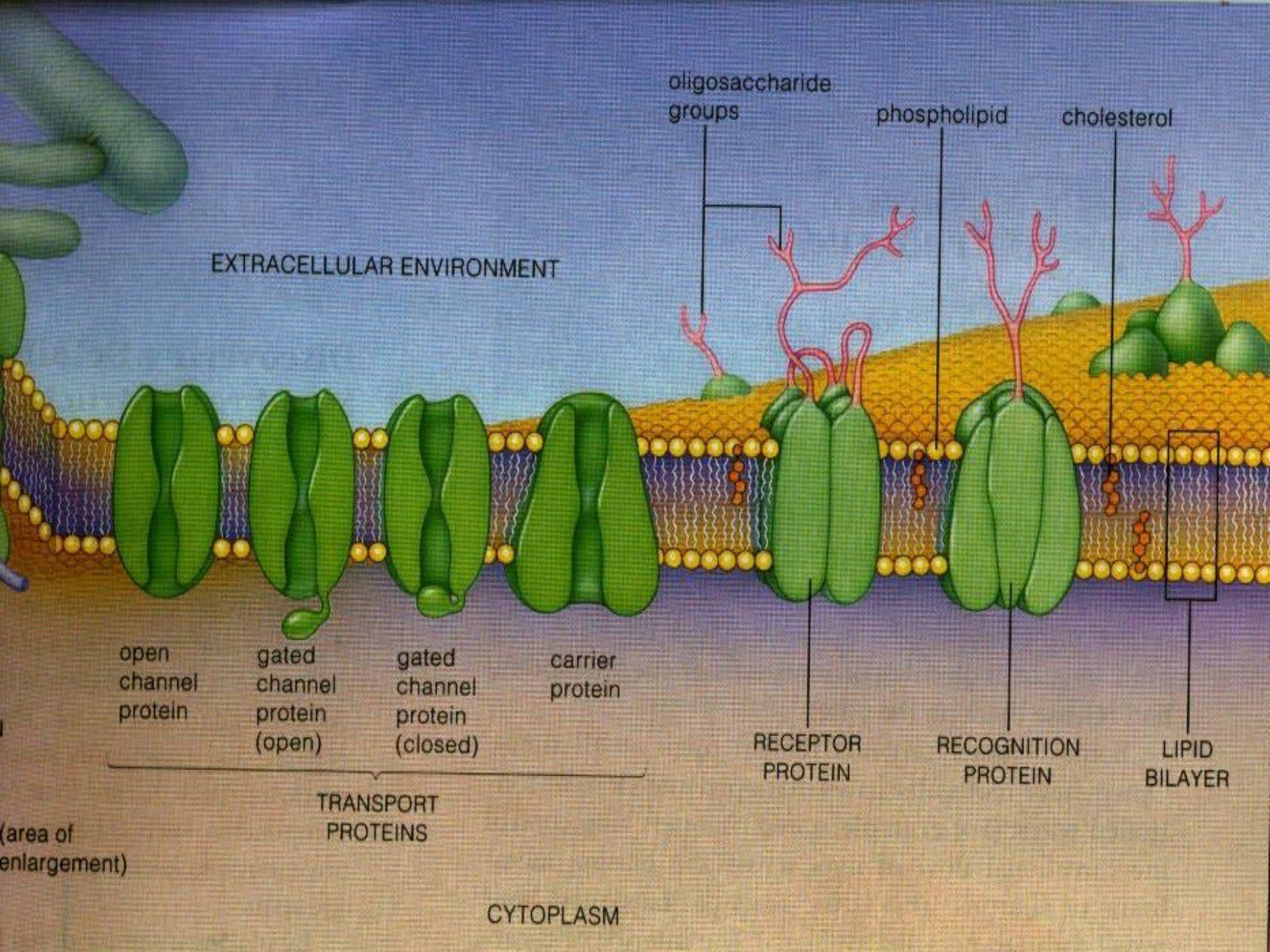
Cell membrane



Membrane proteins

- **Integral proteins and peripheral proteins**
- Glycoproteins or Lipoproteins

- Glycoproteins form receptors for hormones (cell communication)
- Lipoproteins form ion channels
- Enzymes
- Create **channels** /**pores** through which water and water soluble chemicals can pass
- Act as **carrier proteins**
- Are important in **cell recognition** via cell surface antigens
- Receptors


oligosaccharide groups
phospholipid
cholesterol
EXTRACELLULAR ENVIRONMENT
open channel protein
gated channel protein (open)
gated channel protein (closed)
carrier protein
RECEPTOR PROTEIN
RECOGNITION PROTEIN
LIPID BILAYER
TRANSPORT PROTEINS
(area of enlargement)
CYTOPLASM

Functions of carbohydrates

- Carbohydrates form a thin layer throughout the surface of the cell membrane which is called glycocalyx

- Glycolipids/ glycoproteins
- Many of them have negative electrical charge, so overall negative charge repels other molecules
- Glycocalyx of 2 cells can attach to one another
- Form receptors: eg- insulin receptor
- Participate in immune reactions.

Fluid mosaic model

- Cell membranes are made up of phospholipid bilayer admixed with protein molecules freely floating around it.
- Fluid : phospholipids & proteins move freely
- Mosaic: topographic patterns produced by proteins

- **Function of cell membrane:** boundary, selective permeability, internal homeostasis.

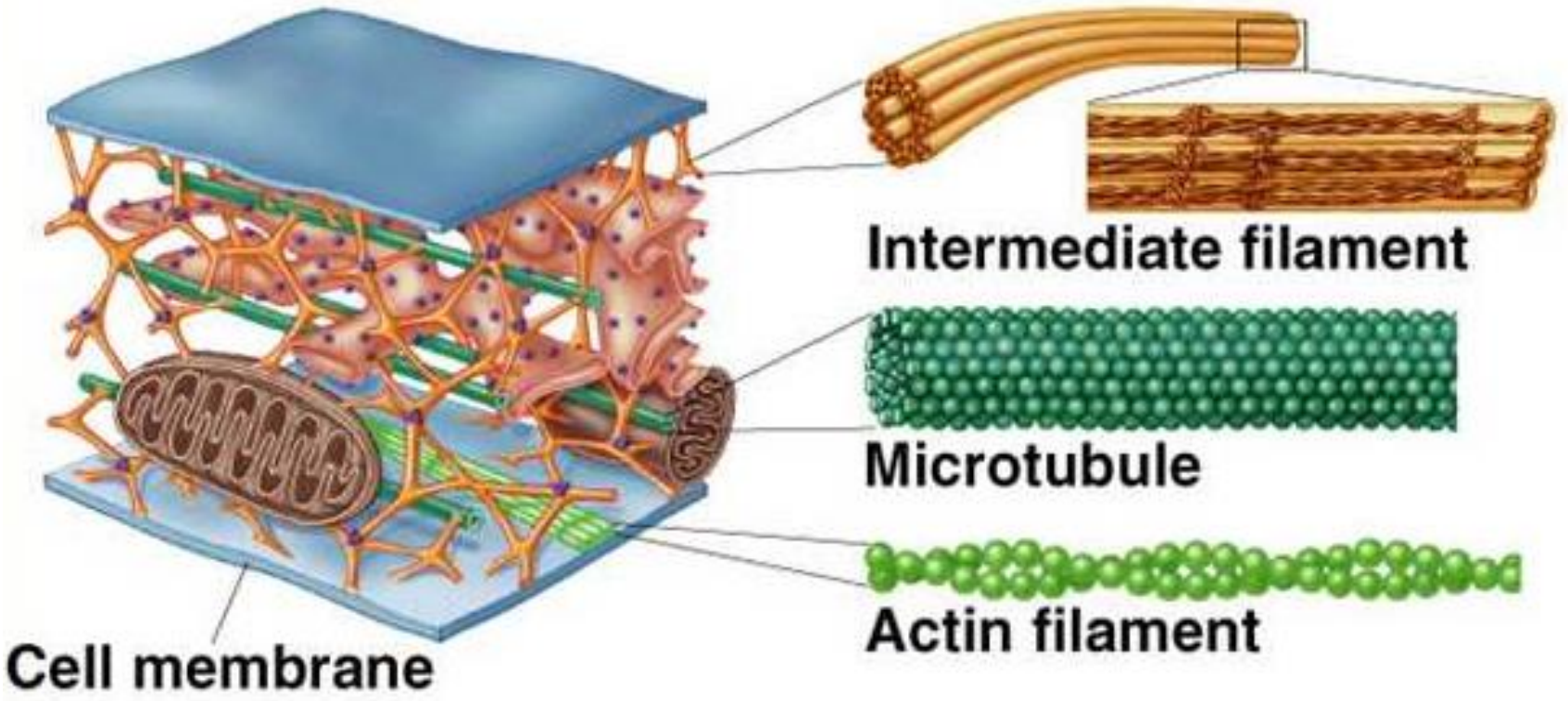
The cytoskeleton

Protein filament that extends throughout the cytosol

3 types in order of their increasing diameter

1. Microfilaments
2. Intermediate filaments
3. Microtubules

cytoskeleton



Cytoskeleton

Microfilament

- 4-8nm
- Actin interact with the membrane bound proteins
- Helps in cell movement

