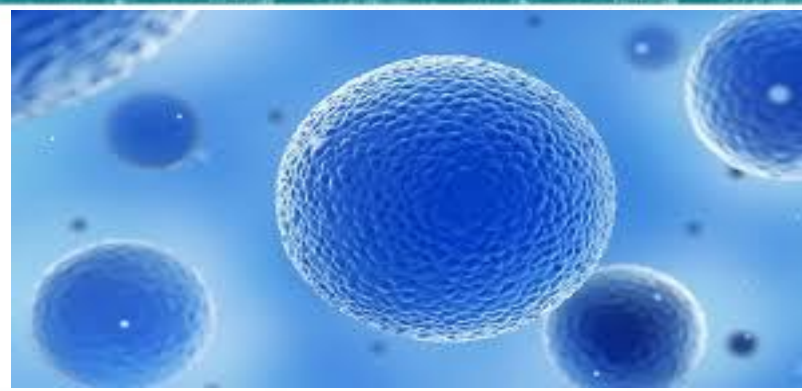

In the name of God

The cell



Tahereh Talaei

Anatomy, histology and embryology

Department of Anatomy

In Collaboration with Virtual School, Center of Excellence for E-Learning

Vice-Chancellery for Education, Shiraz University of Medical Sciences

Human histology

- histos means tissue
- Logy means the study of a science

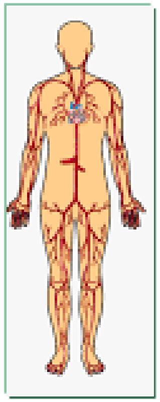
The definition of the tissue

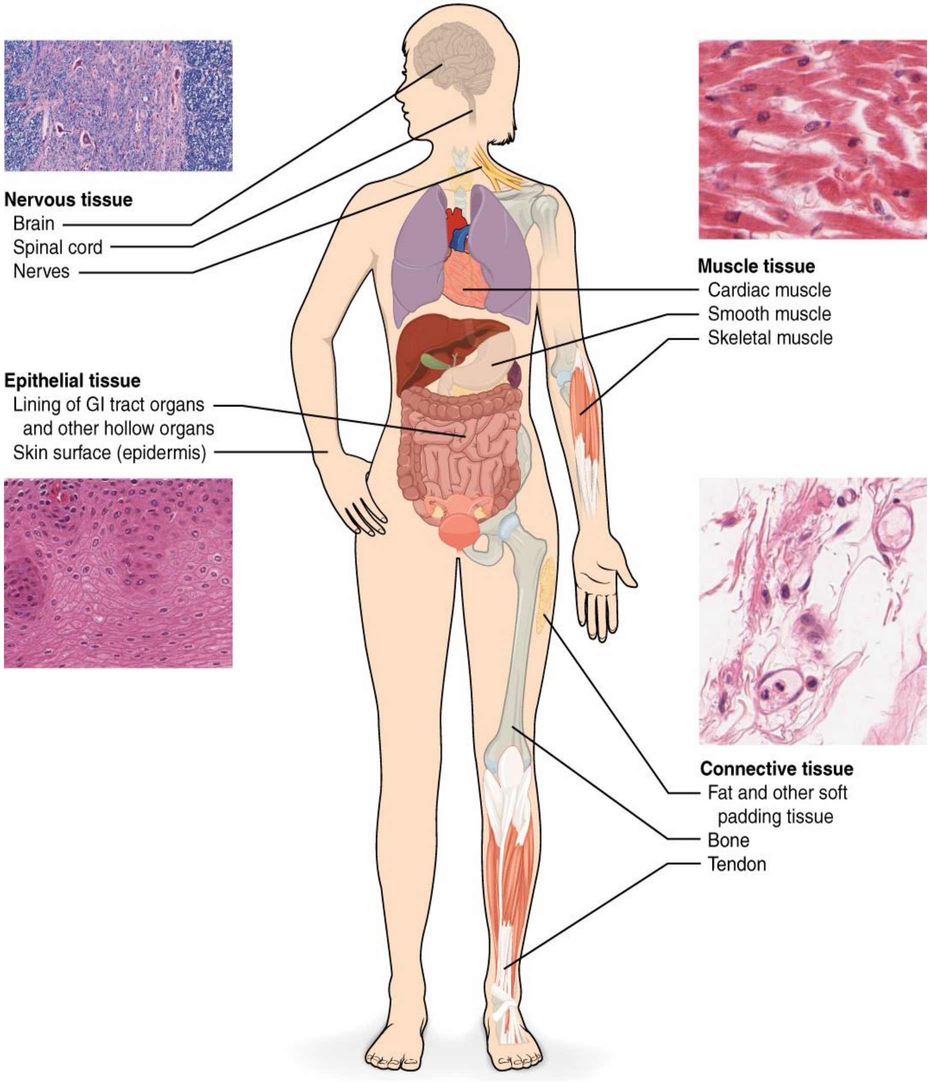
- A group of biological cells that perform a similar function.
- Extracellular matrix forms a scaffold for a tissue.

Basic tissues

- Epithelial tissue
- Connective tissue
- Muscular tissue
- Nervous tissue

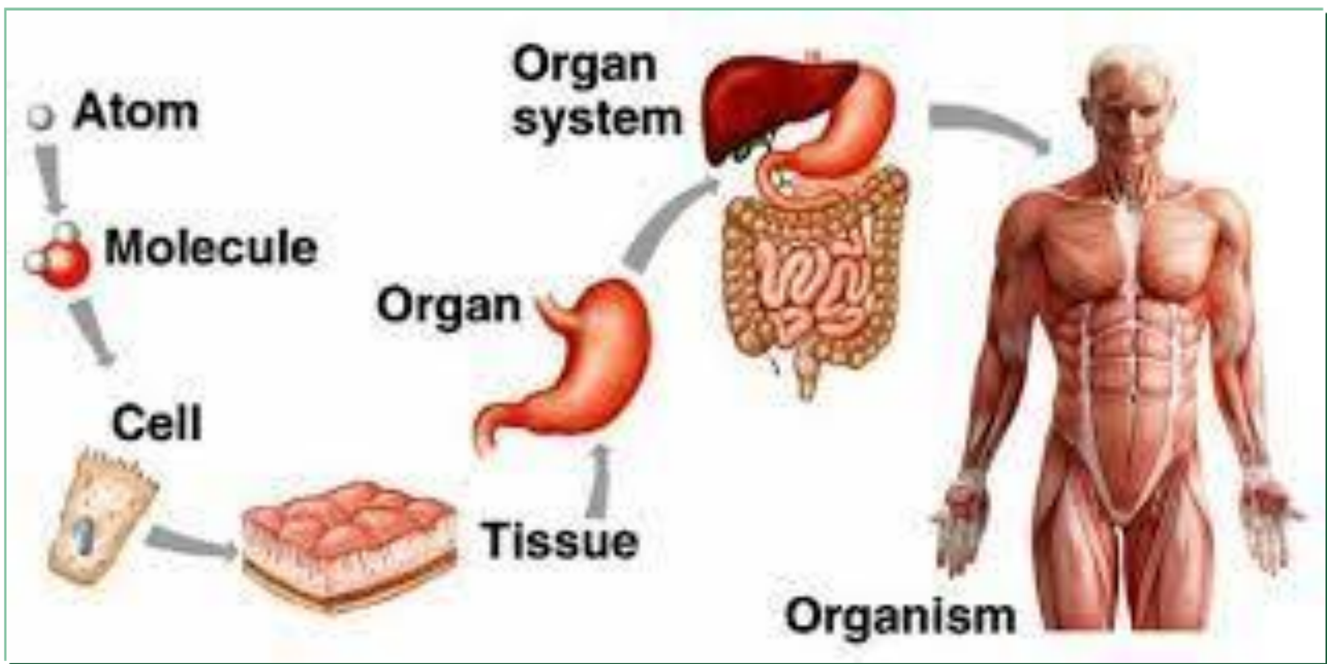




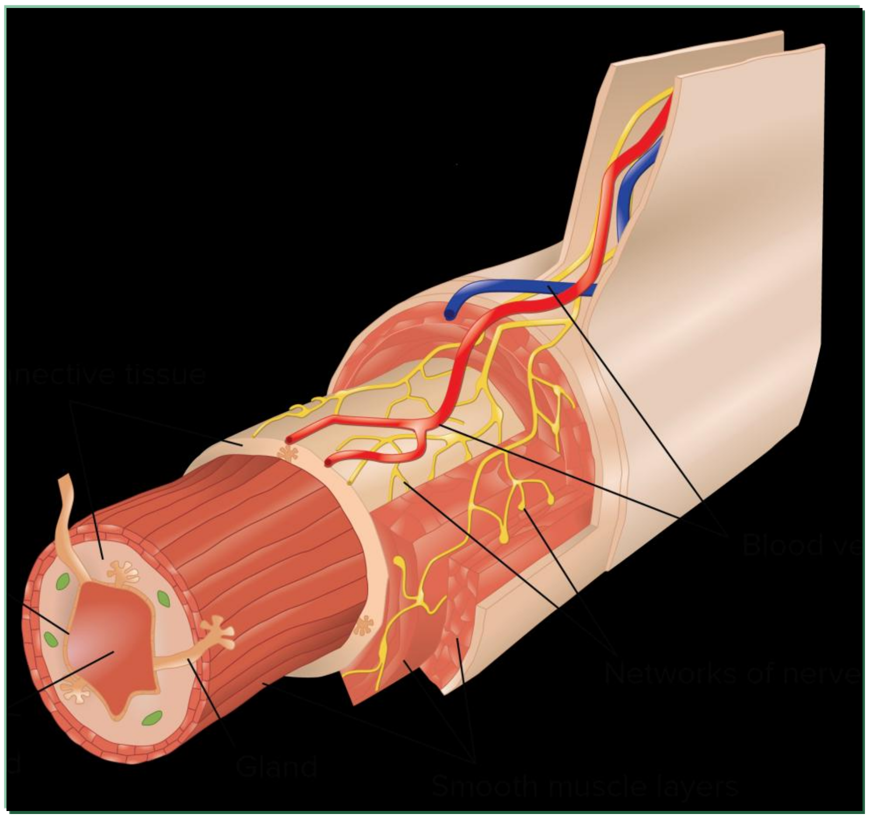


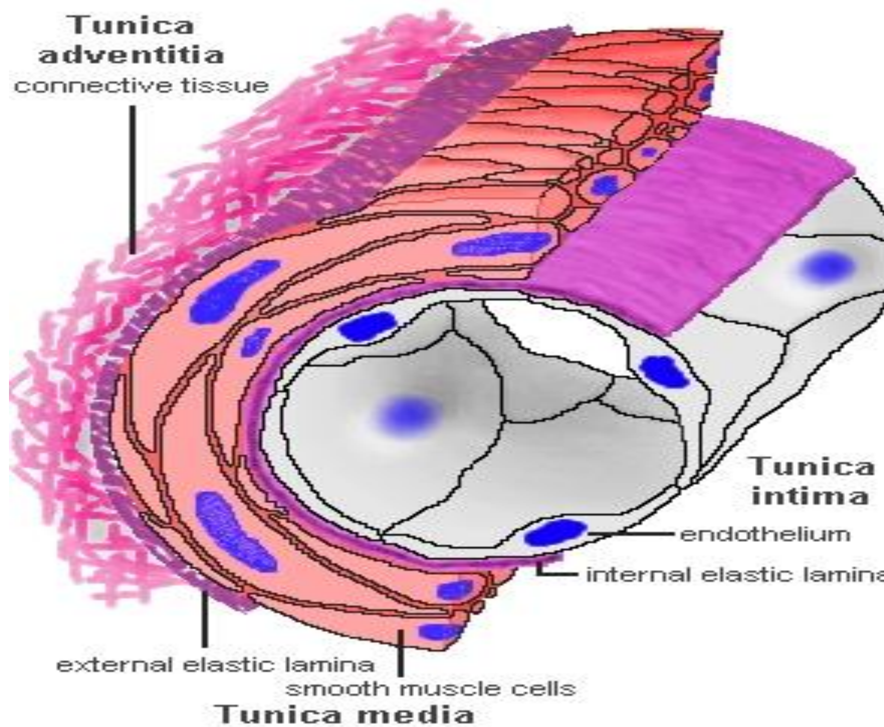
The definition of an organ

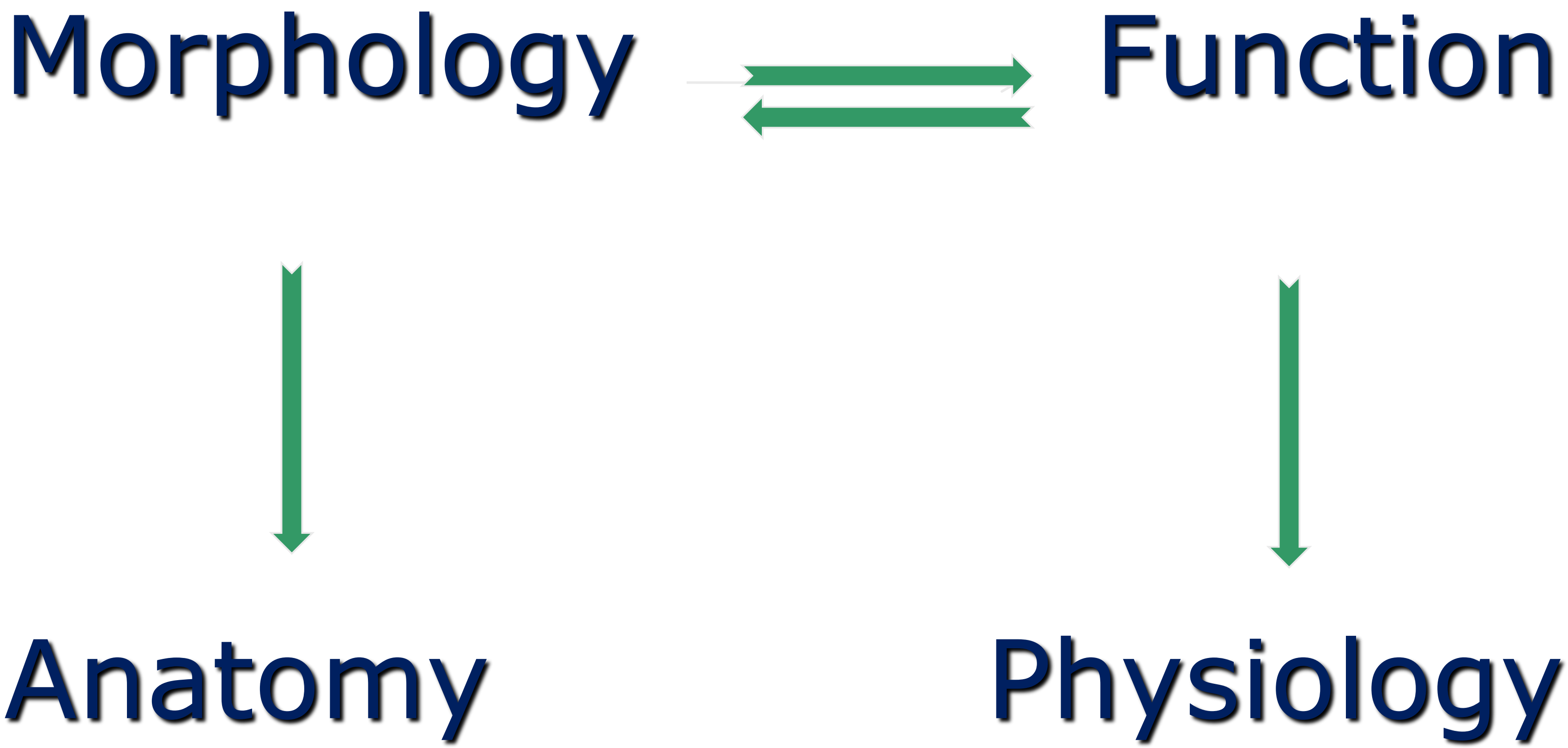
- Forms from functional grouping of multiple tissues.



The organs form from four basic tissues but they differ from each others

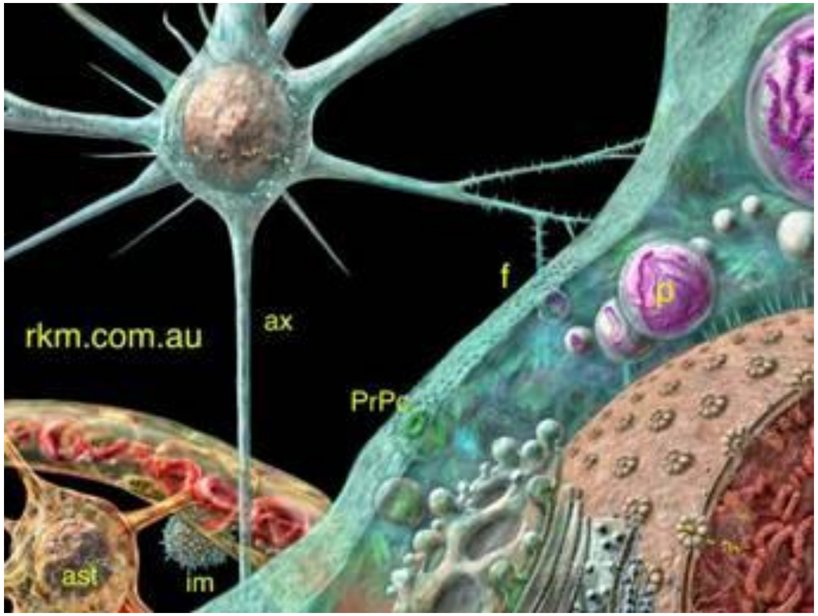





Morphology
Function
Anatomy
Physiology

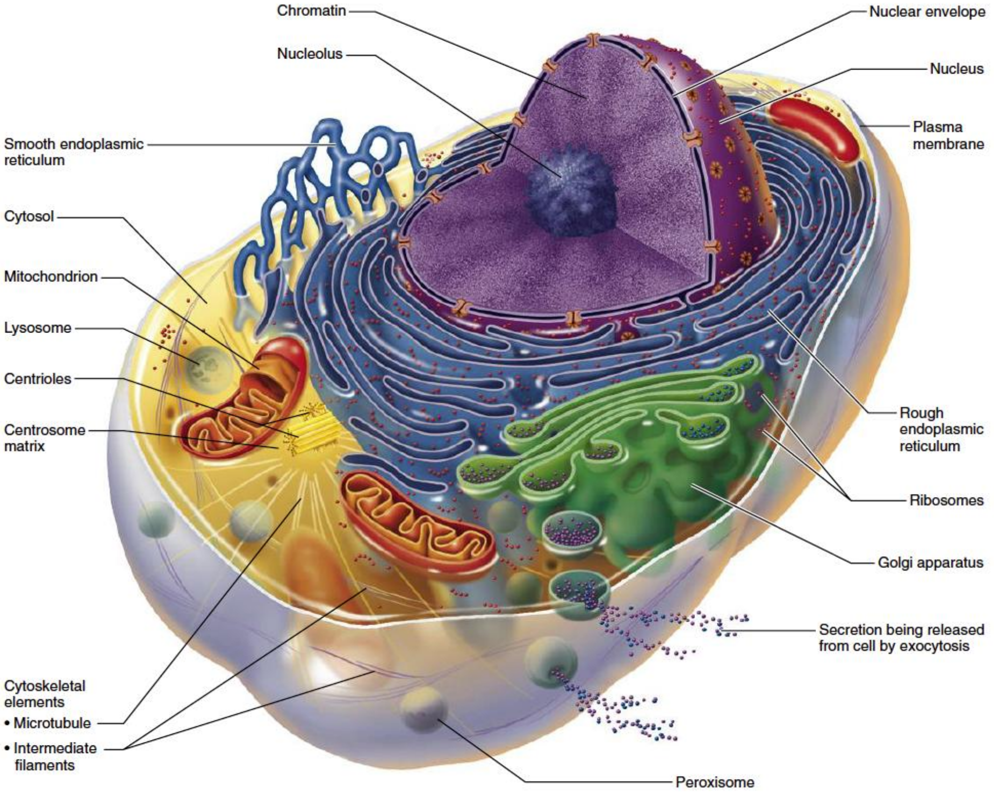
Cell definition

- Cell (from latin cella, meaning “small room”) is the basic structural, functional and biological unit of all known living organisms



Types of the cells

- Eukaryotic
- Prokaryotic

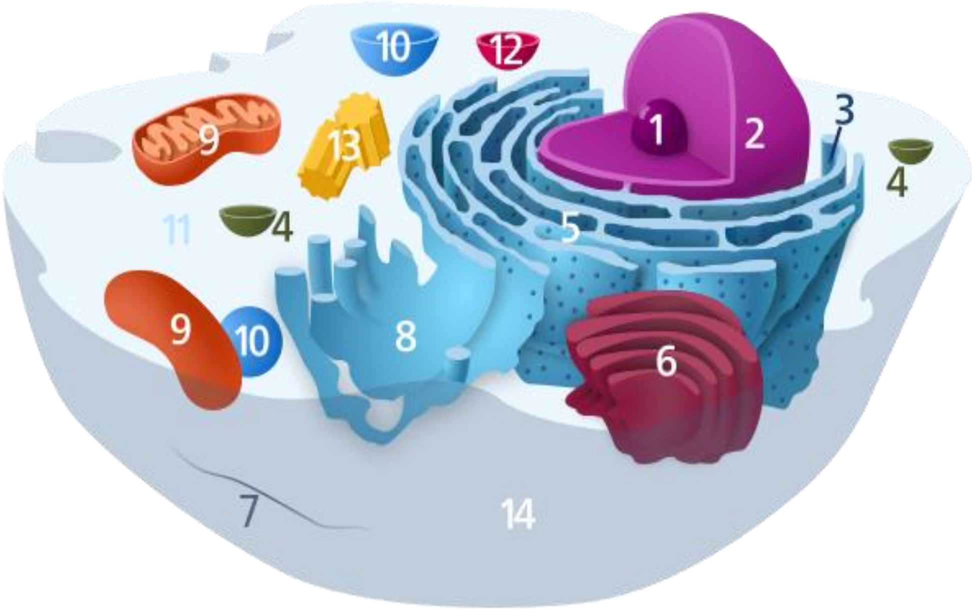


The cell consists of :

the cytoplasm and

the nucleus

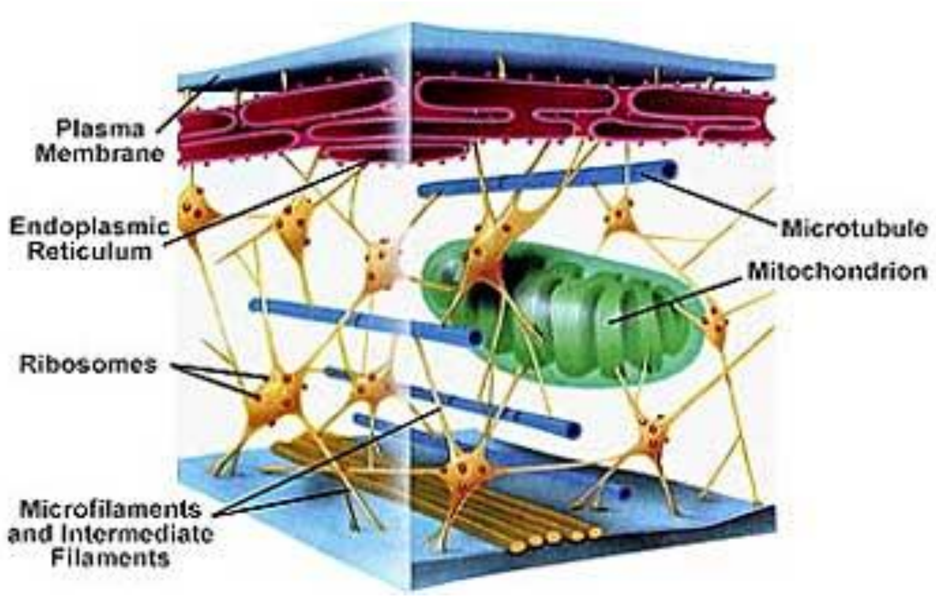
Cytoplasm



- Organelle
- Is a specialized subunit within the cell that has a specific function.
- It contains enzymes that involve in metabolic functions
- It is alive

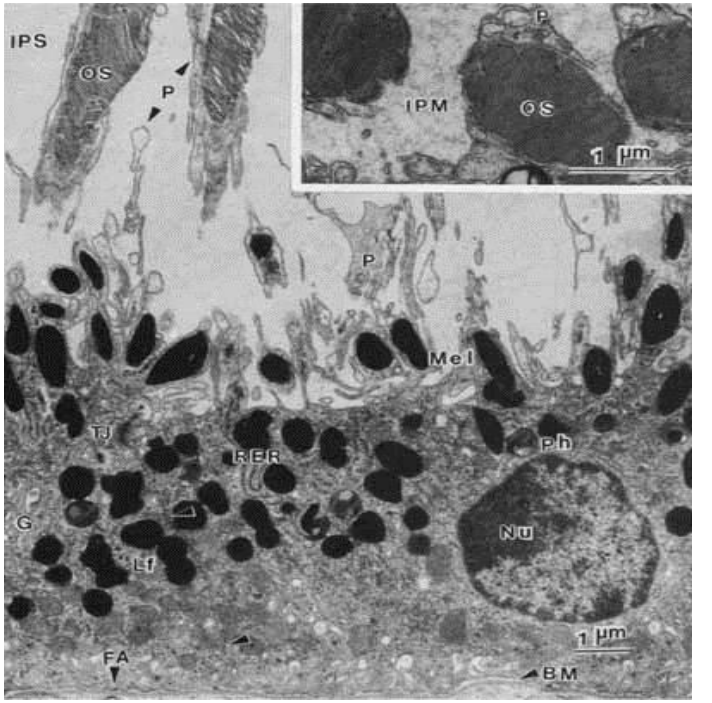
Cytoplasm

- Cytoskeleton
- Is a series of intercellular proteins that support the cell shape and movement
- Converts the energy into mechanical works

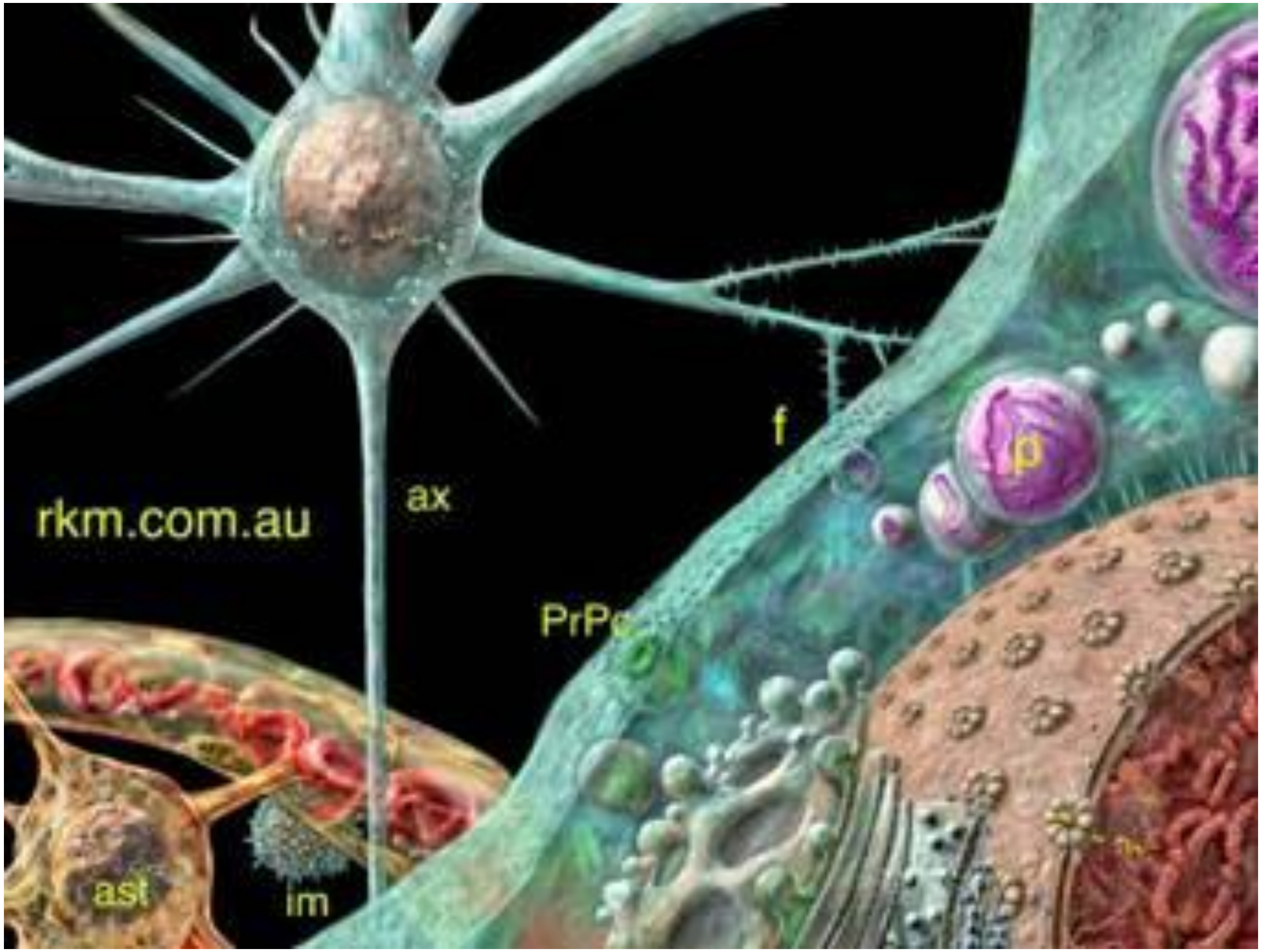


Cytoplasm

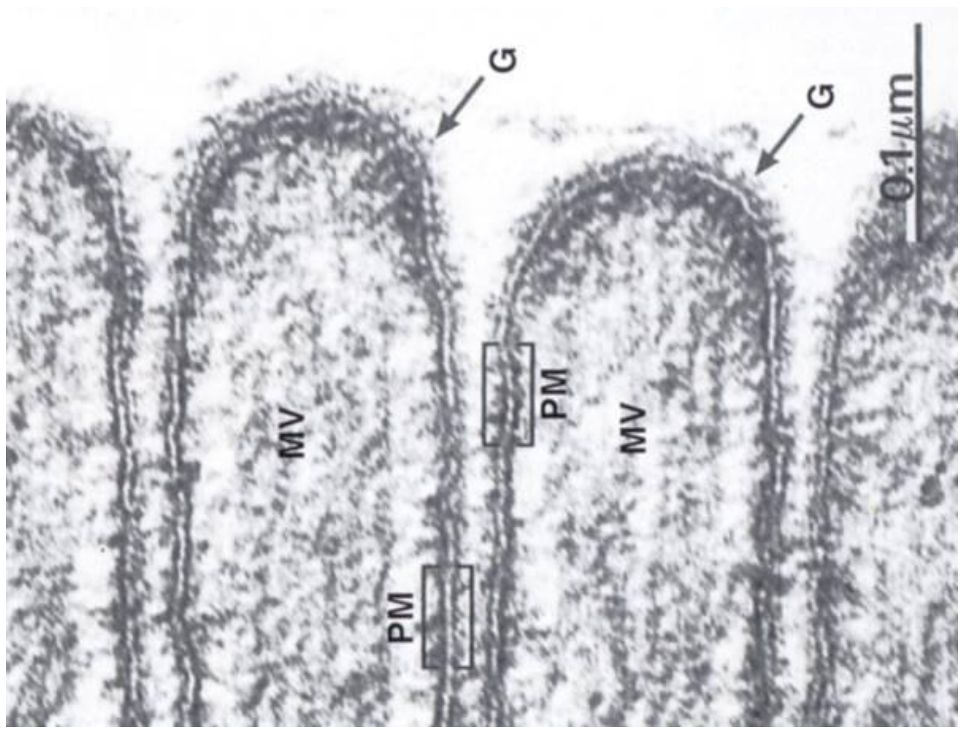
- Inclusion
- Non-living components of the cells
- Do not possess metabolic activities
- Are not bound by membrane
- The storage particles



The cell

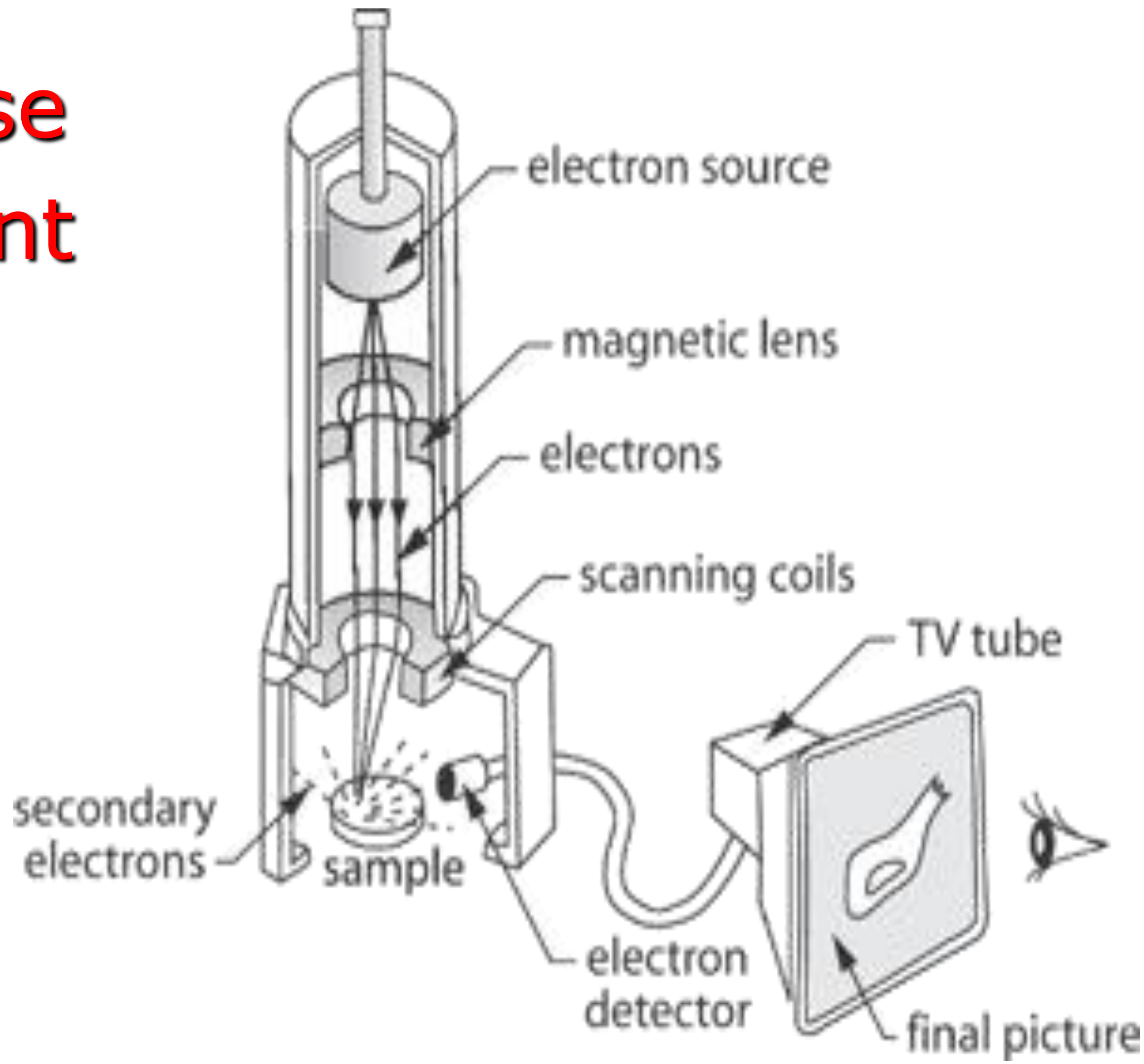


Cell membrane



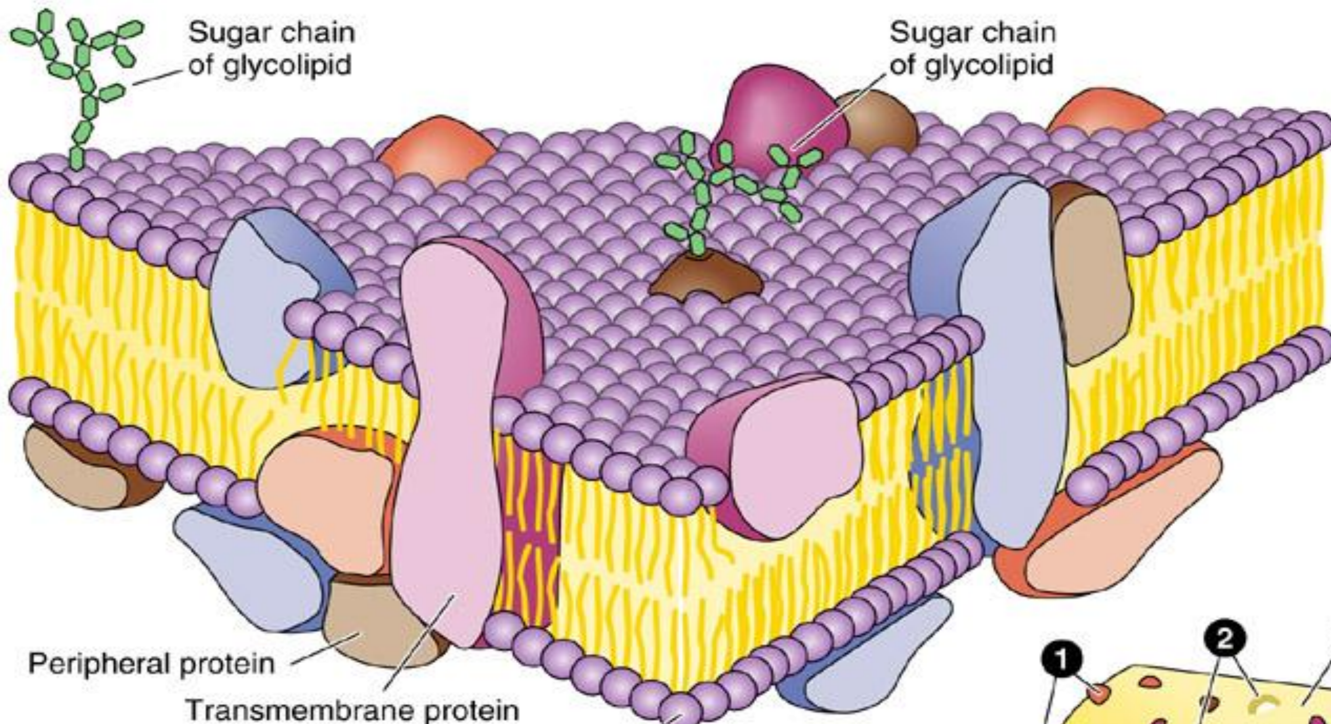
Electron microscope

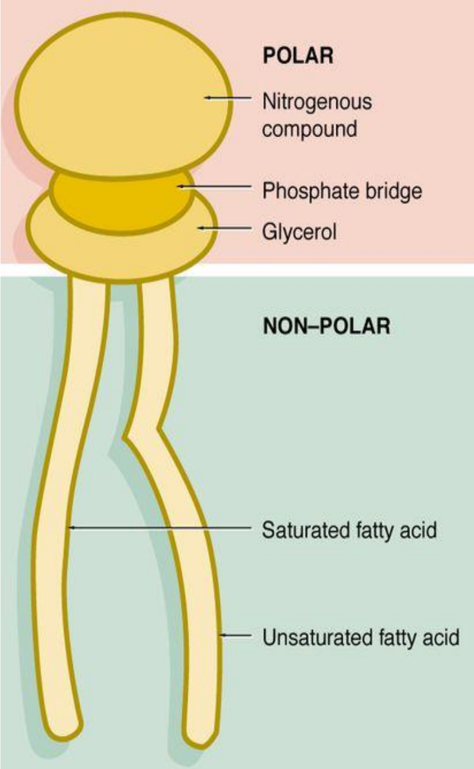
- Electron dense
- Electron lucent

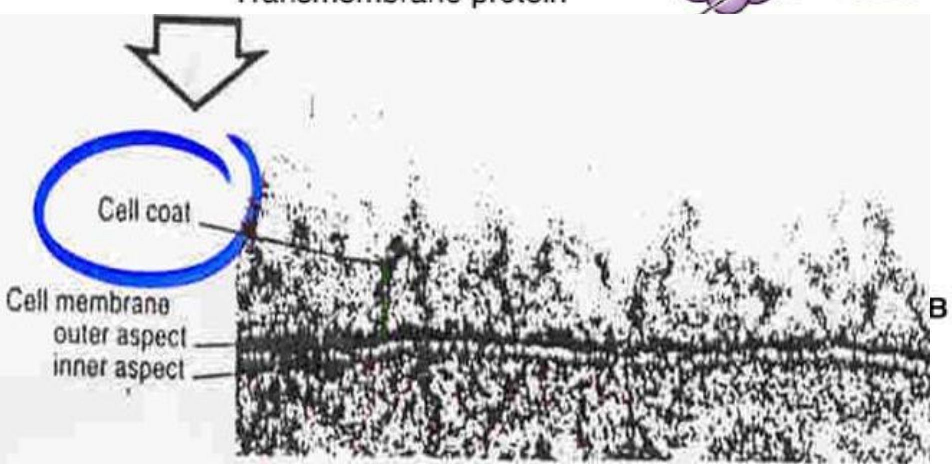


Cell membrane

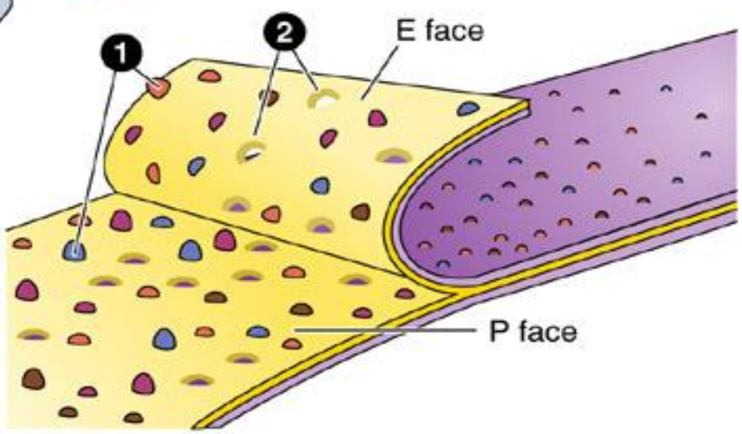
A Carbohydrate chains bound to lipids and proteins