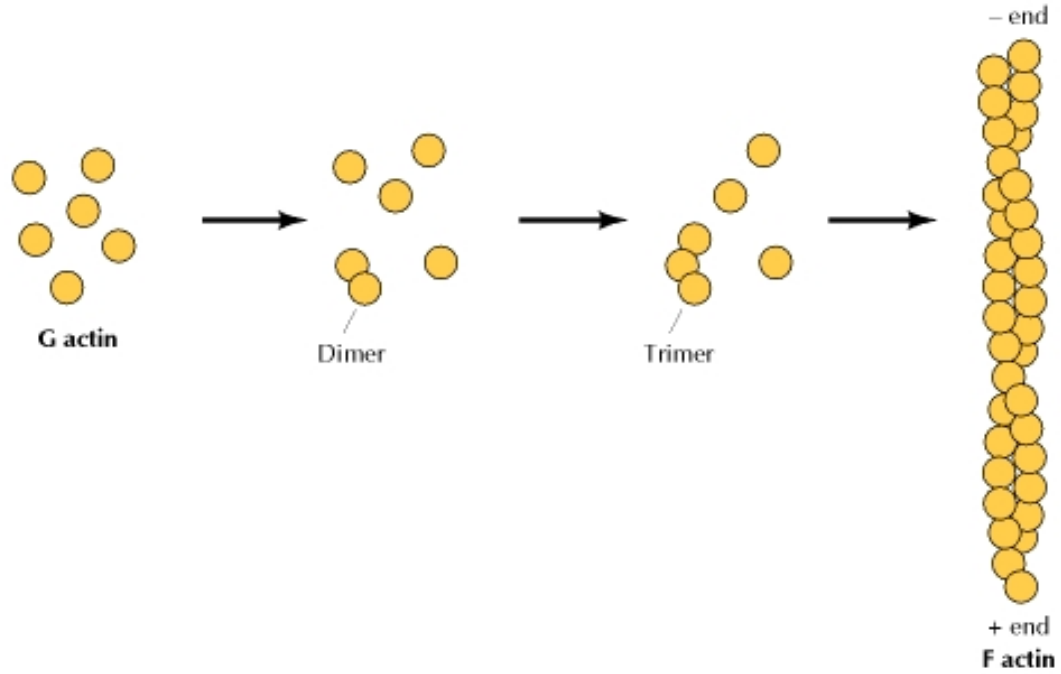
Intermediate filament

- 8-14nm
- connect nucelar membrane to cell membrane
- Resists external pressure

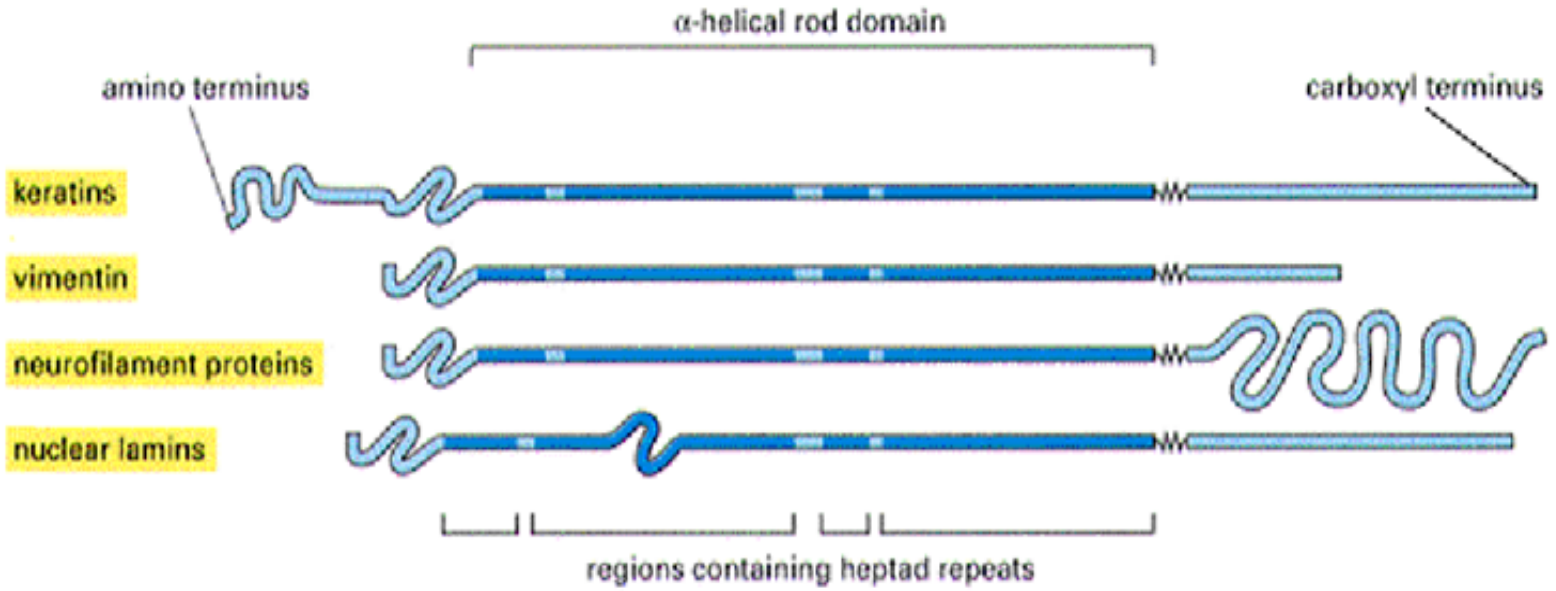
Microtubules

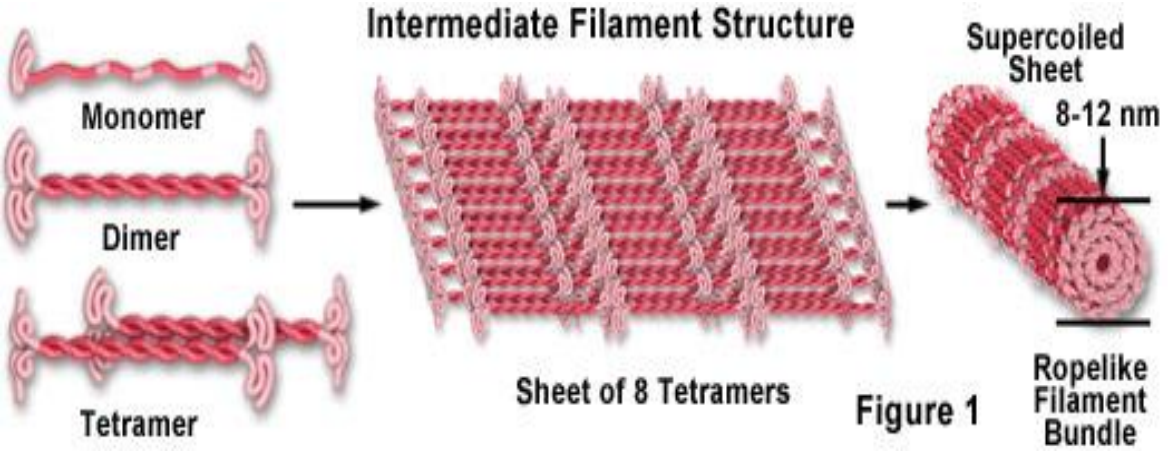
- 15nm
- Provide tract for transportation of vesicles and organelles
- Anticancer drugs

Microfilament



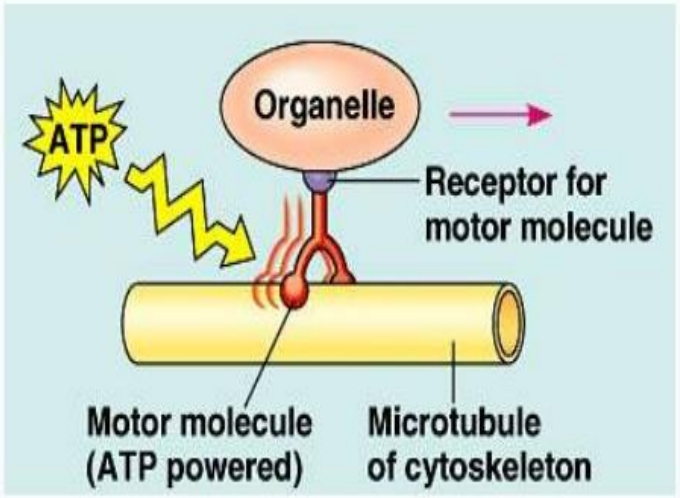
Intermediate filaments



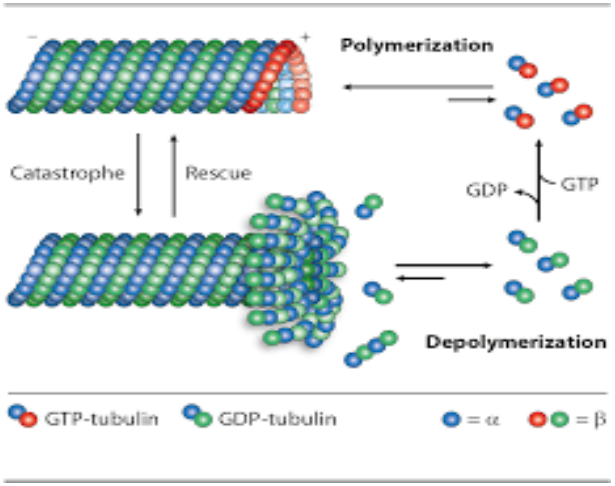


Microtubules

- Provide the basis for subcellular motility
- Spindle fibres – microtubules
- **Molecular motors** – **Dyneins** and **Kinesin**

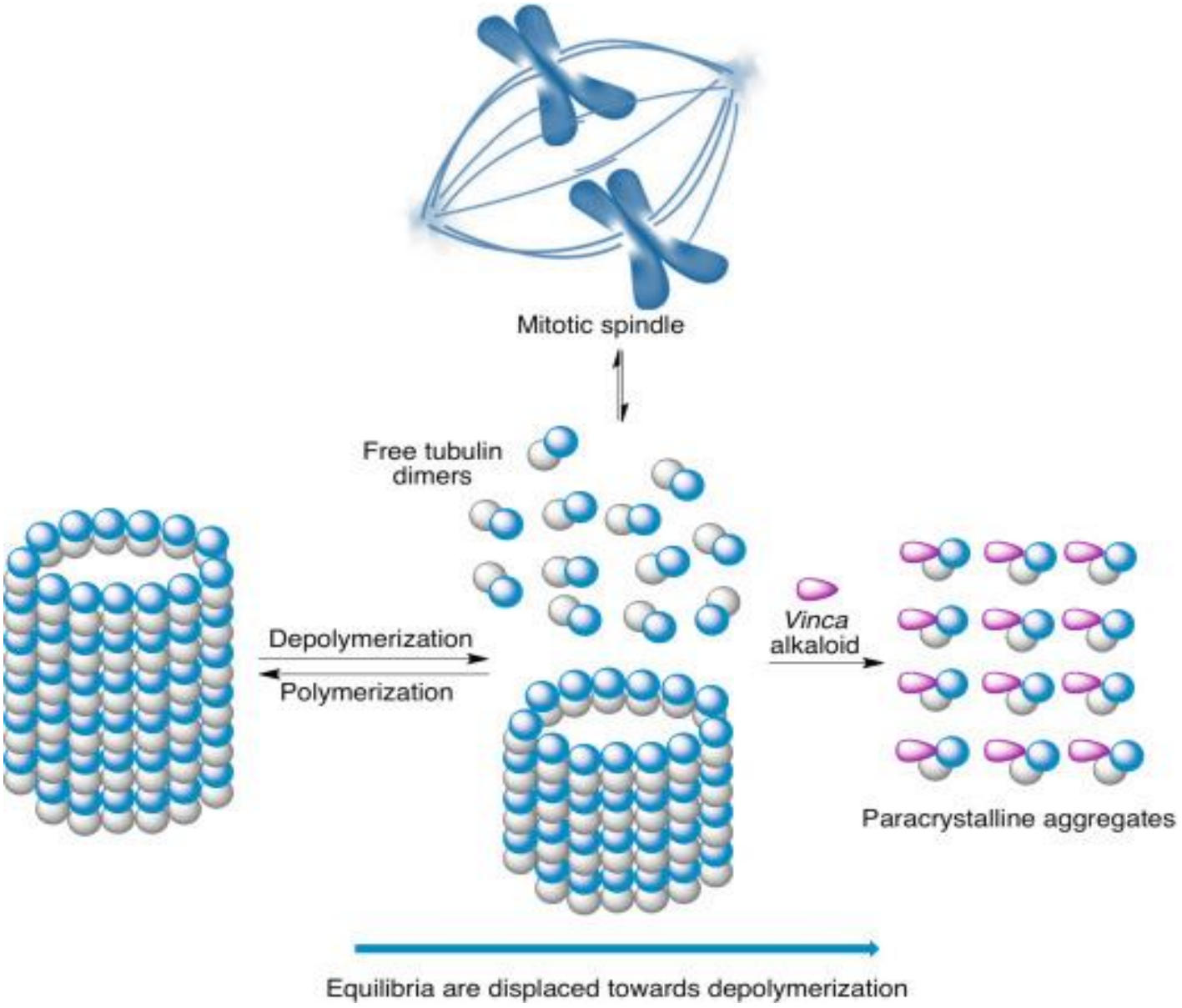


Motor molecules also carry vesicles or organelles to various destinations along "monorails' provided by the cytoskeleton.



- Microtubules assembly is inhibited by drugs like colchicine, vincristine, vinblastine

- Paclitaxel enhances polymerization and it stabilizes microtubules and thereby inhibits disassembly


Mitotic spindle
Free tubulin dimers
Depolymerization
Polymerization
Vinca alkaloid
Paracrystalline aggregates
Equilibria are displaced towards depolymerization

Intercellular connections/ junctions

- Consist of multi-protein complexes that provide contact between neighbouring cells or between a cell and the extracellular matrix

INTERCELLULAR CONNECTIONS

- Intercellular junctions are divided into two groups:

1) Junctions that fasten the cells to one another and to surrounding tissues

Why?

This tie cells together and endow tissues with strength and stability

2) Junctions that permit transfer of ions and other molecules from one cell to another.

why?

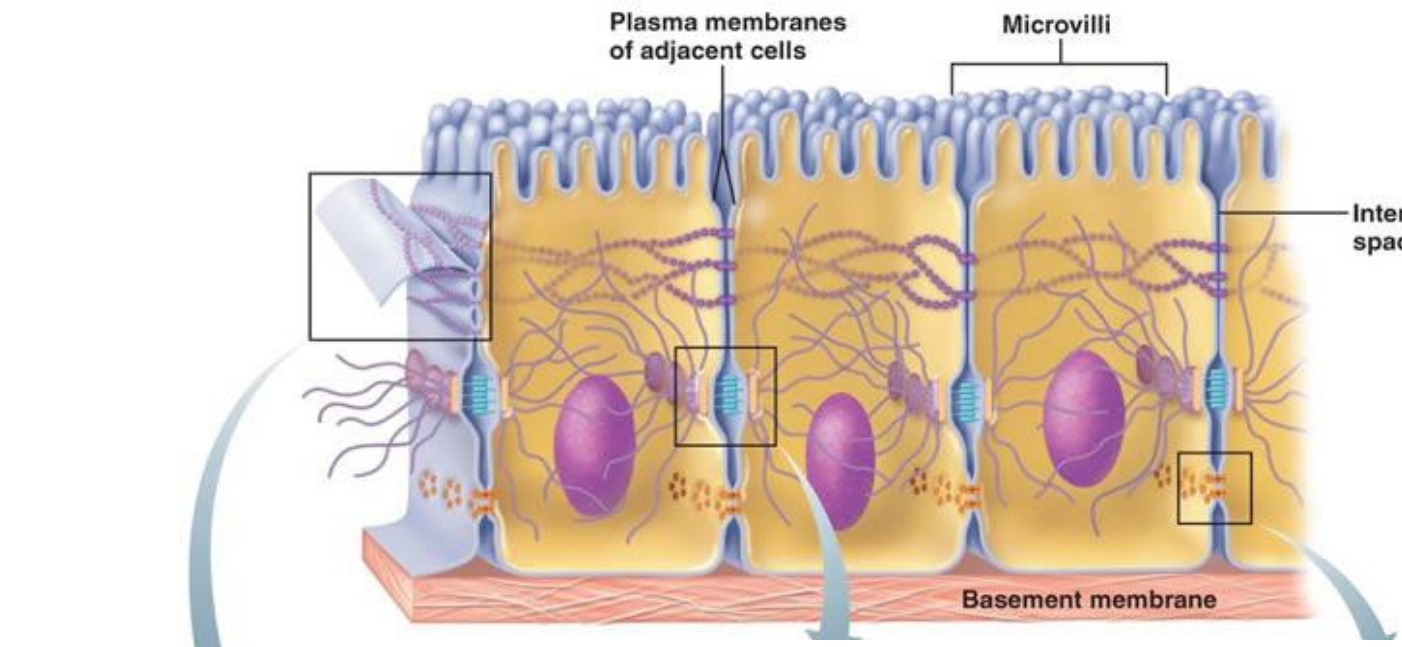
Transfer of ions from one cell to another for effective functioning

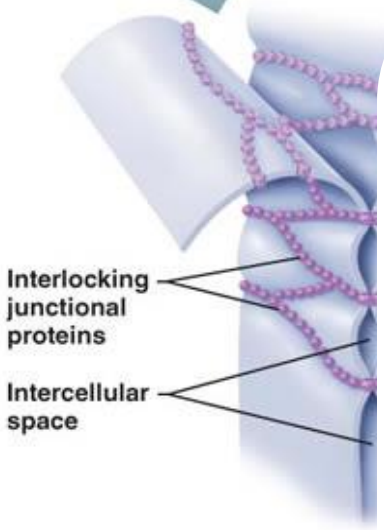
Table Types of intercellular connections.

A. Junctions that tie cells together
1. Tight junctions
2. Anchoring junctions
a. Cell to cell anchoring junctions
– Desmosome
– Zonula adherens
b. Cell to basal lamina anchoring junctions
– Hemidesmosome
– Focal adhesion
B. Junctions that allow transfer of ions and small molecules
1. Gap junctions

Tight junctions/ zonula occludens :

- Attach 2 cells near apical margins of the cells in epithelia
- Location: Intestinal mucosa, Renal tubules, and the choroid plexus.
- There are 3 main families of transmembrane proteins that contribute to tight junctions: **occludin, junctional adhesion molecules (JAMs),** and **claudins**.
- Tight junctions permit the passage of some ions and solute in between adjacent cells **(paracellular pathway)**.