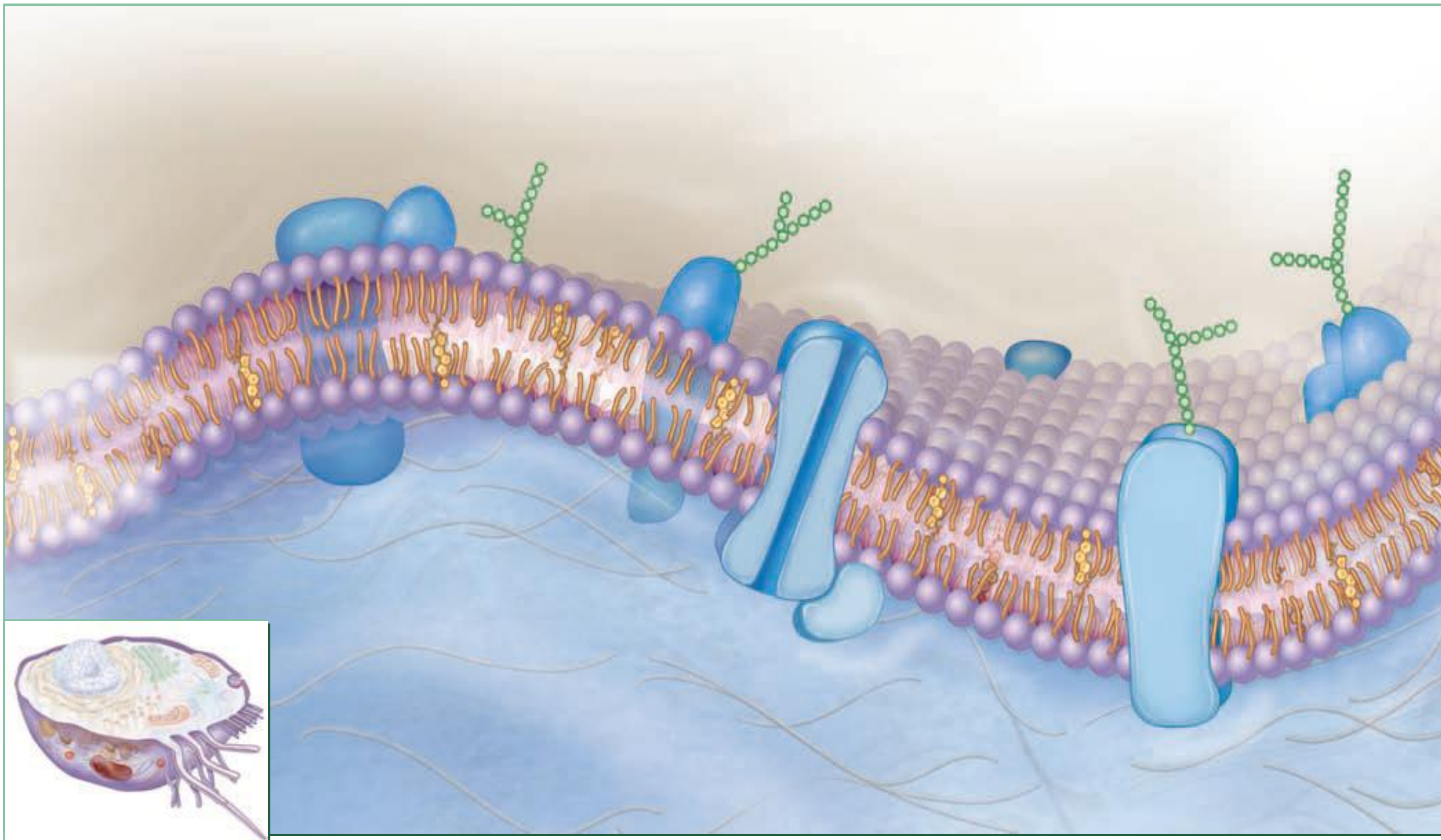


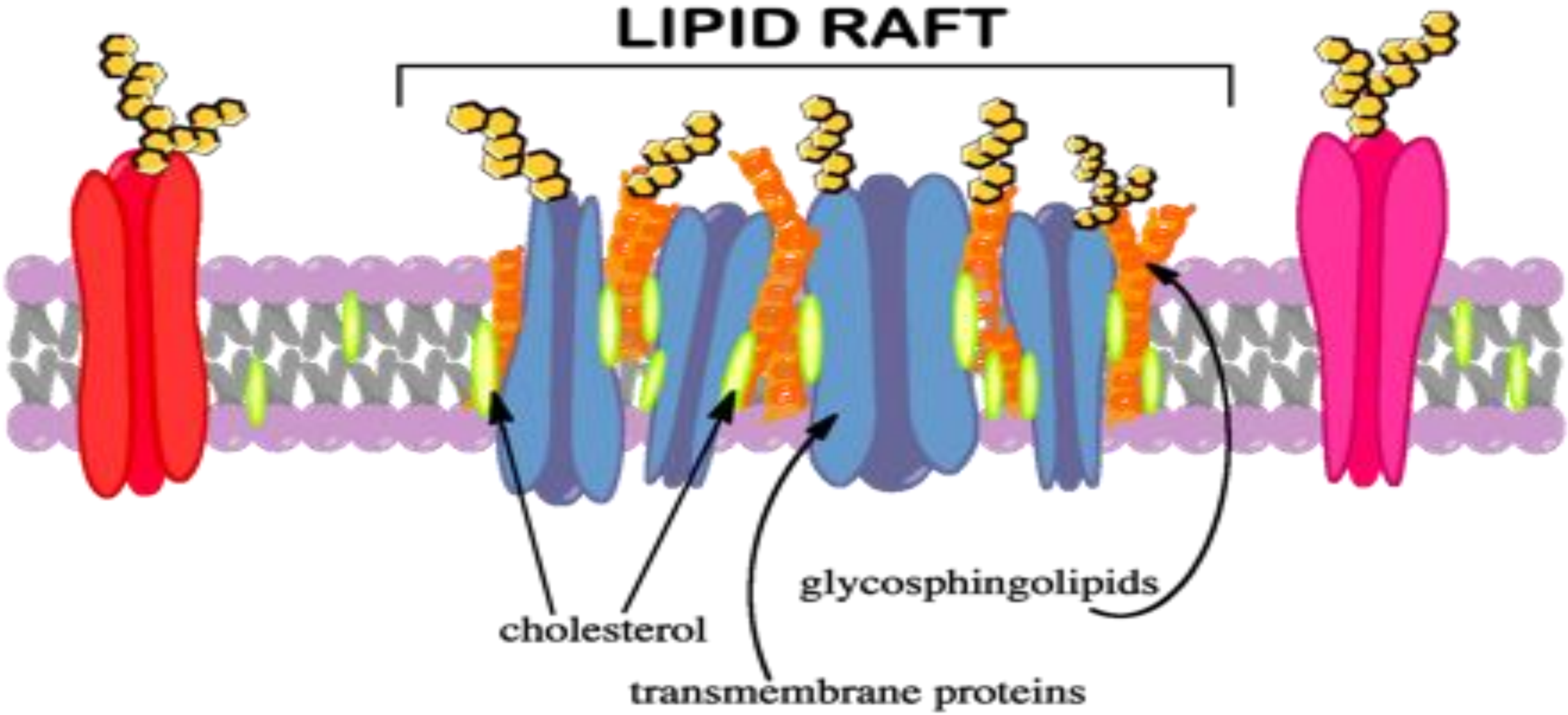


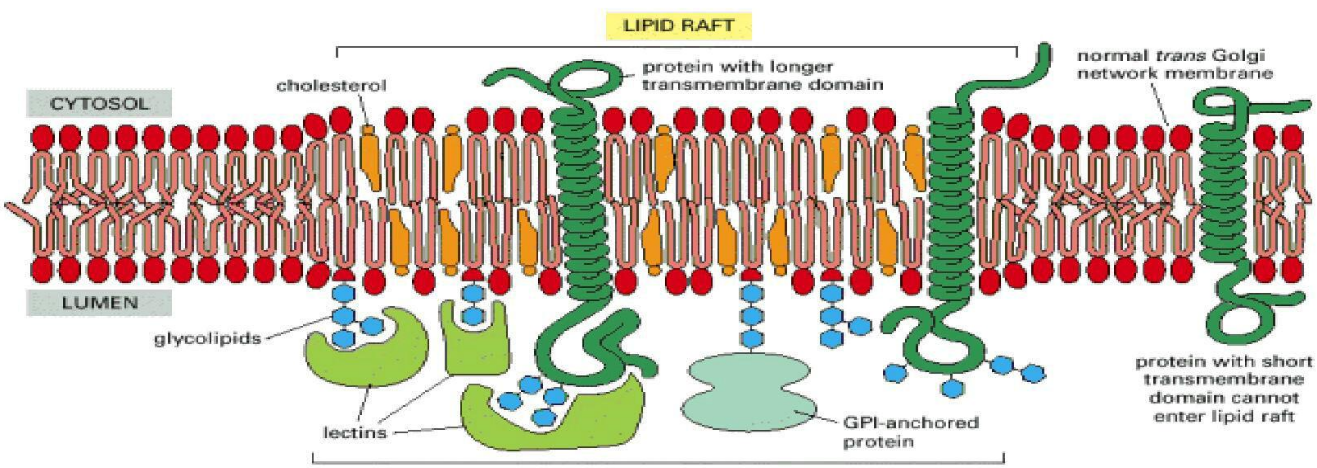
B



Cholesterol in the lipid bilayer




LIPID RAFT
glycosphingolipids
cholesterol
transmembrane proteins

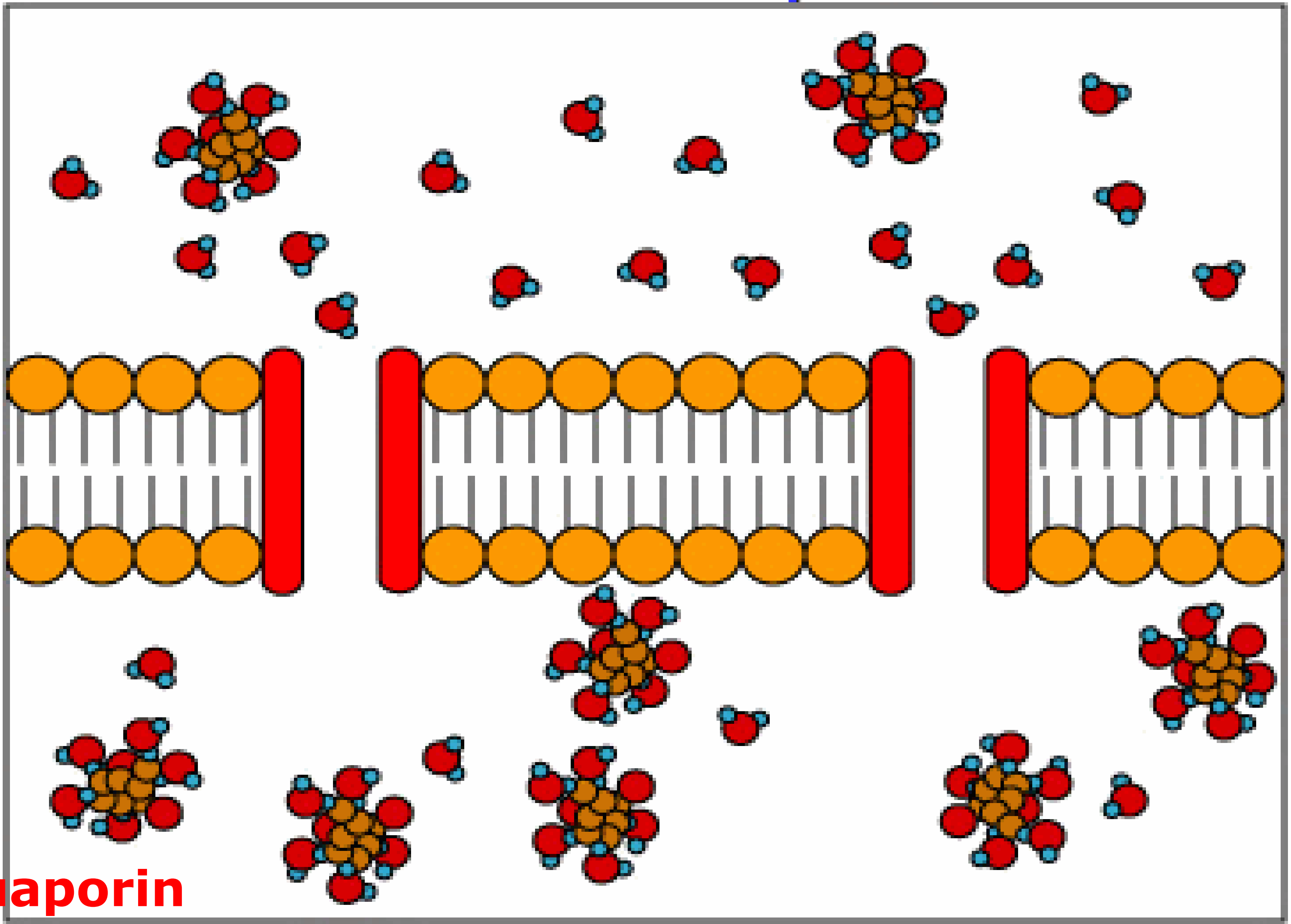

LIPID RAFT
CYTOSOL
cholesterol
protein with longer transmembrane domain
normal trans Golgi network membrane
LUMEN
glycolipids
lectins
GPI-anchored protein
protein with short transmembrane domain cannot enter lipid raft

The functions of cell membrane

Membrane acts as

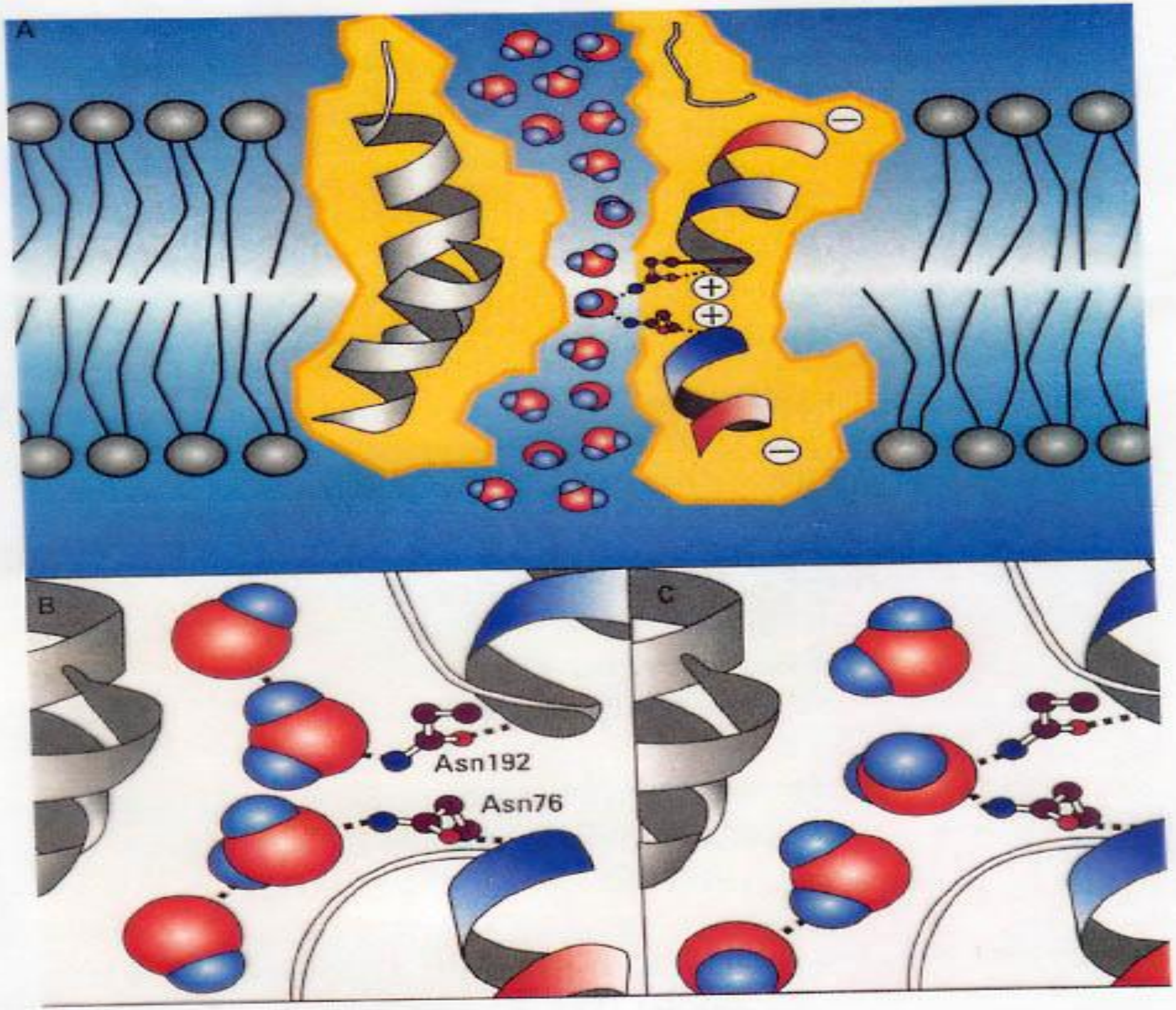
- Selective barrier
- Receptor
- Cell-cell interaction
- Cell recognition
- Transport

Water transport



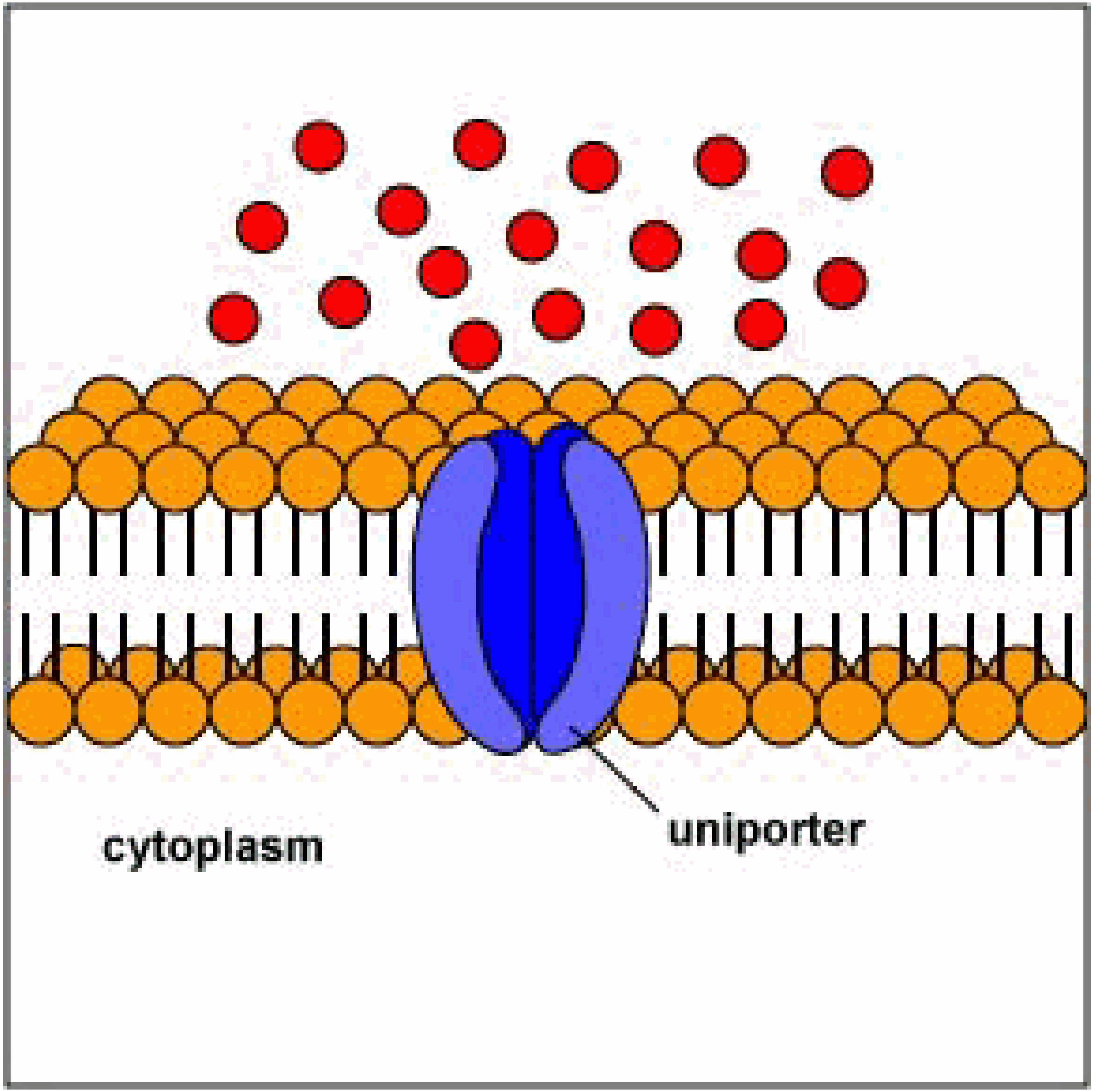
equaporin

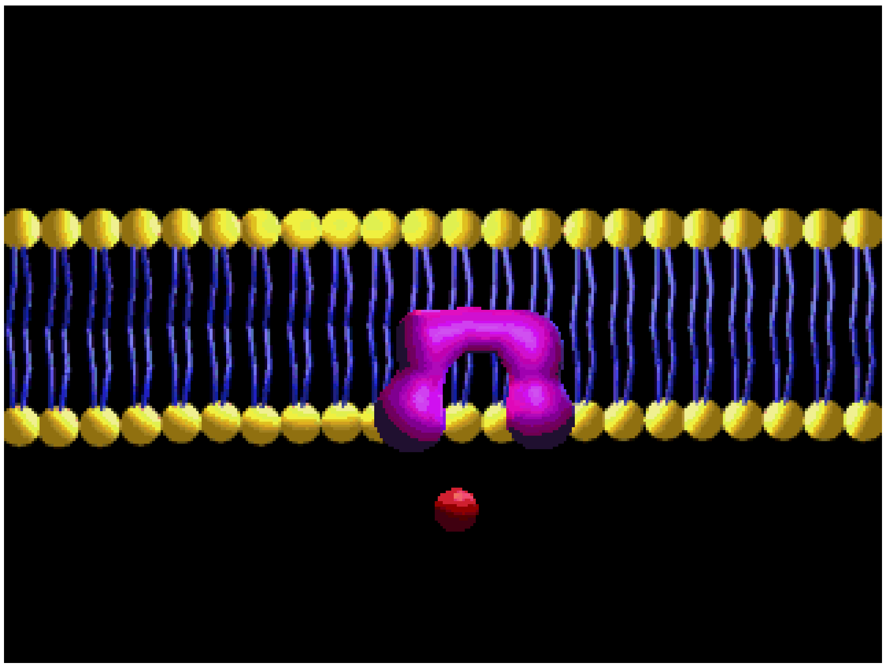
Aquaporin water channel



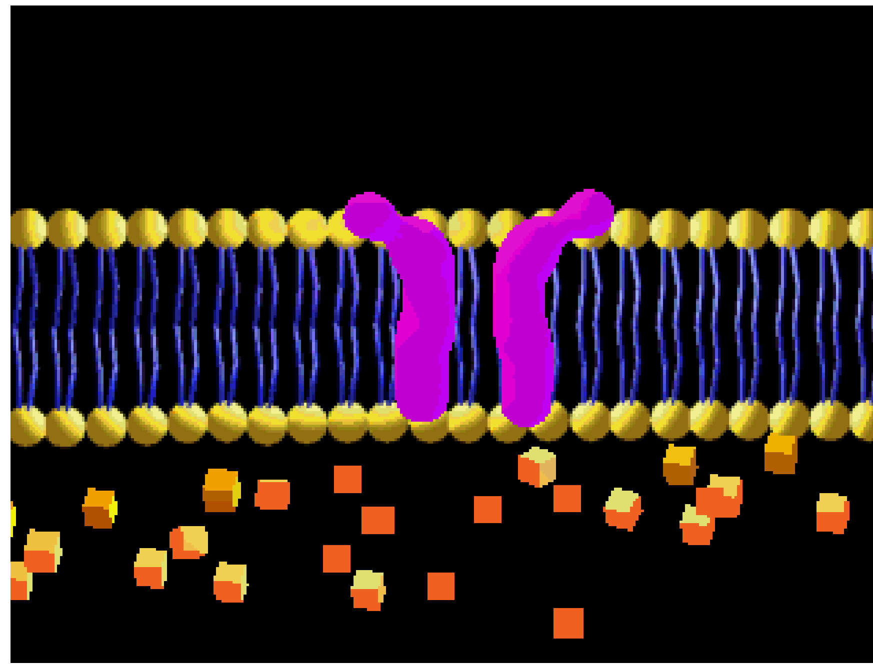
H₂O molecules become aligned by interaction with Asn molecules at constriction site