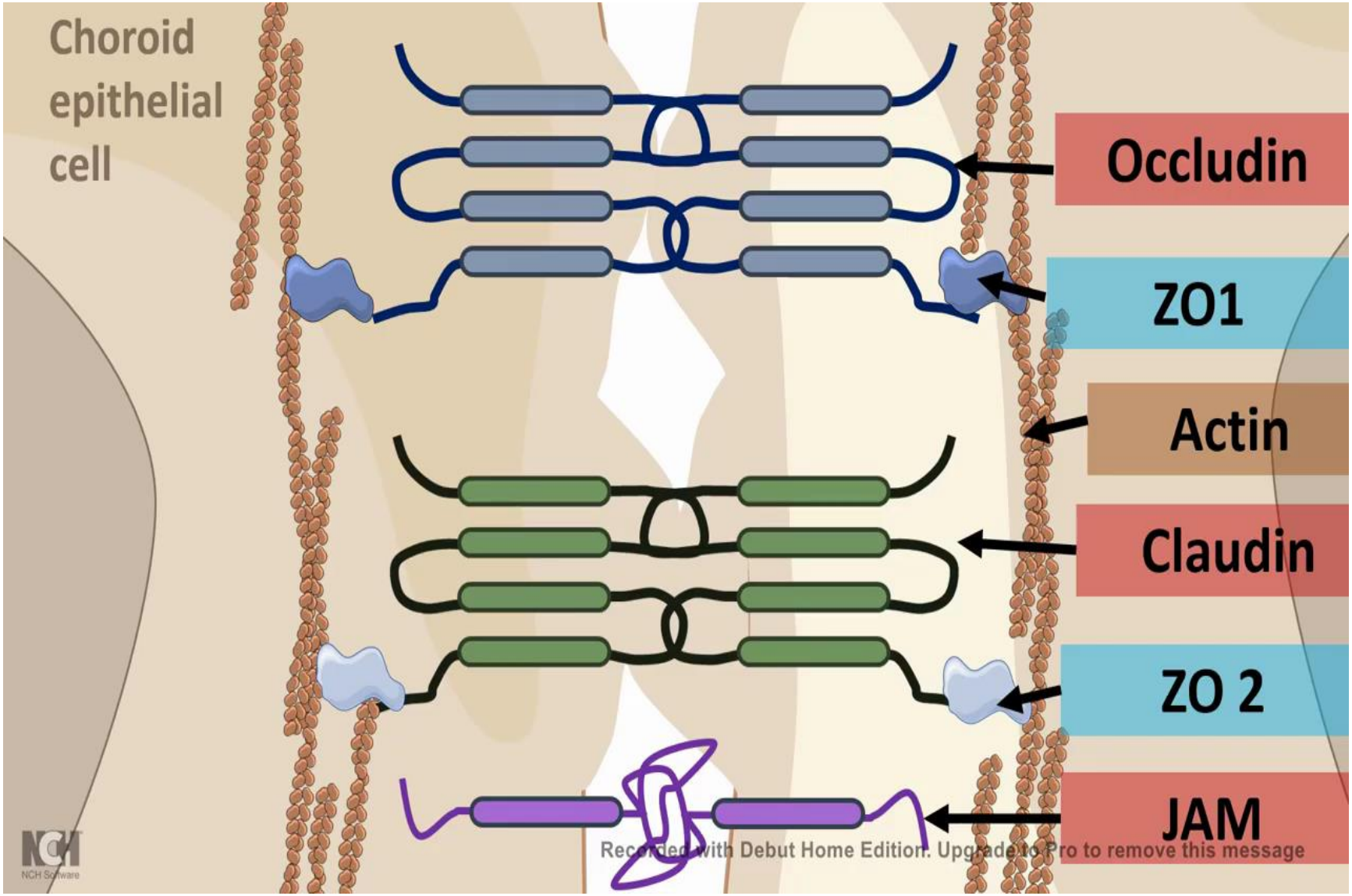


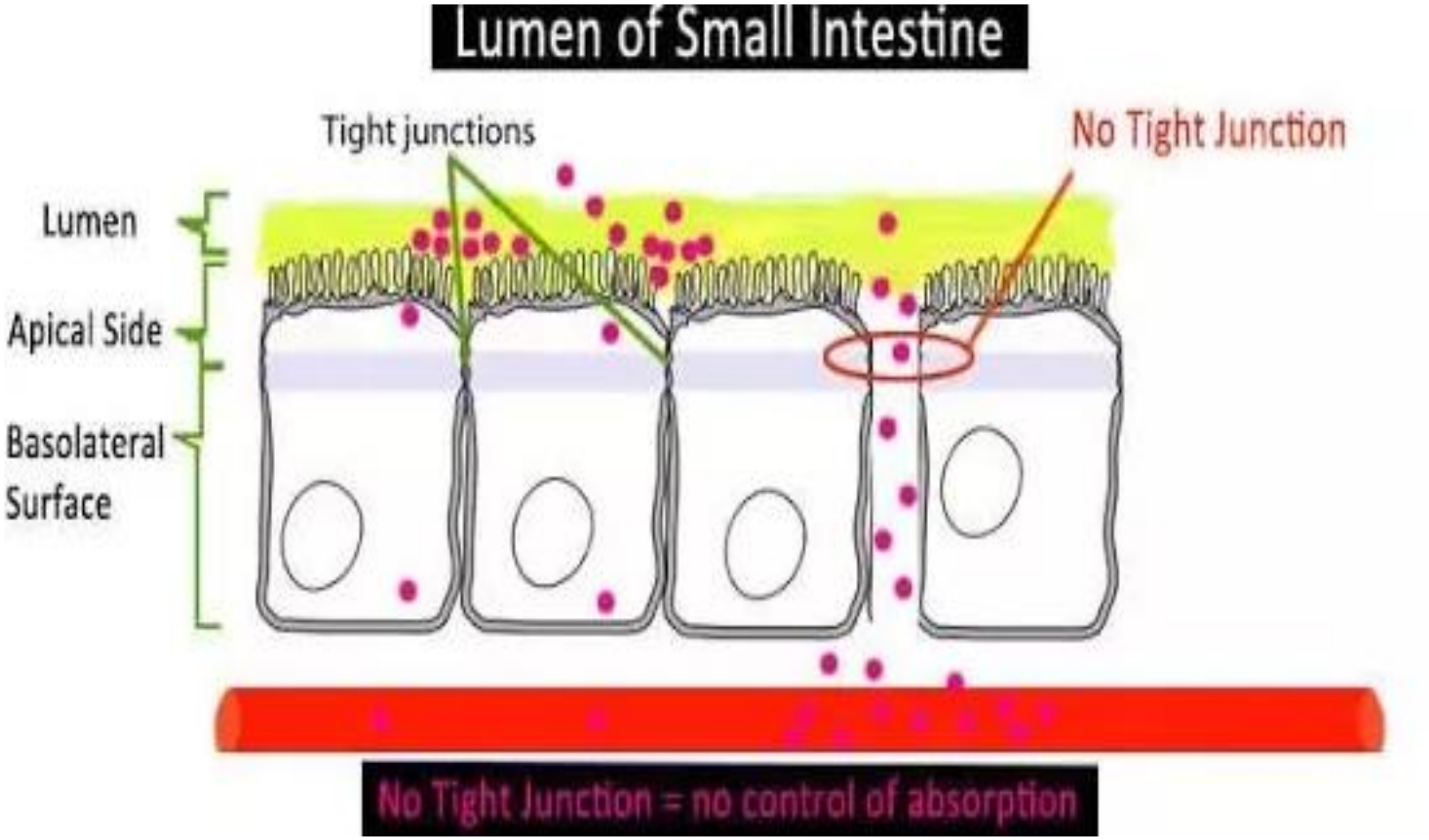


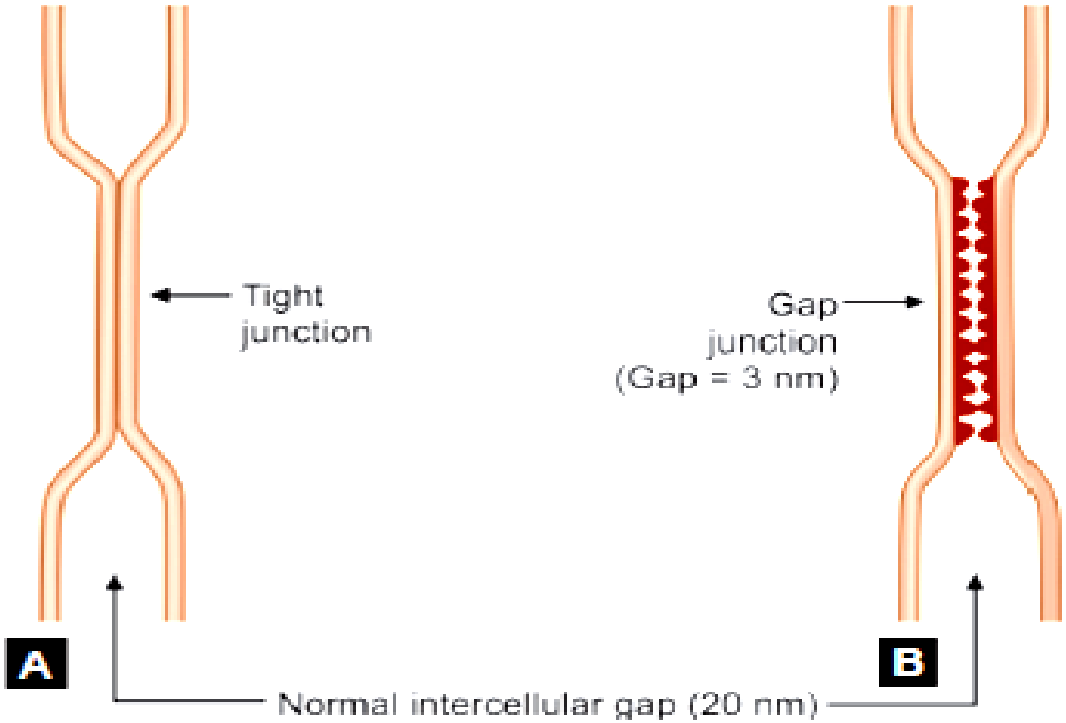
(a) **Tight junctions:** Imperme
prevent molecules from pas
the intercellular space.

Functions of Tight junctions

- Selective permeability barrier
- Paracellular transport of solutes and solvents
- Blood brain barrier


Choroid epithelial cell
Occludin
ZO1
Actin
Claudin
ZO 2
JAM
Recorded with Debut Home Edition. Upgrade to Pro to remove this message
NCH Software


Lumen of Small Intestine
Tight junctions
No Tight Junction
Lumen
Apical Side
Basolateral Surface
No Tight Junction = no control of absorption



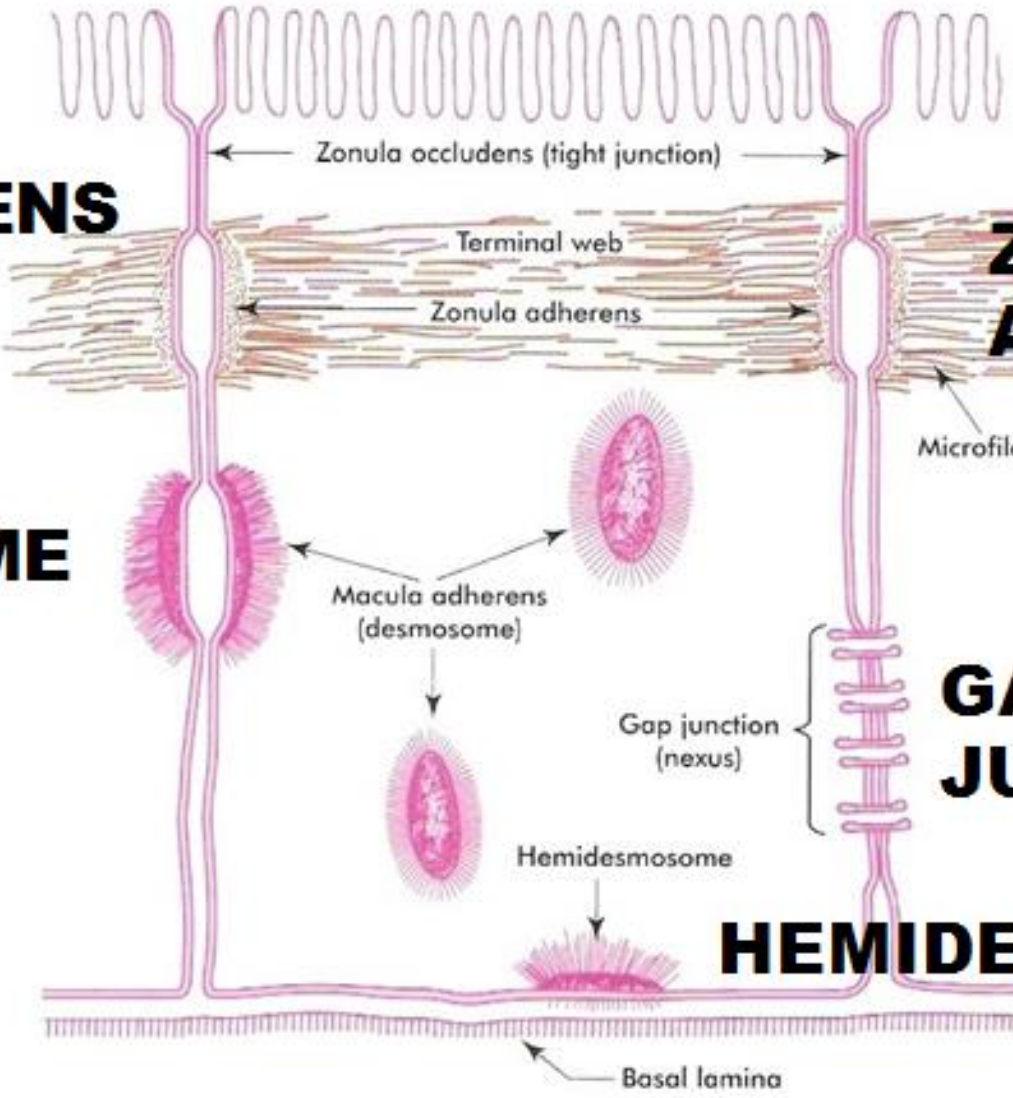
Figs. 4.18A and B: Gap of 3 nm between cells at gap junctions (B), and no gap between cells at tight junctions (A).

Cell to cell anchoring junctions

- **Zonula adherens**: is located on the basal side of the zonula occludens,
- It is a major site of attachment for intracellular microfilaments.
- It contains cadherins.

- **Desmosomes** are patches characterized by opposed thickenings of the membranes of two adjacent cells.
- Attached to the desmosomes in each cell are intermediate filaments.
- Between the two membrane thickenings the intercellular space contains cadherins.

ZONULA OCCLUDENS



ZONULA ADHERENS

DESMOSOME

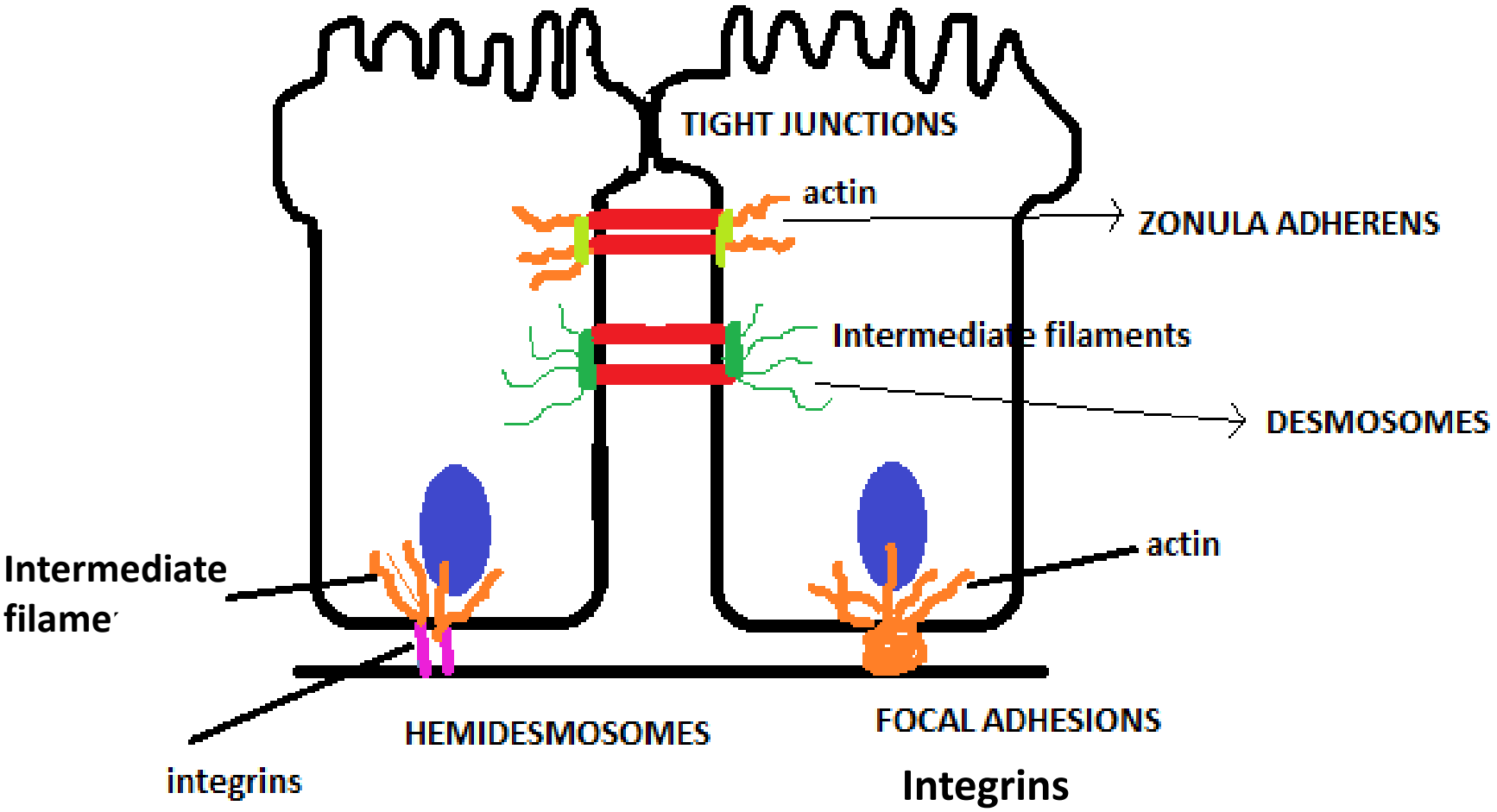
GAP JUNCTION

HEMIDESMOSOME

- **Hemidesmosomes**: look like half-desmosomes that attach cells to the underlying basal lamina and are connected intracellularly to intermediate filaments. They contain integrins rather than cadherins.

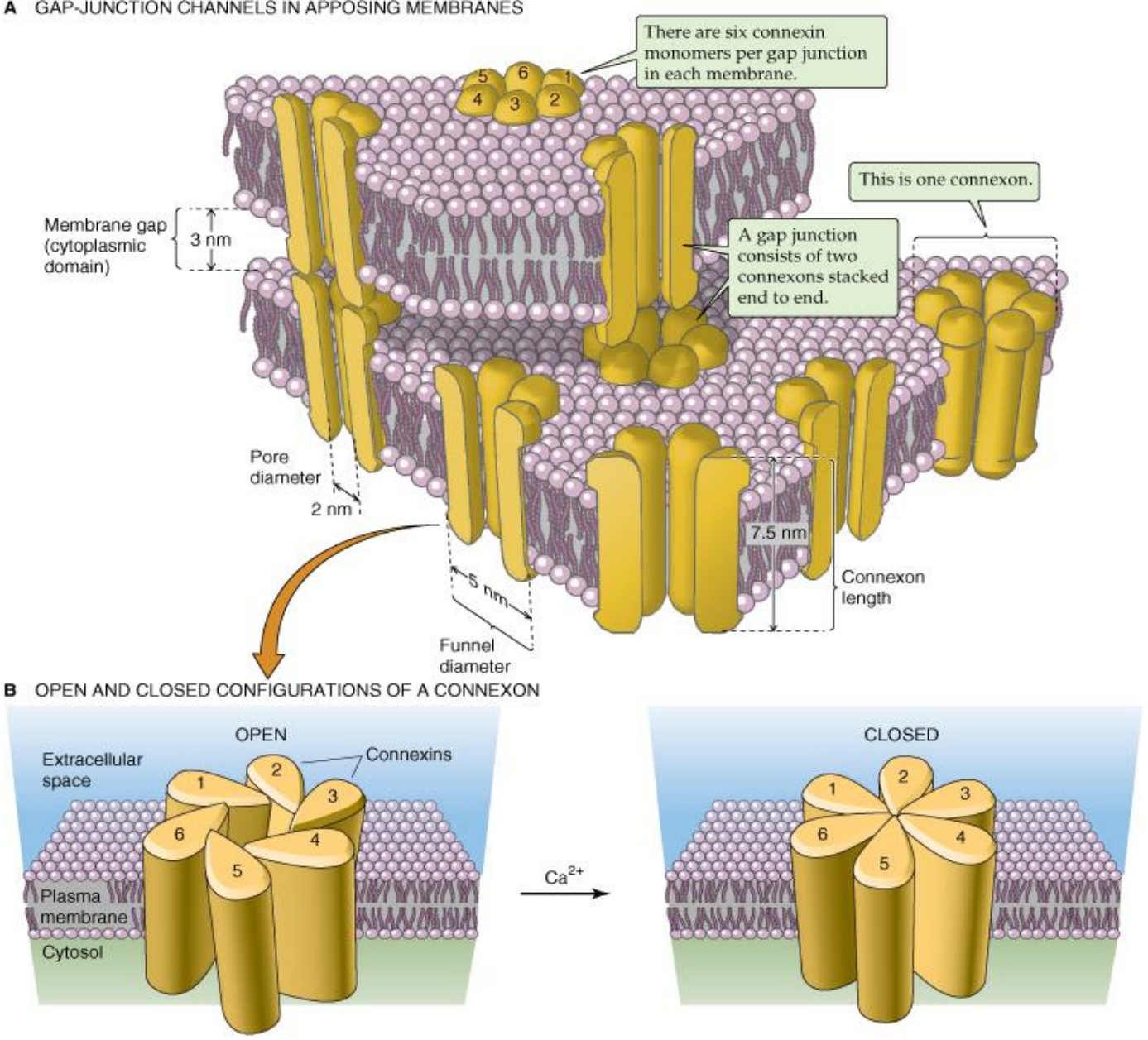
- **Focal adhesions** also attach cells to their basal laminas. They are associated with actin filaments inside the cell, and they play an important role in cell movement.