Carrier



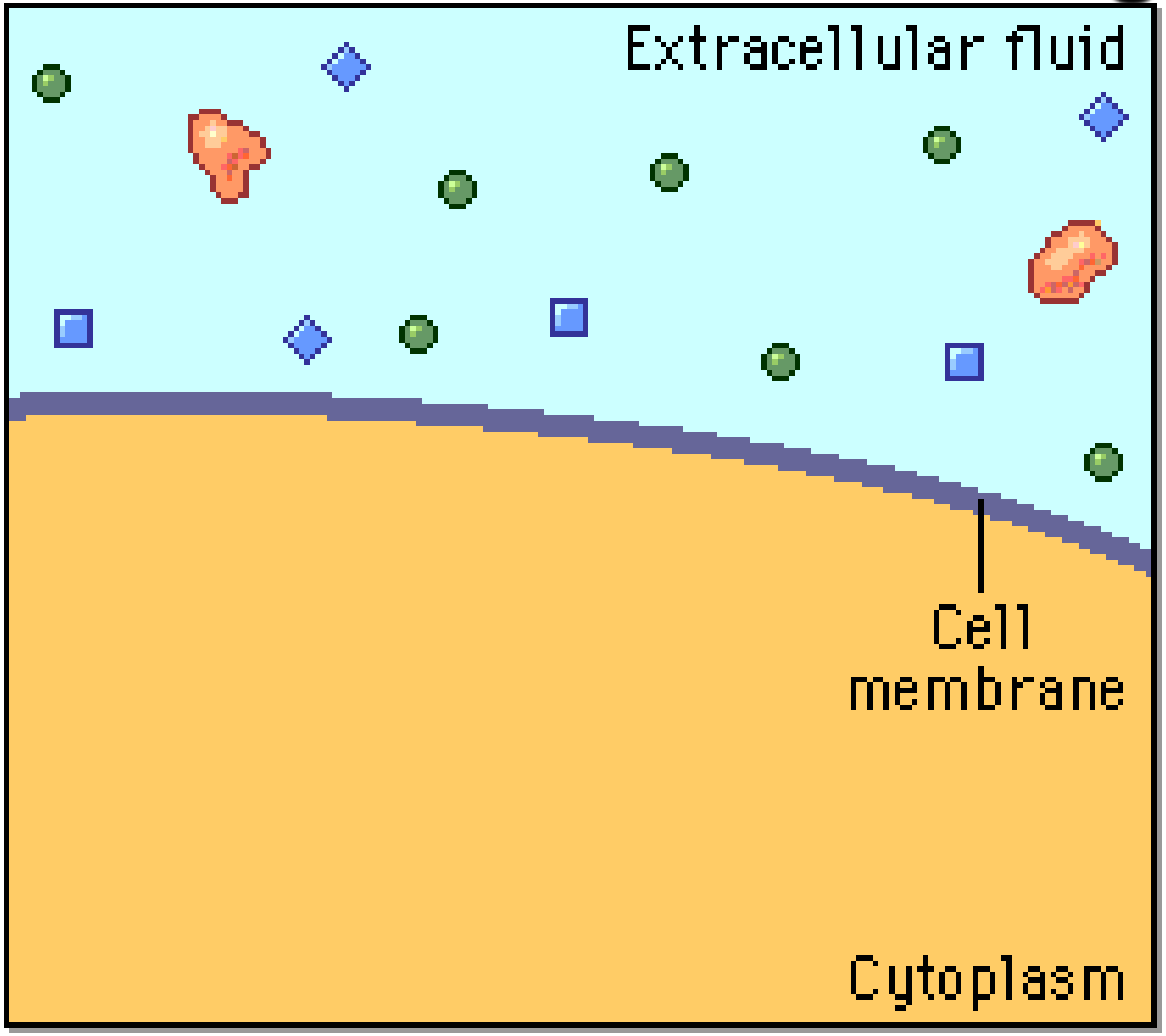


Carrier

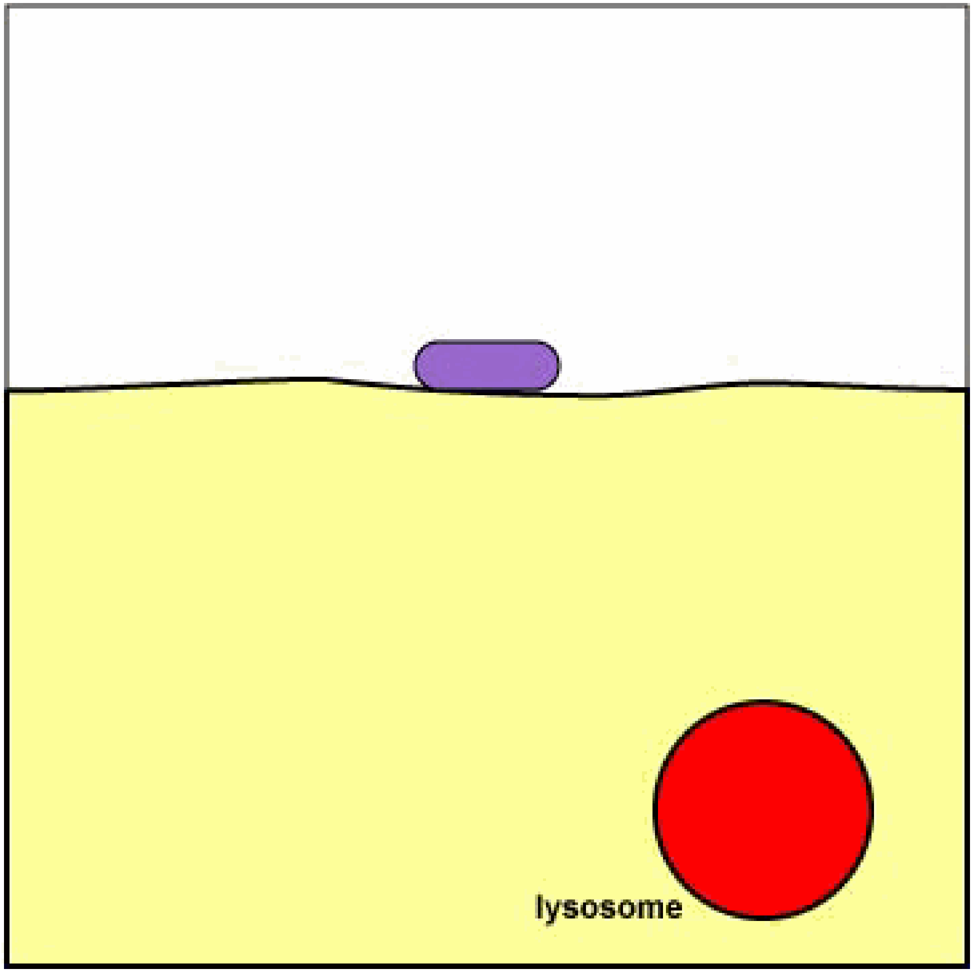


Channel

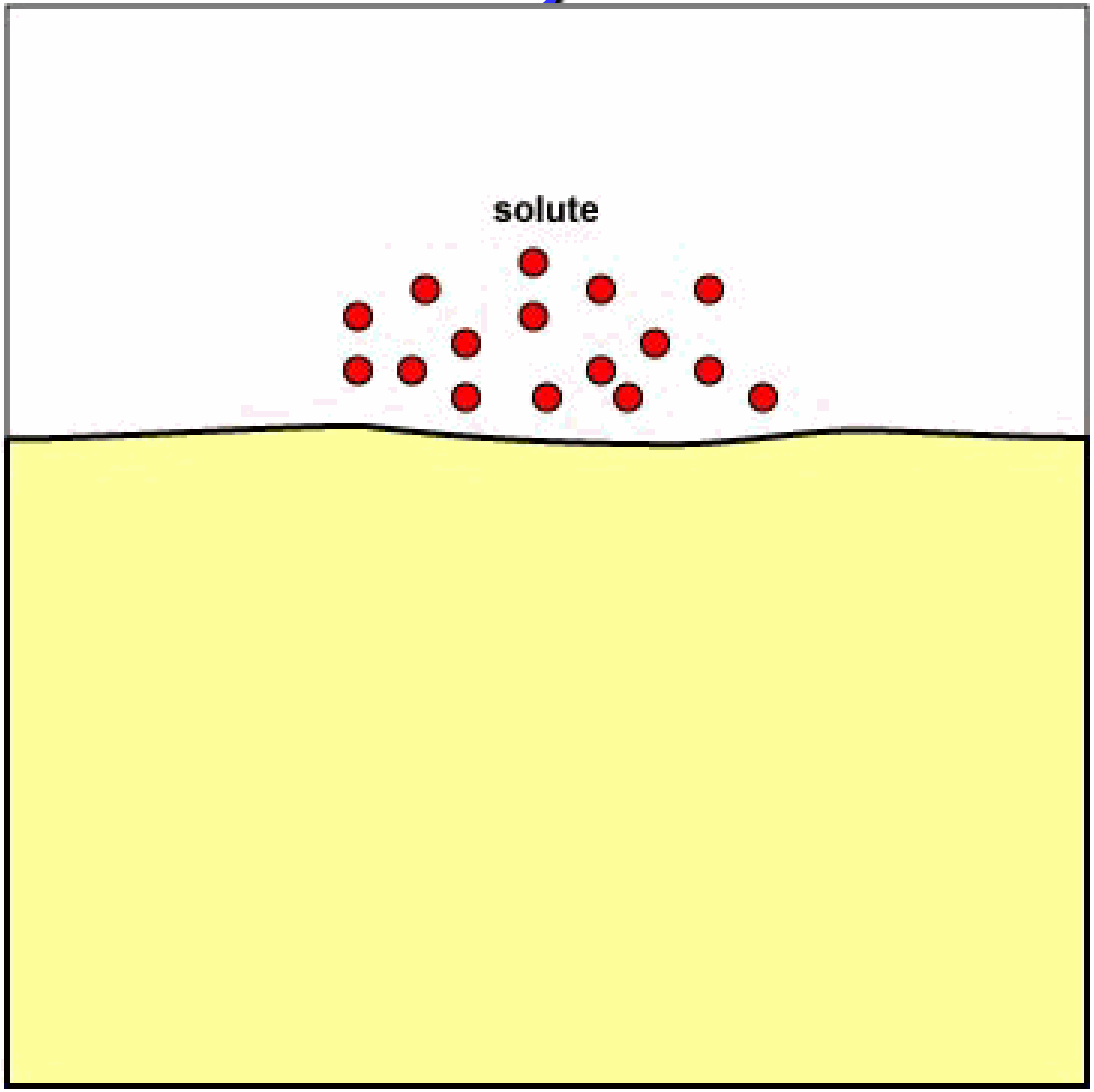
Cell membrane trafficking



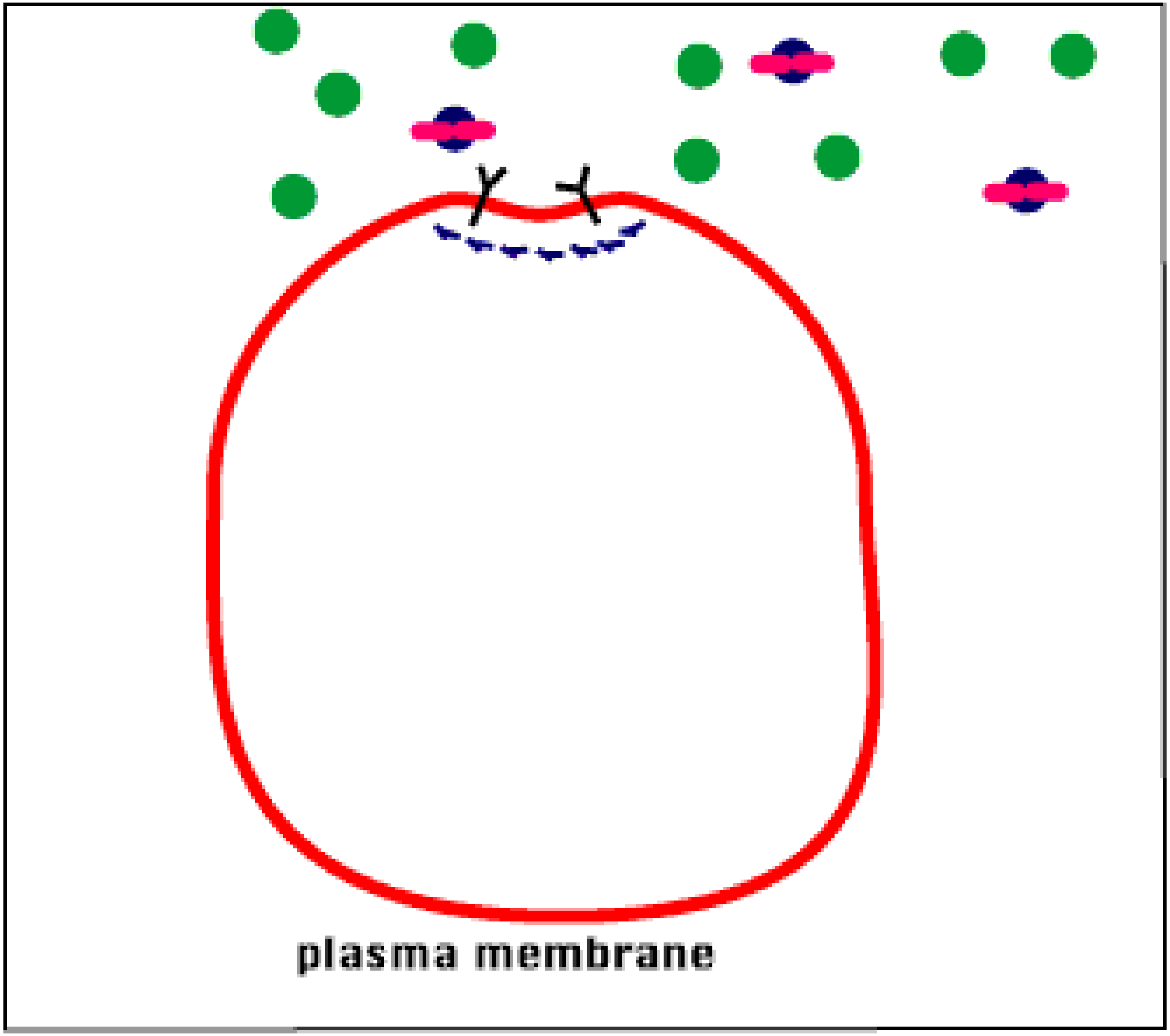
Phagocytosis

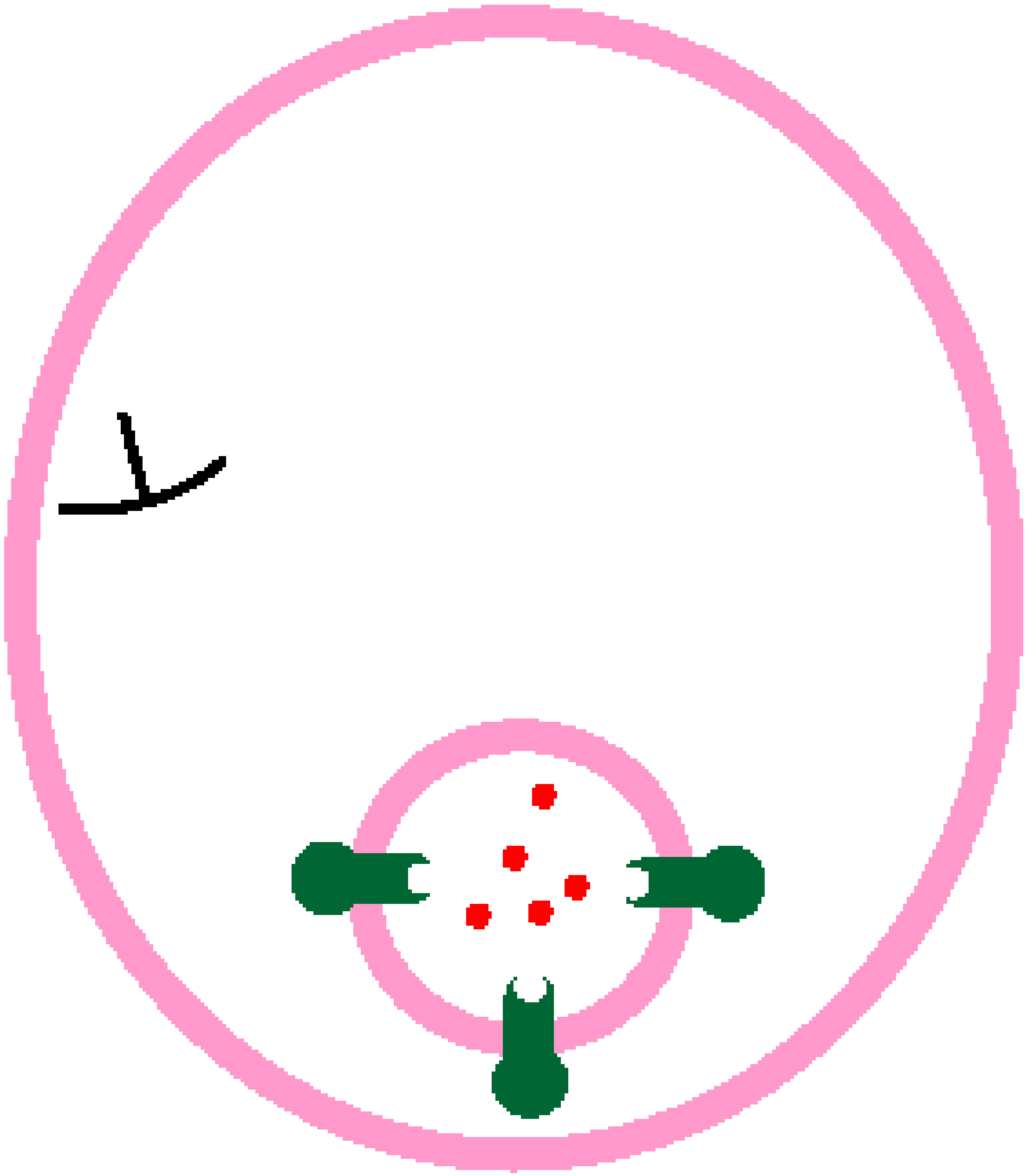


Pinocytosis

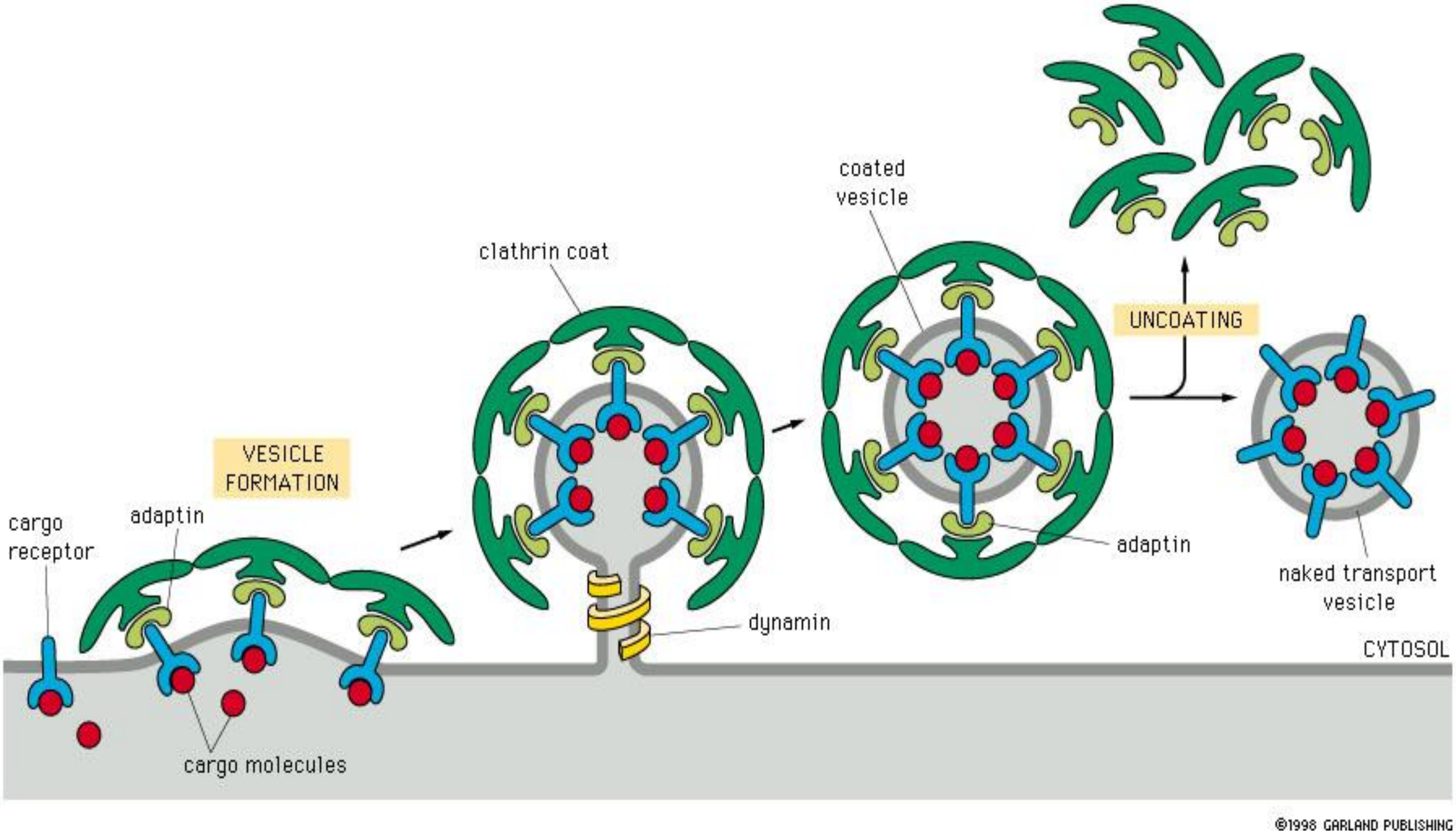


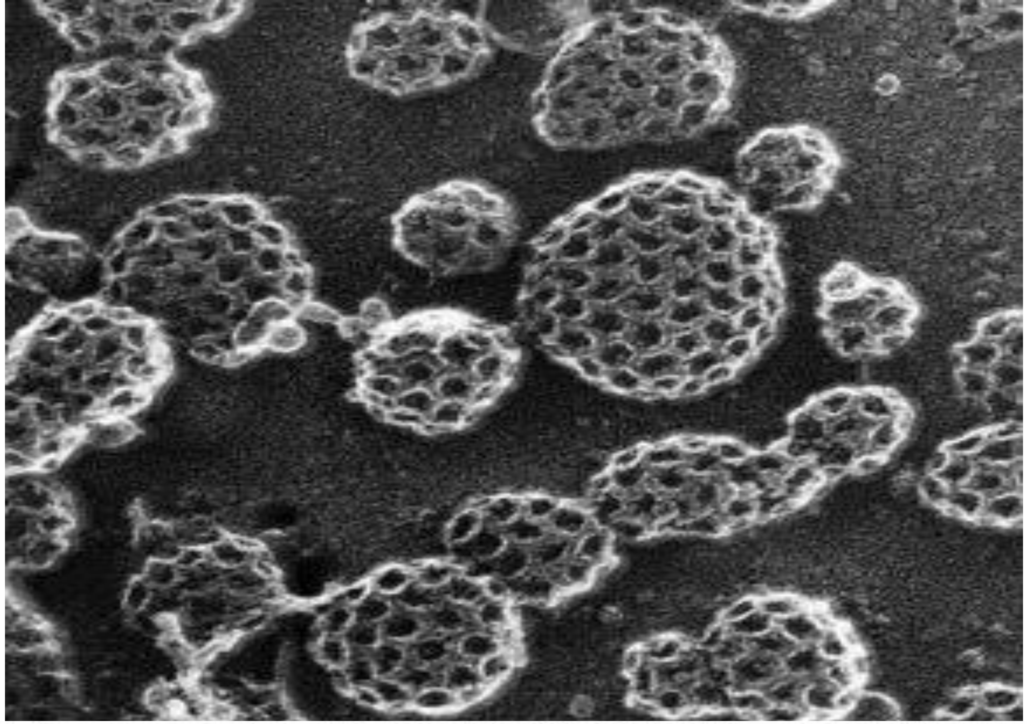
Receptor mediated endocytosis

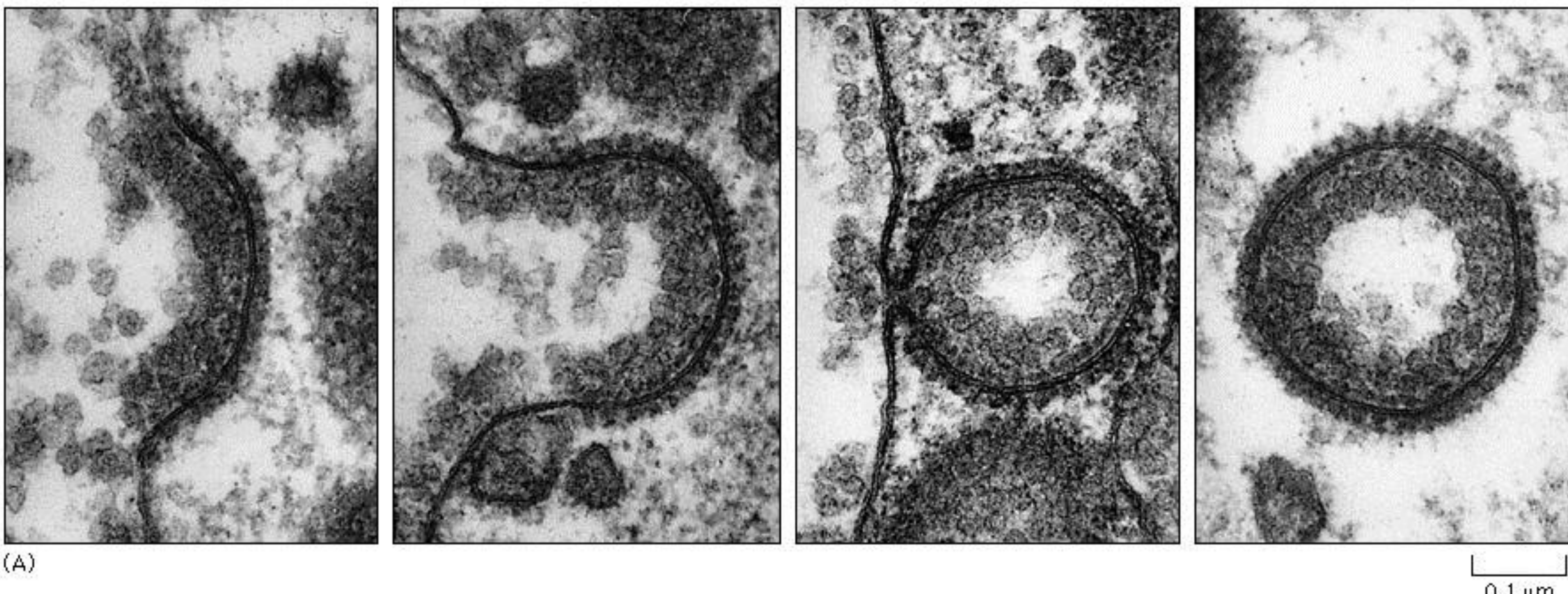




Receptor mediated endocytosis



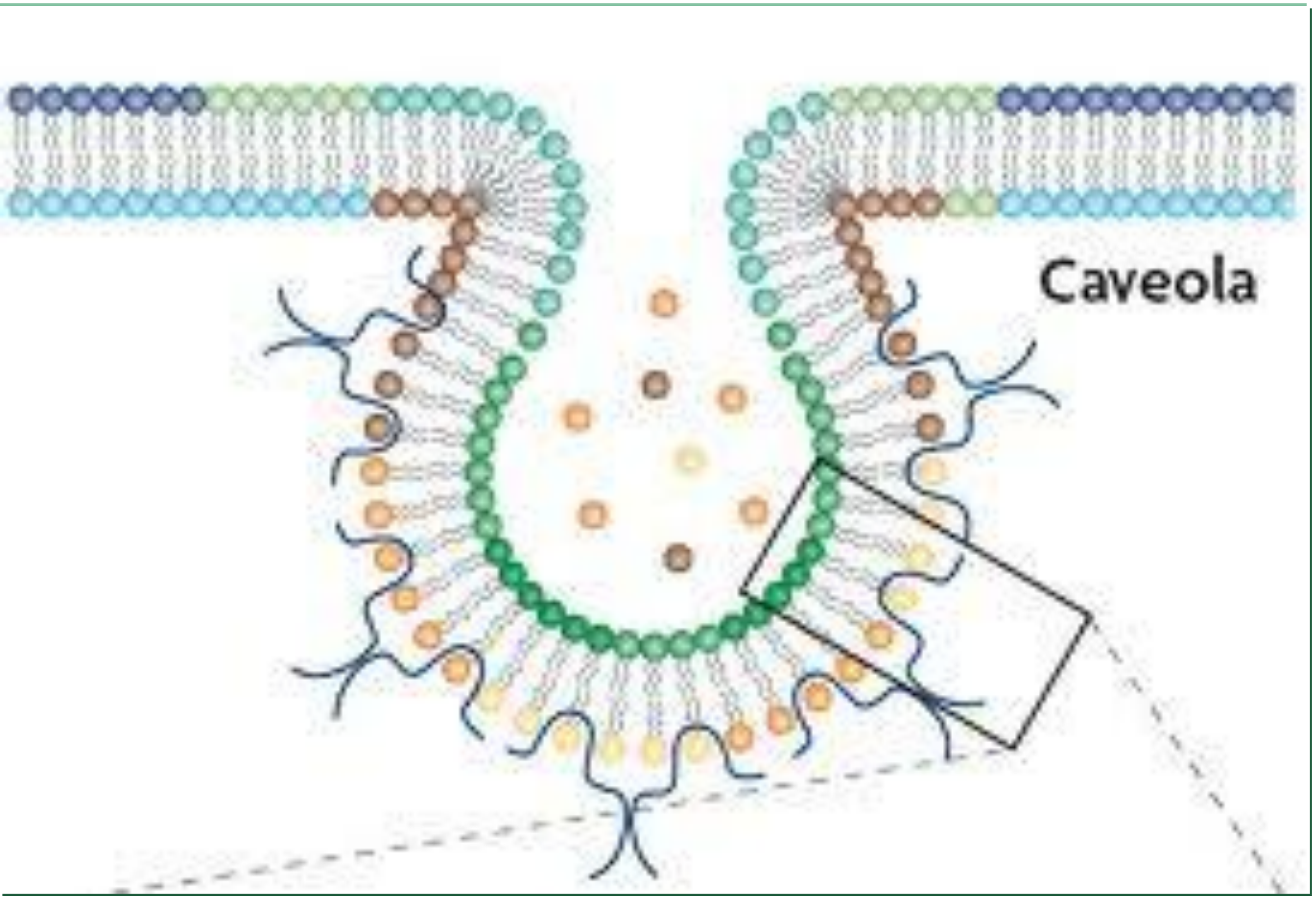


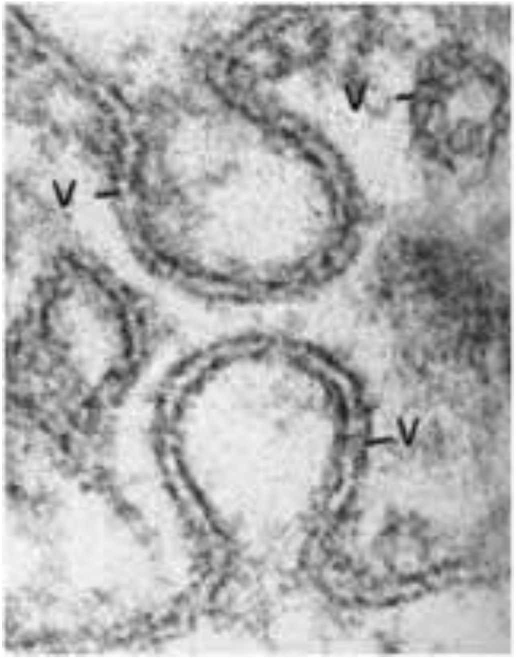


(A)

Receptor mediated endocytosis

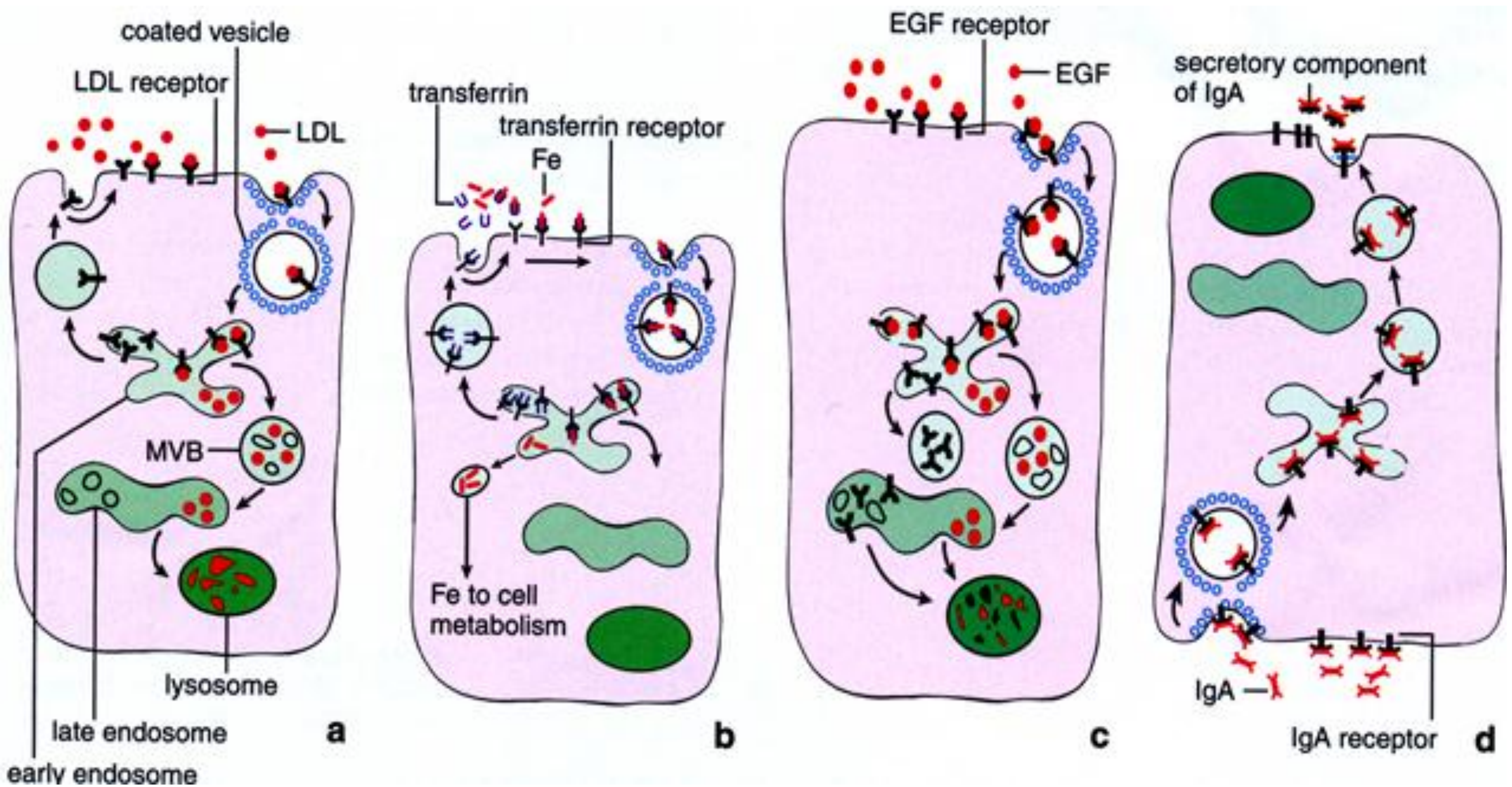
Caveolin





Electron micrograph of an endothelial cell within a capillary, Caveolae vesicles

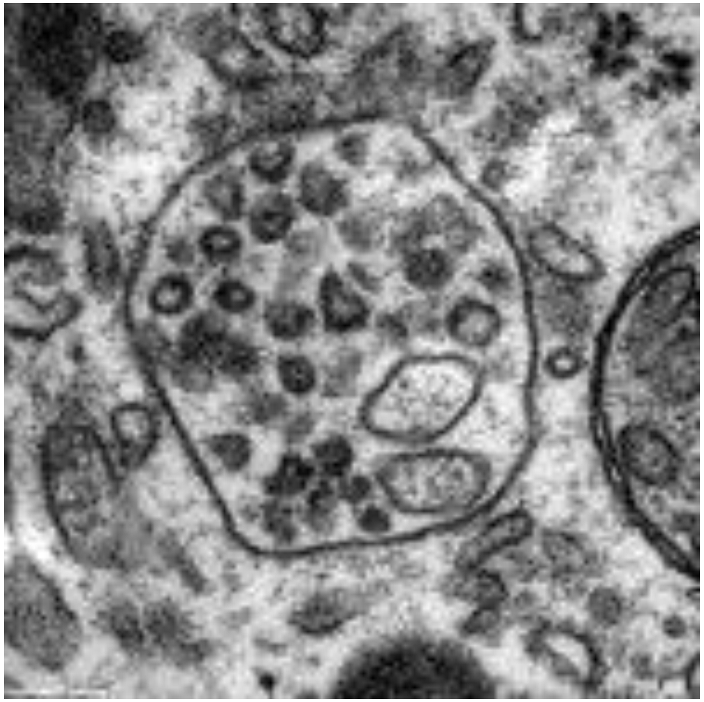
Receptor mediated endocytosis

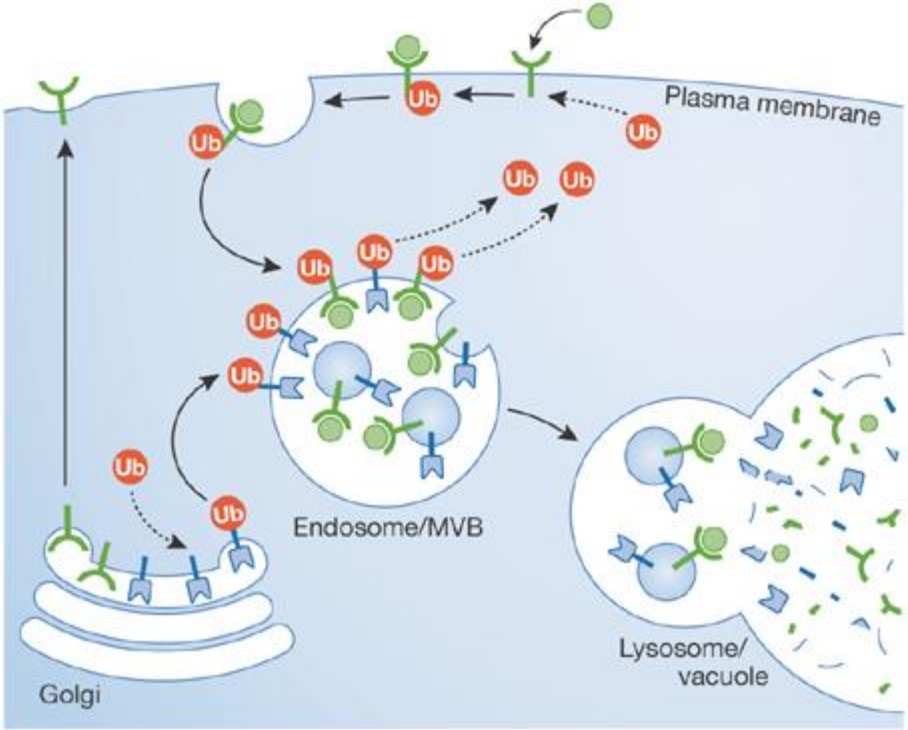


Case report

- A 45-year-old male patient with a family history of hypercholesterolemia presented with elevated serum cholesterol levels (total cholesterol: 350 mg/dL). He reported fatigue and chest pain upon exertion.
- **Clinical Investigation:**
  Laboratory tests revealed significantly elevated low-density lipoprotein (LDL) cholesterol levels. Genetic testing identified a mutation in the LDL receptor gene, confirming a diagnosis of familial hypercholesterolemia. This hereditary condition is characterized by defective receptor-mediated endocytosis of LDL particles, primarily due to malfunctioning or absent LDL receptors.

Multivesicular body





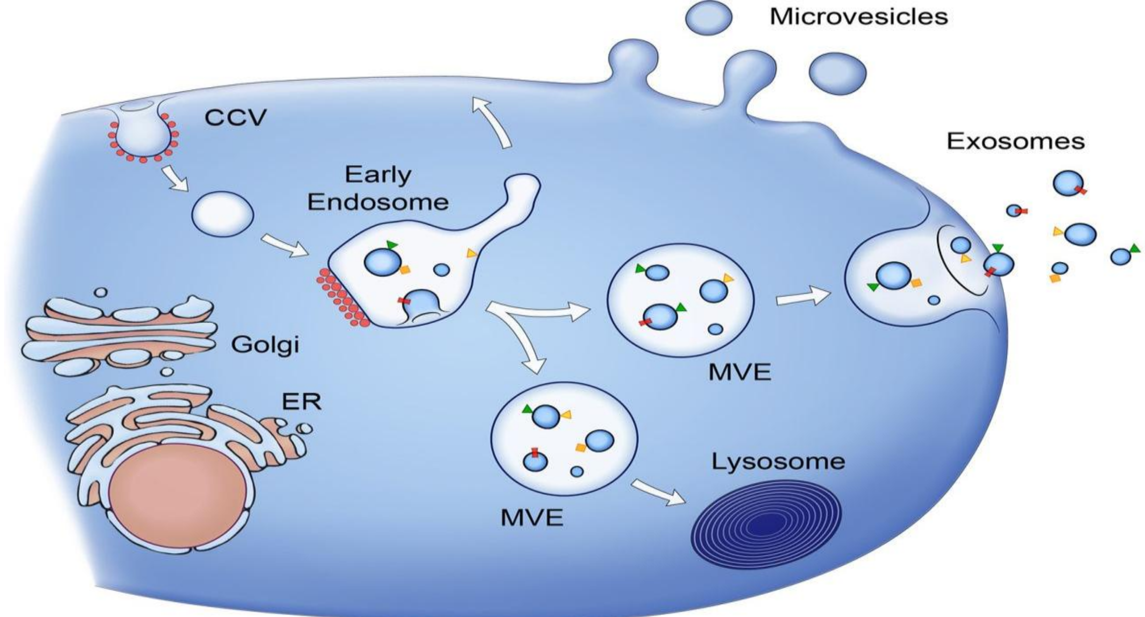
are round to oval cell organelles containing more or less smaller vesicles among the early and late endosome

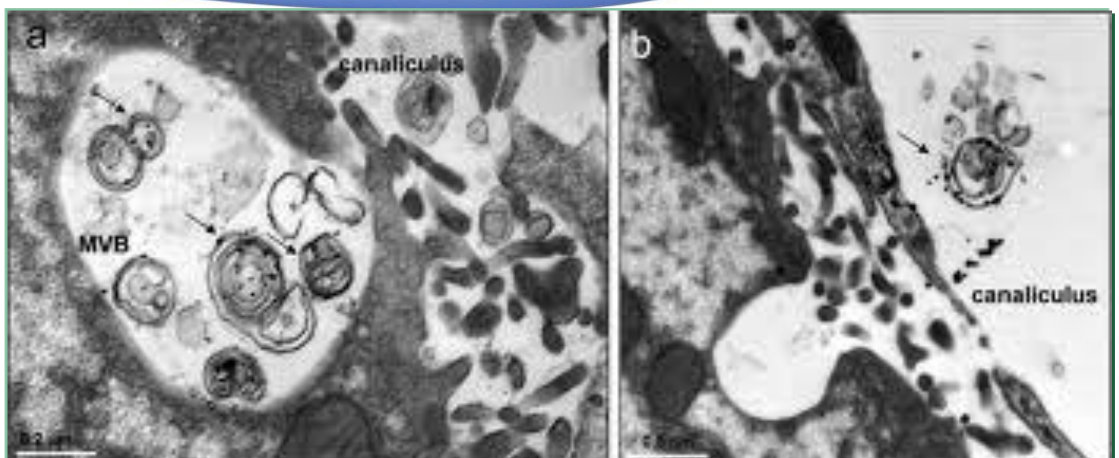
may merge with lysosomes for selective degradation of their contents or fuse with the plasma membrane and release the intralumenal vesicles outside the cell.

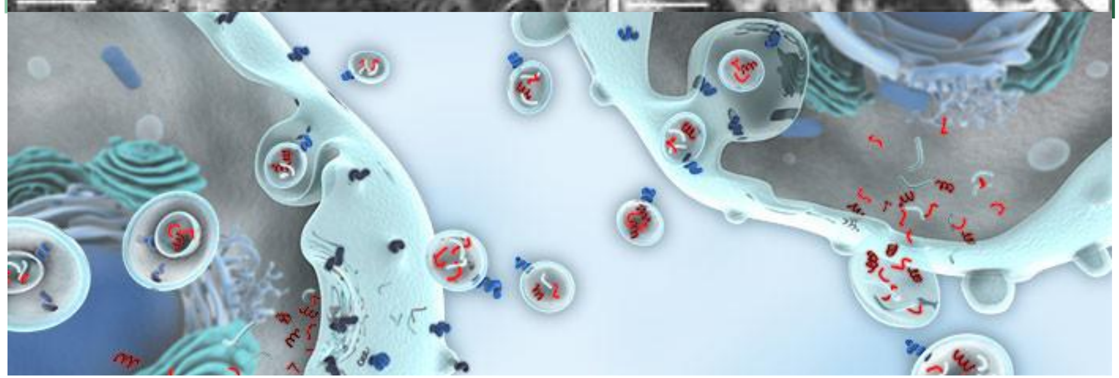
Exosomes

Exosome

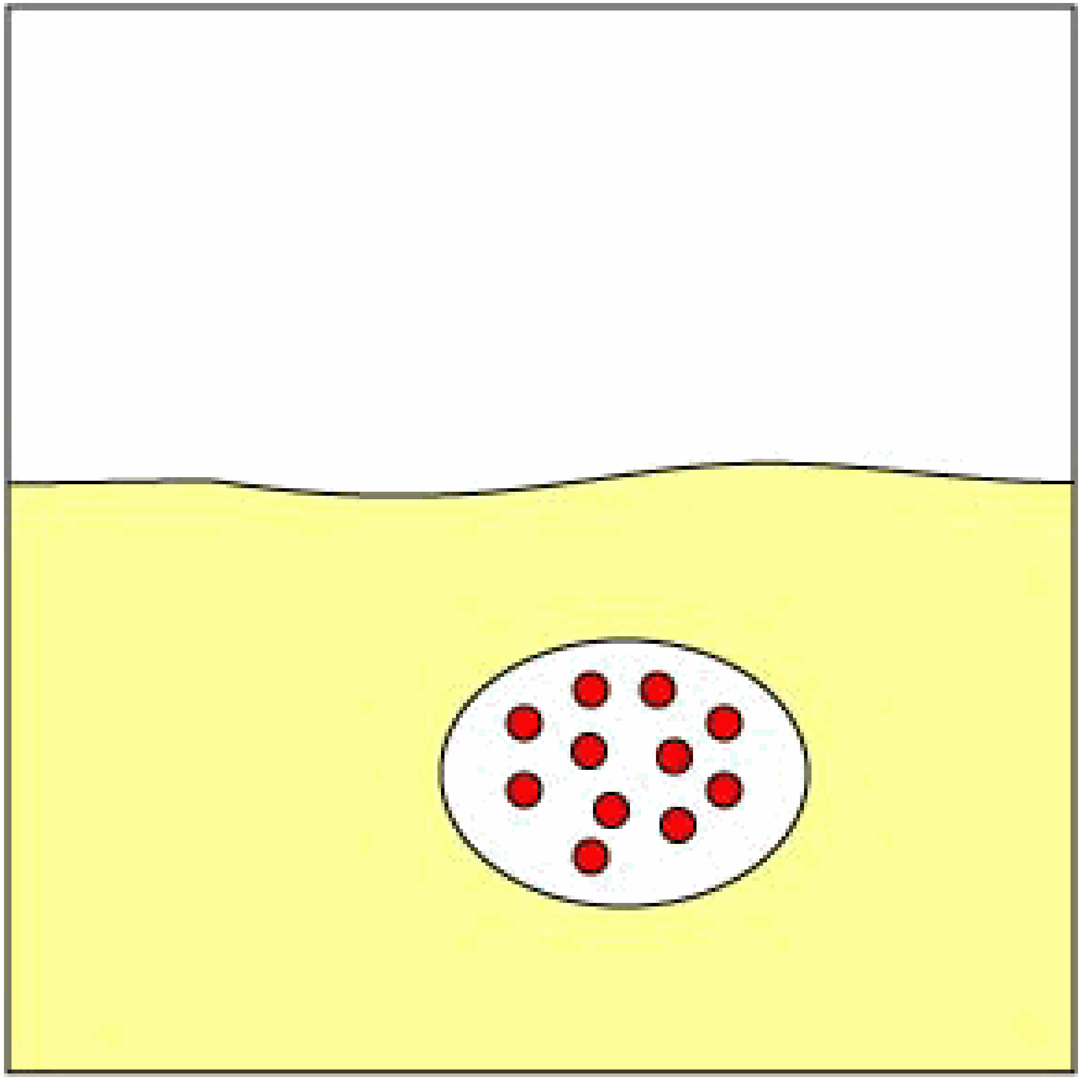
Containing mRNA, miRNA, protein and DNA





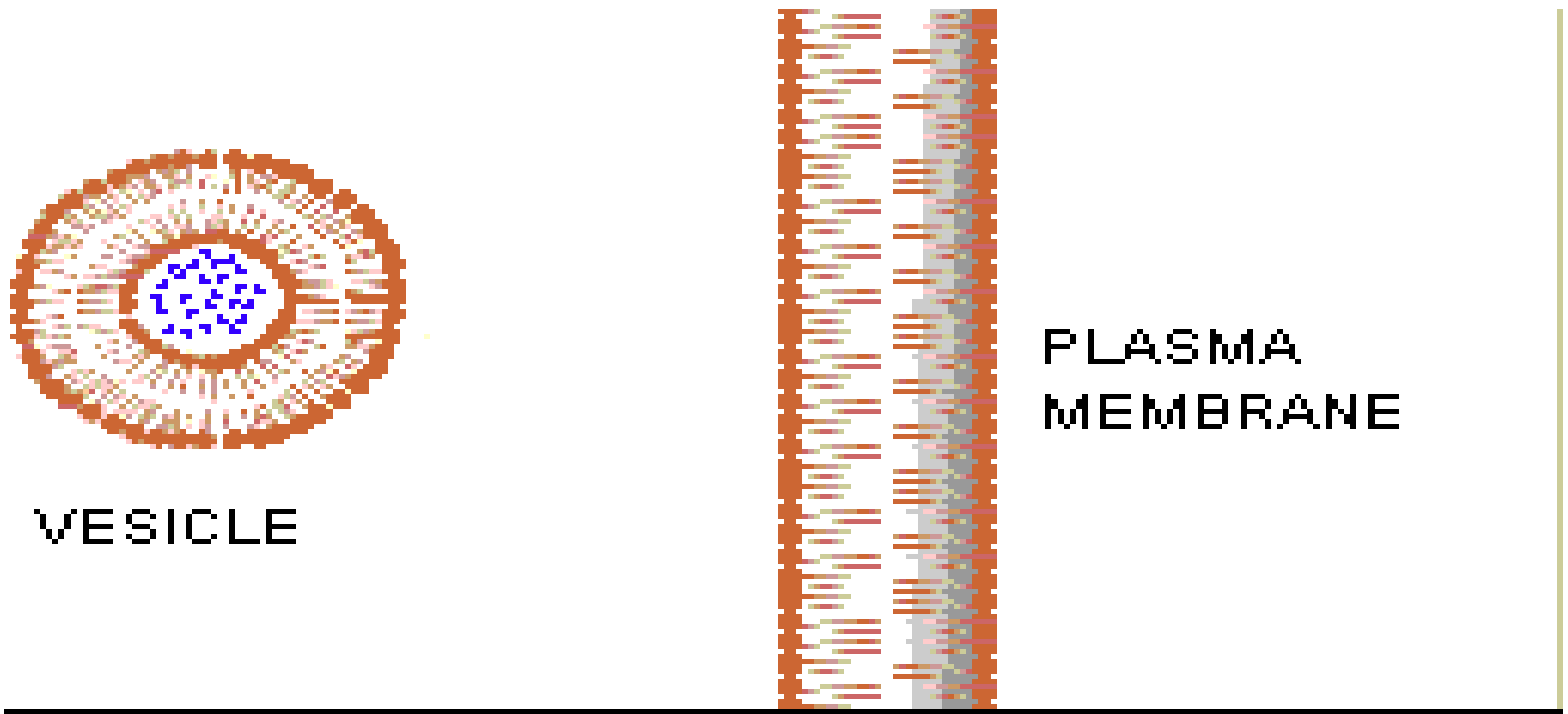


Exocytosis

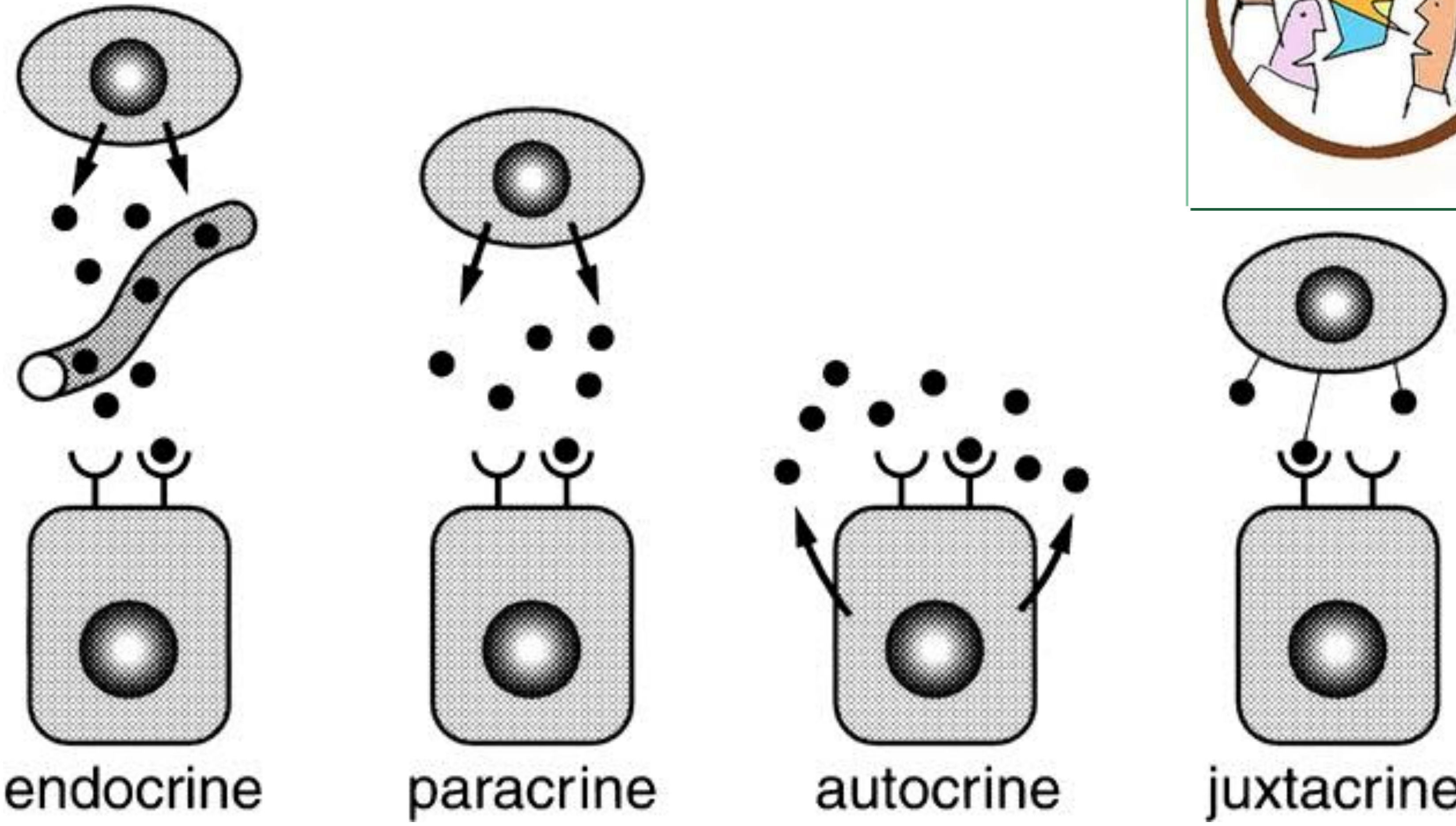


Exocytosis

- triggered in many cells by transient increase in cytosolic Ca2+
- Constitutive secretion
- Regulated secretion

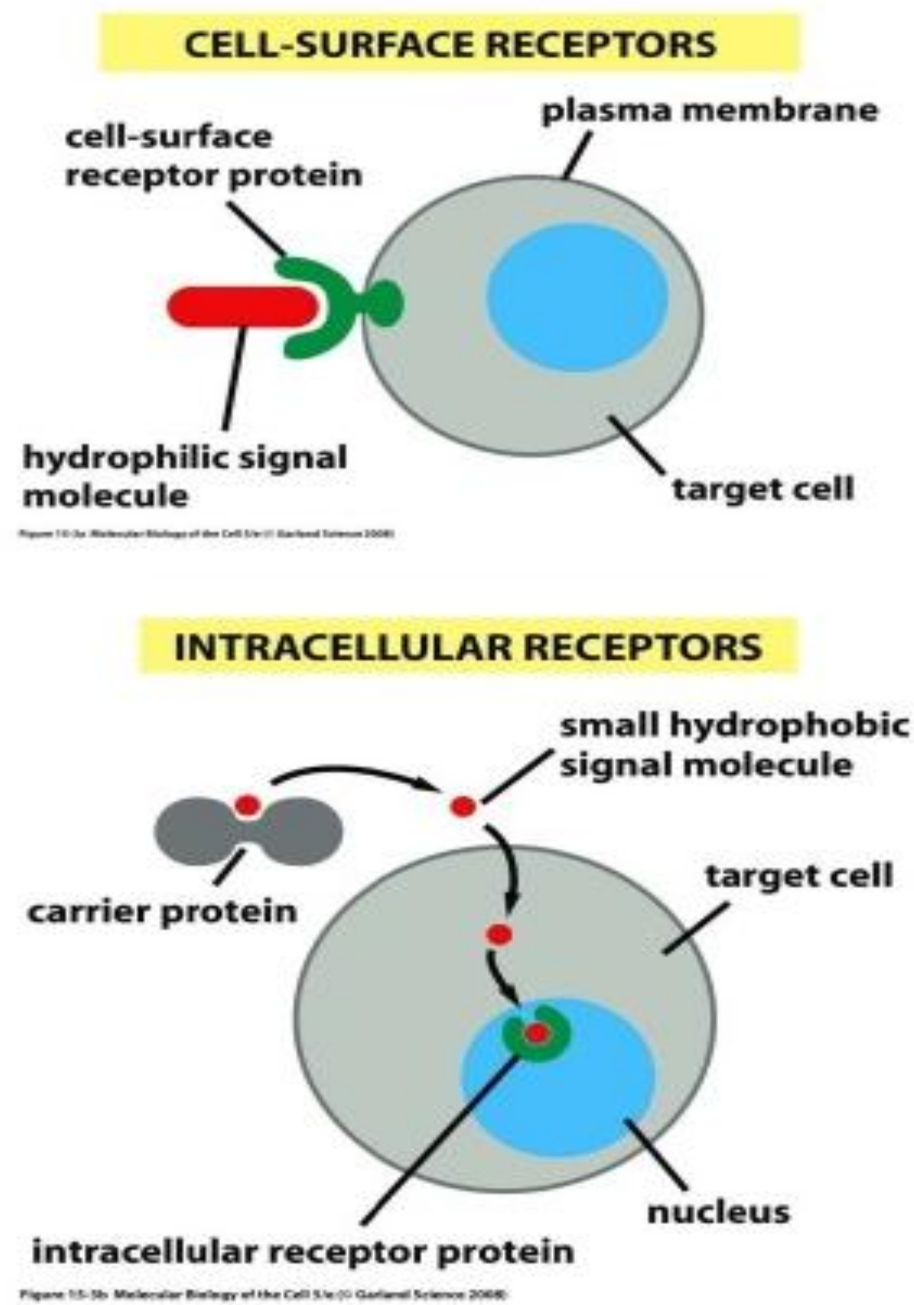


Signaling pathway

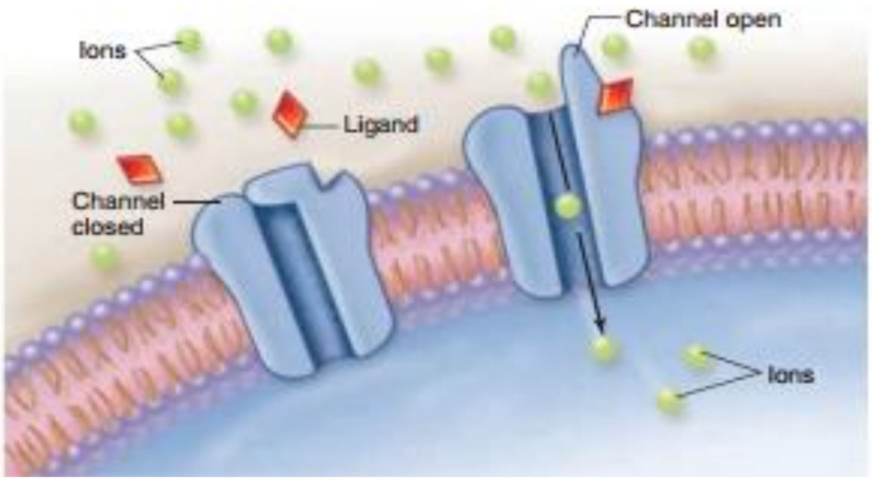


Signaling molecules

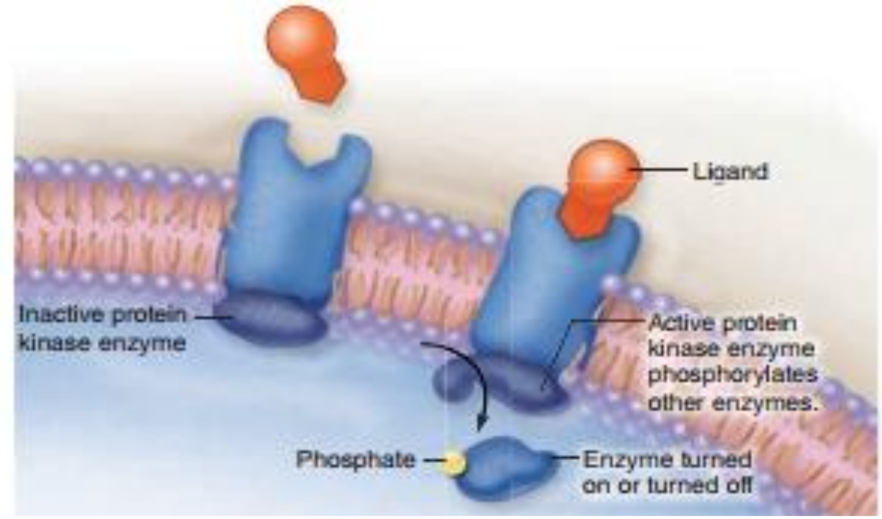
- Hydrophobic
- Small molecules
- Large hydrophilic