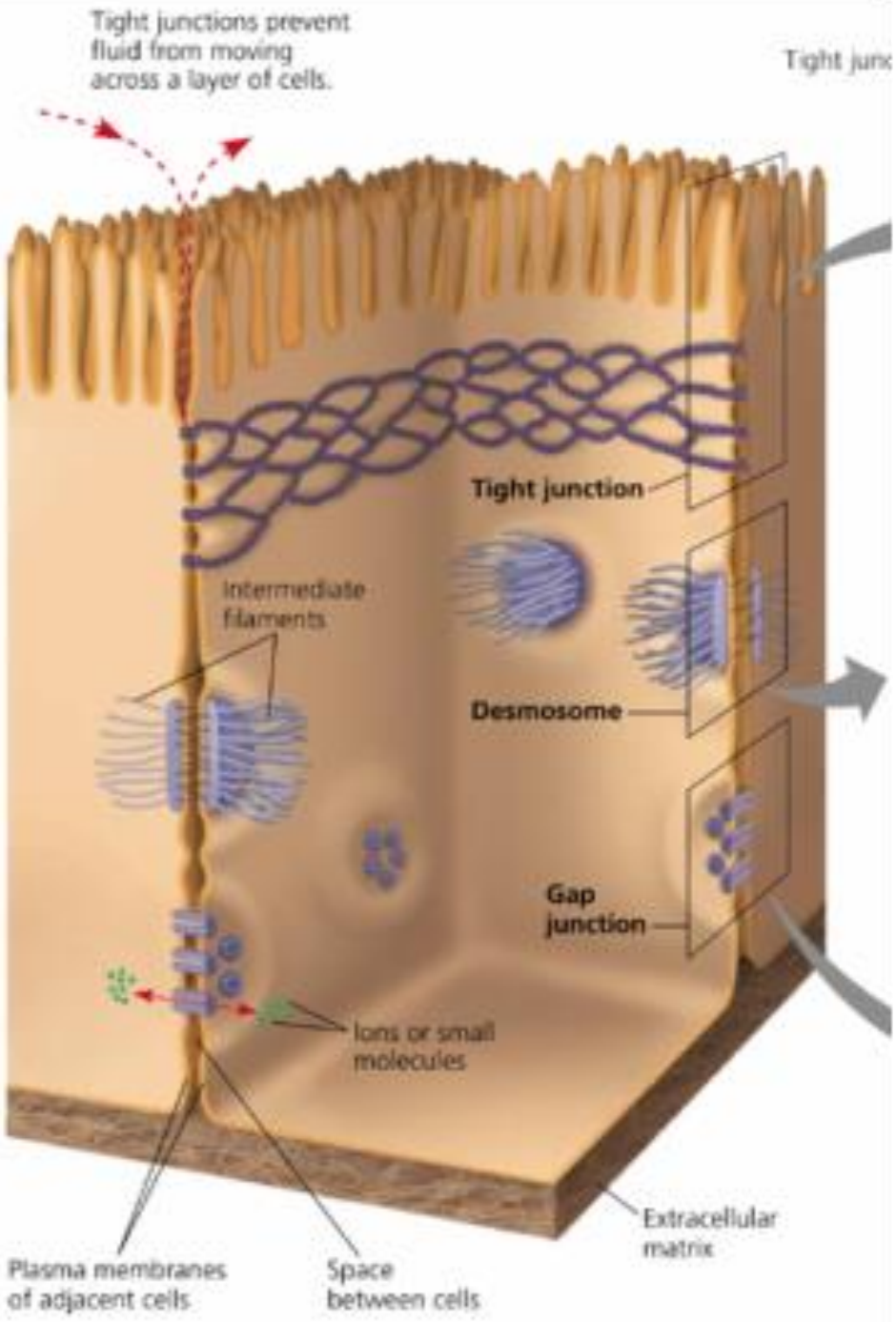
JUNCTIONS THAT TIE CELLS TOGETHER



Gap Junctions

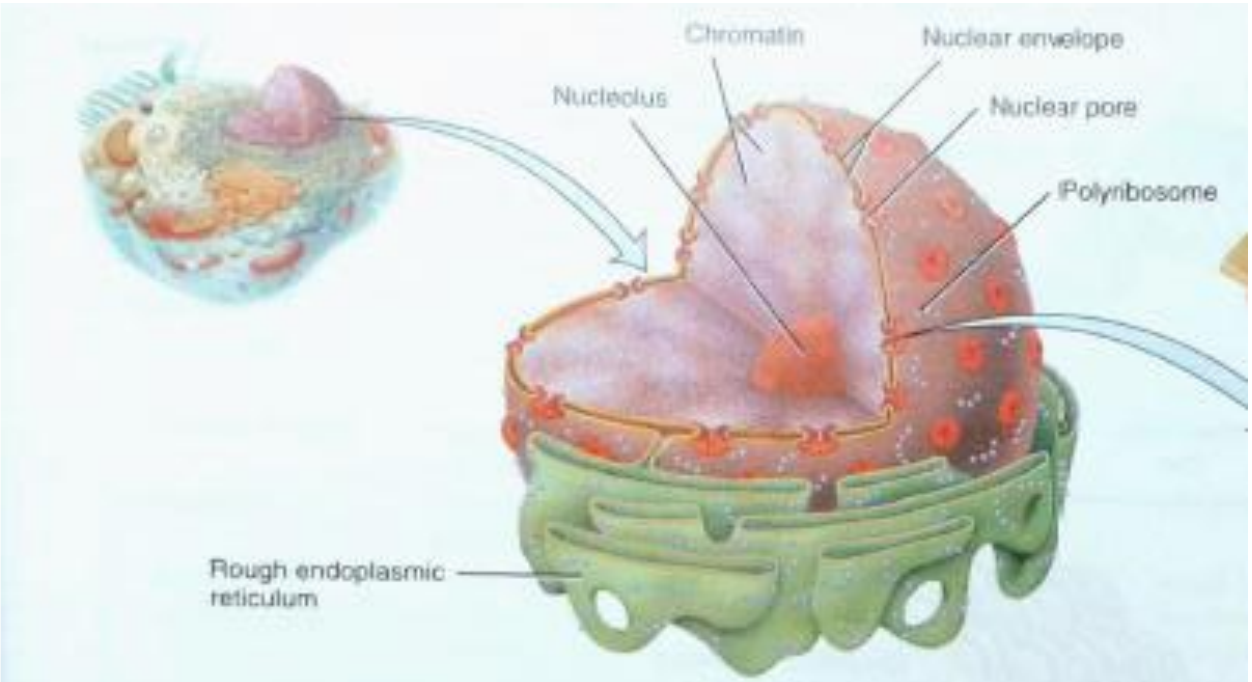
- At gap junctions, the intercellular space narrows from 25 nm to 3 nm, and units called **connexons** in the membrane of each cell are lined up with one another .
- Each connexon is made up of six protein subunits called **connexins.**
- X-linked **Charcot–Marie–Tooth disease** is a peripheral neuropathy associated with mutation of one particular connexin gene (approximately 20 genes codes for connexions).
- Cardiac muscles form synctitium due to gap junctions.



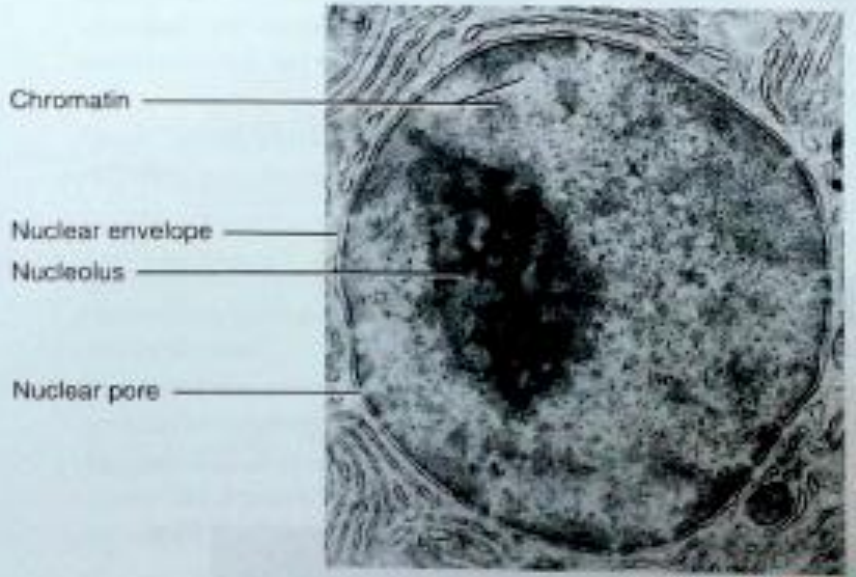

Tight junctions prevent fluid from moving across a layer of cells.
Tight junction
Intermediate filaments
Desmosome
Gap junction
Ions or small molecules
Extracellular matrix
Plasma membranes of adjacent cells
Space between cells

Nucleus Functions

- Stores & transmits the genetic material in the cell in the form of DNA
- Acts as the control centre of the cell through the production of mRNA and protein synthesis
- Manufactures ribosomal RNA (rRNA)