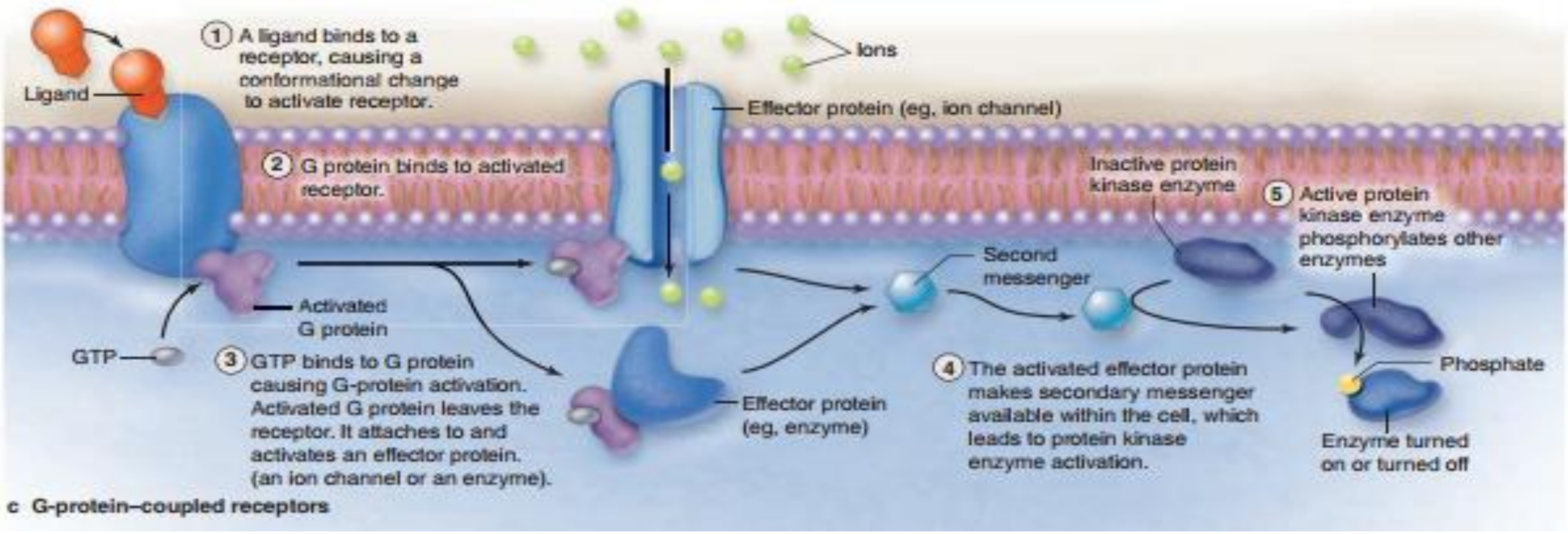
Hydrophilic signaling pathways through three different signaling pathways



Channel-linked receptors

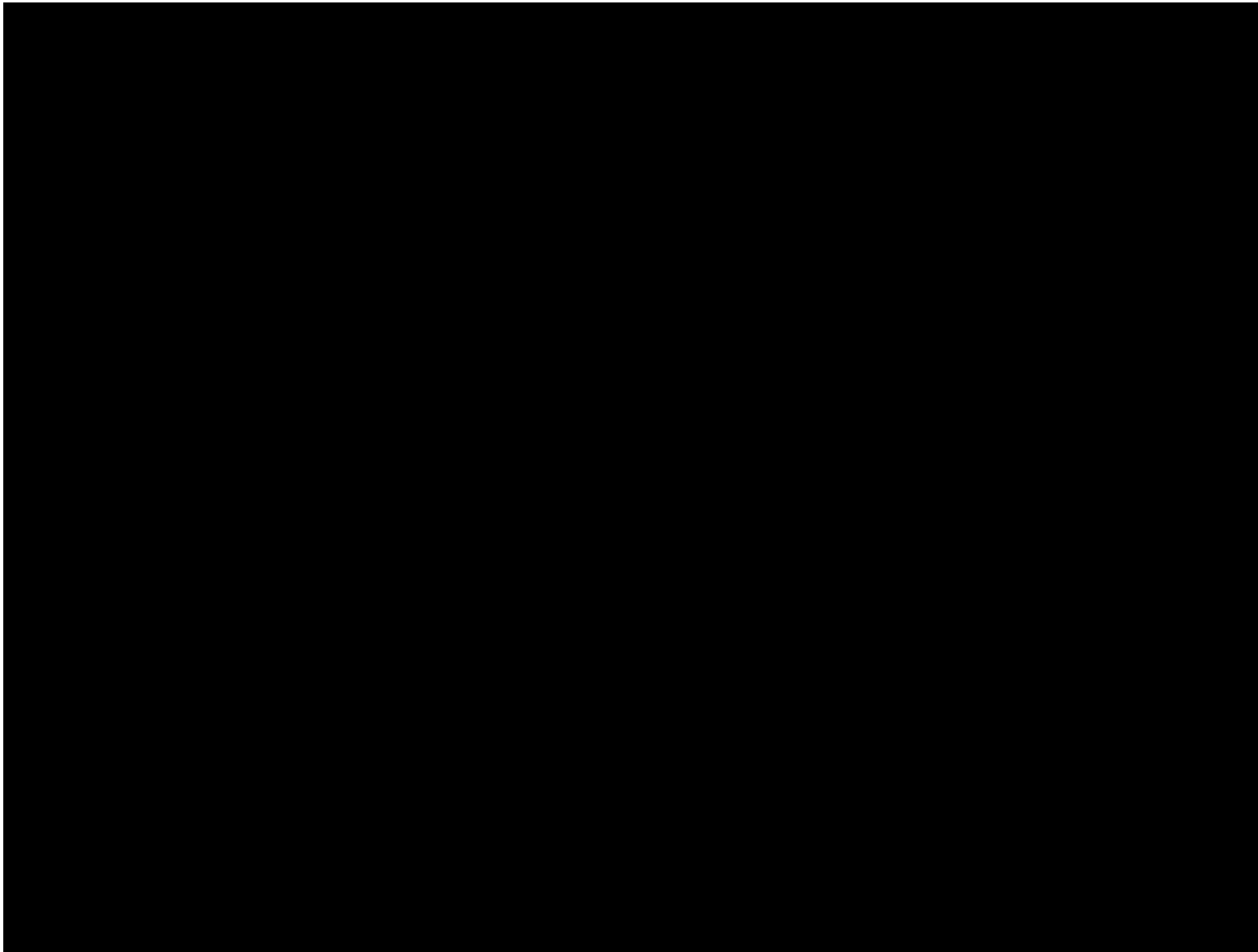


Enzymatic receptors

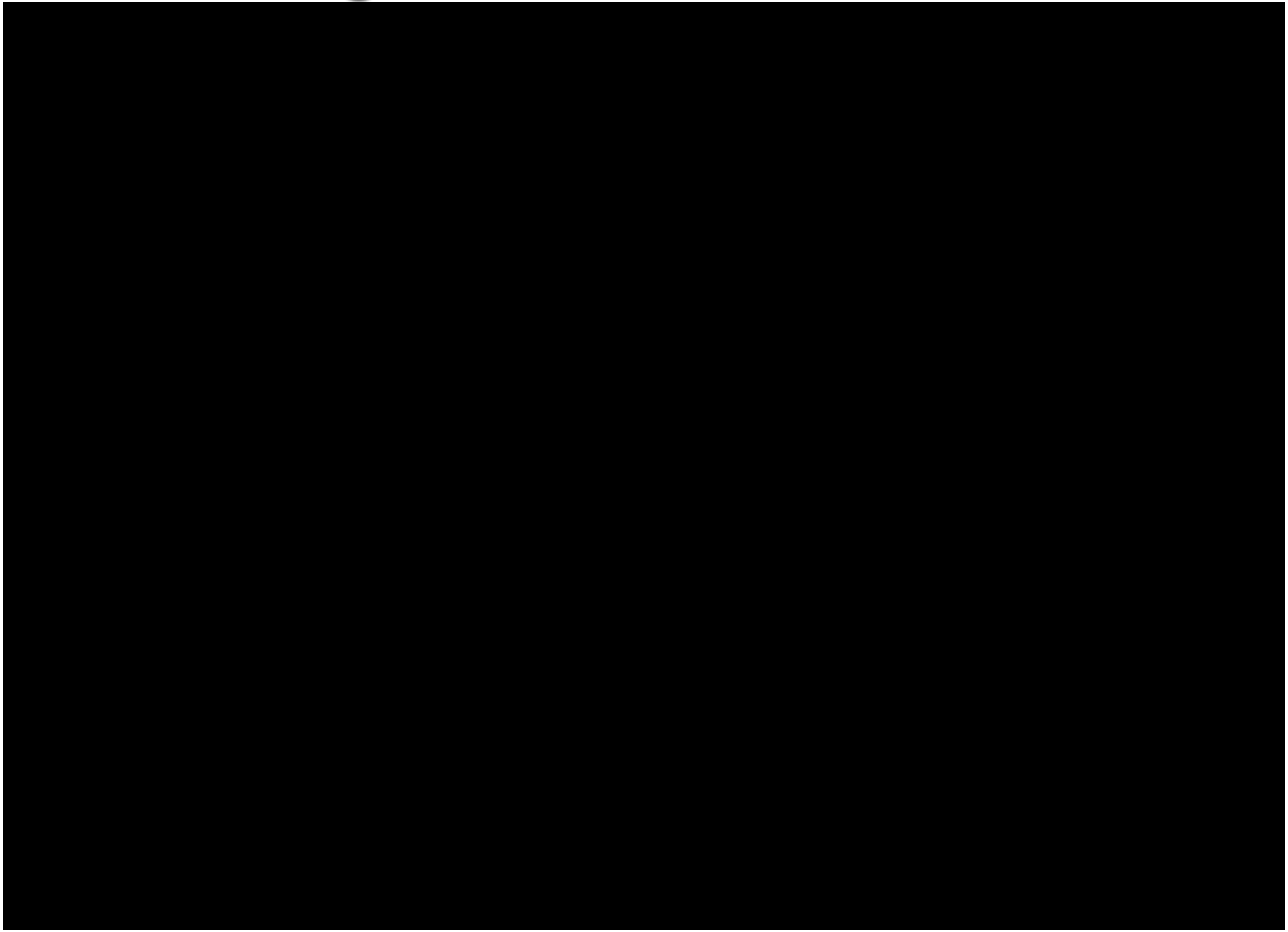


G-protein–coupled receptors

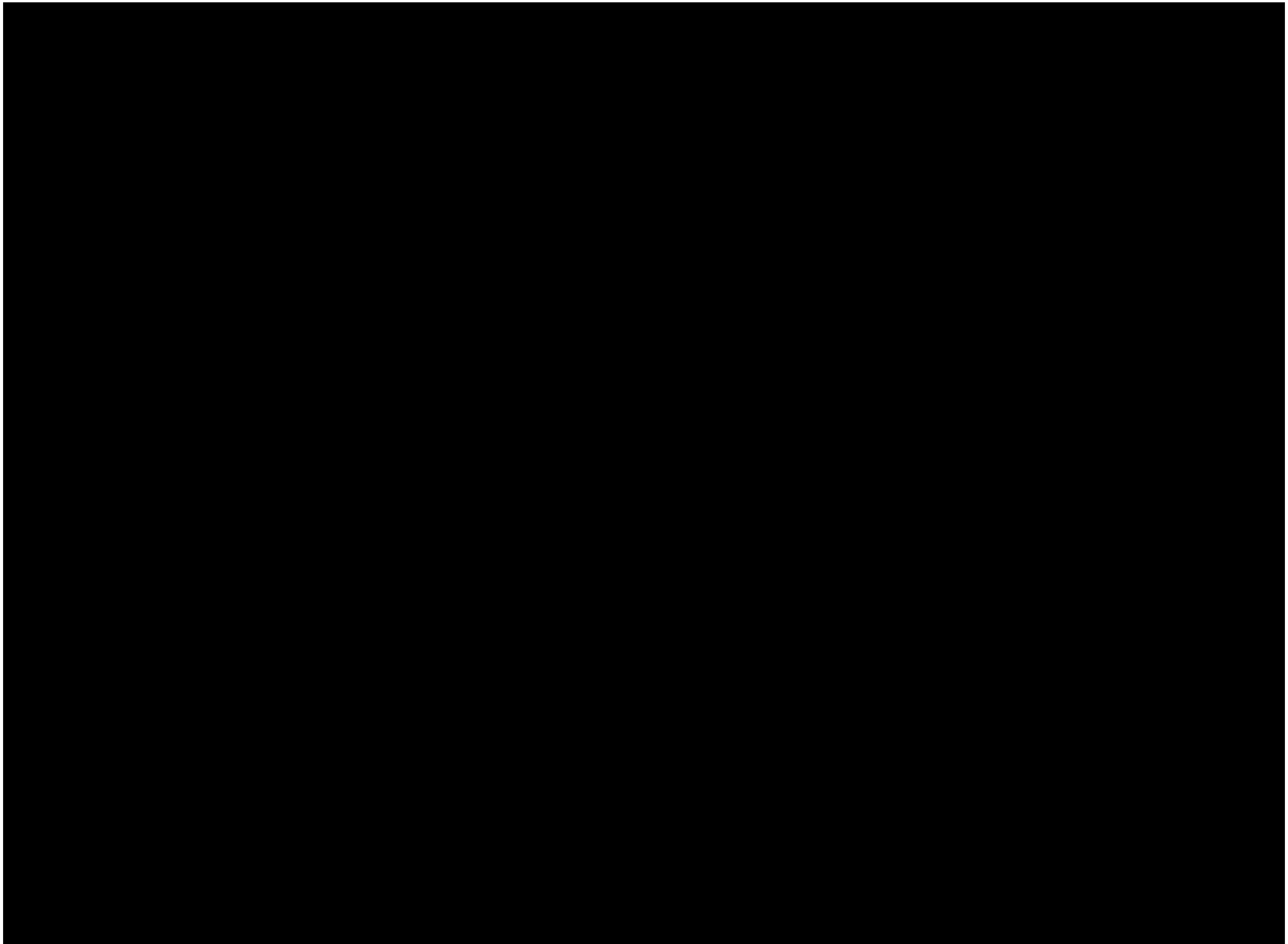
cAMP signialling



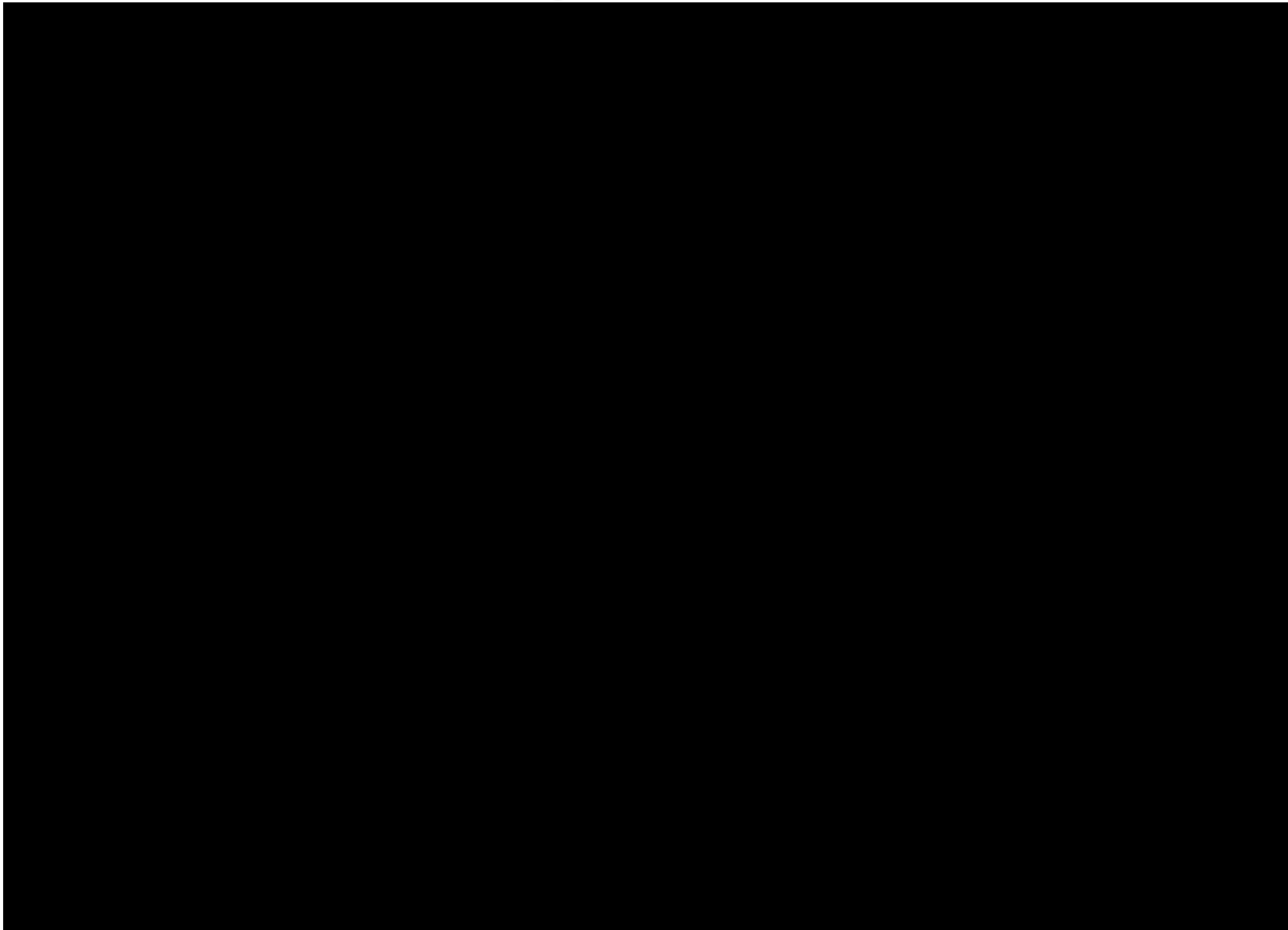
Signal transduction



Cell signaling



G protein



Mitochondria

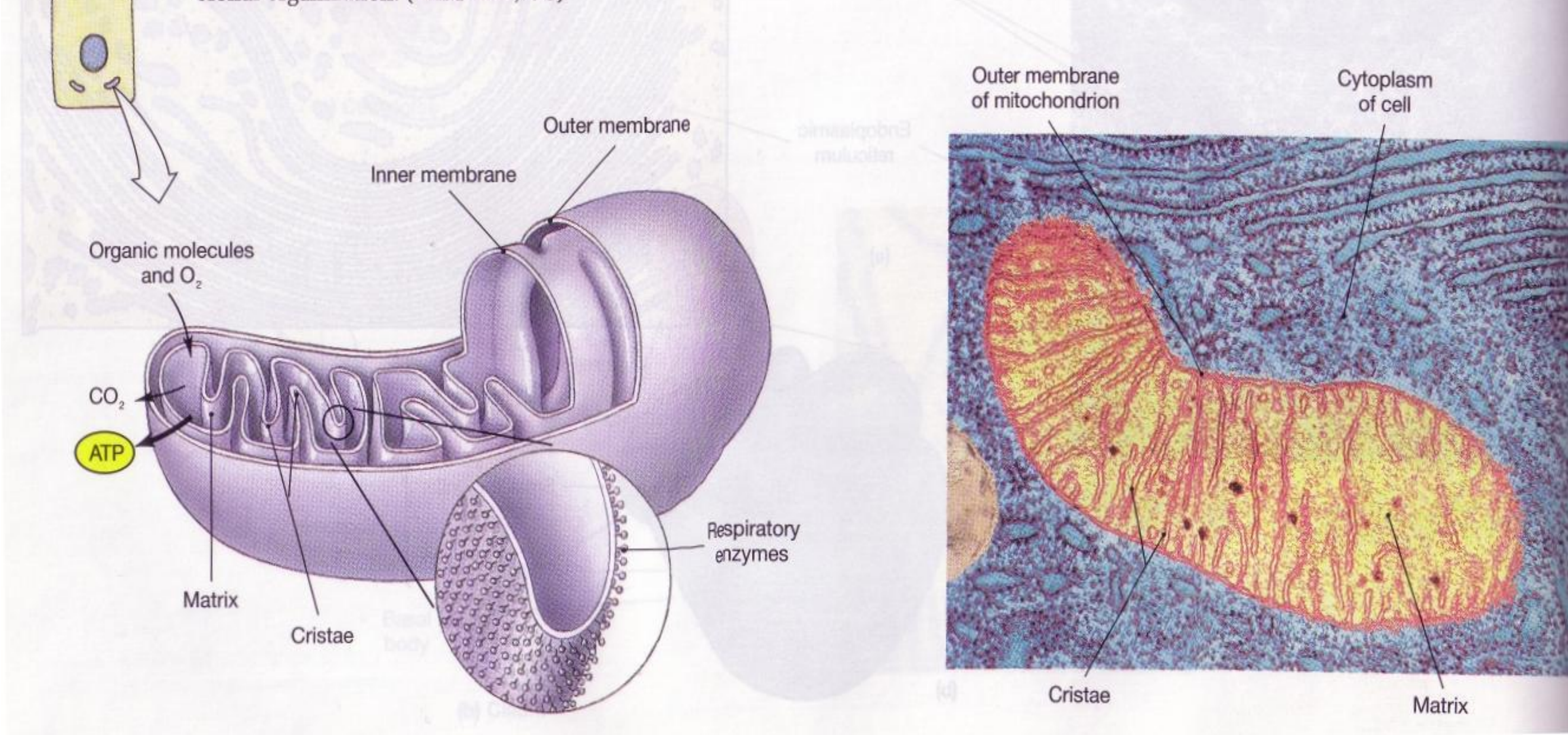
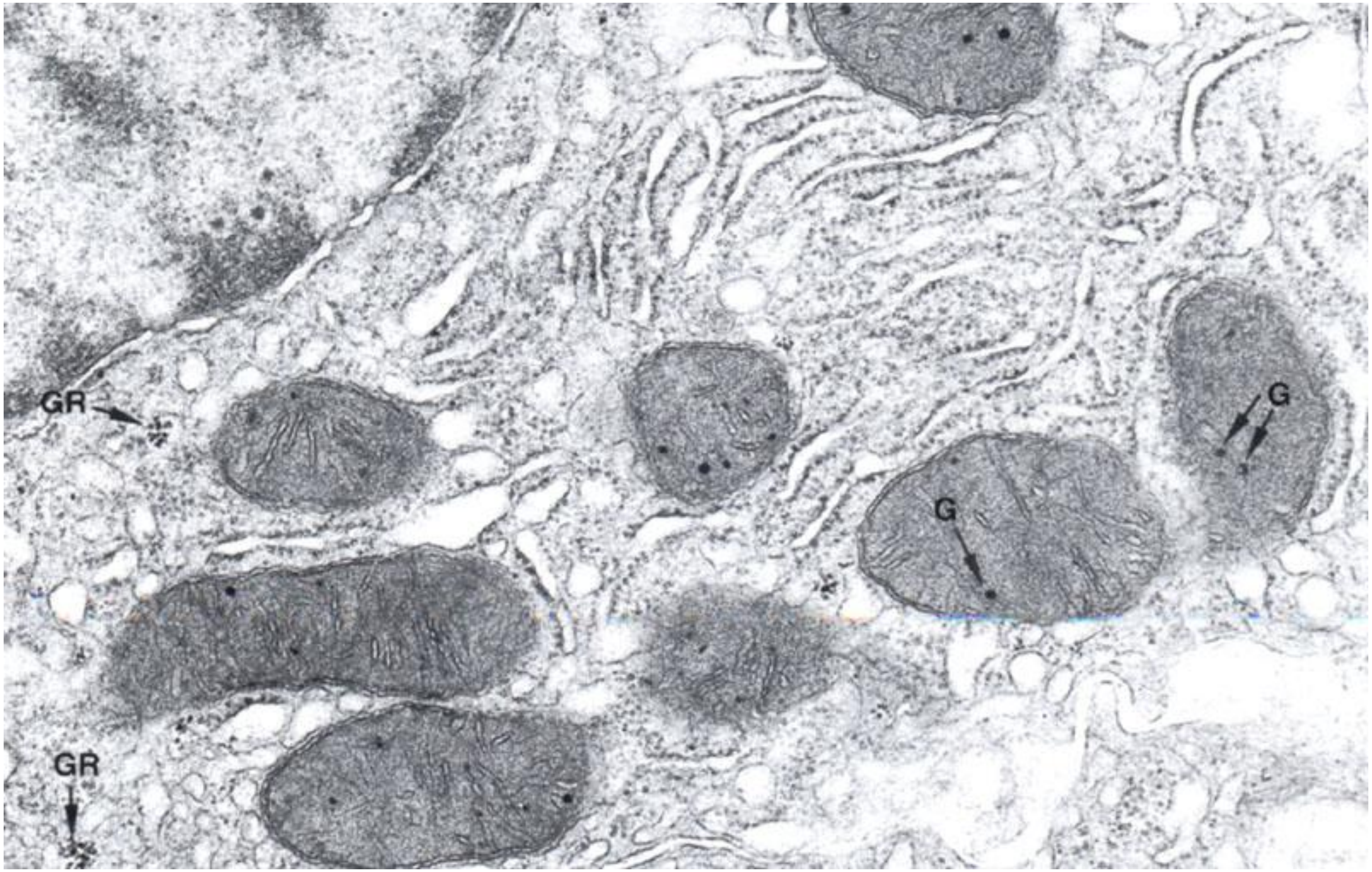
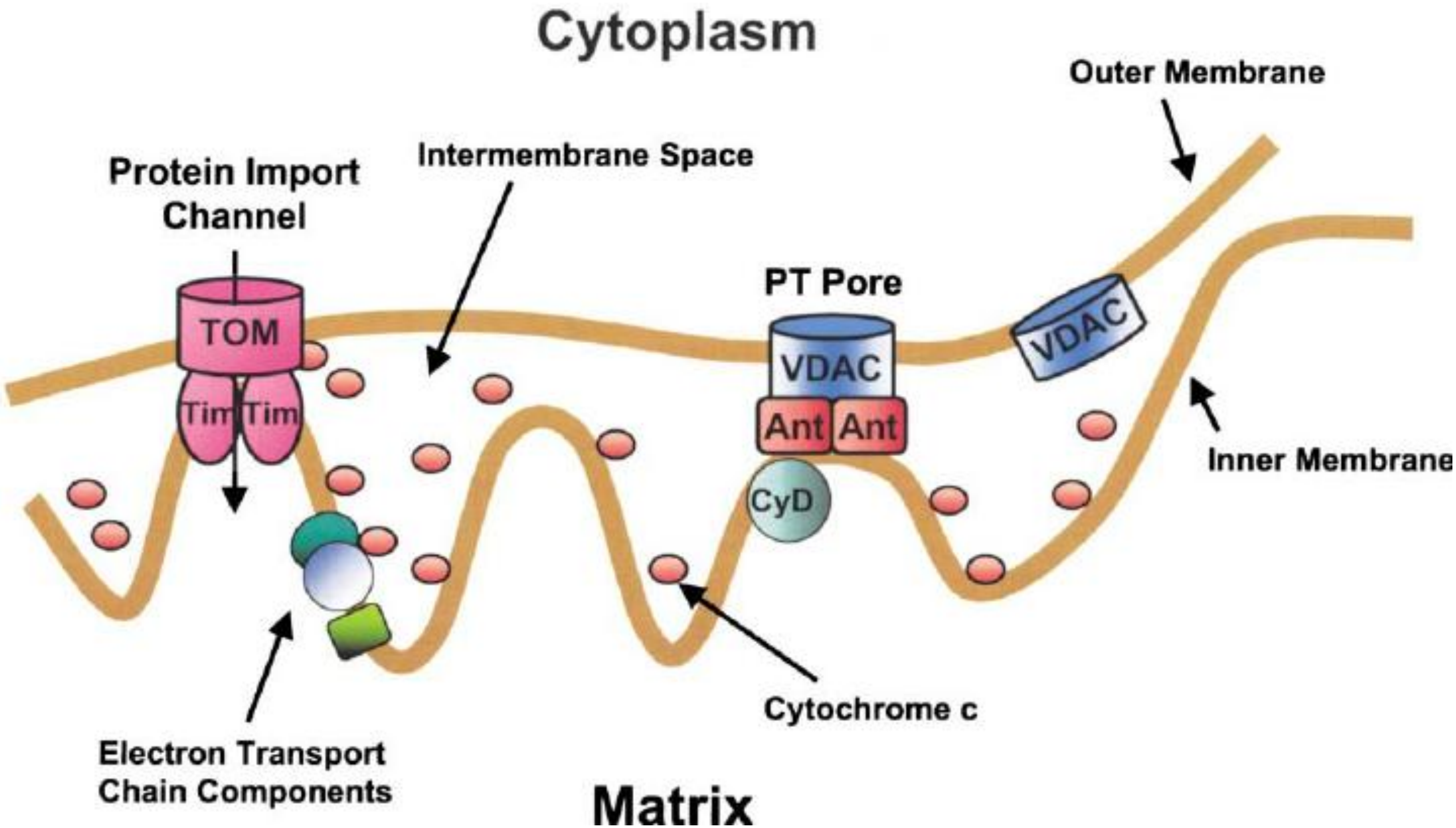


FIGURE 2-12
Mitochondria. This false-color TEM shows a typical mitochondrion in section, and the sketch details its three-dimensional organization. (TEM × 61,776)

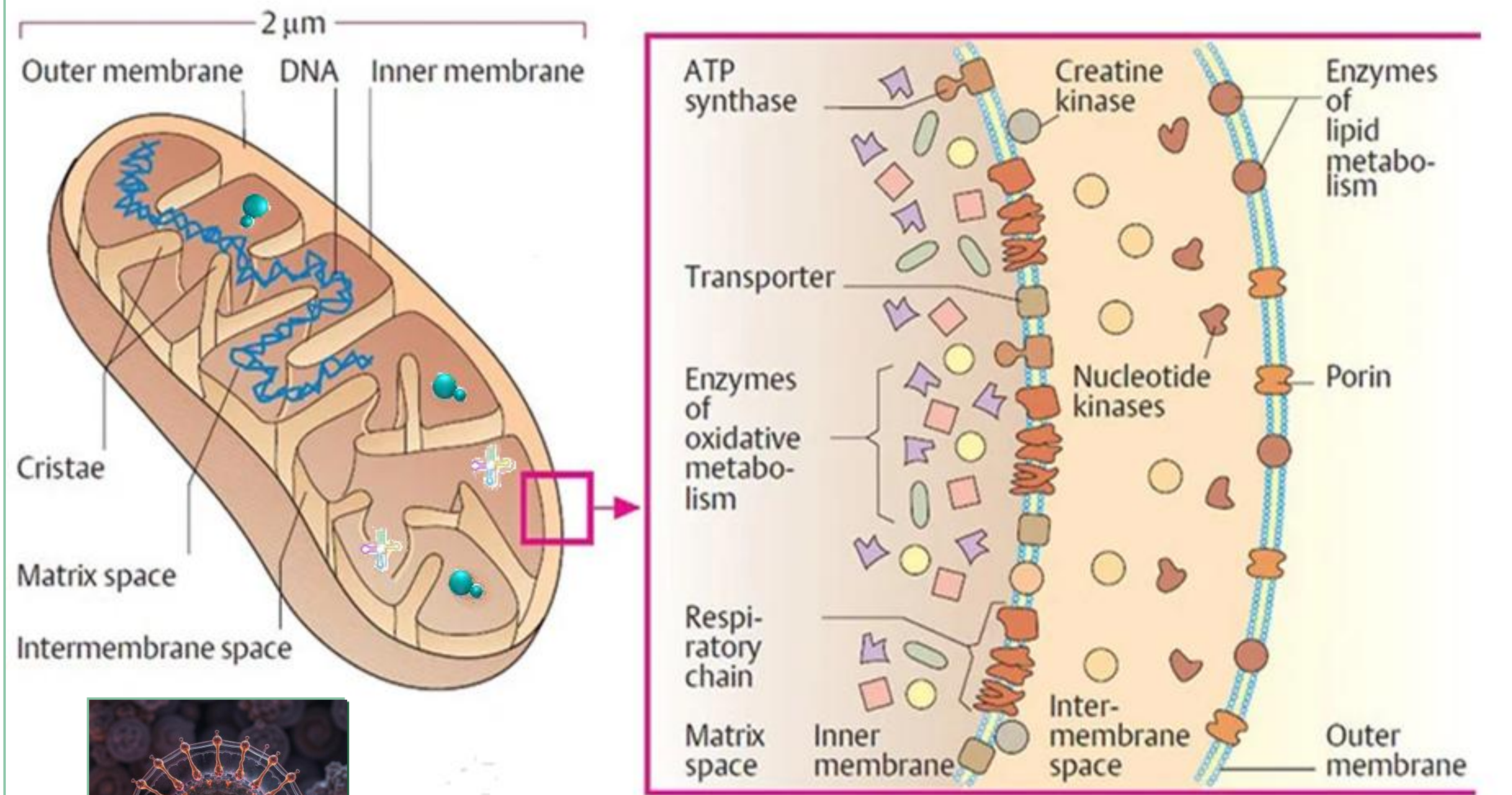
Mitochondrion



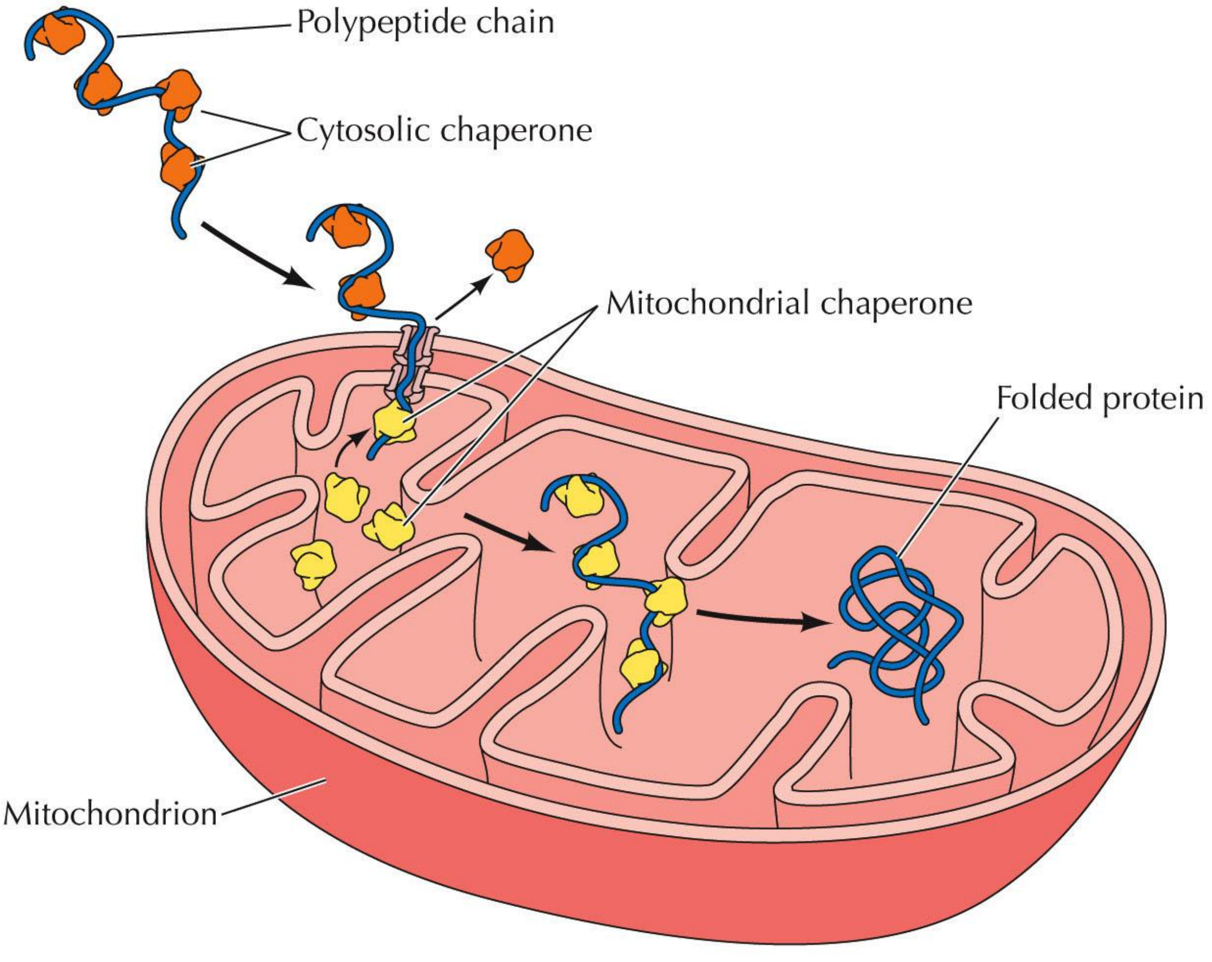
Pores in the outer membrane of mitochondria



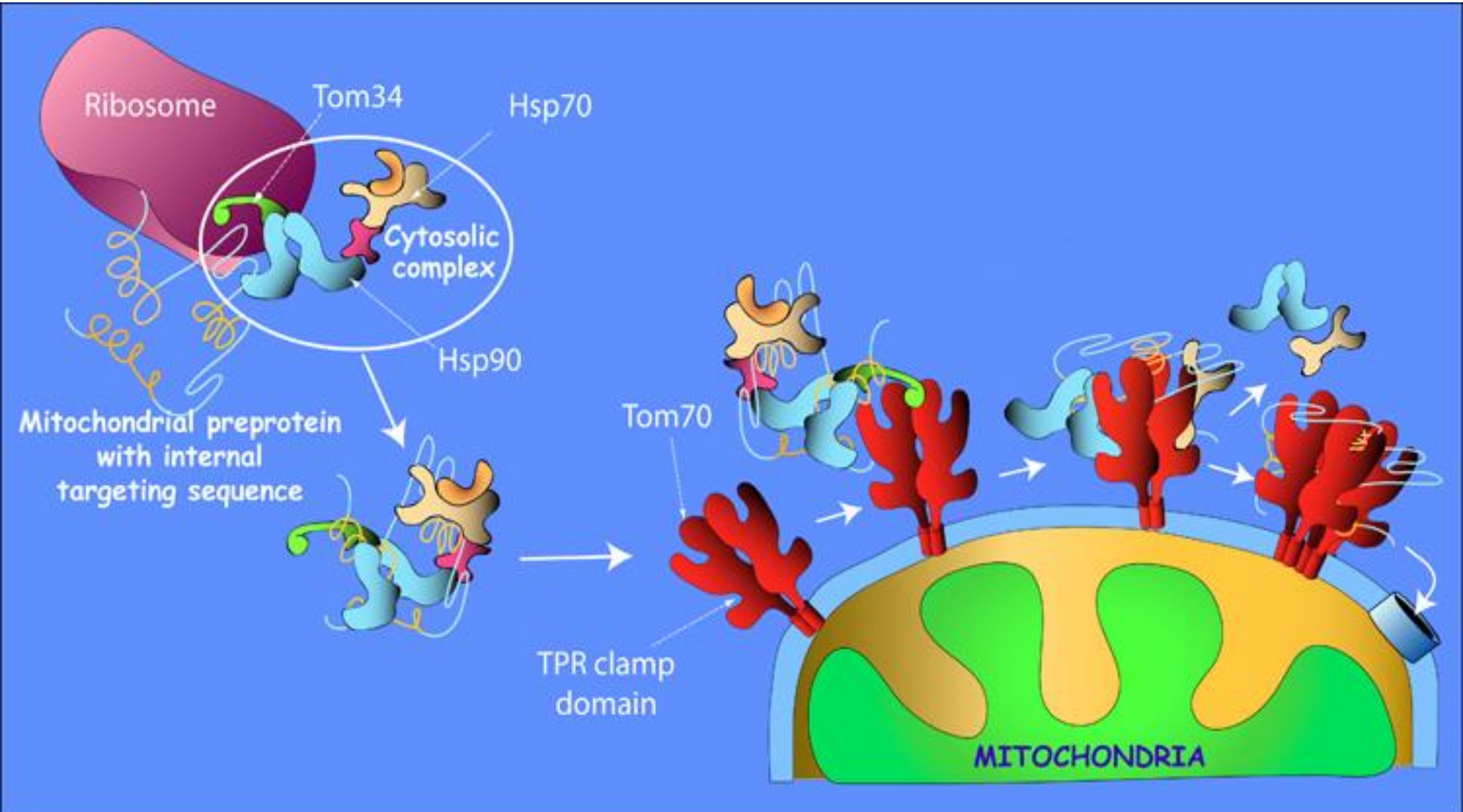
Matrix of the mitochondrion



Synthesis of the mitochondrial proteins

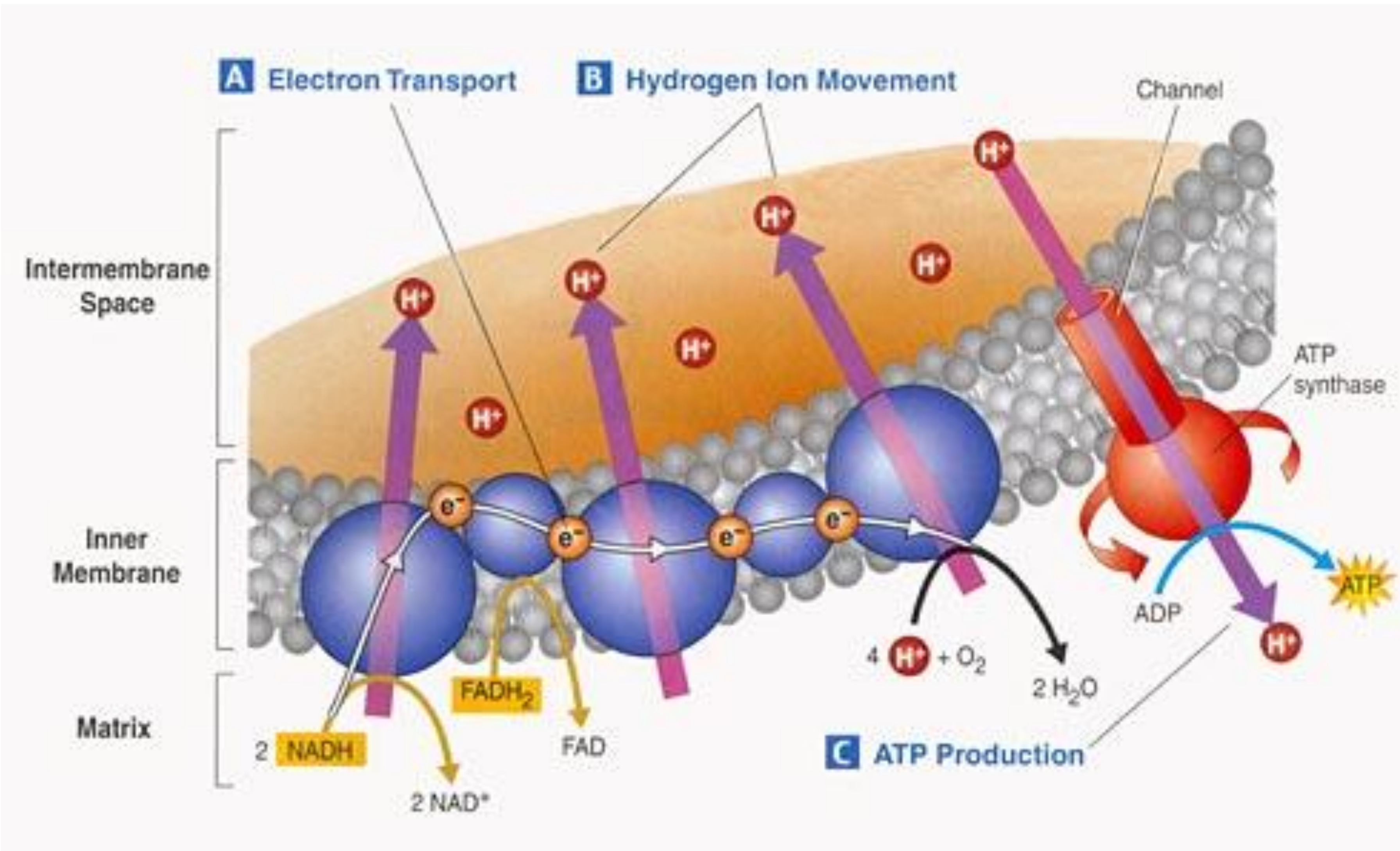


Chaperones role in protein targeting to mitochondria

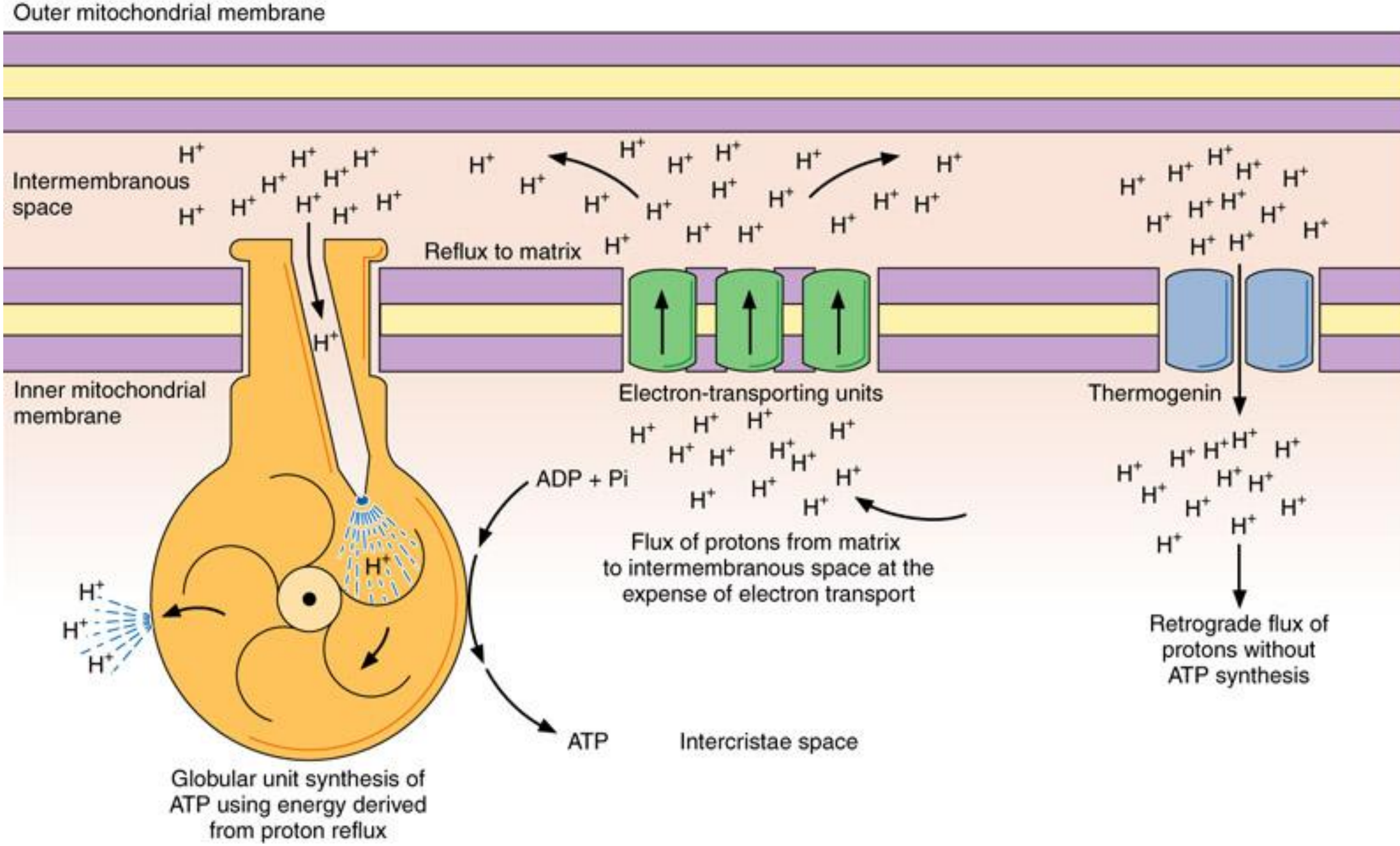


ATP synthase (EC 3.6.3.14) is an important enzyme that provides energy for the cell to use through the synthesis of adenosine triphosphate (**ATP**).