(a) Details of the nucleus



Ribosomes-Protein Factory

Structure

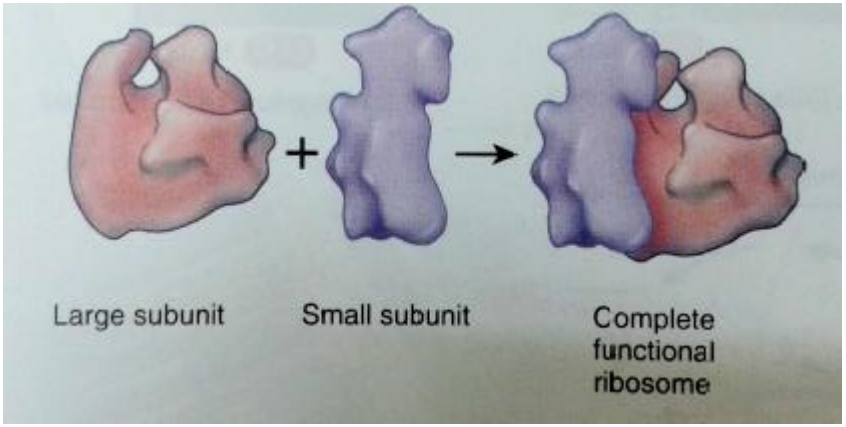
Composed of two subunits

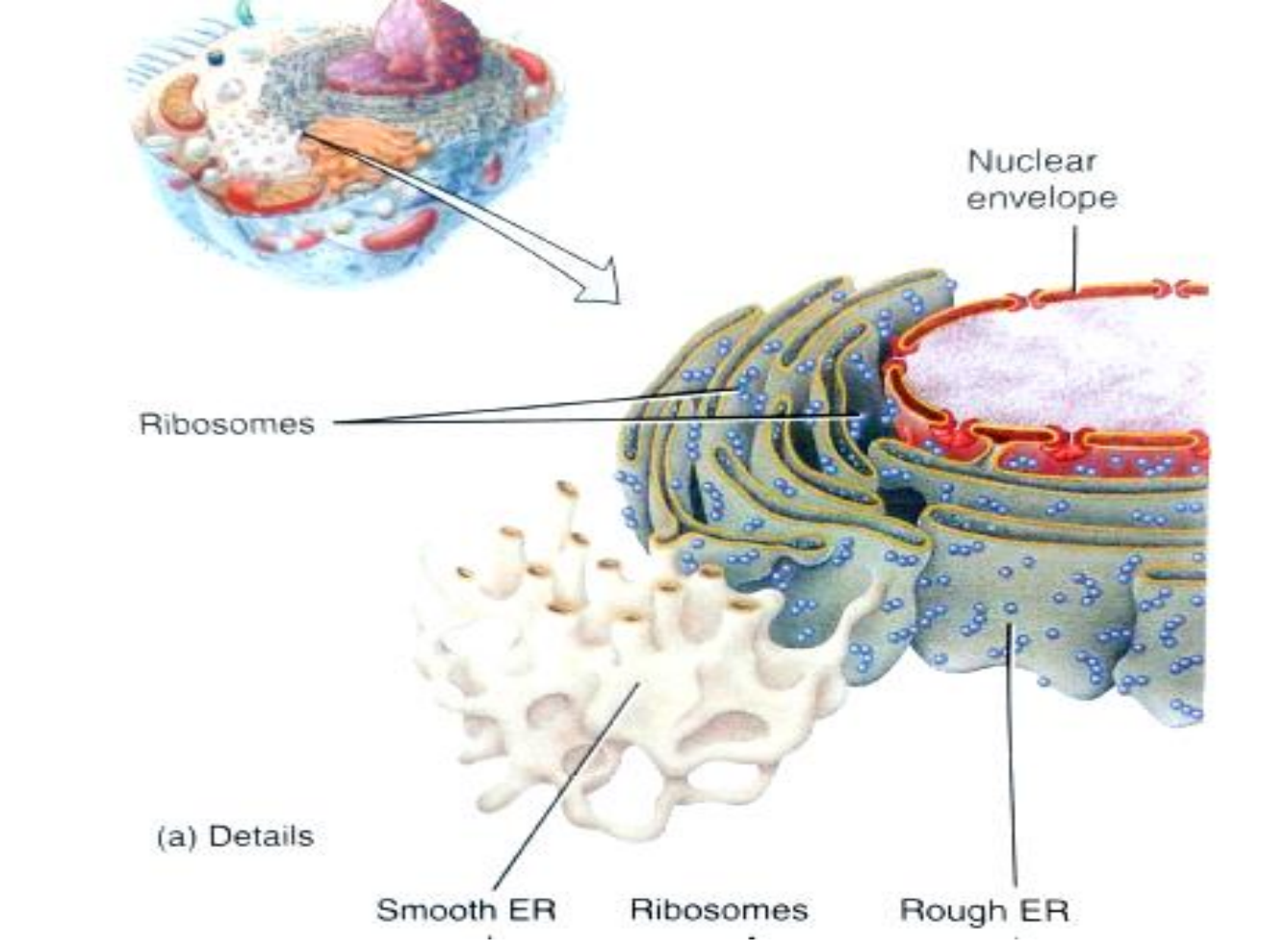
Contains ribosomal RNA and proteins

Ribosomes may be free in cytosol or attached to rough ER.

Functions

Protein synthesis




Nuclear envelope
Ribosomes
(a) Details
Smooth ER
Ribosomes
Rough ER

Rough/Granular Endoplasmic reticulum

- Proteins synthesized from ribosomes enter into lumen of endoplasmic reticulum(endoplasmic matrix), from here it will be sent to other organelles.
- Produces secretory proteins, membrane proteins

Smooth ER functions:

1. Smooth ER synthesizes fatty acids & steroids (estrogen, testosterone)
2. In Liver it inactivates or detoxifies drugs & other potentially harmful substances(alcohol, carcinogens)
3. In muscle it stores & releases calcium ions. (sarcoplasmic reticulum)

Golgi Apparatus

- Consists of 3-20 flattened membraneous sacs called cisternae

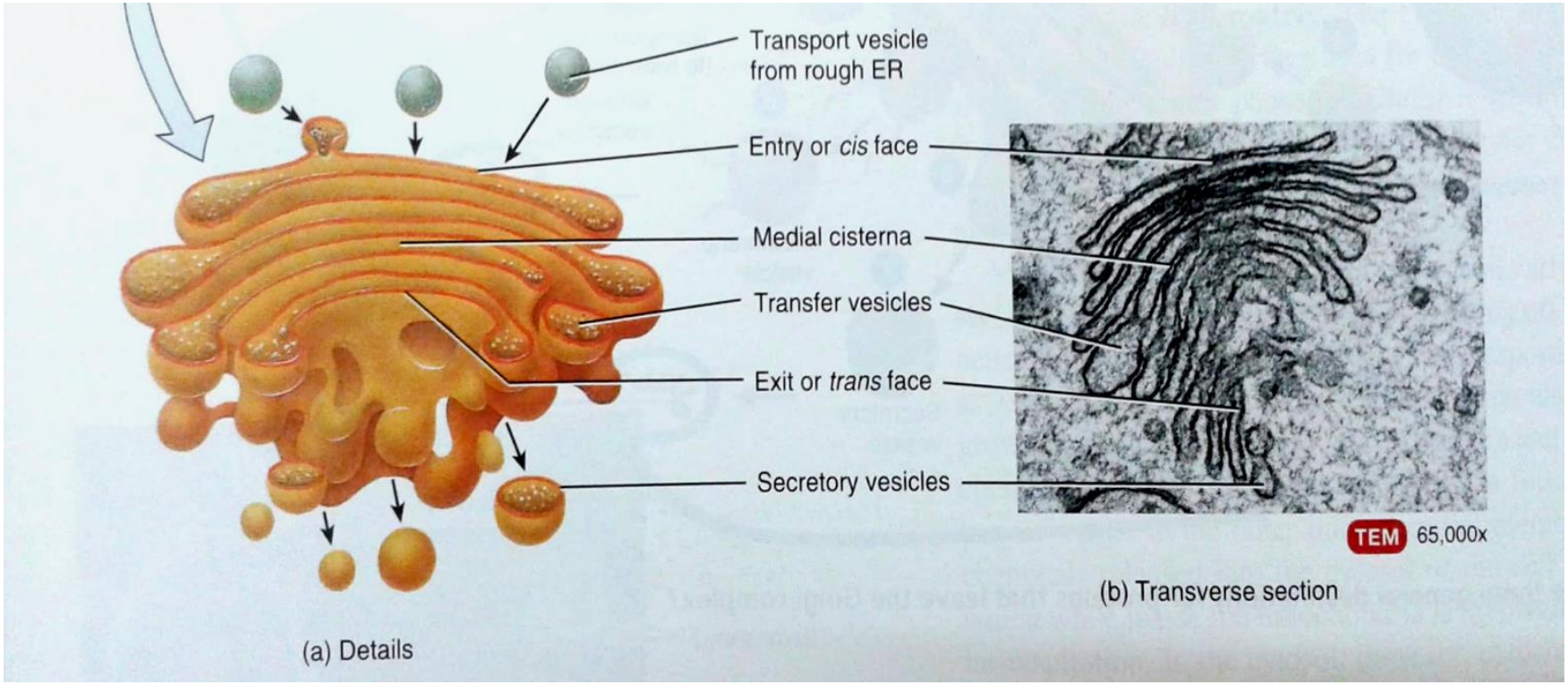
- structurally and functionally divided into
  entry (cis) face, medial cistern, and exit (trans) face.

Functions

- Entry (cis) face accepts proteins from rough ER; medial cisterane form glycoproteins, glycolipids, and lipoproteins

- (trans) face modifies the molecules further, then sorts and packages them for transport to their destinations.