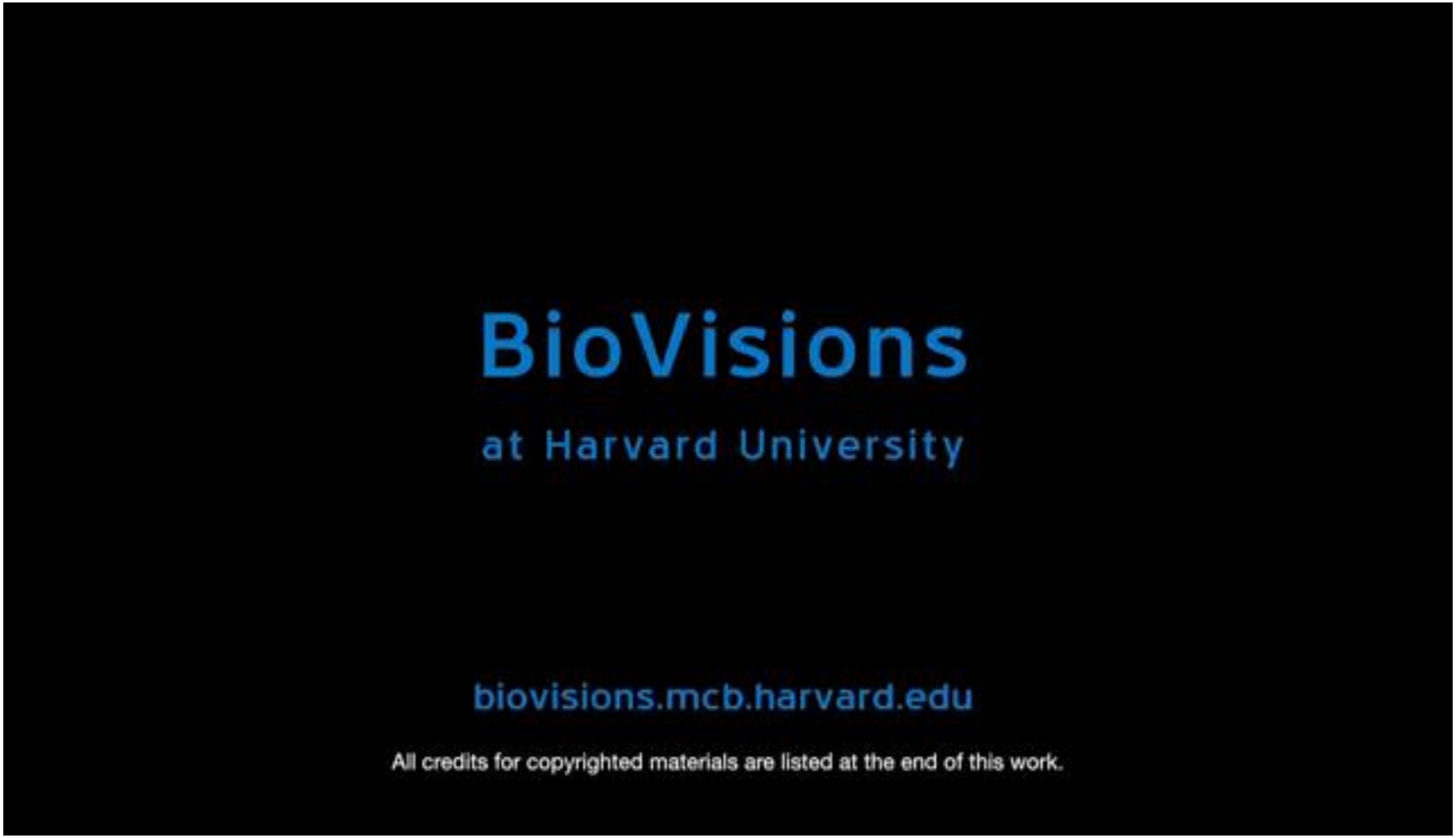
An **electron transport chain** (ETC) is a series of compounds that **transfer electrons** from **electron** donors to **electron acceptors** and produces energy



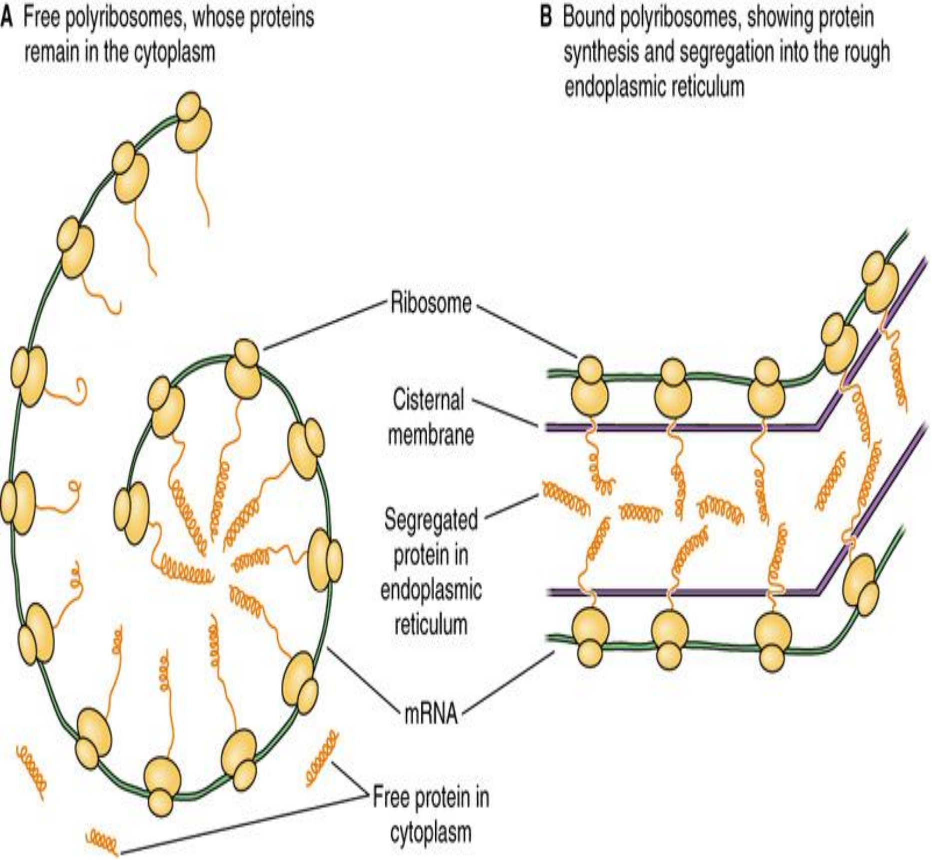
Energy production



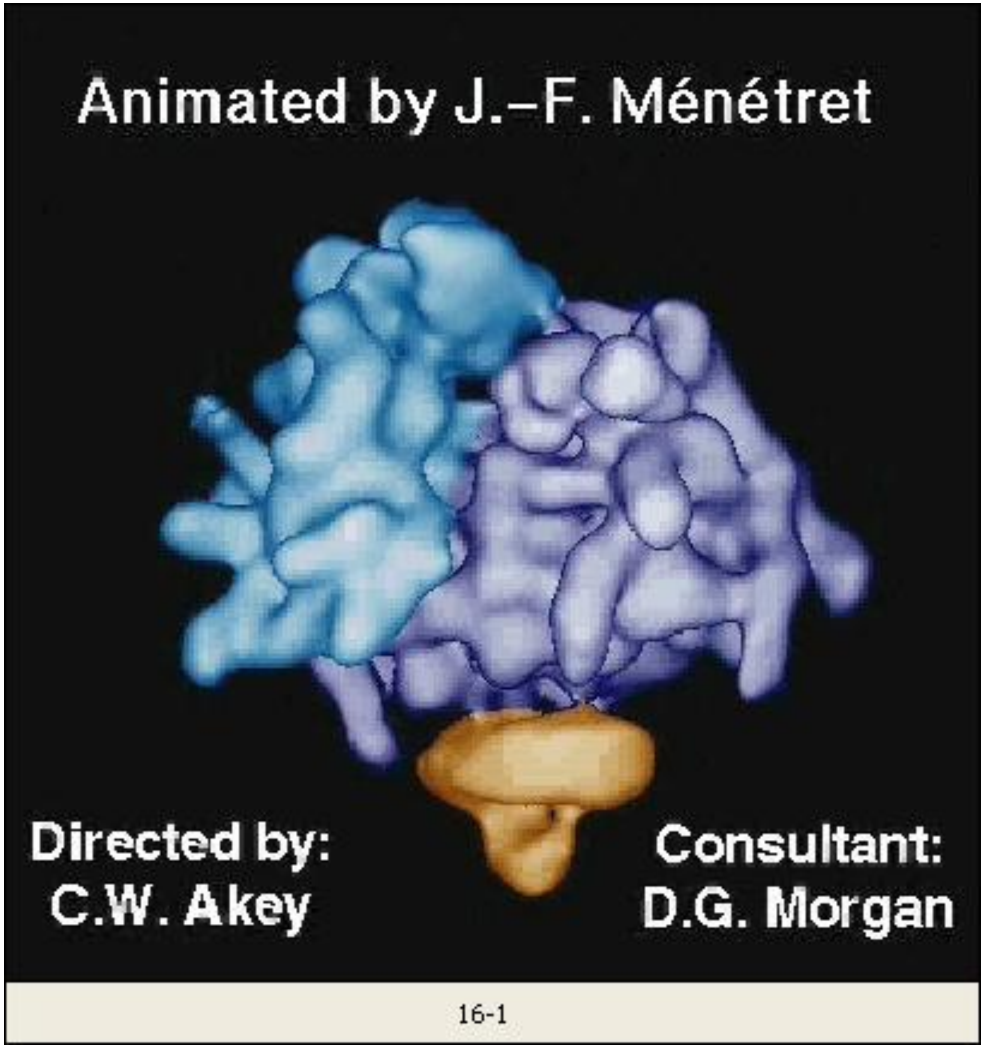
Electron transport chain



Ribosome

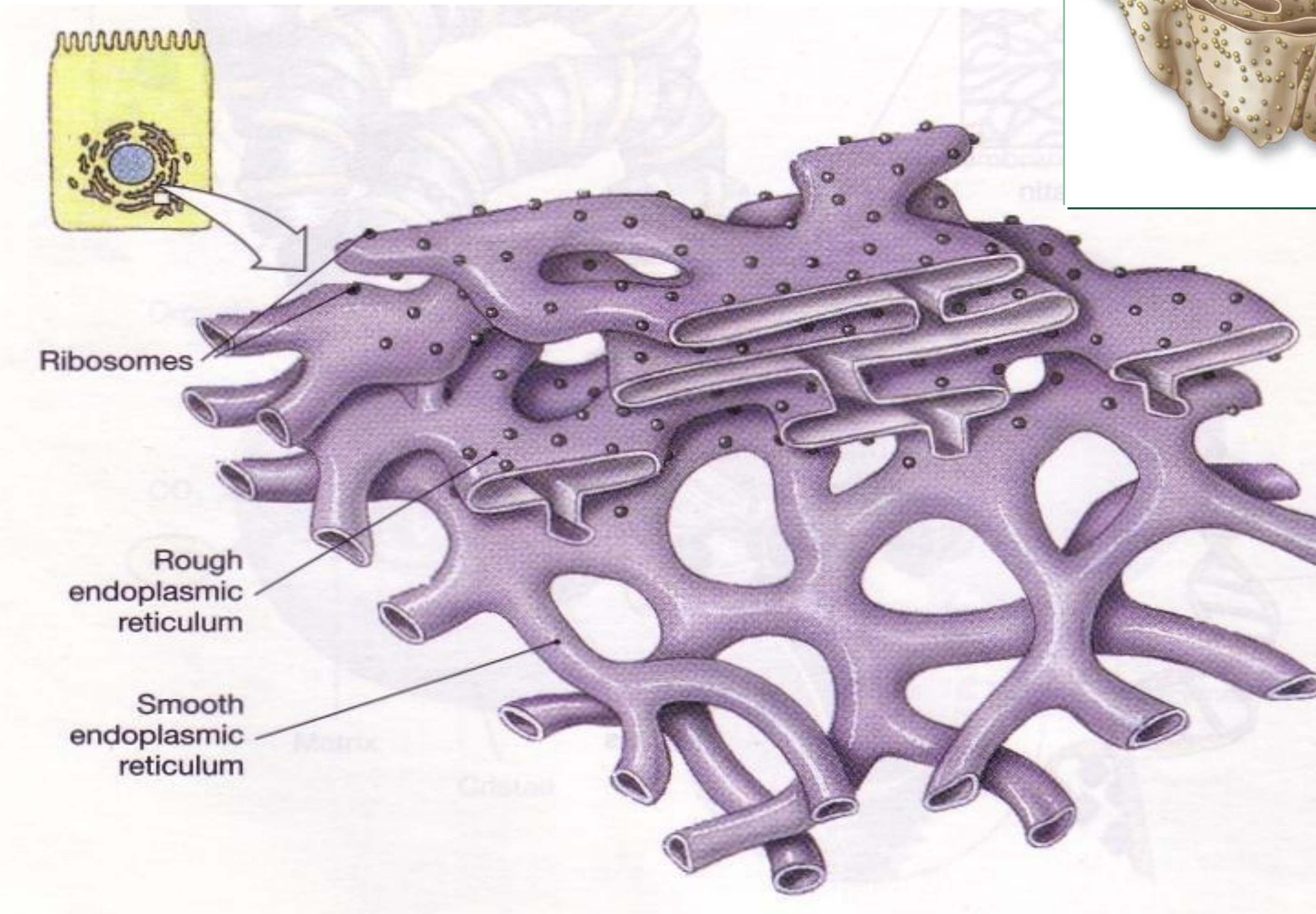


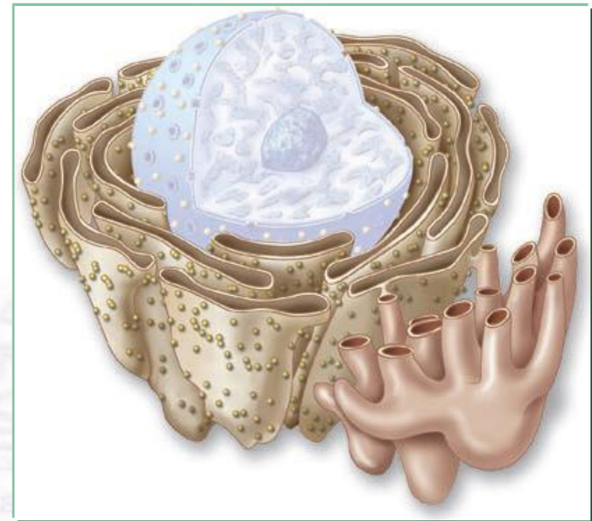
A Free polyribosomes, whose proteins remain in the cytoplasm
B Bound polyribosomes, showing protein synthesis and segregation into the rough endoplasmic reticulum
Ribosome
Cisternal membrane
Segregated protein in endoplasmic reticulum
mRNA
Free protein in cytoplasm



Animated by J.–F. Ménétret
Directed by:
C.W. Akey
Consultant:
D.G. Morgan
16-1

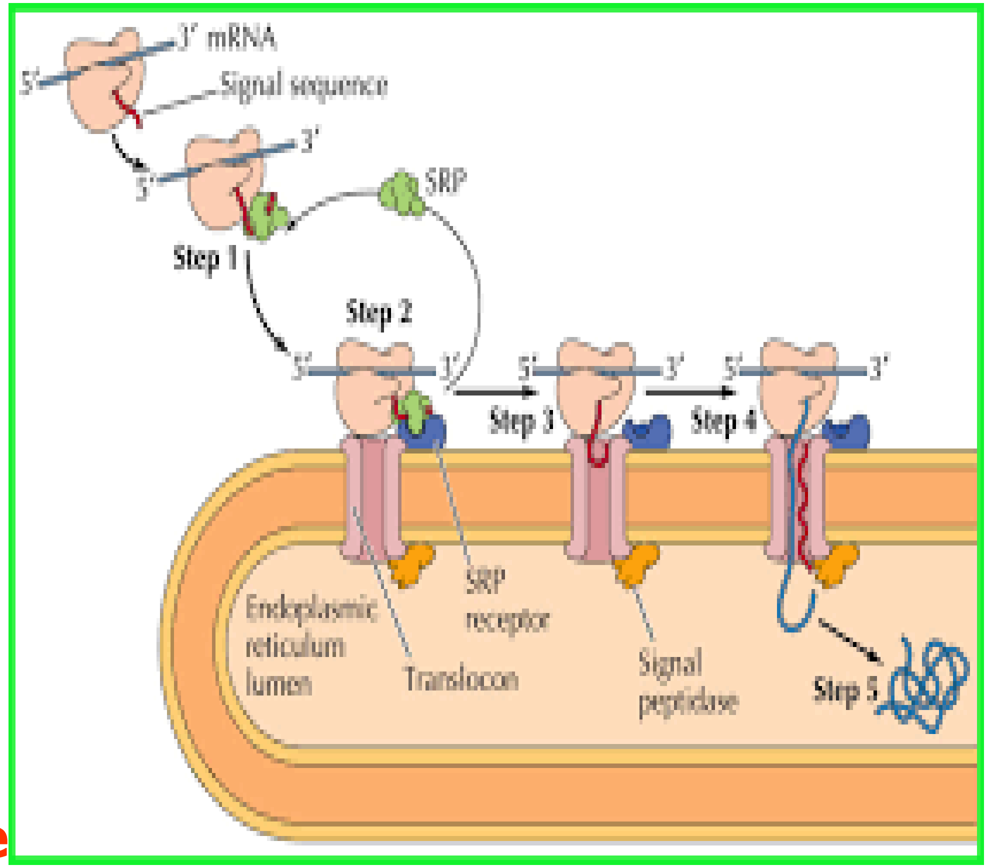
Reticulum endoplasmic



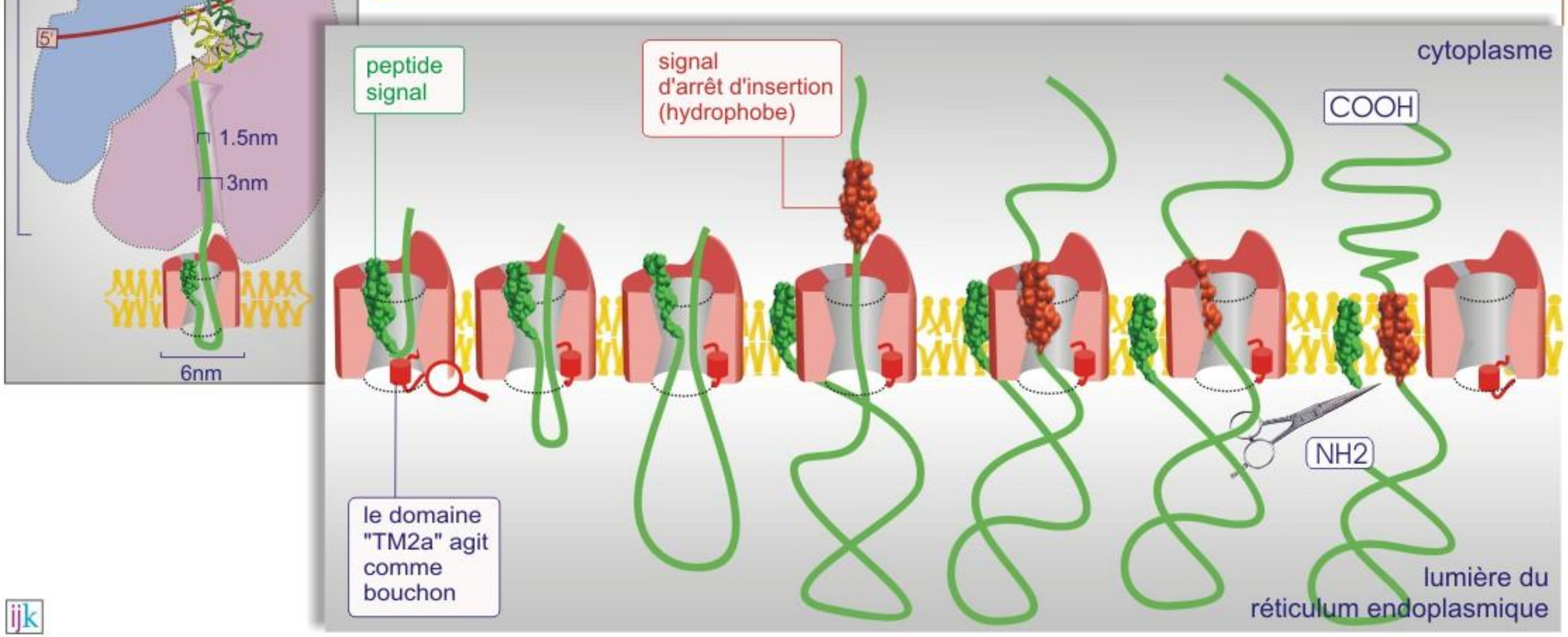


Protein synthesis for export, incorporation in the cell membrane and lysosome

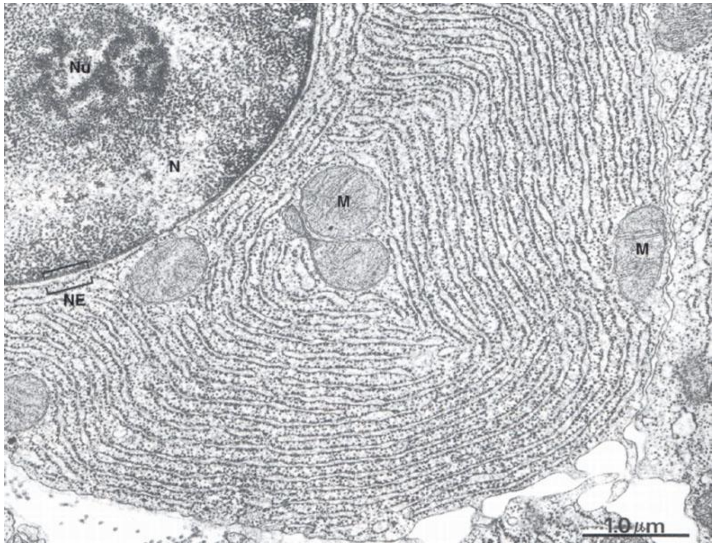
- Translation of signal sequence (SS)
- Interaction of SS with signal recognition particle (SRP)
- Inhibition of continuation of translation
- Attachment of SS-SRP complex with docking protein
- Detachment of SRP
- Continuation of translation
- Incorporation of secretary proteins in RER lumen
- Removing of SS from protein by signal peptidase

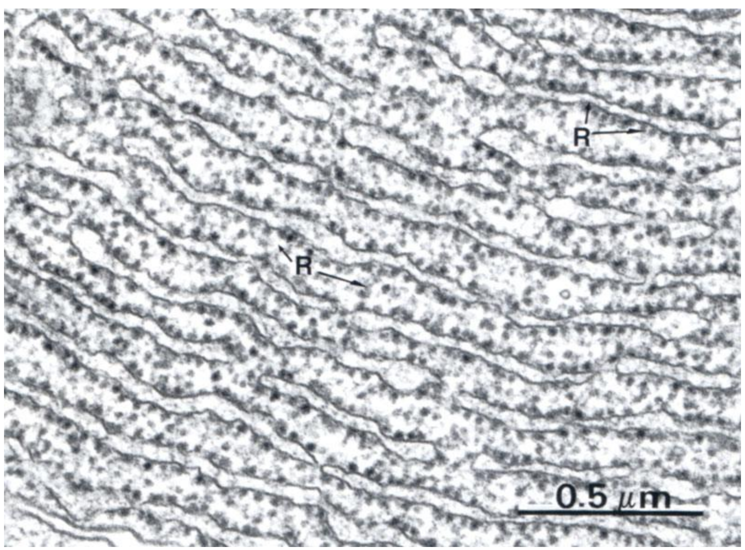


passage de la chaîne polypeptidique par le canal de translocation suivi par son insertion dans la membrane



Rough Endoplasmic Reticulum

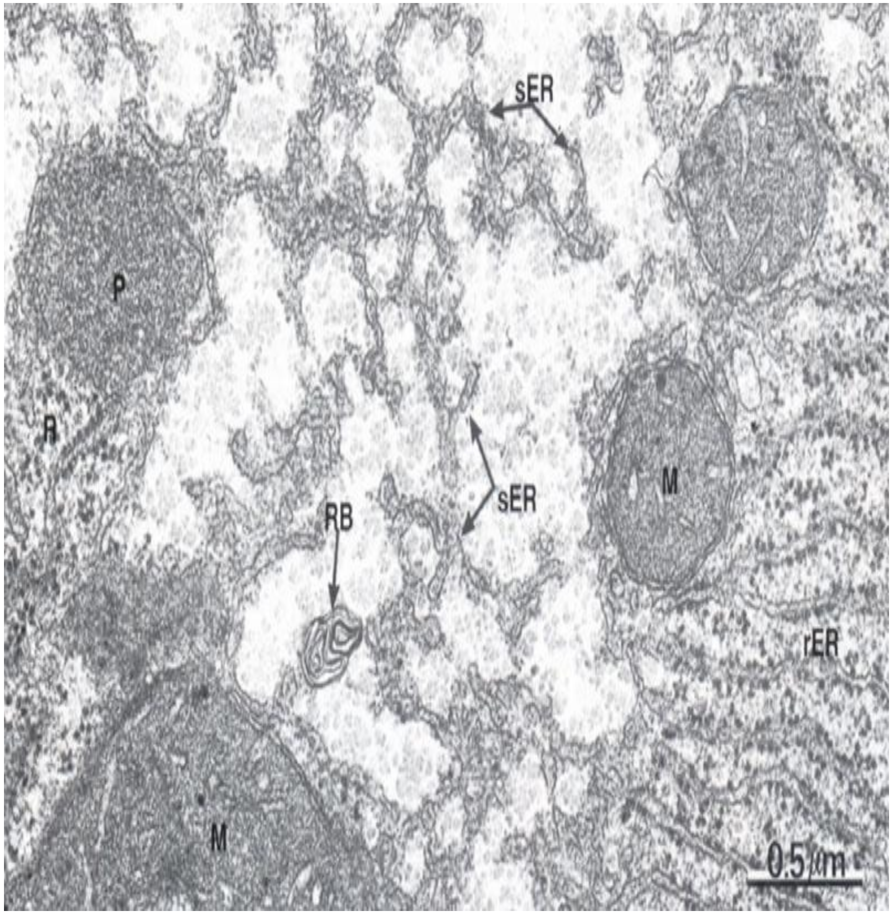




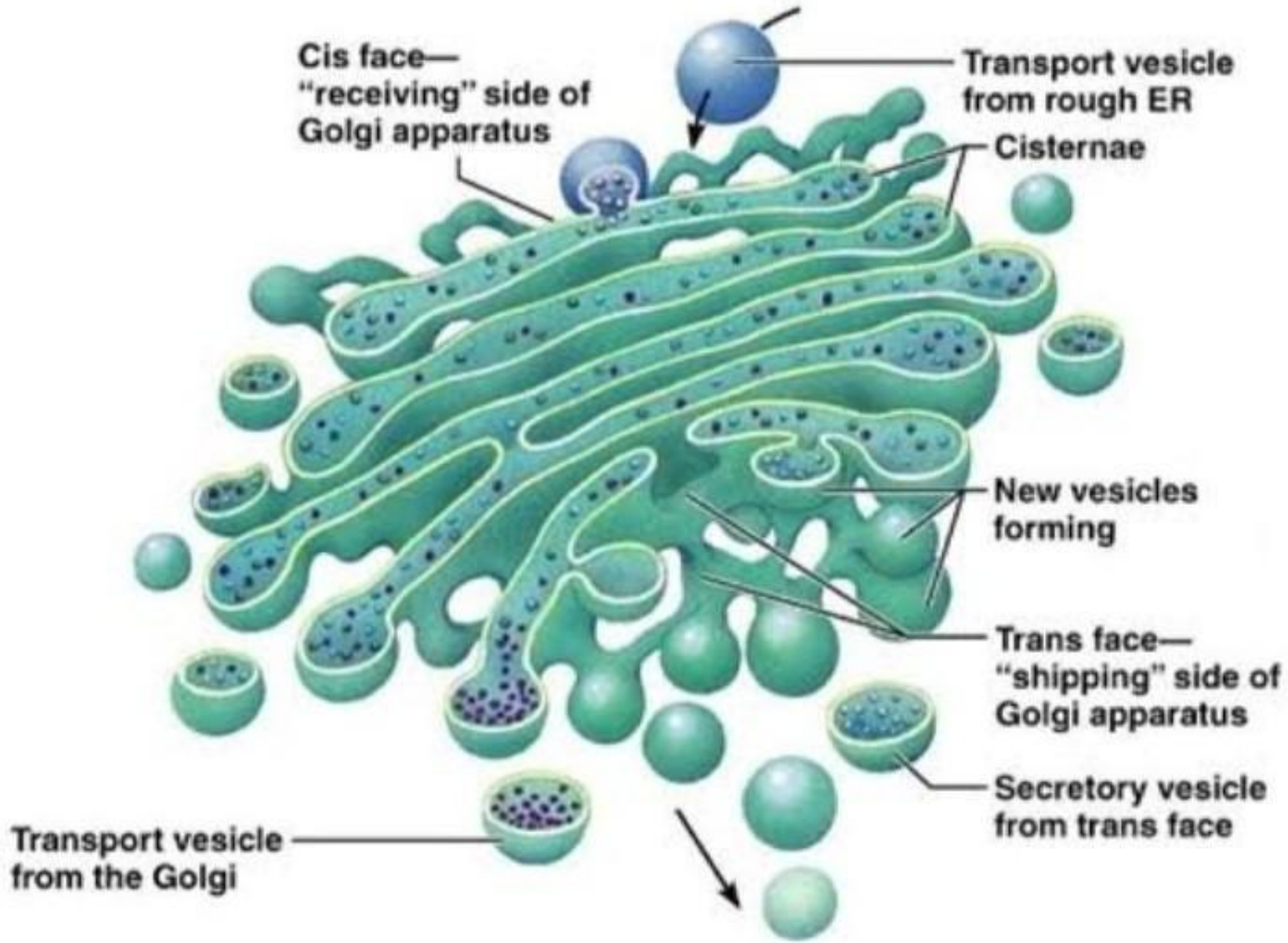
- Segregation of secretary proteins
- Phospholipid synthesis
- Post-translational modification
- Initiation of glycosylation
- Assembly of multichain proteins

Smooth endoplasmic reticulum

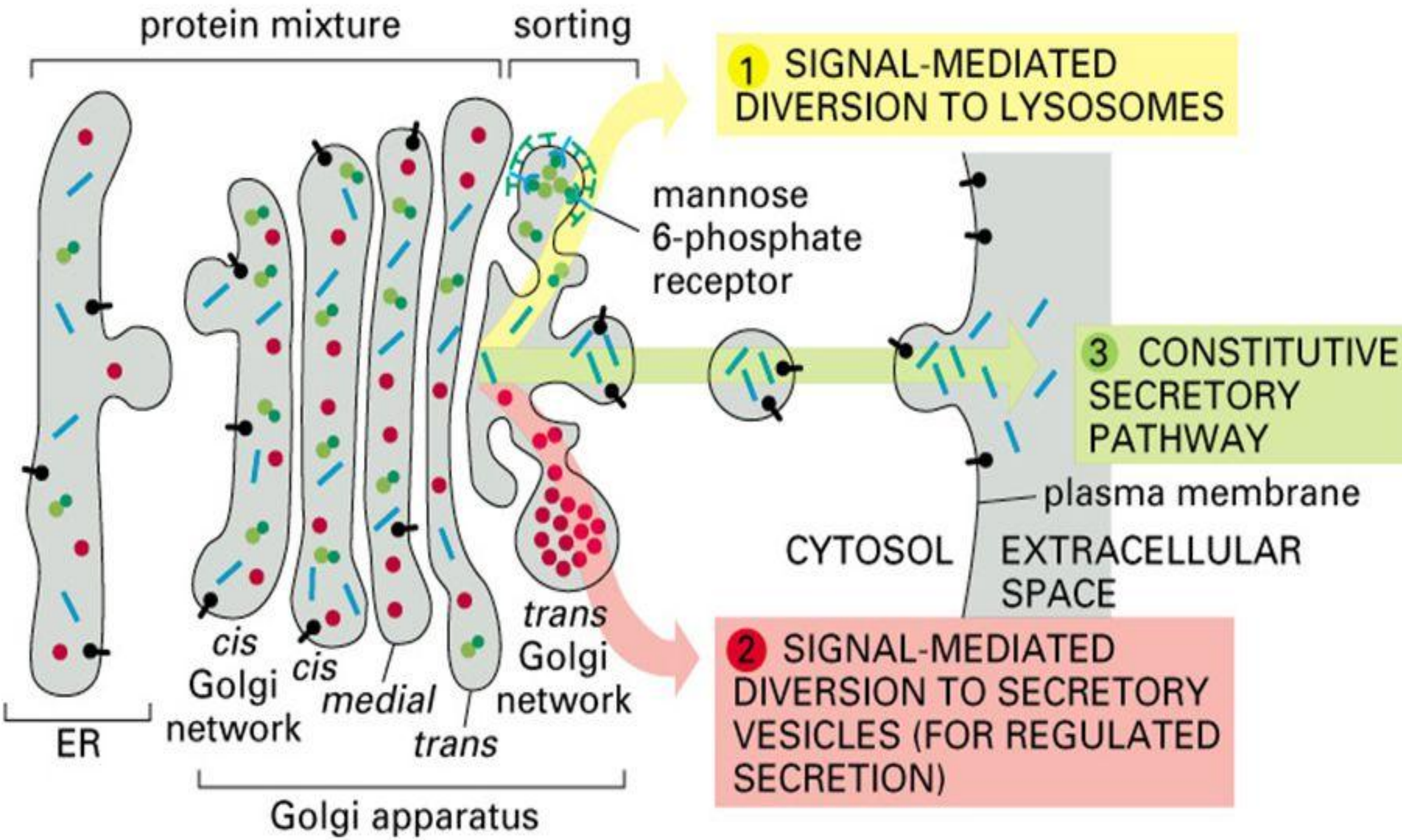
- Steroid synthesis
- Phospholipids synthesis
- Vesicle
- Transfer proteins
- Continuation with RER
- Sequestration of Ca
- Detoxification
- Glycogen synthesis

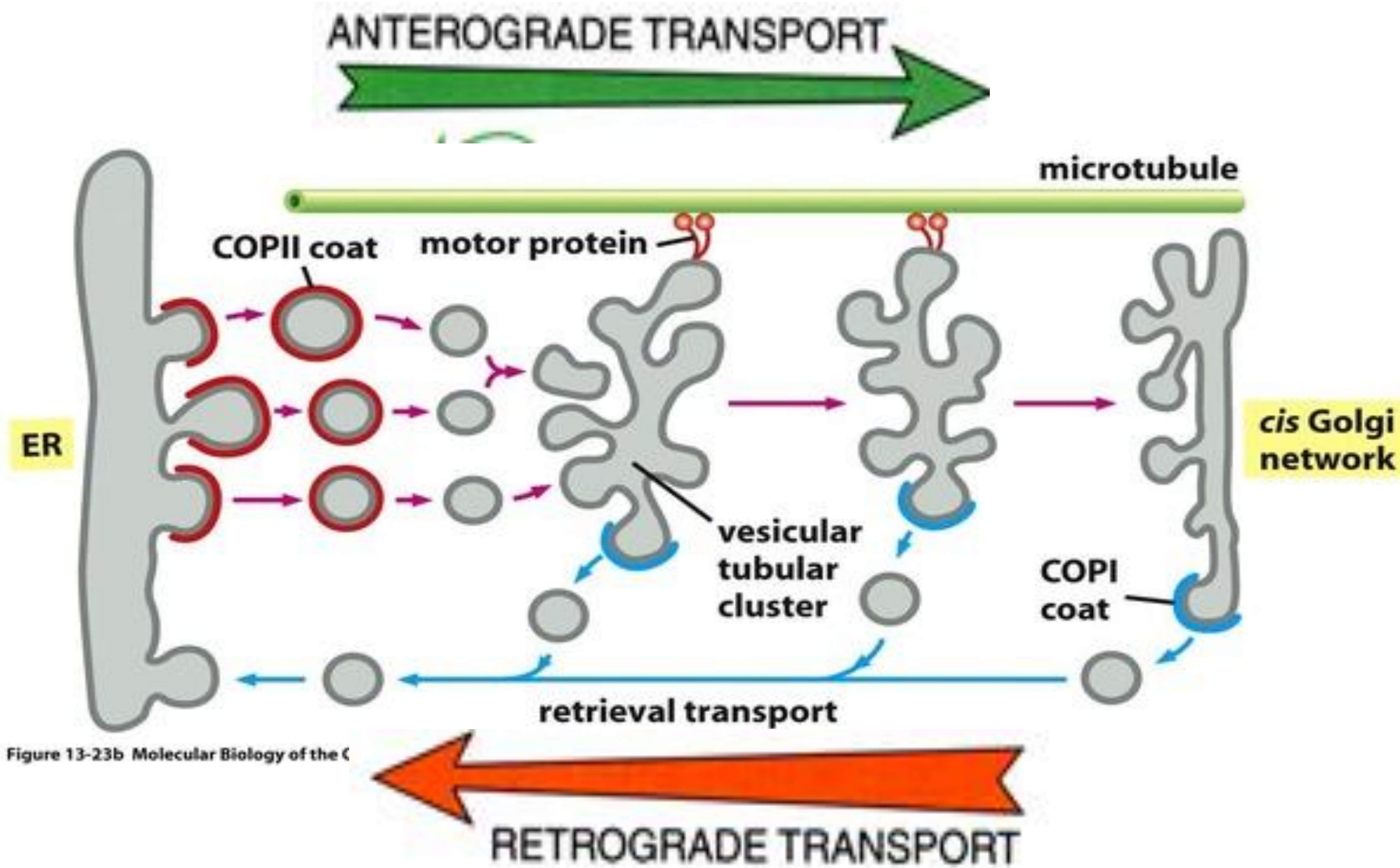


Golgi apparatus



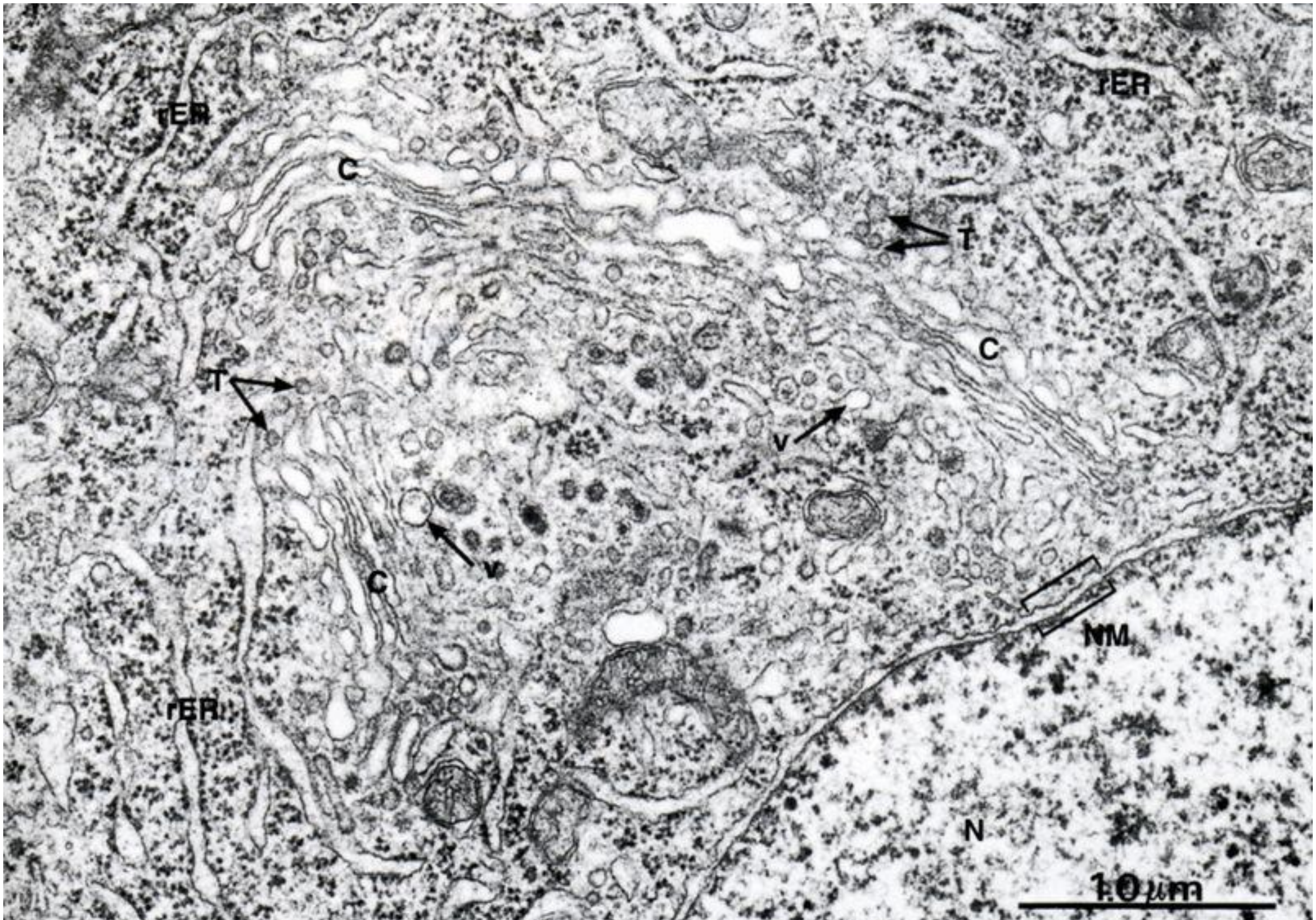
Three pathways of protein sorting in the trans Golgi network

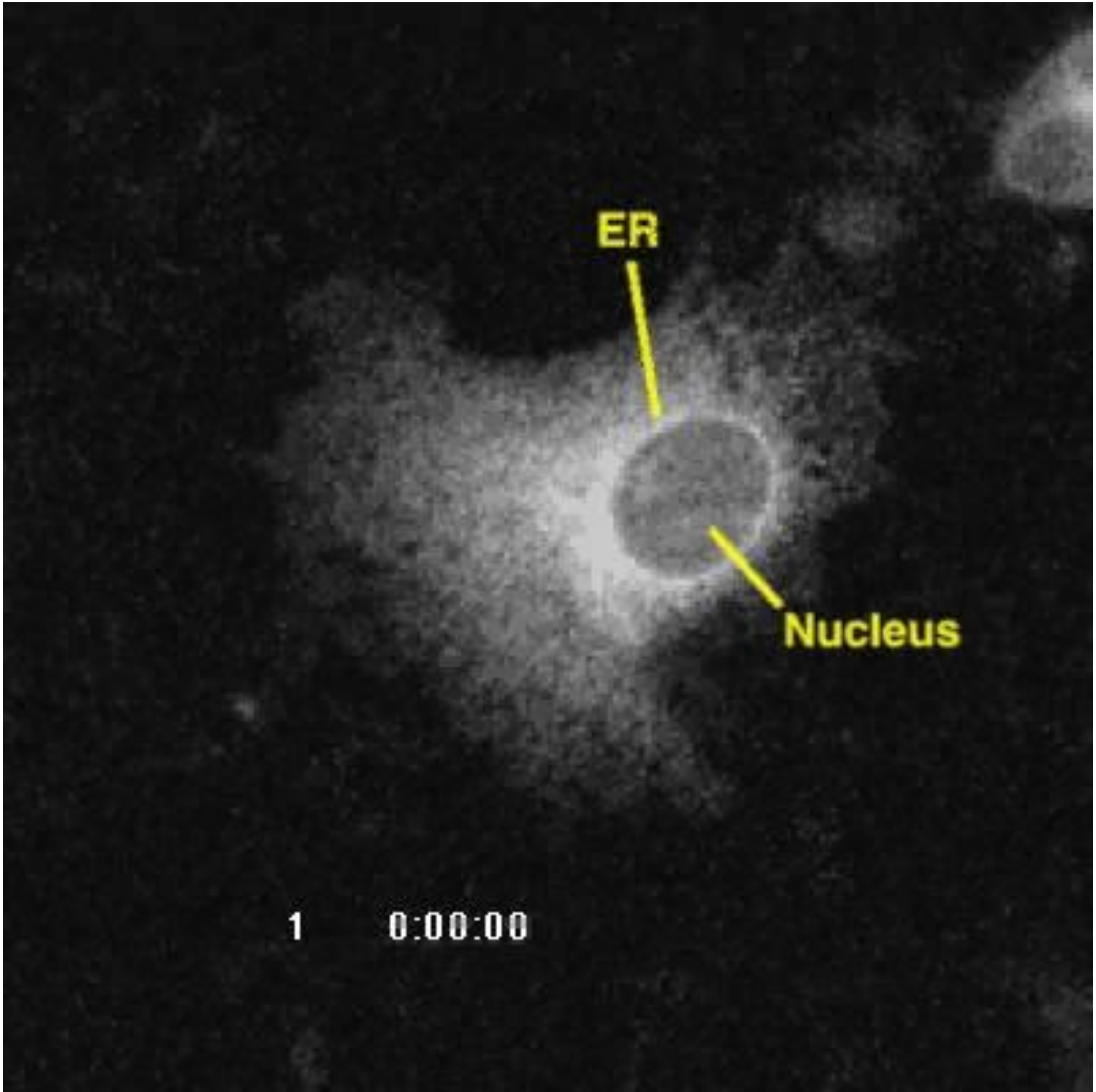




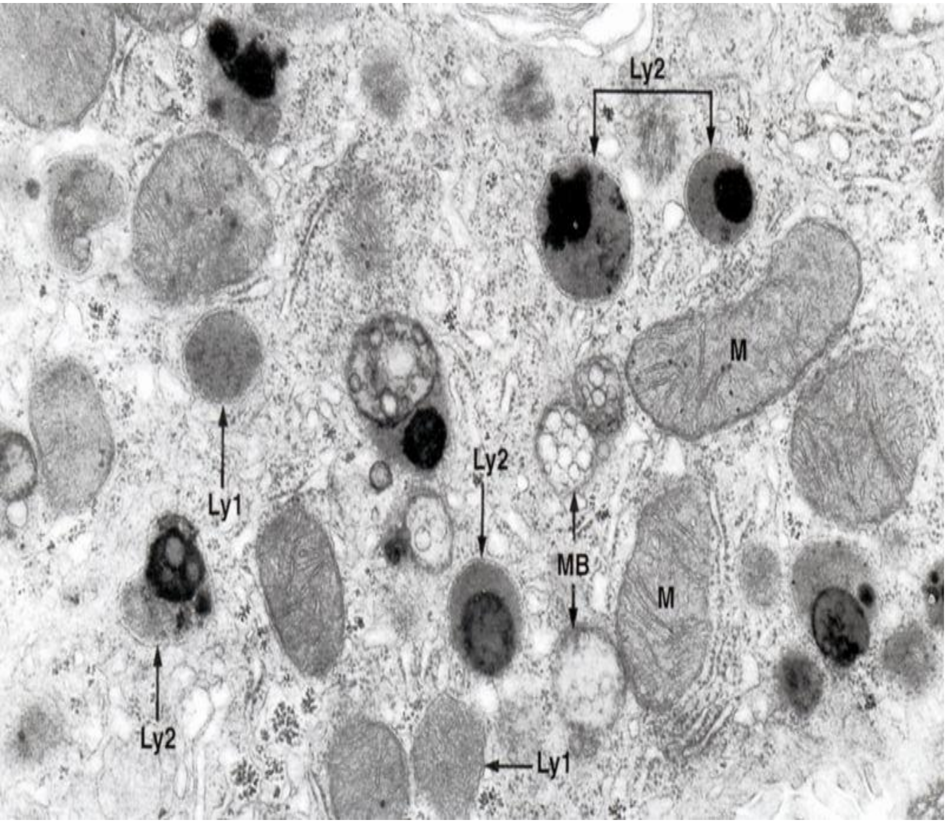
•**Forward movement of vesicles in the *cis* Golgi network of saccules is promoted by the coat protein COP-II, while retrograde movements in that region involve COP-I.**
•**Other membrane proteins important for directed vesicle fusion include golgins**

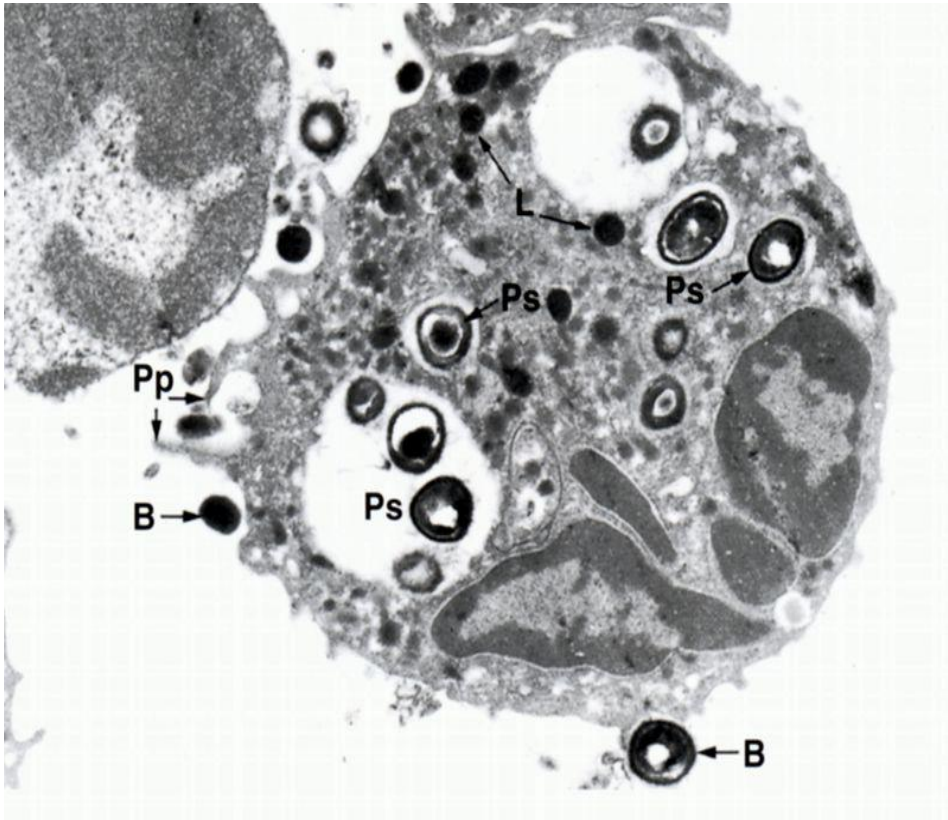
Golgi complex



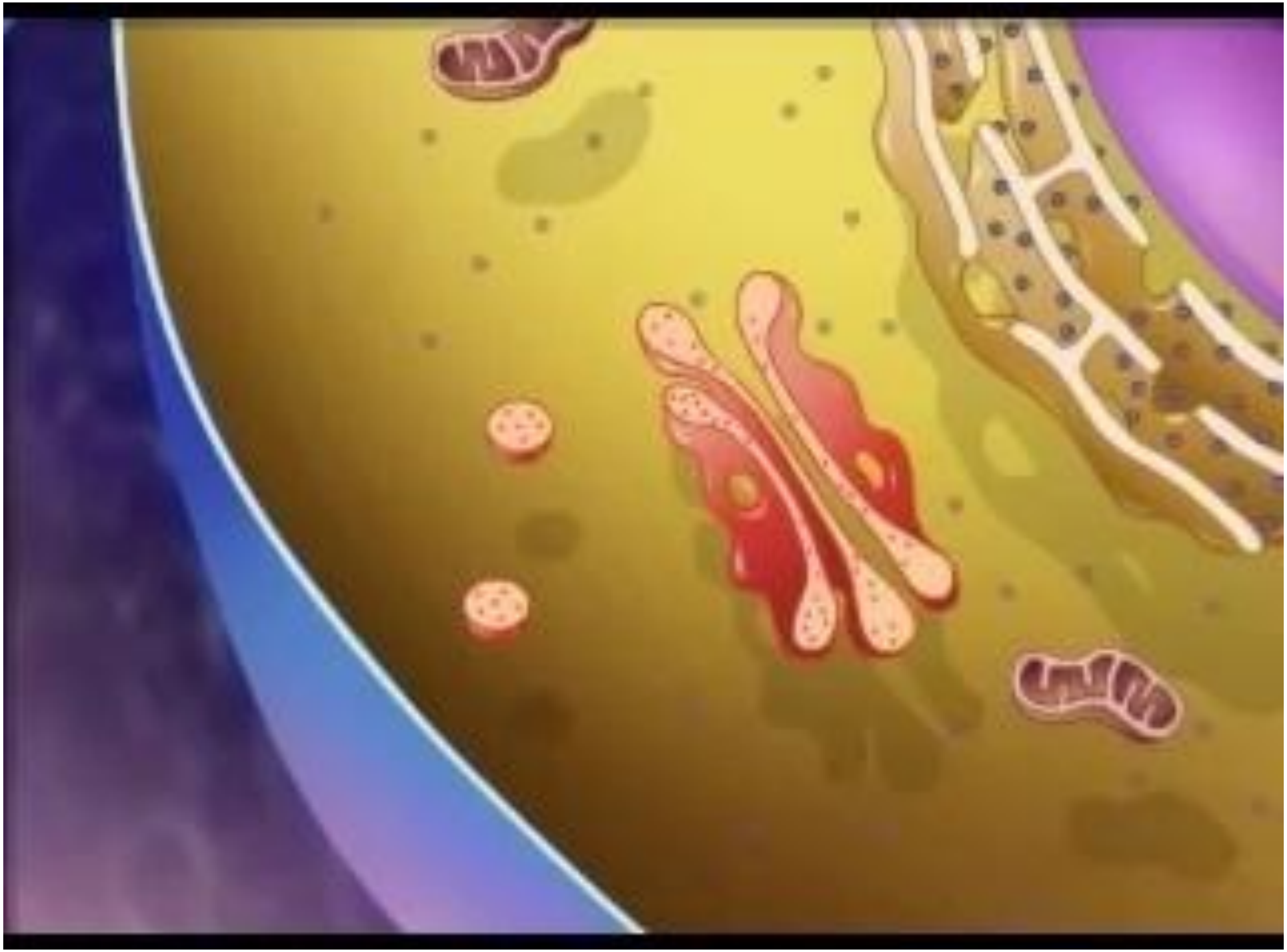

ER
Nucleus
1 0:00:00

Lysosome

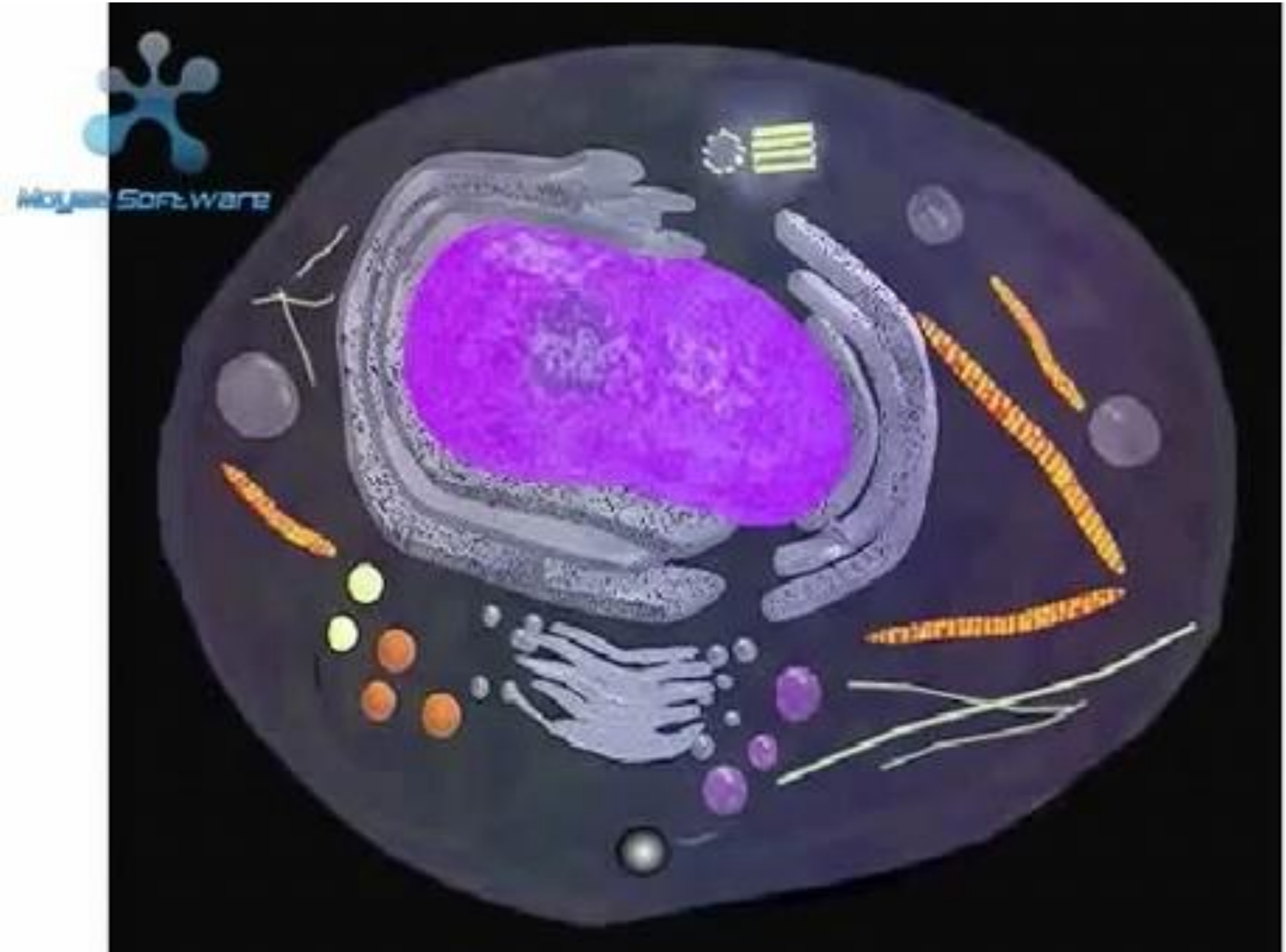




Heterophagy and Autophagy

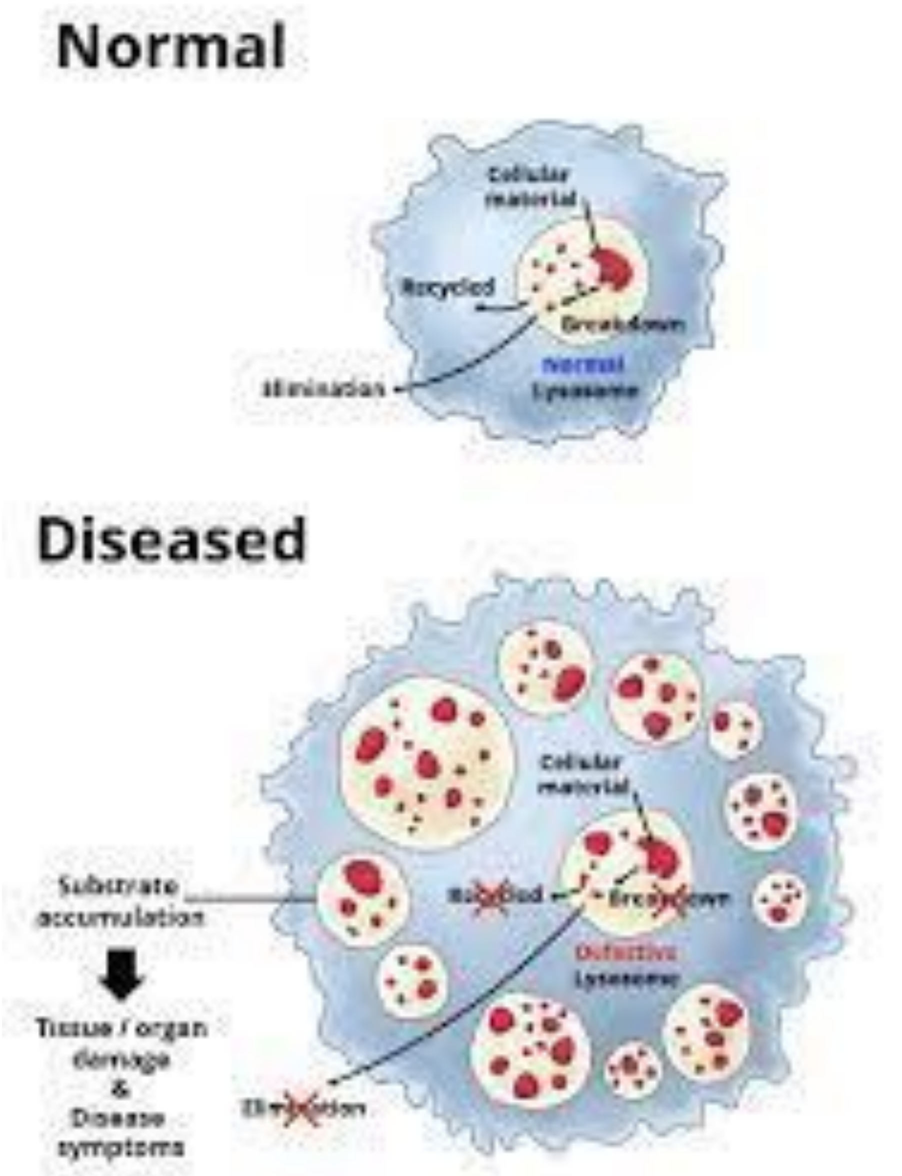


Autophagy

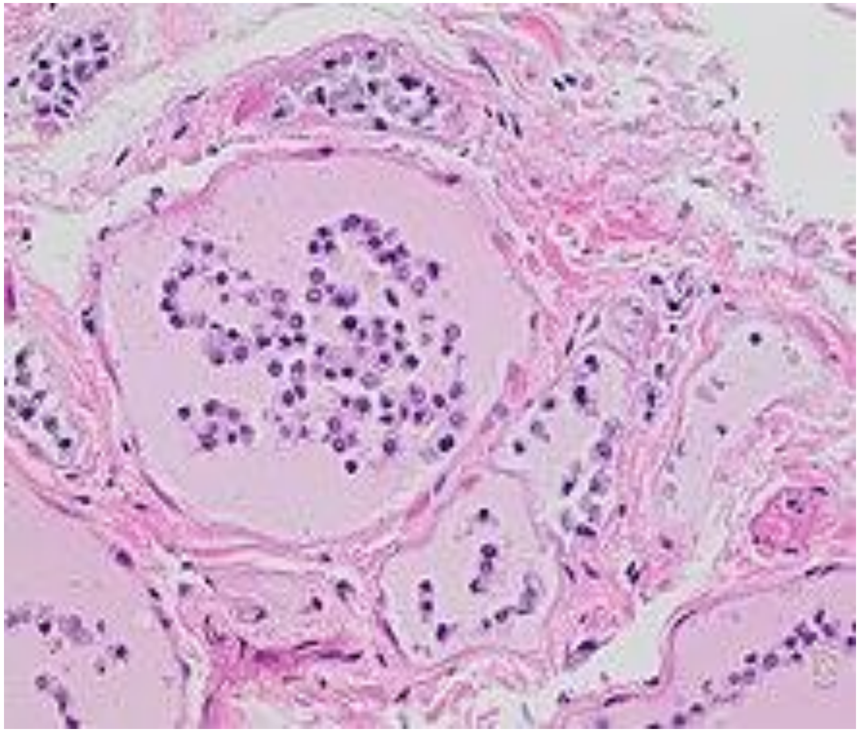


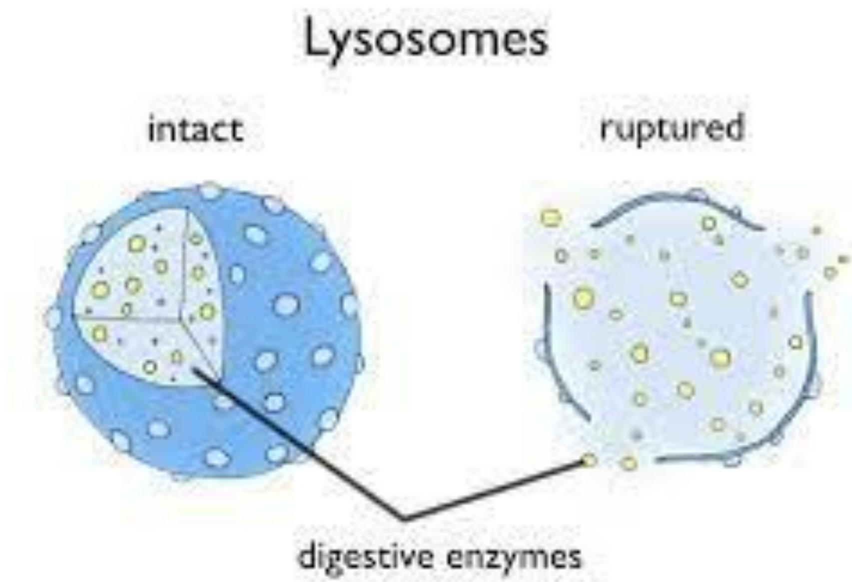
Lysosomal storage disorder

- Lysosomal enzyme deficiency



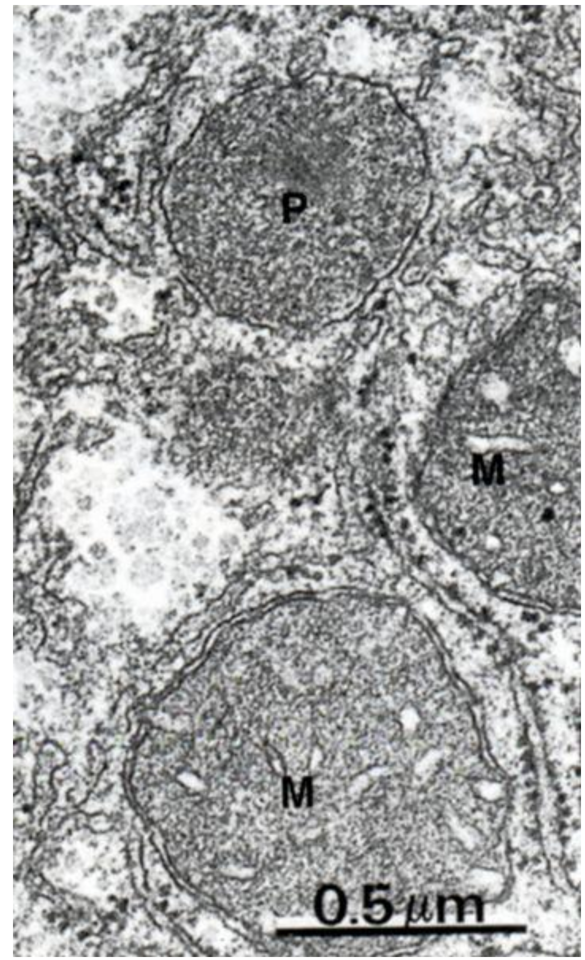
Autolysis





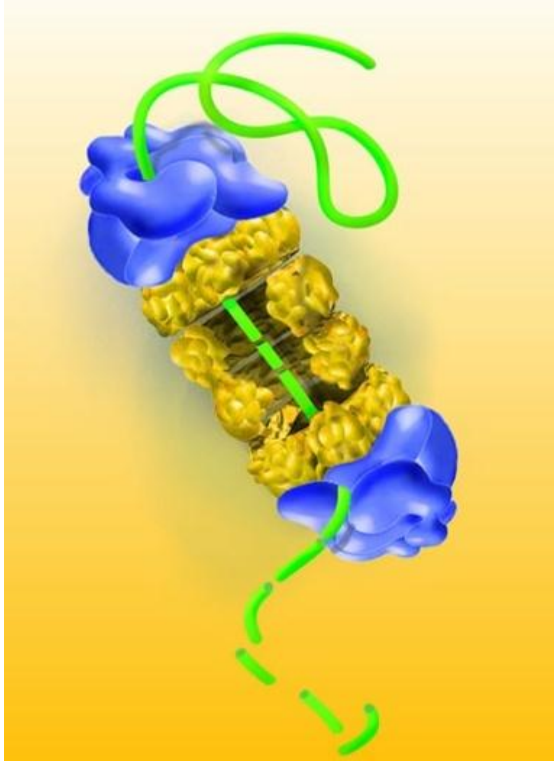
Peroxisome

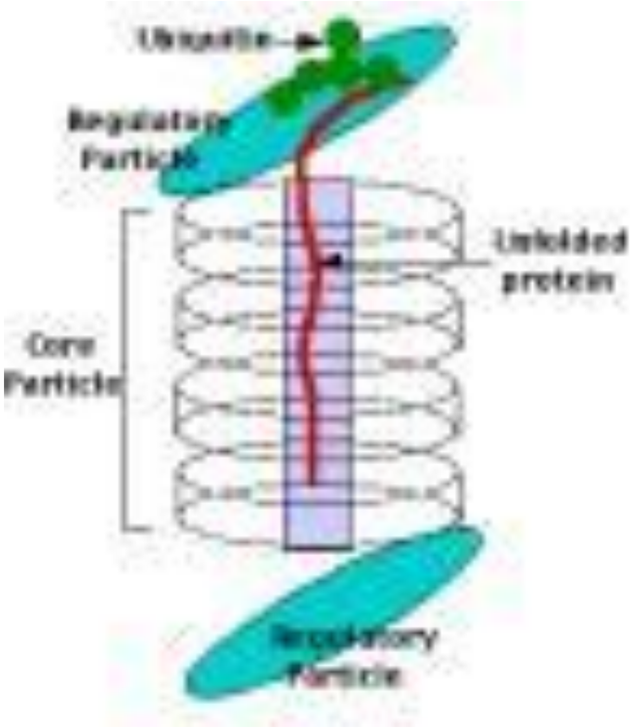
- Oxidase
- Catalase
- Enzyme that involved in lipid metabolism



Proteasome

- Digestion of targeted proteins by ubiquitin

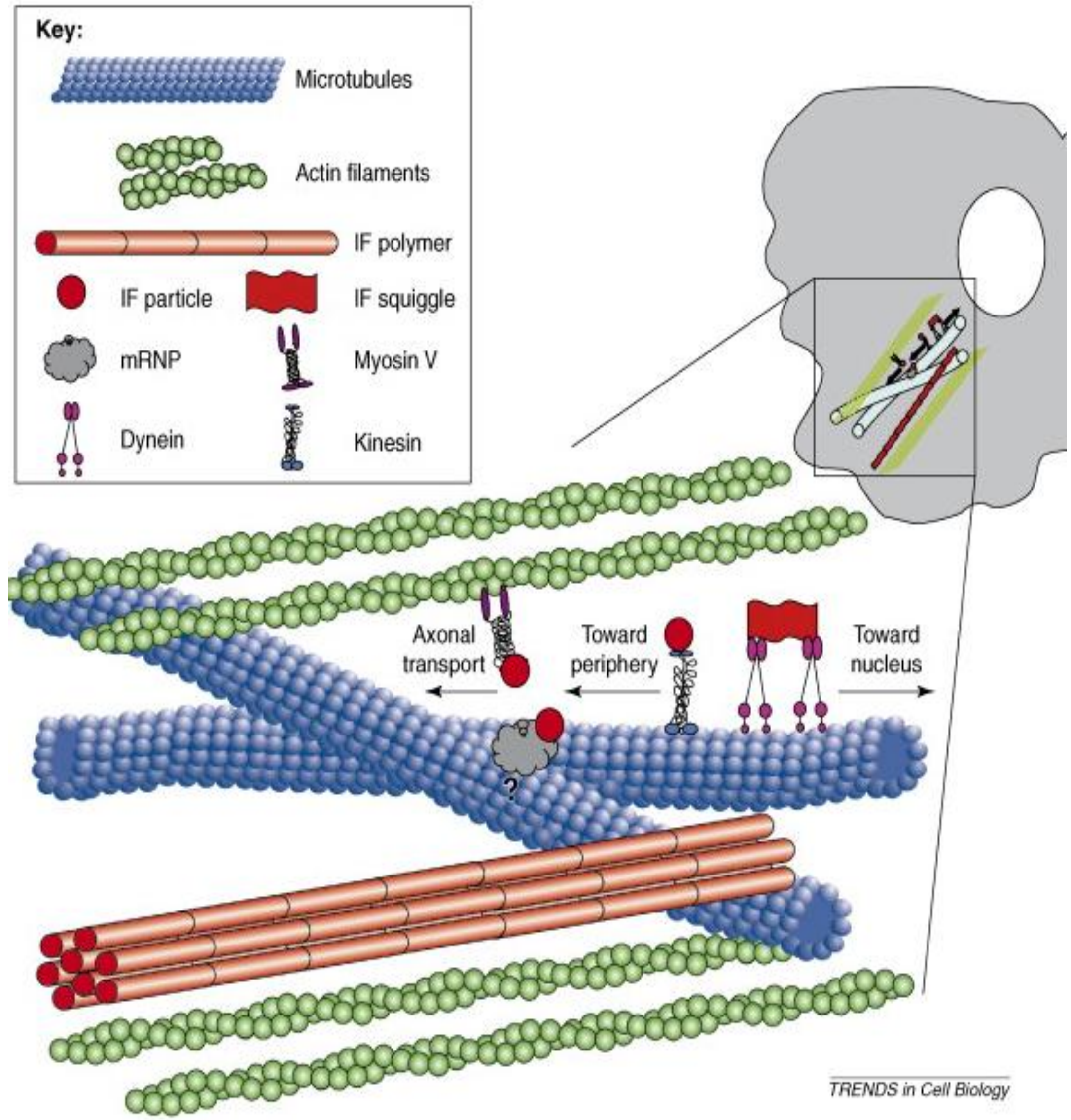




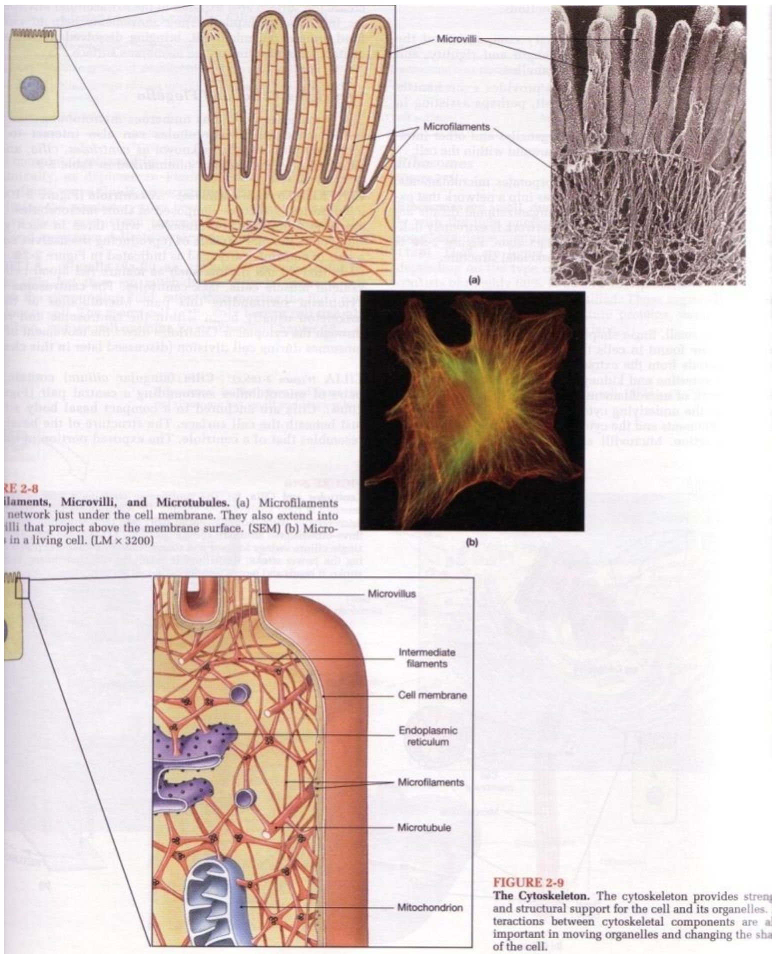
Proteasome

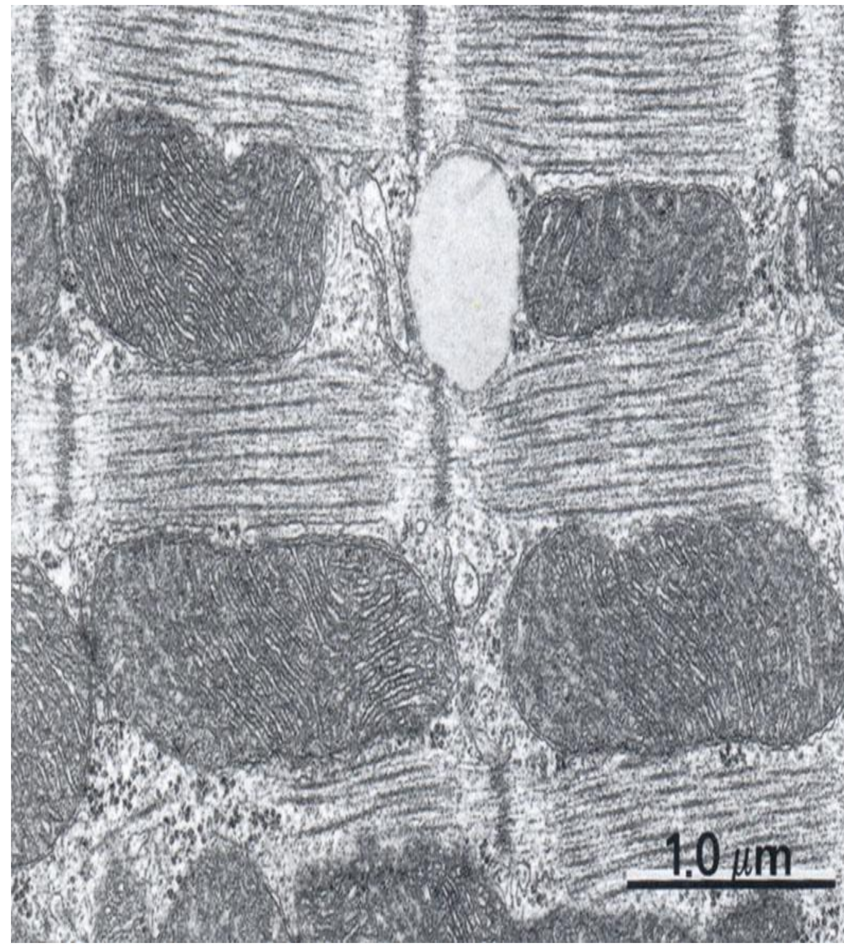
CYTOSKELETON

- Microfilament
  - Thin filament (actin)
  - Thick filament (myosin)
- Intermediated filament
- Microtubule