Transport vesicles/ ER vesicles

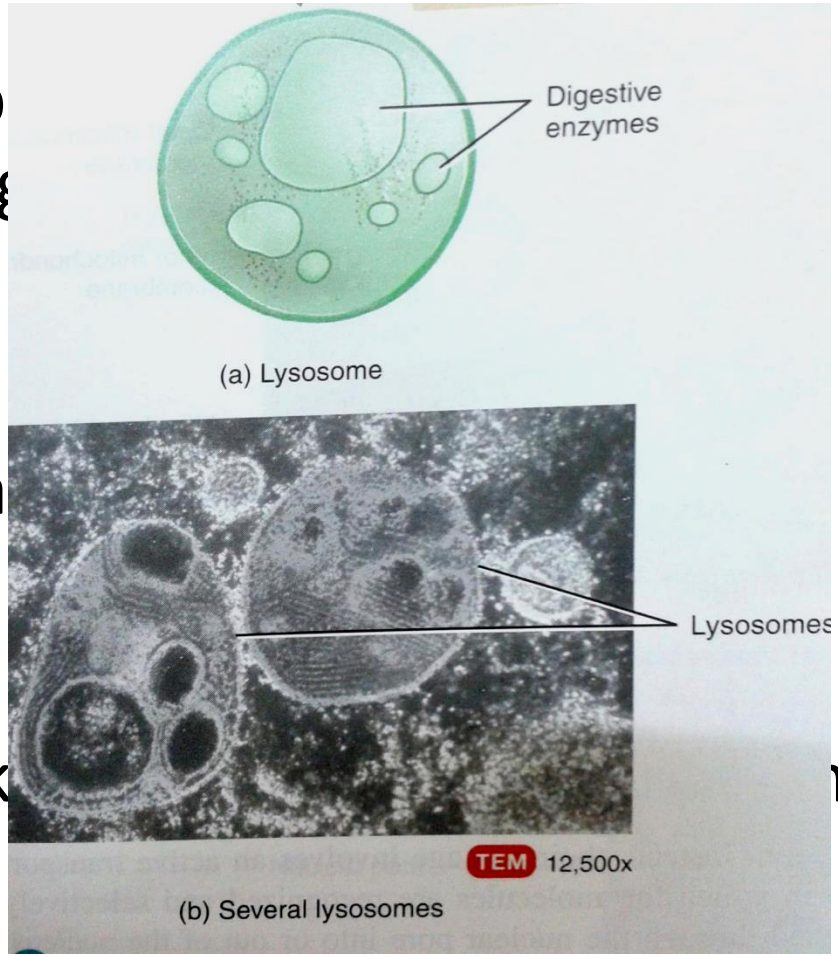


Golgi complex Functions

1. Modifies,Sorts,packages & transport the proteins received from roughER
2. Forms the secretory vesicles that discharge processed proteins via exocytosis into the ECF
3. Transport vesicles ferry digestive enzymes to Lysosomes

Lysosomes(Lyso-dessolving,somes-bodies)

- Lysosomes are memb… are formed from the Golg…
- ACID HYDROLASES (a… identified)
- Interior of the cell is k…mp (H+ ATPase pump)



Lysosomes

- Intracellular digestive system
- Digests – damaged cellular structures
- Digests food particles (proteins- aminoacids, glycogen- glucose, unwanted matter- bacteria)
- Lysosomes are filled with large number of small granules
- Hydrolase enzymes ($H_2O \rightarrow$ H & OH)

Lysosomes Functions

It helps to recycle the worn out cell structure by the process called **Autophagy**

Lysosome enzymes may also destroy entire cell by **Autolysis**

Peroxisomes

- Physically peroxisomes are similar to lysosomes

- It contains enzymes that either produce H_2O_2 or degrade H_2O_2.
- oxidases / catalases
- But are different in two ways:

  1.They are believed to be formed by self replication

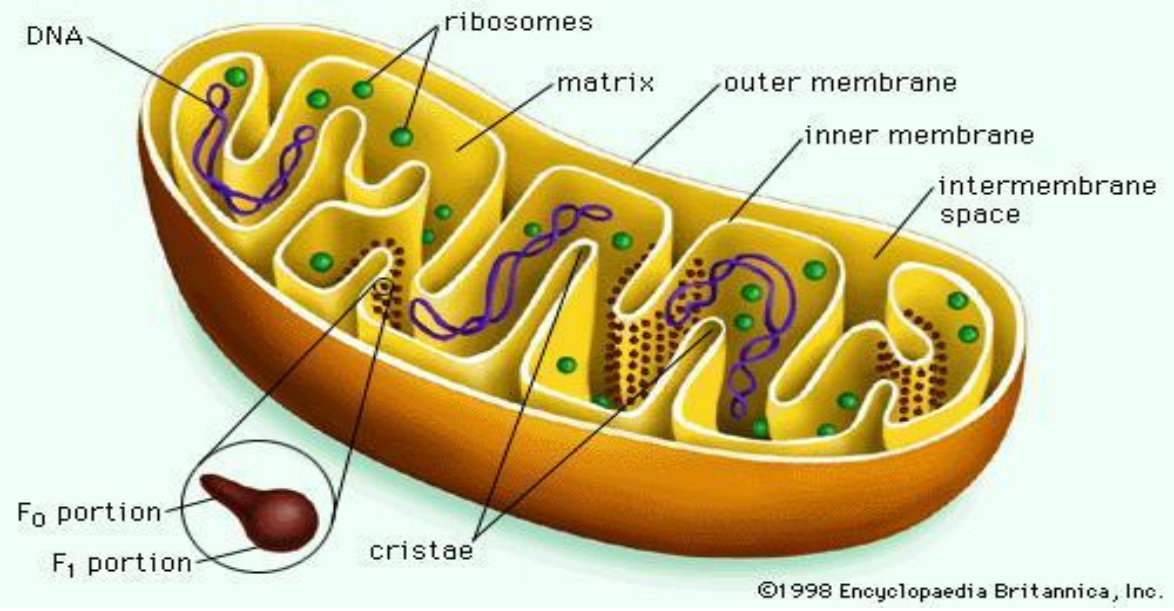
  2.They contain oxidases rather than hydrolases

Peroxisomes are also formed by budding from the endoplasmic reticulum.

Function: oxidizes toxic substances such as alcohol in liver

MITOCHONDRIA

- Major site of ATP production, oxygen utilization, and carbon dioxide formation
- Contains enzymes for krebs cycle and oxidative phosphorylation

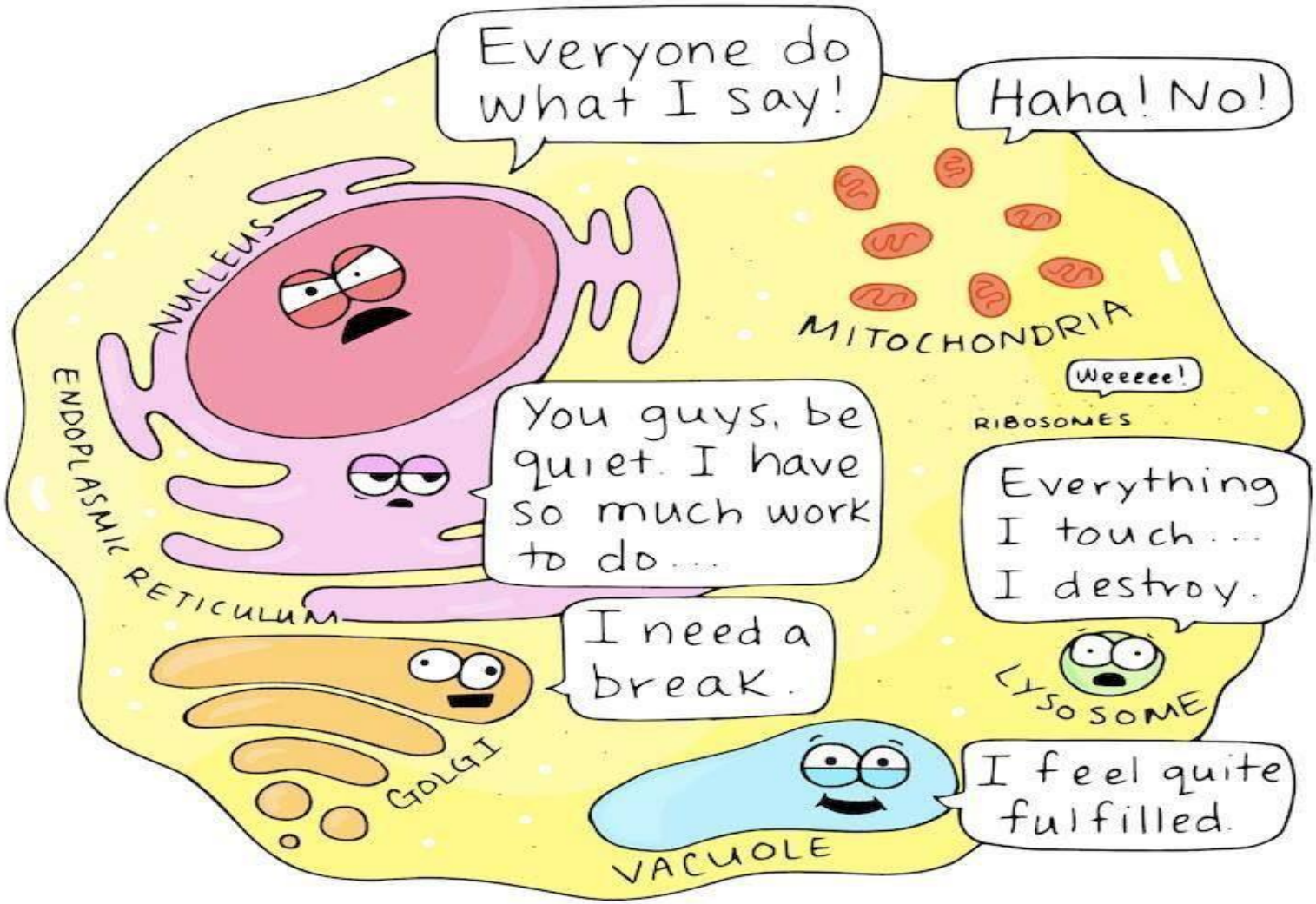


Mitochondria

- Number of mitochondria in a cell varies.
- Mitochondria are self-replicative, which means that one mitochondrion can form a second one, a third one, and so on, whenever there is a need in the cell for increased amounts of ATP.
- Mitochondrial DNA controls its own replication.

Mitochondrial DNA

- Zygote mitochondria is derived from ovum.
- Mutation in Mitochondrial DNA is 10 times more than nuclear DNA.
- Many disease are identified.
- Leber’s hereditory optic atrophy is a mitochondrial disease.



If organelles could talk.

Beatrice the Biologist