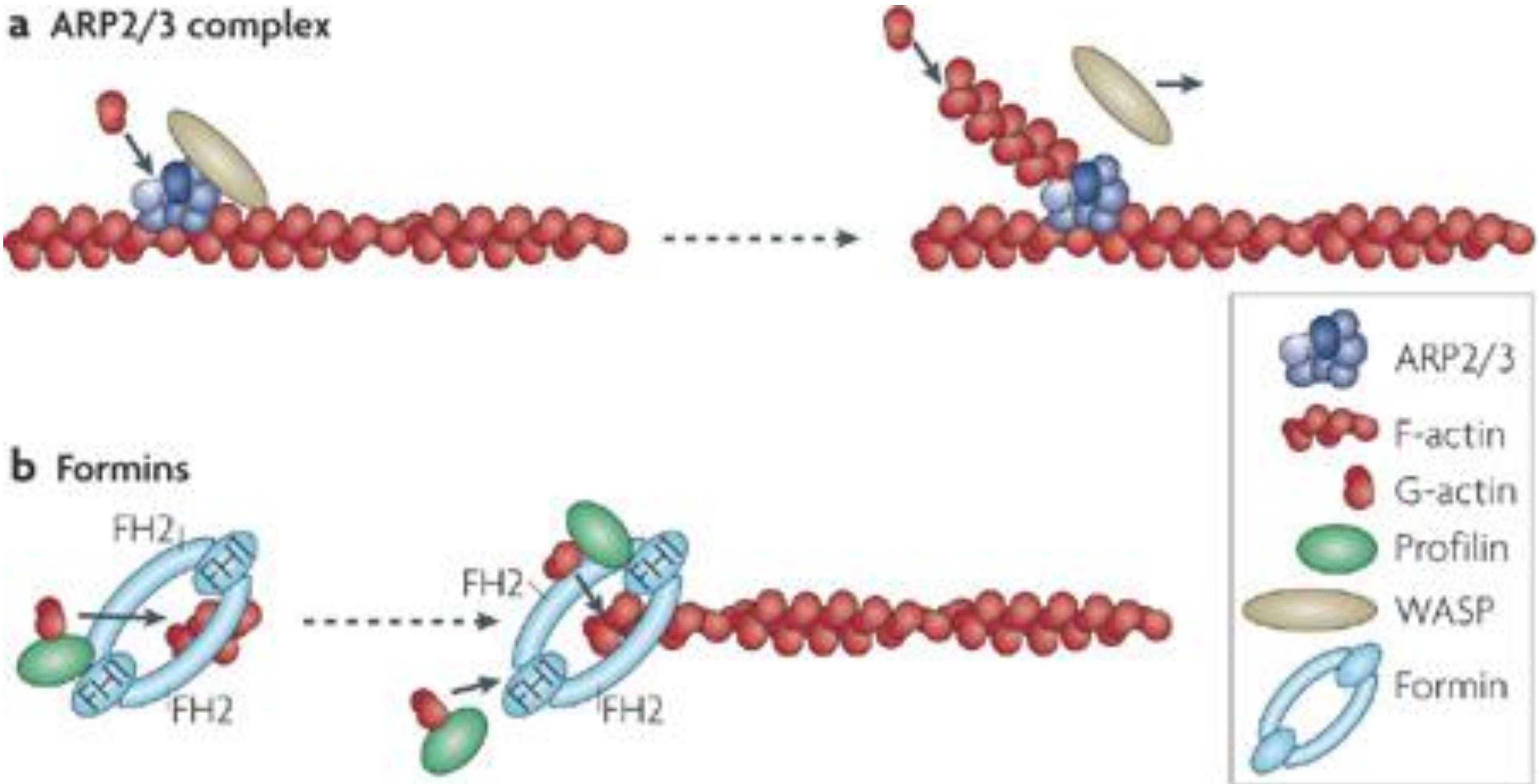


Microfilament





new filaments can be formed from a pool of G-actin by the action of nucleation factors such as formin



actin-related protein 2/3

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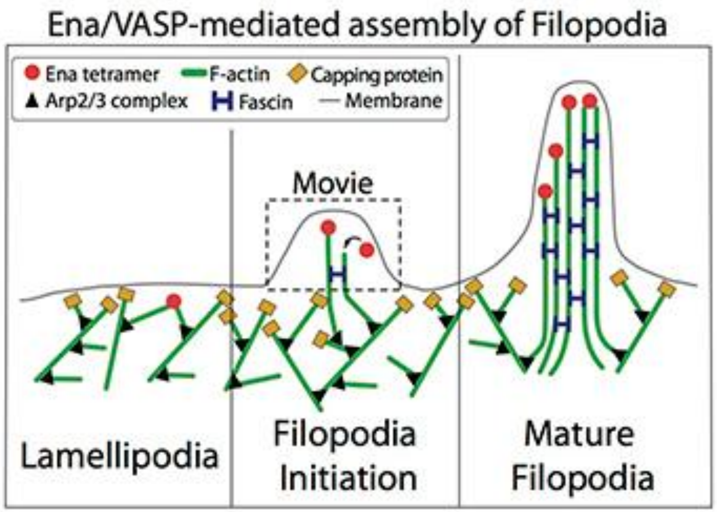
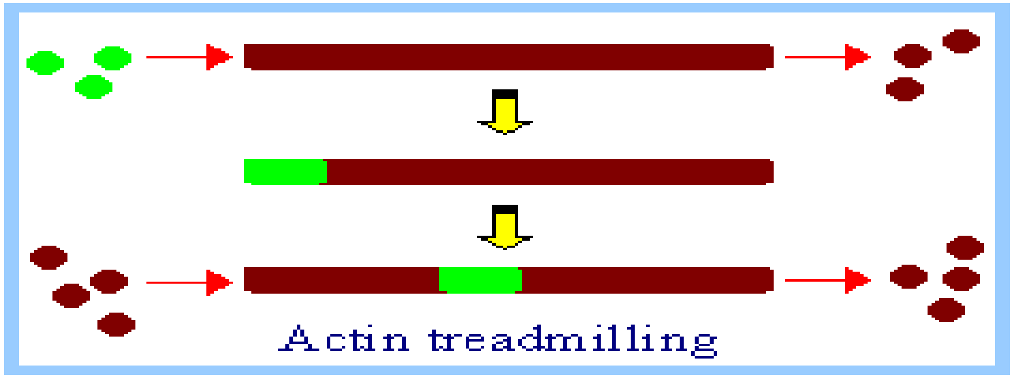
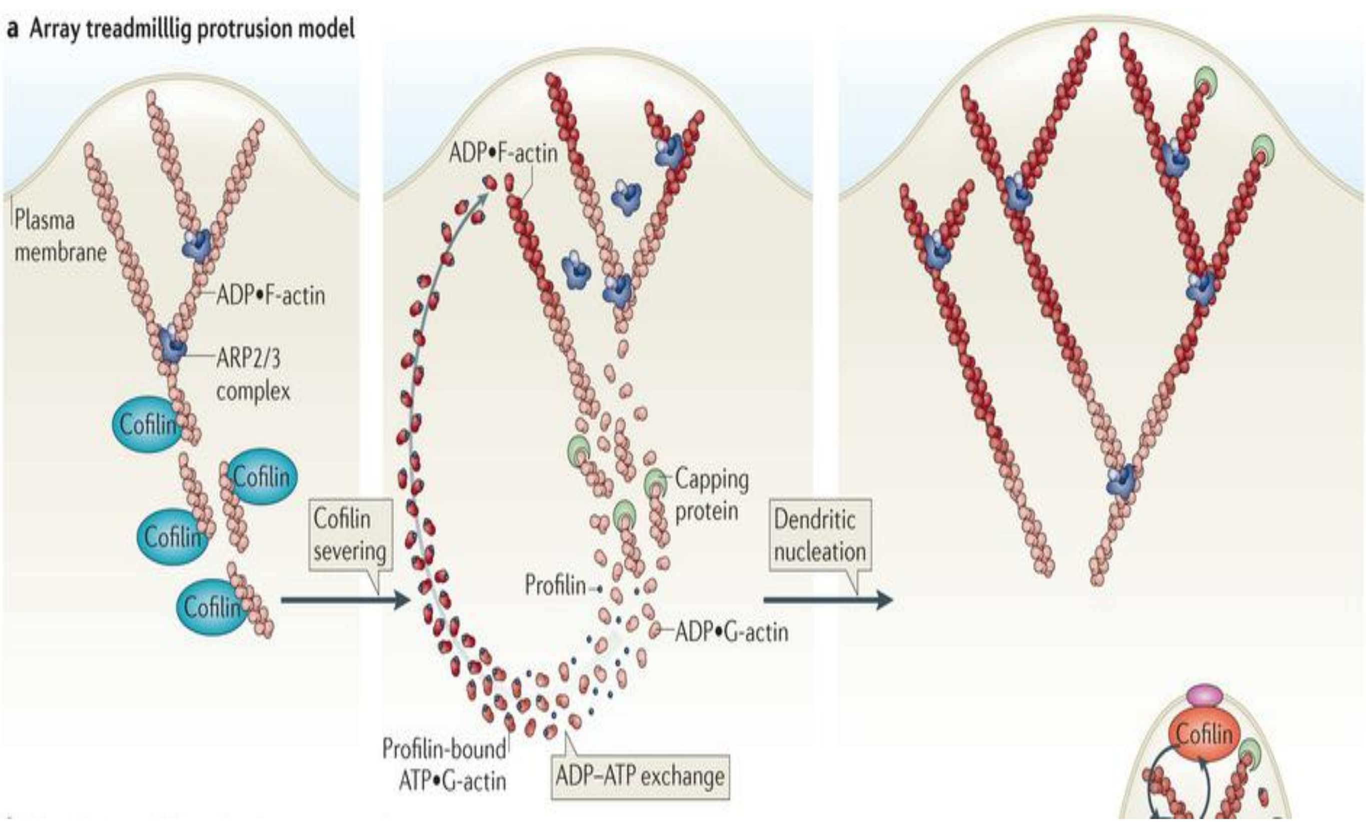
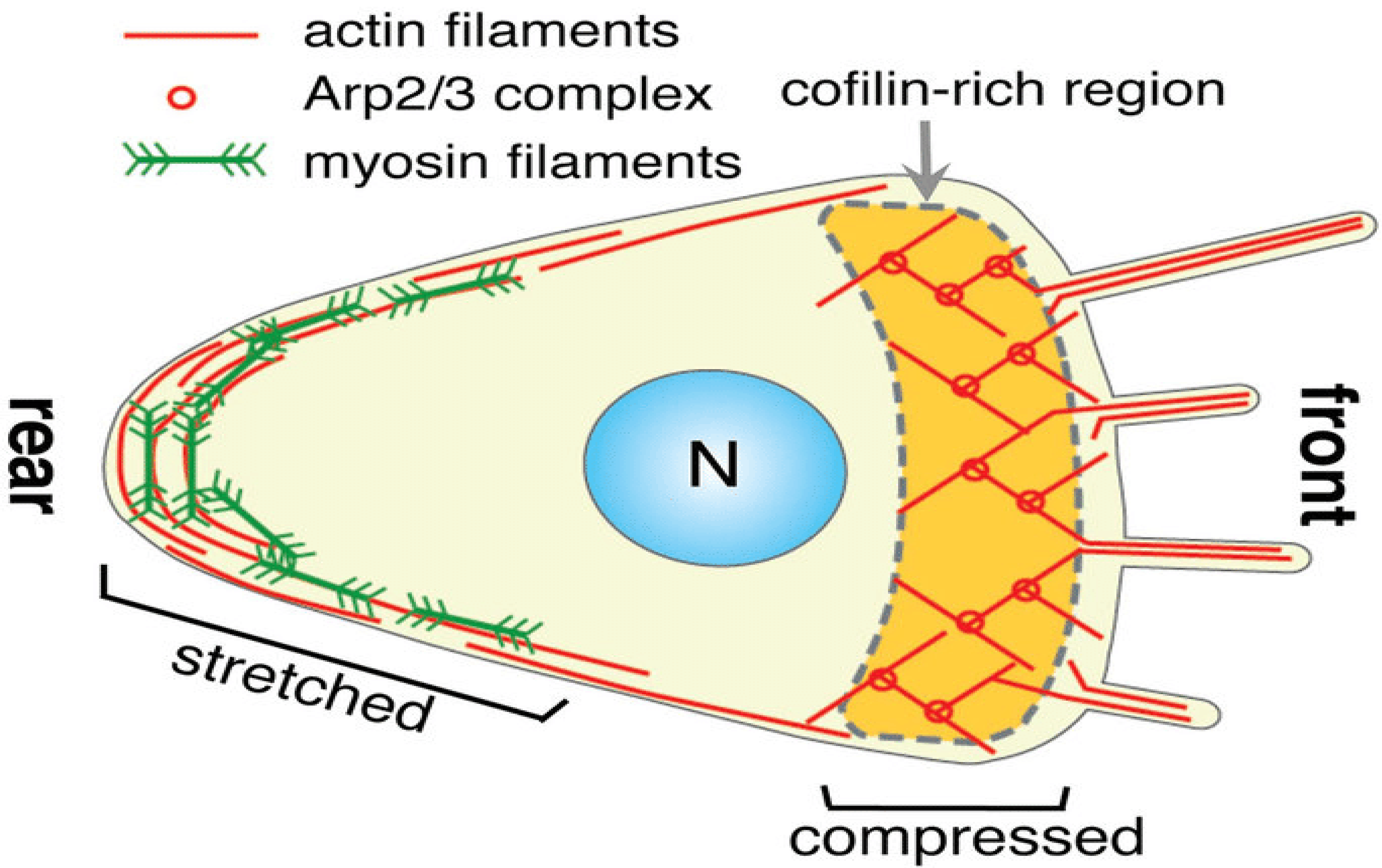
Actin dynamic





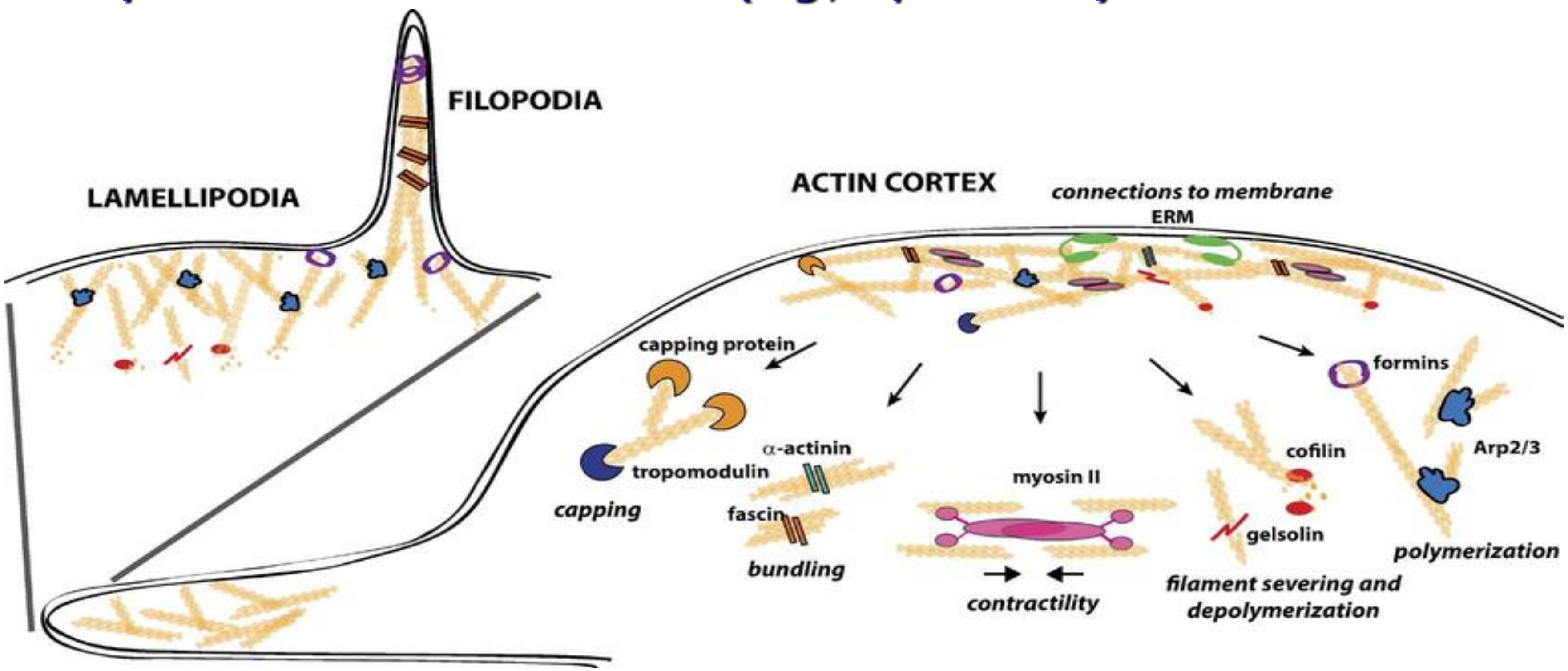


Microfilament polymerization/depolymerization leads to cell movement



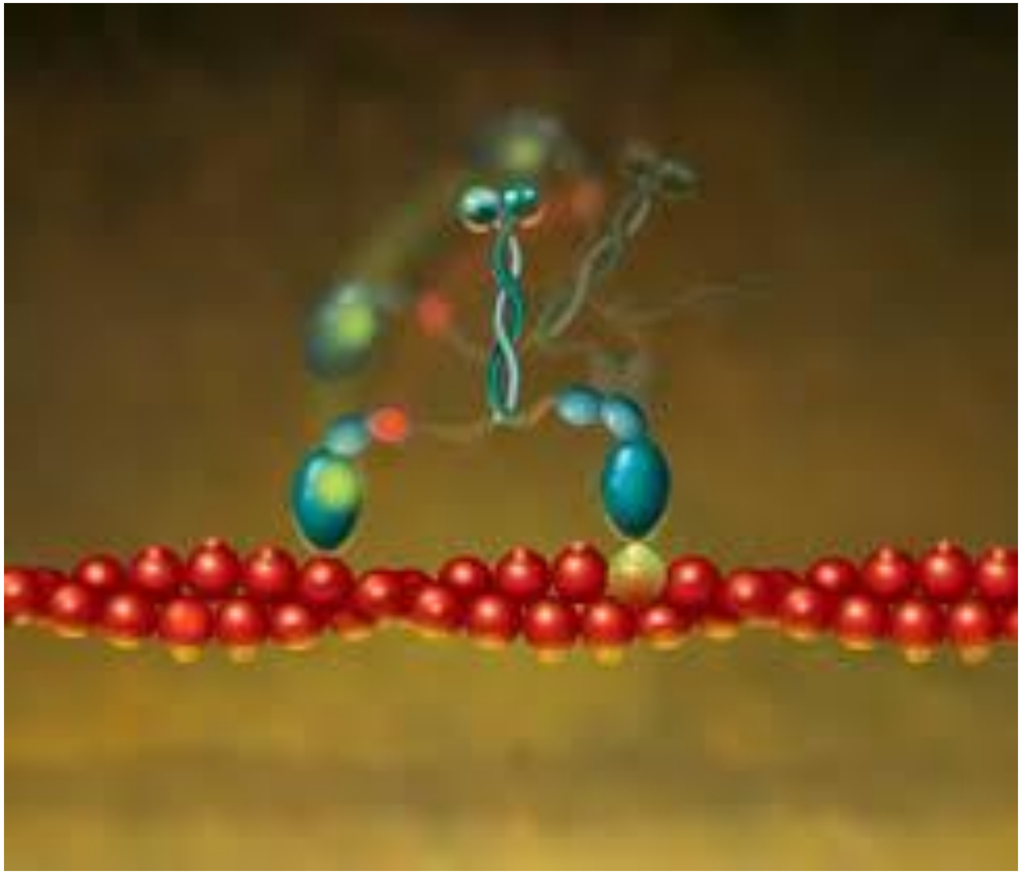
Actin-binding proteins

- Severing and/or capping the end of F-actin (eg, *gelsolin, capZ*)
- Cross-linking (eg, *filamin*) or bundling (eg, *fimbrin, α-actinin*) actin filaments
- Linking F-actin to membrane proteins and other cytoskeletal filaments (eg, *spectrin*)



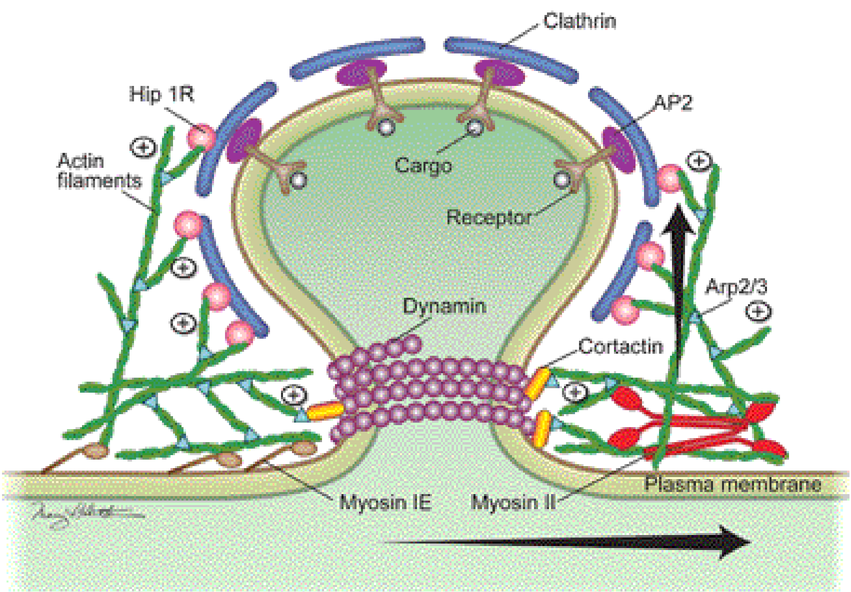
Myosin

- Movement is usually toward the barbed (+) end of actin filaments; myosin VI is the only known myosin that moves in the other direction

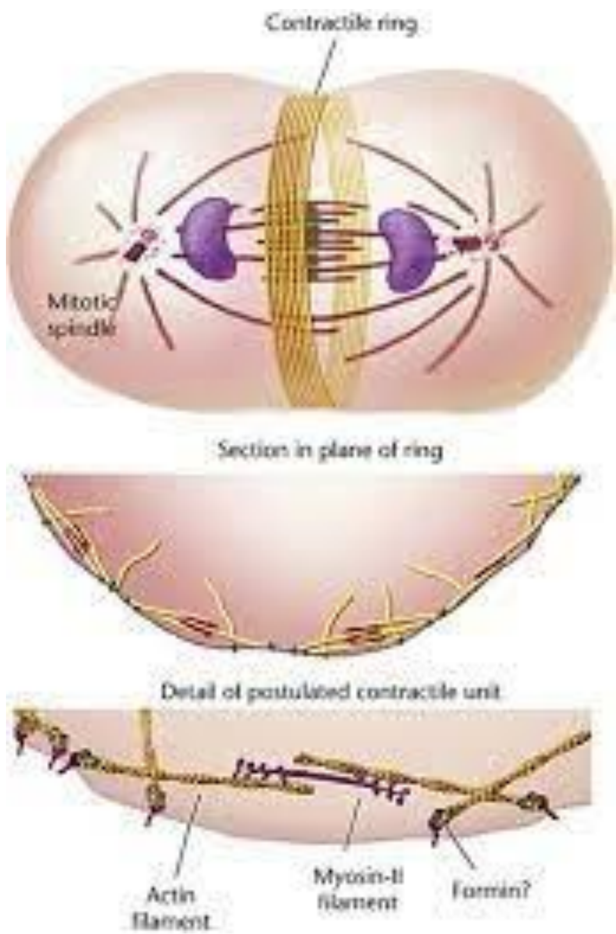


Myosin involvement in cell functions

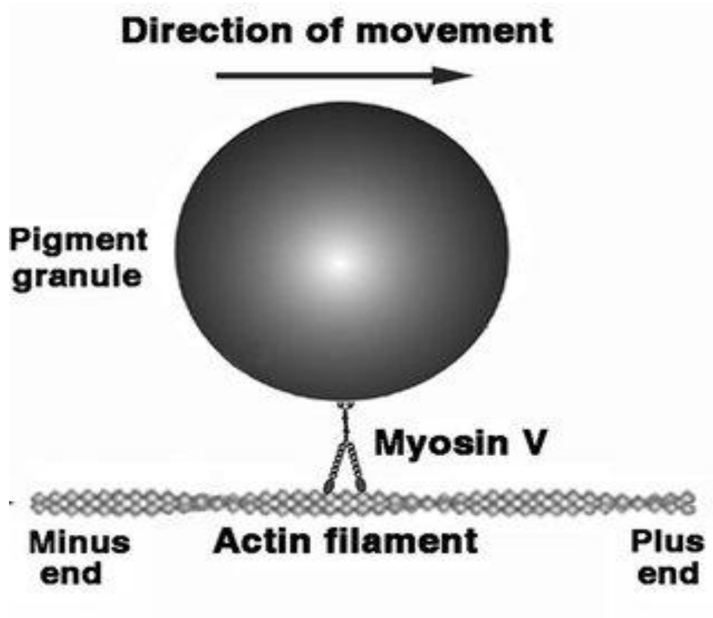
Myosin I in endocytosis



Myosin II Regulates Endocytosis Traffic 2014; 15: 418–432

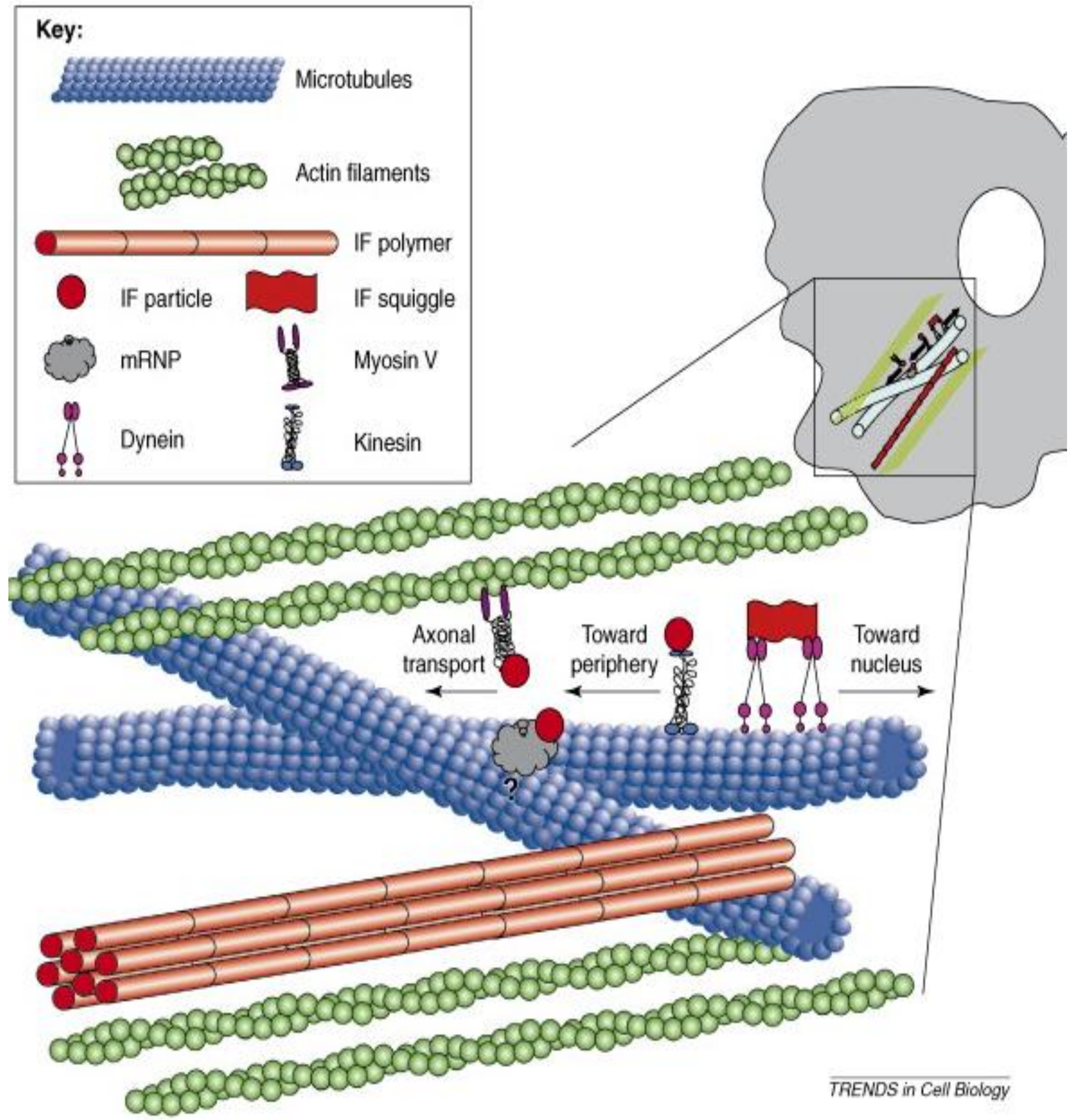


Myosin II in cytokinesis



CYTOSKELETON

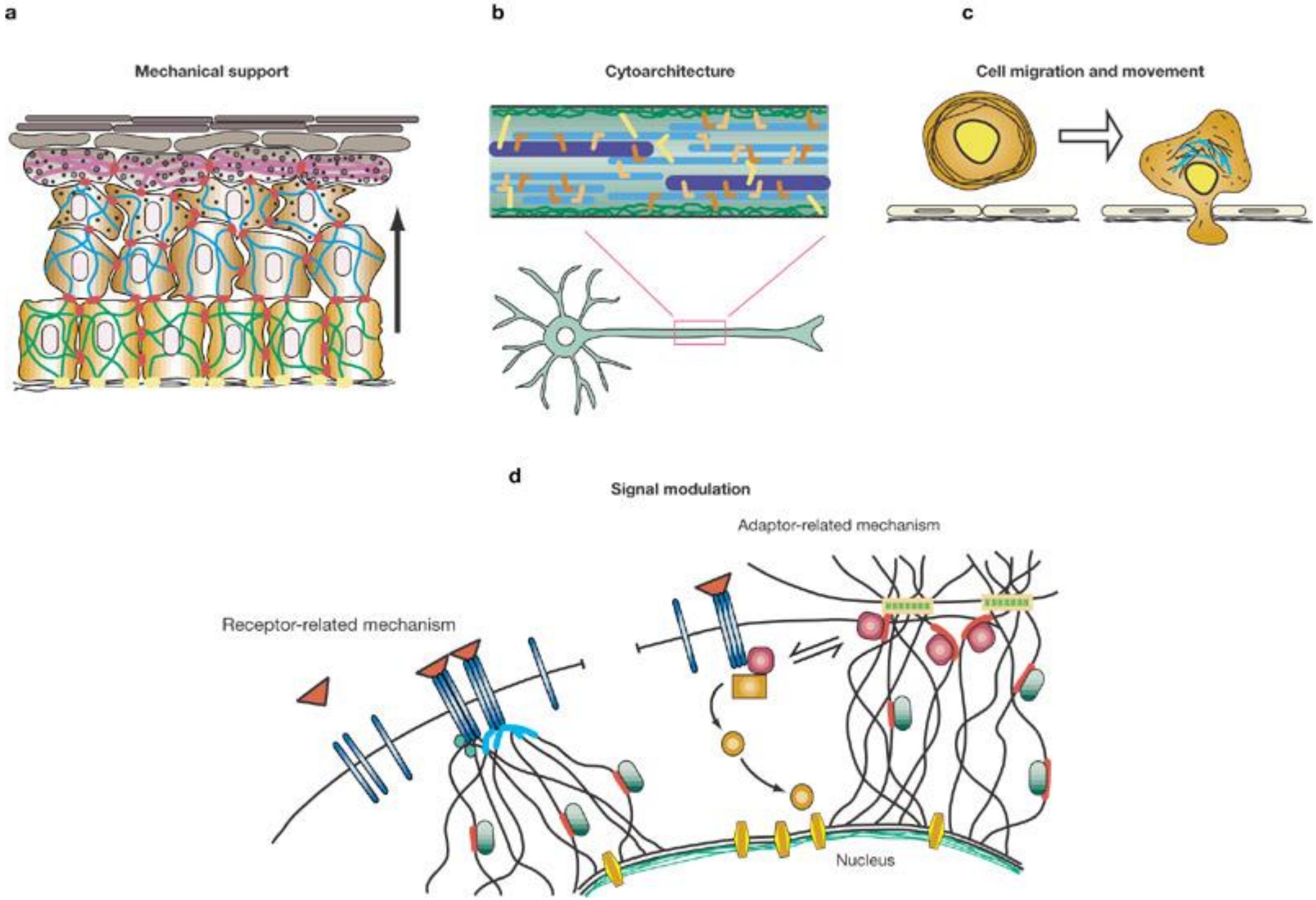
- Microfilament
  - Thin filament (actin)
  - Thick filament (myosin)
- Intermediated filament
- Microtubule



Intermediated filament

Epithelial	Keratin
Mesenchymal cell	Vimentin
Muscle	Desmin
Gilial cell	Gilial fibrillary protein
Neurons	Neurofilaments
Nucleous	Lamins

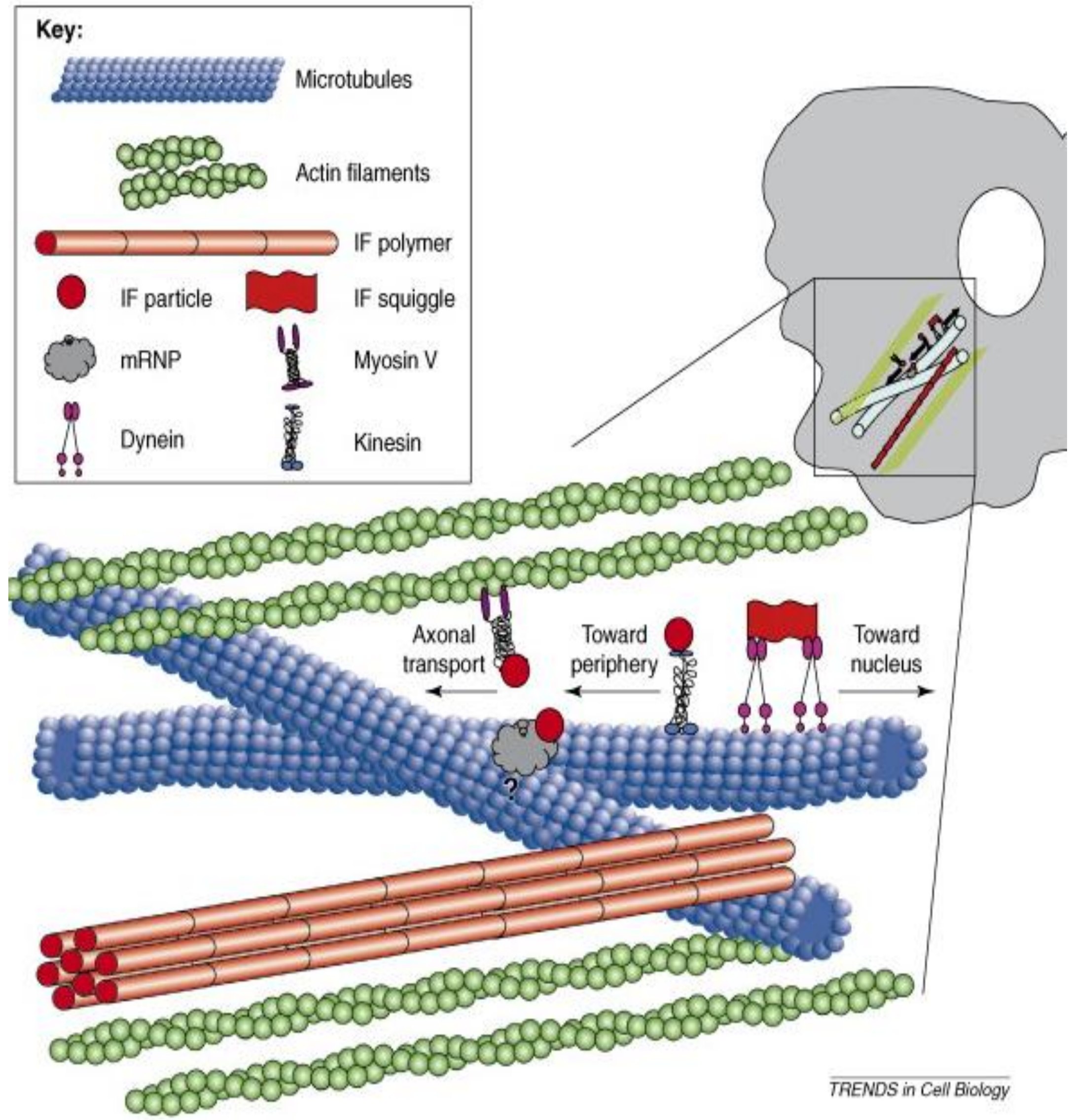
Function of intermediated filament

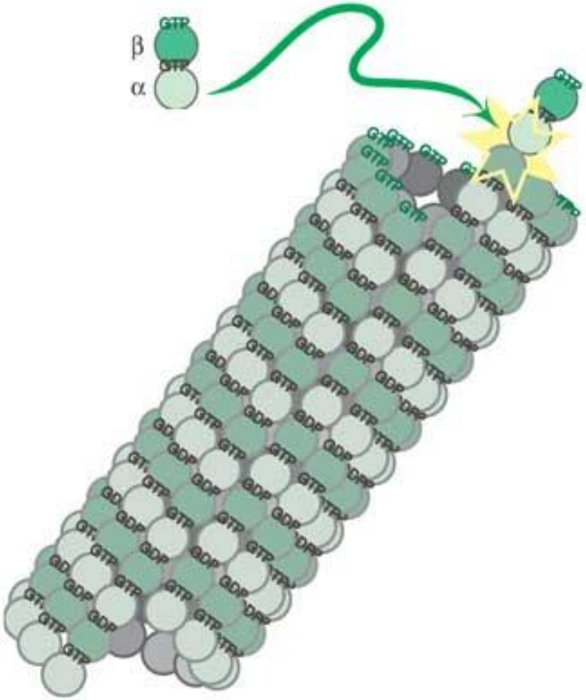


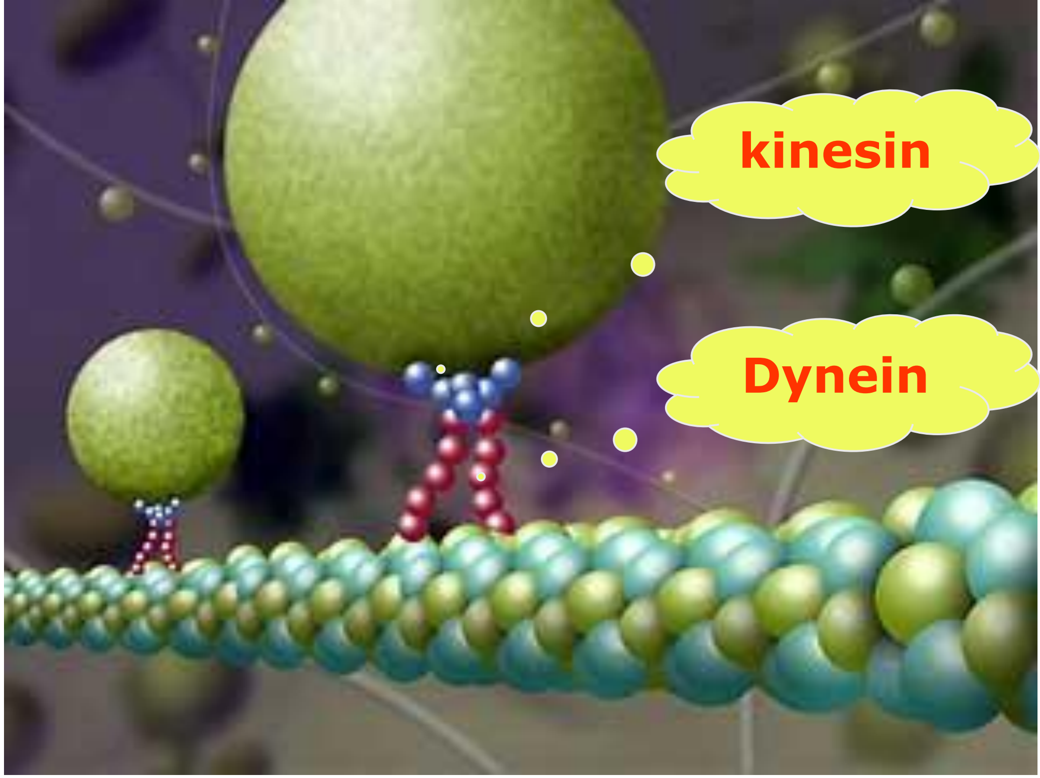
Intermediated filaments

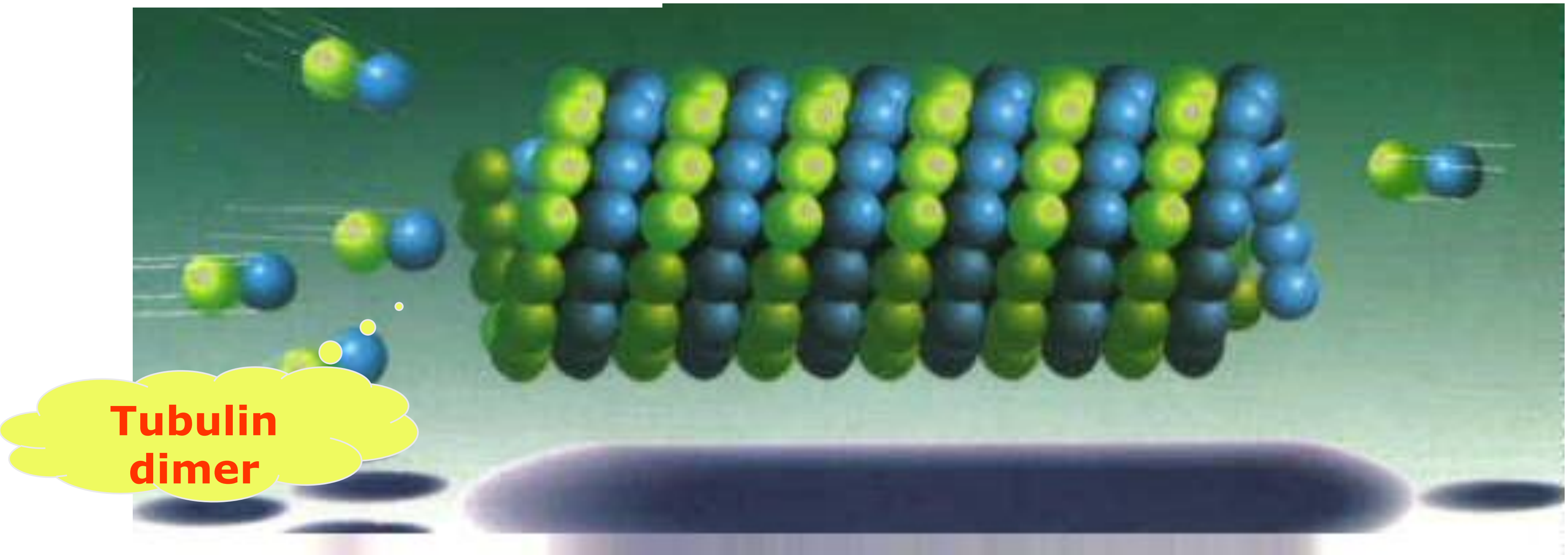
CYTOSKELETON

- Microfilament
  - Thin filament (actin)
  - Thick filament (myosin)
- Intermediated filament
- Microtubule

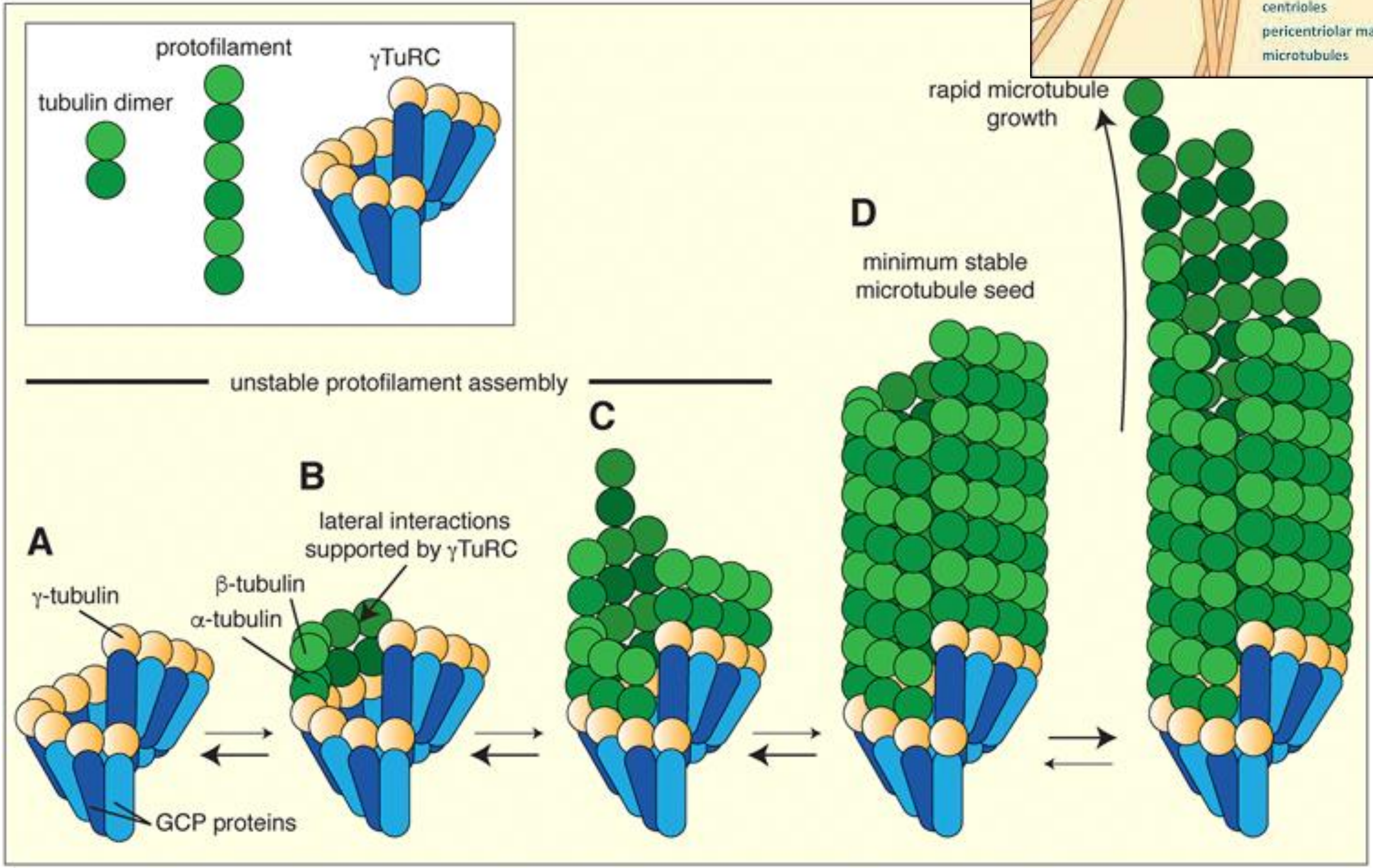


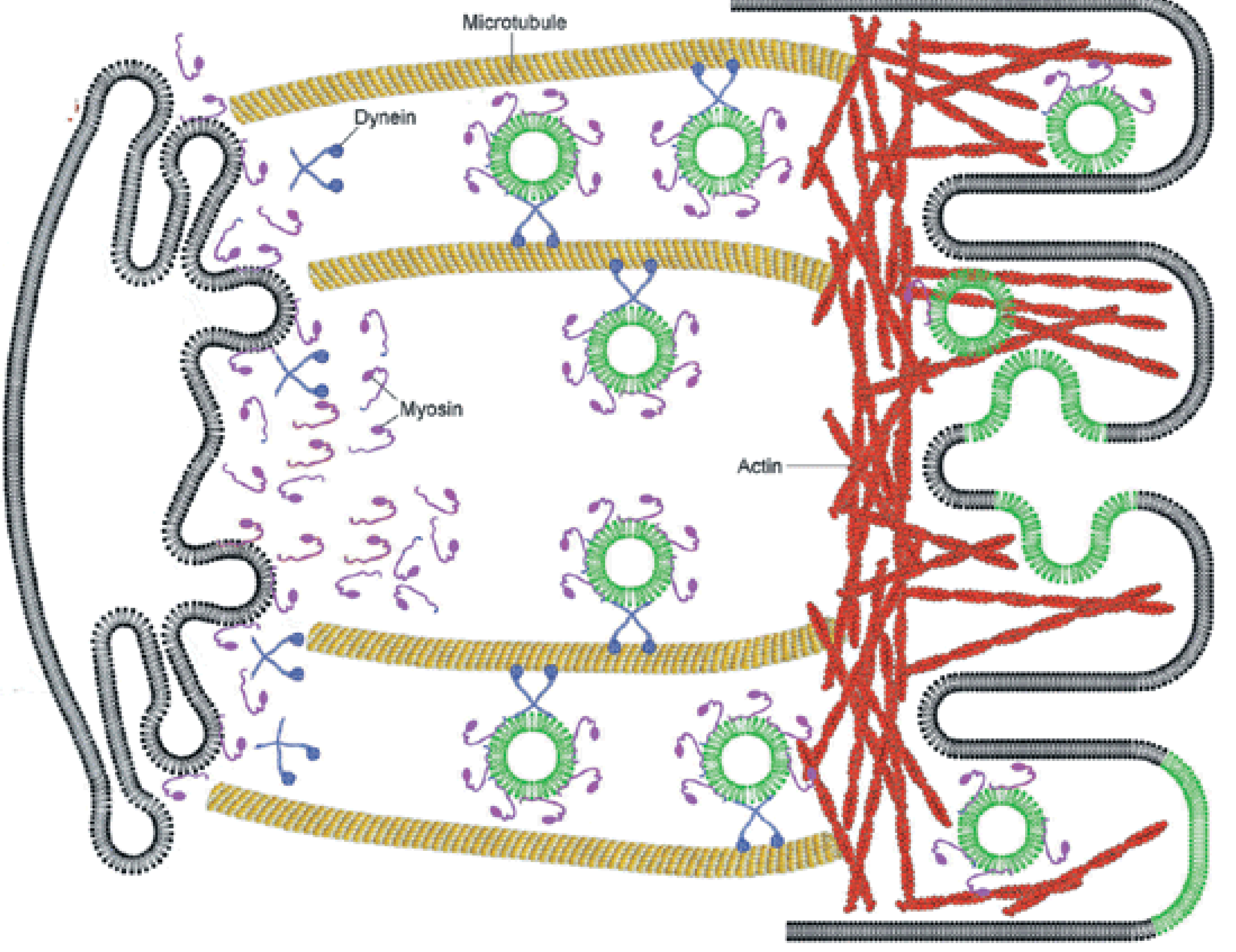

β
α
GTP
GDP


kinesin
Dynein


Tubulin
dimer

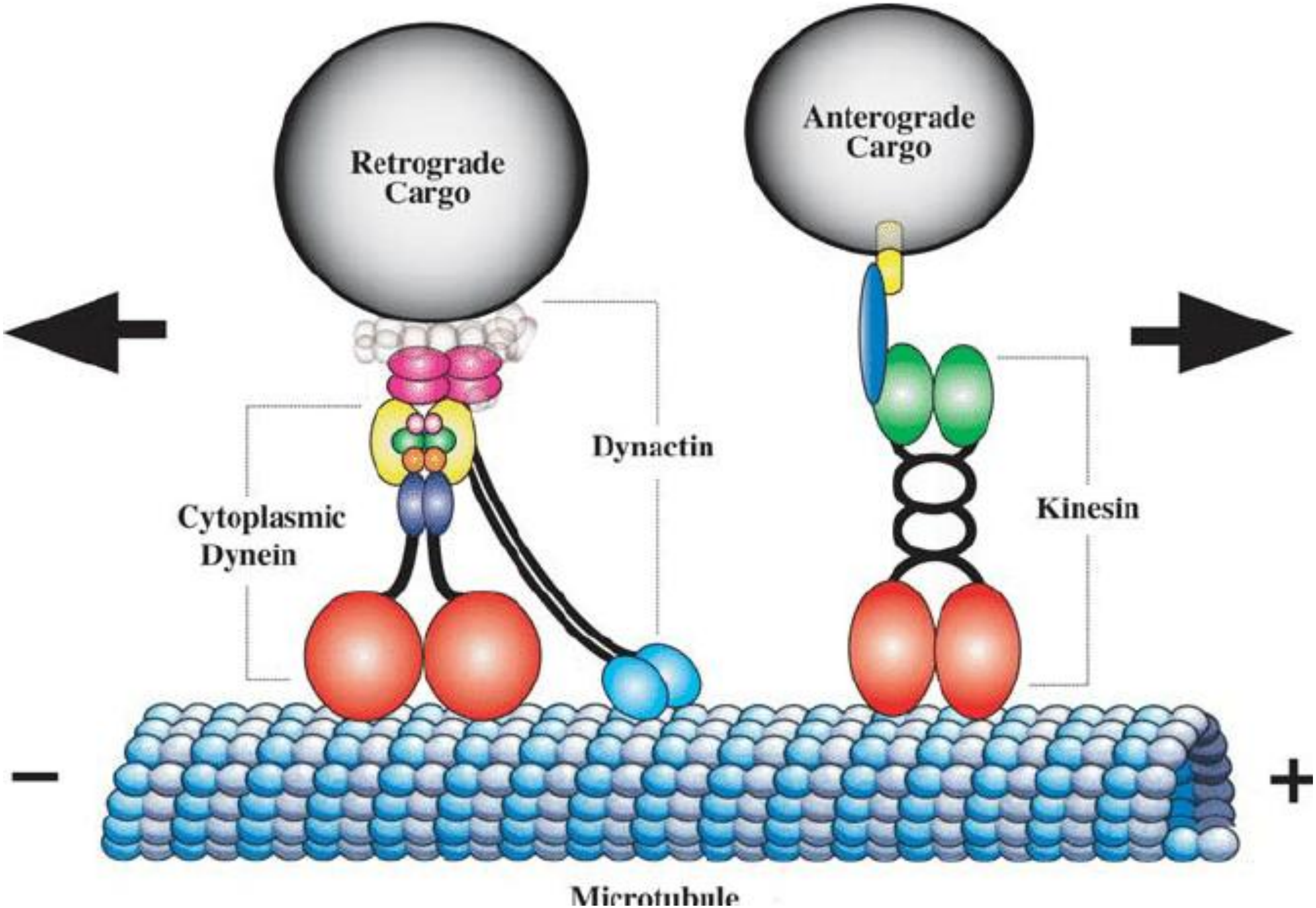
Microtubule organizer



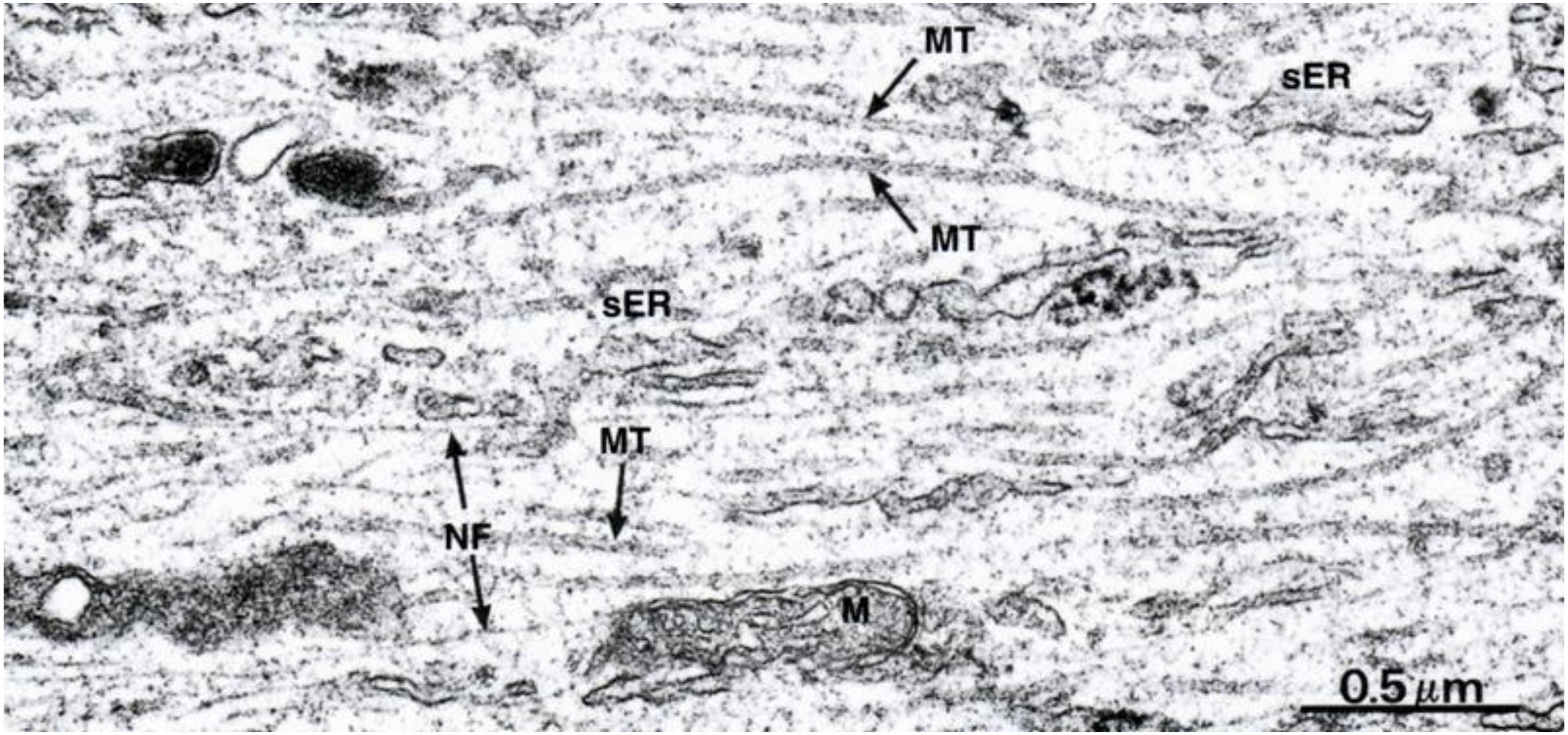


Microtubule
Dynein
Myosin
Actin

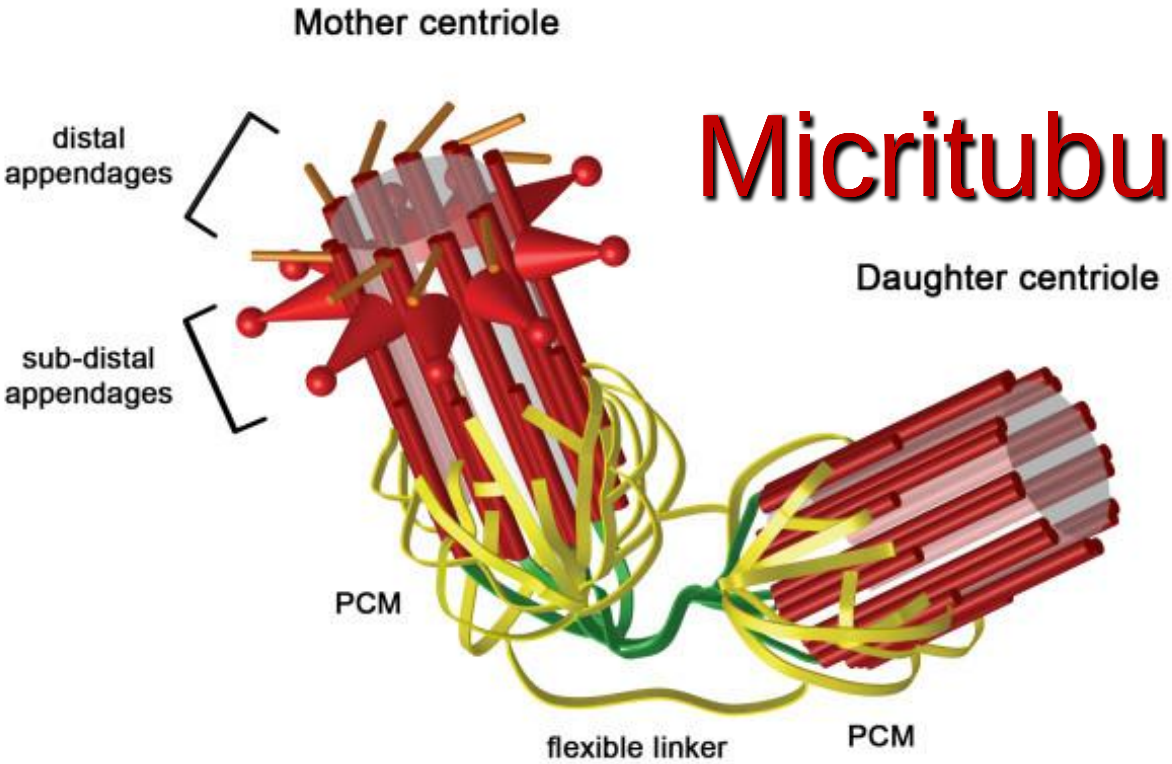
Motor proteins

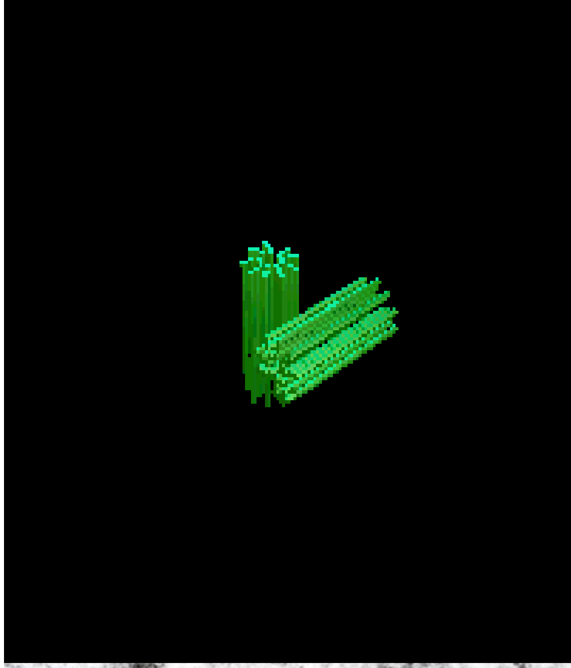


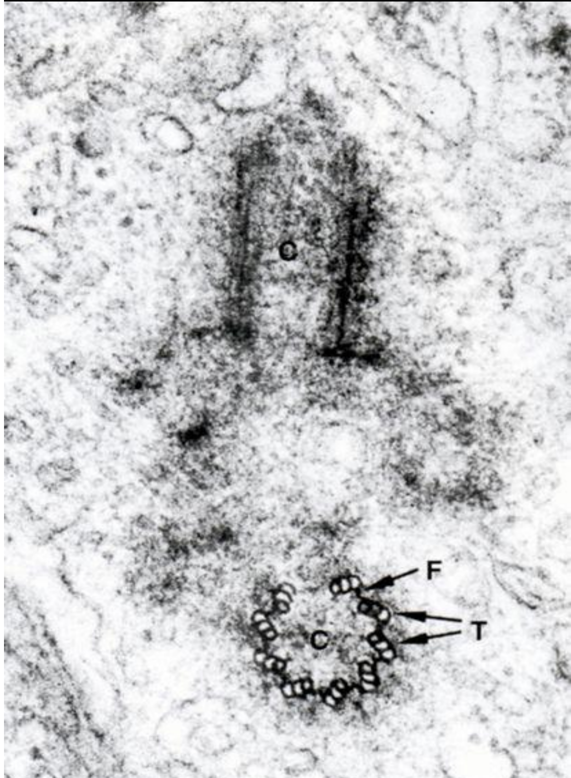
Microtubule

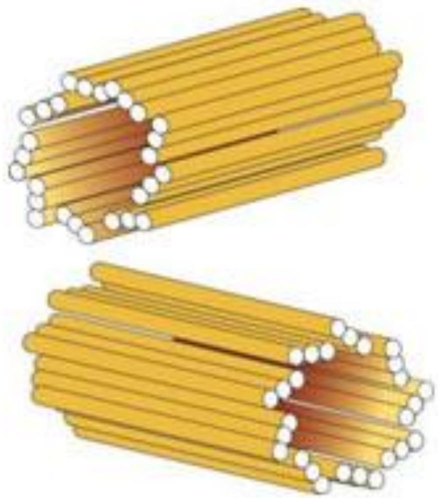


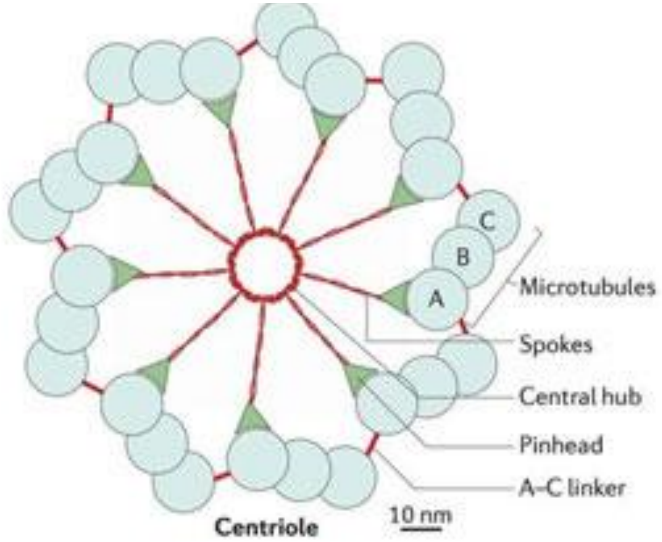
Micritubule



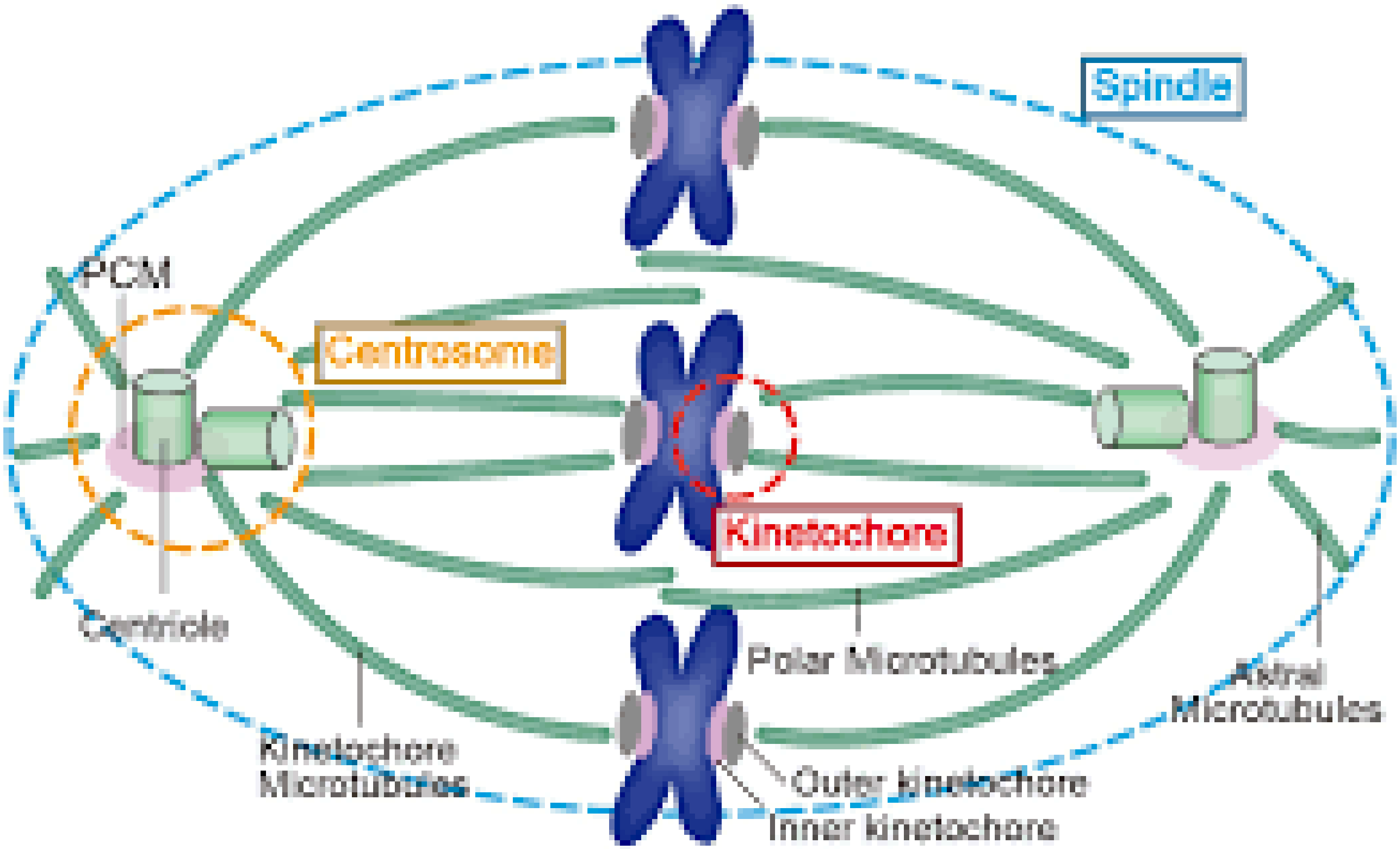






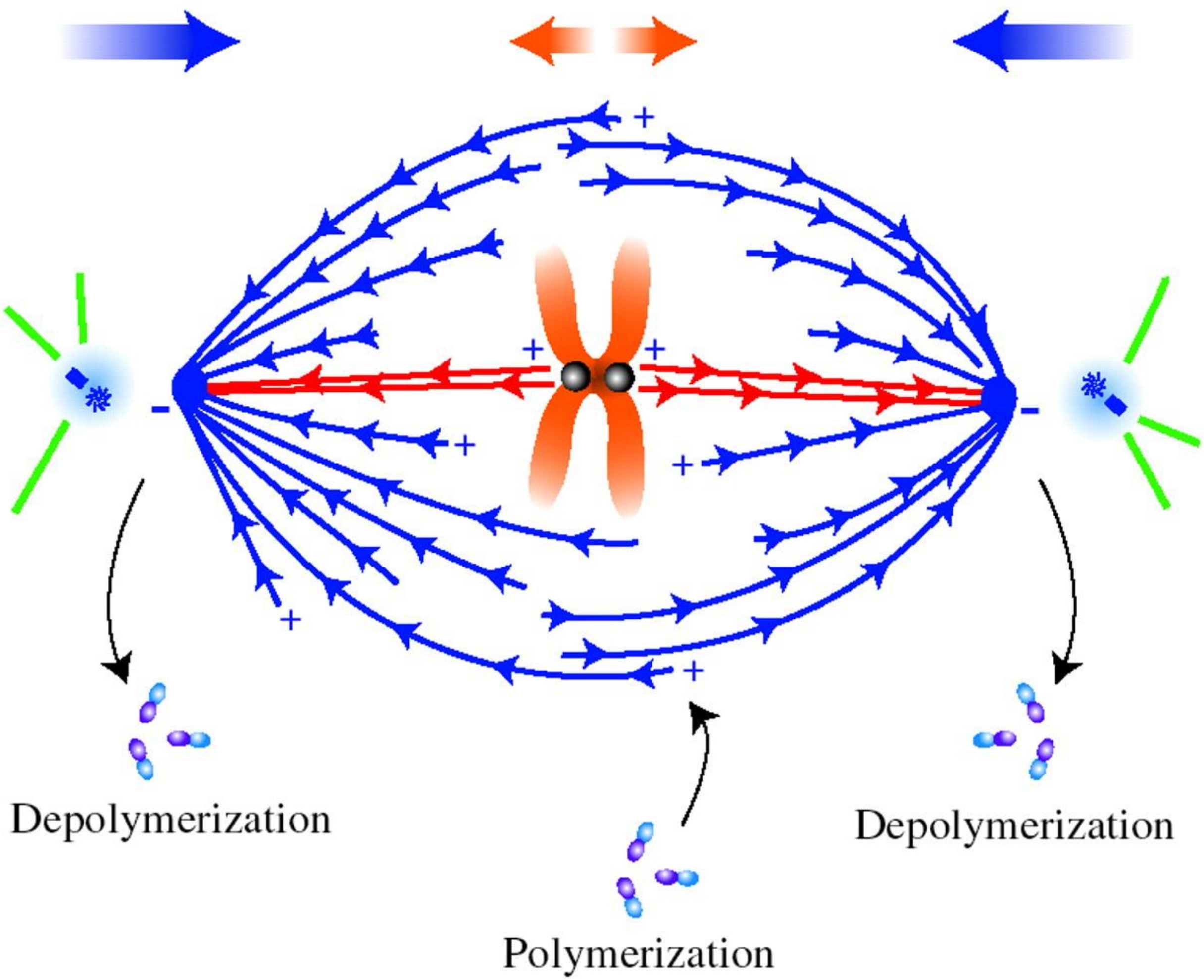


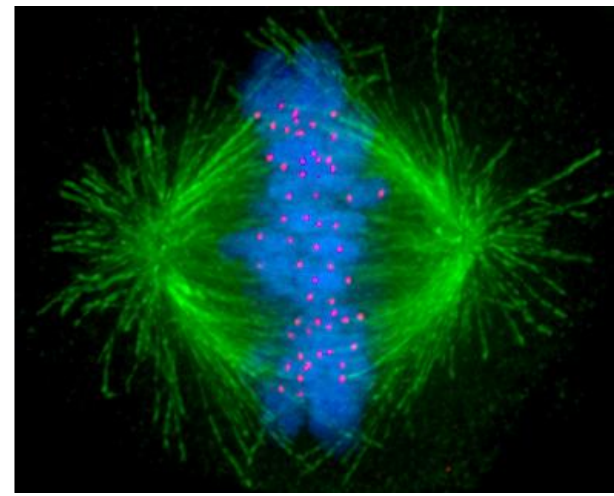
Mitotic spindle

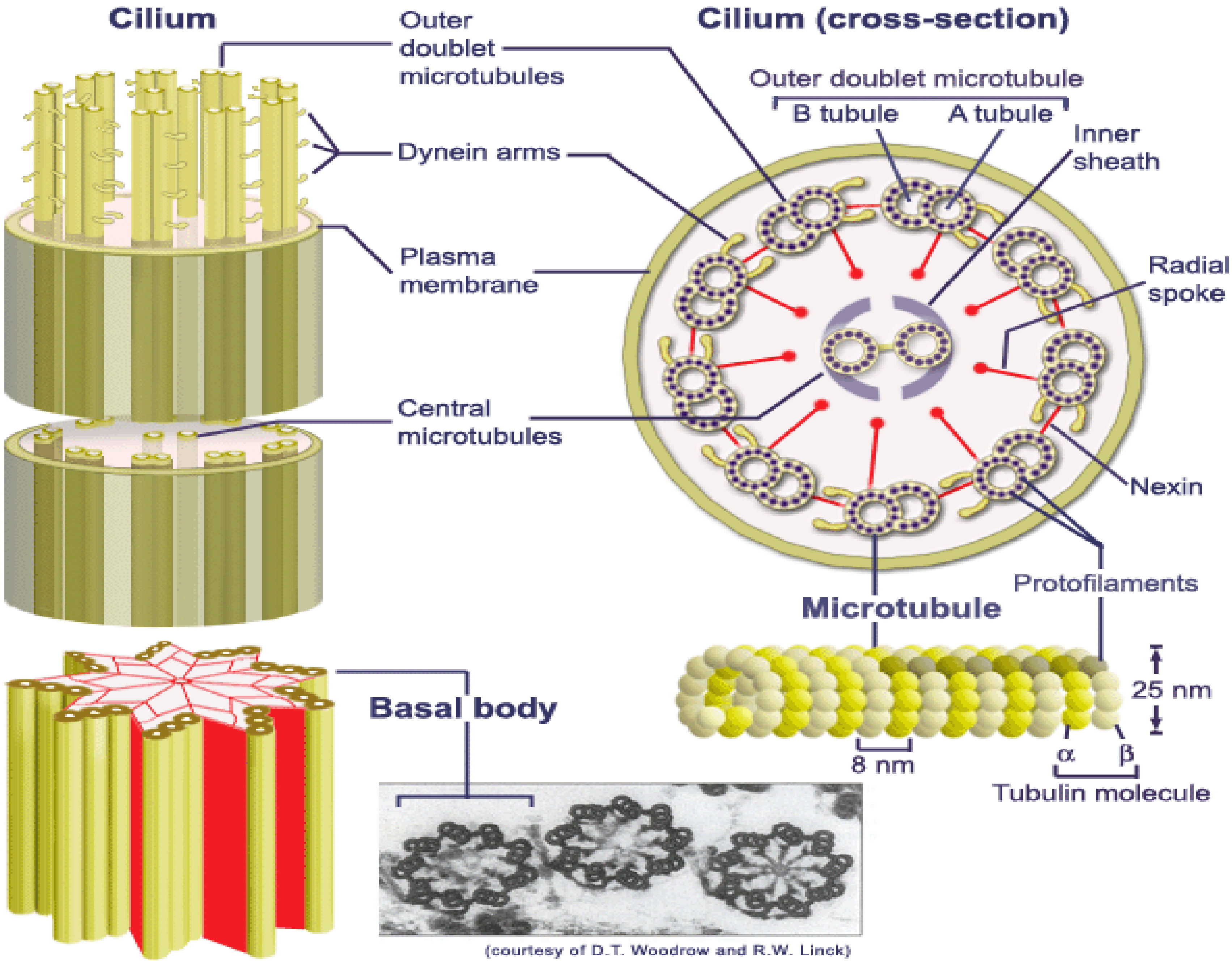


Mitotic apparatus

Mitotic spindle

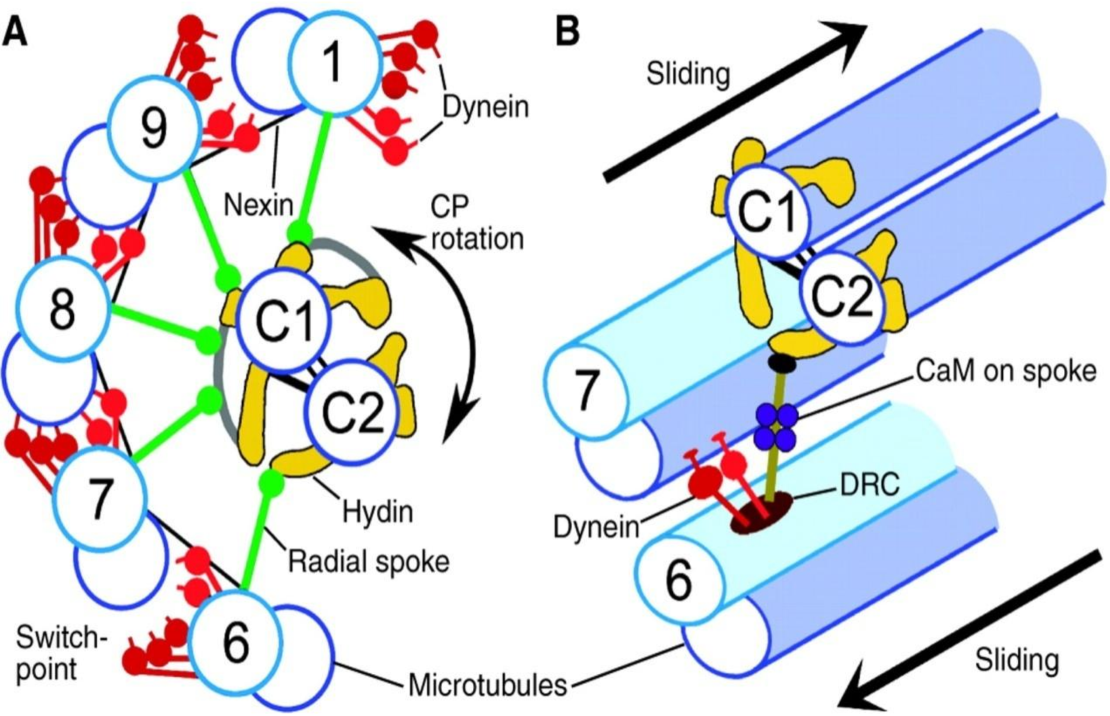


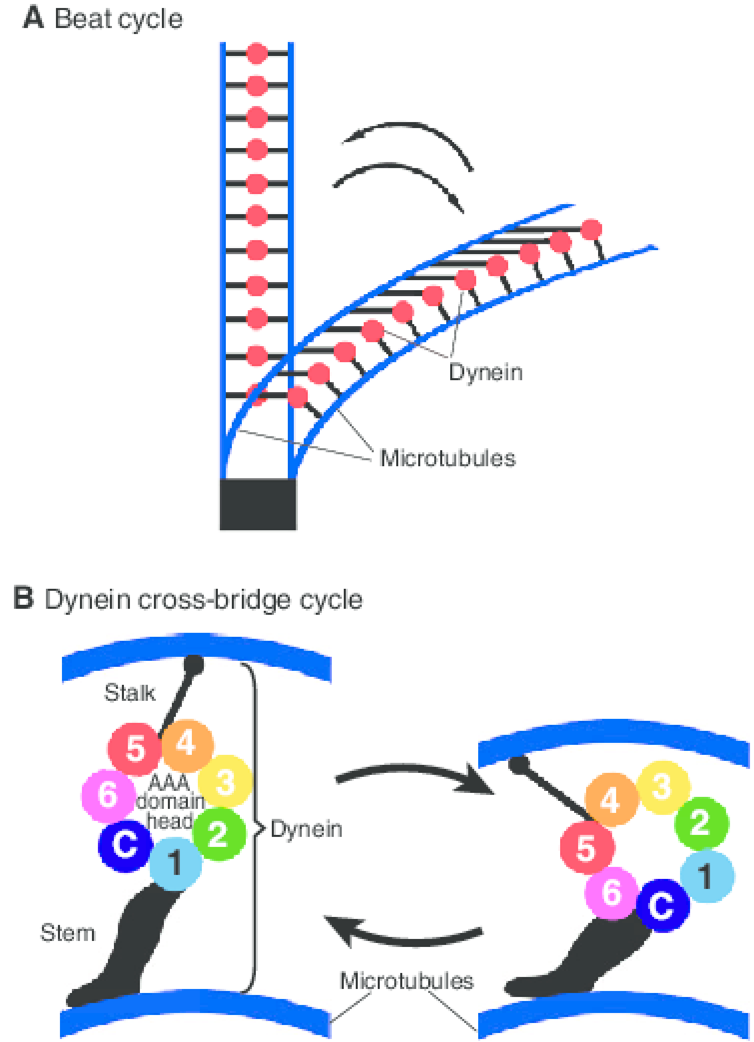




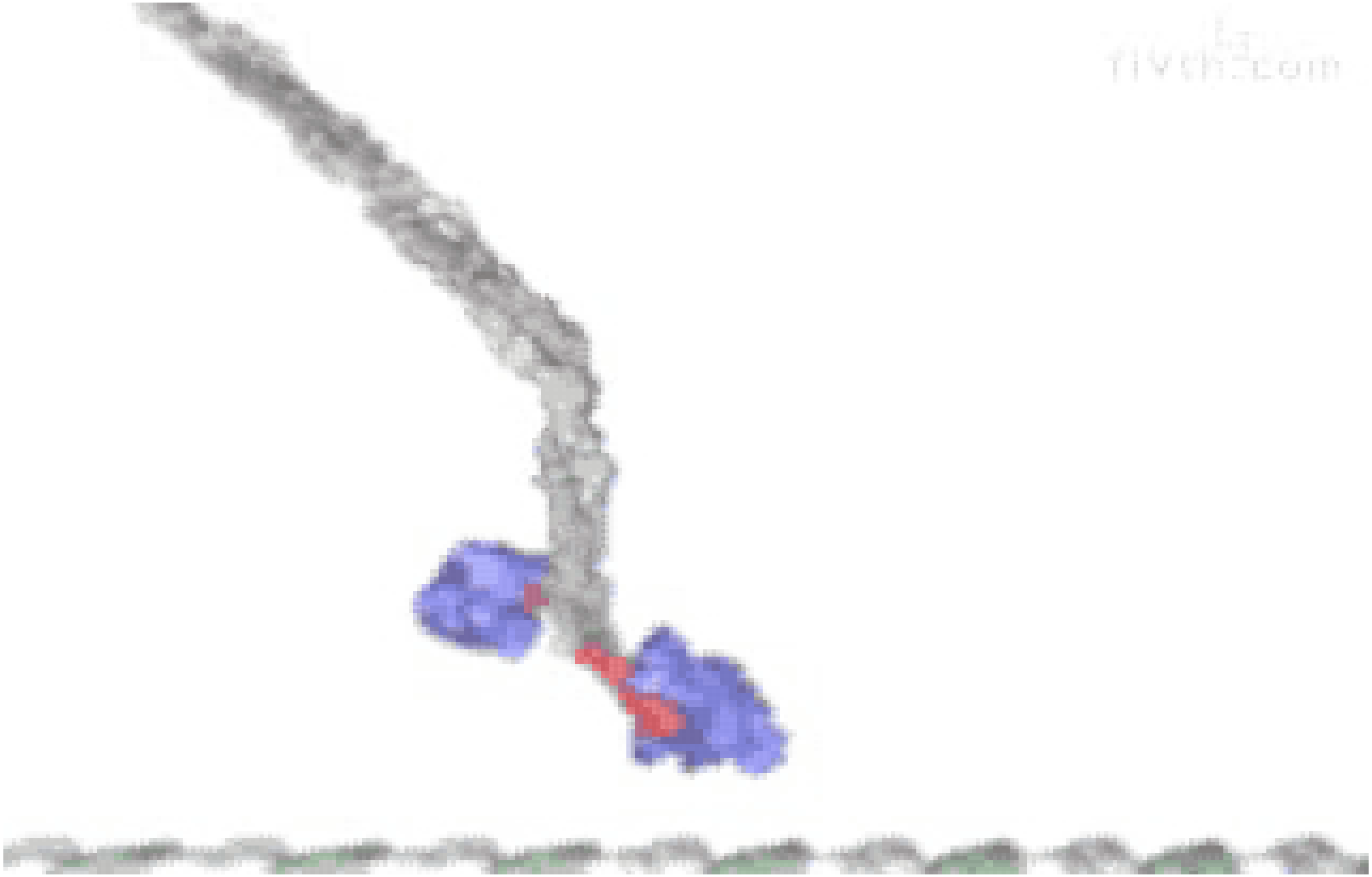
Cilium
Outer doublet microtubules
Dynein arms
Plasma membrane
Central microtubules
Cilium (cross-section)
Outer doublet microtubule
B tubule
A tubule
Inner sheath
Radial spoke
Nexin
Protofilaments
Microtubule
25 nm
8 nm
α
β
Tubulin molecule
Basal body
(courtesy of D.T. Woodrow and R.W. Linck)

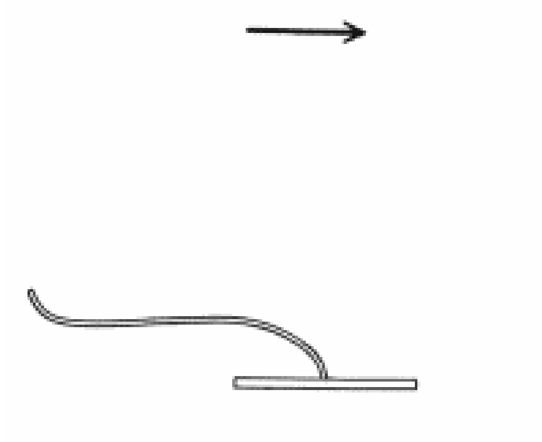
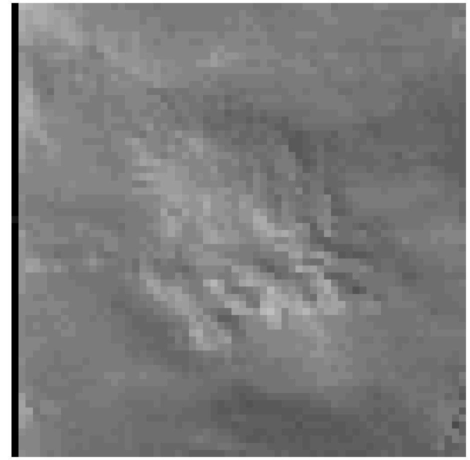
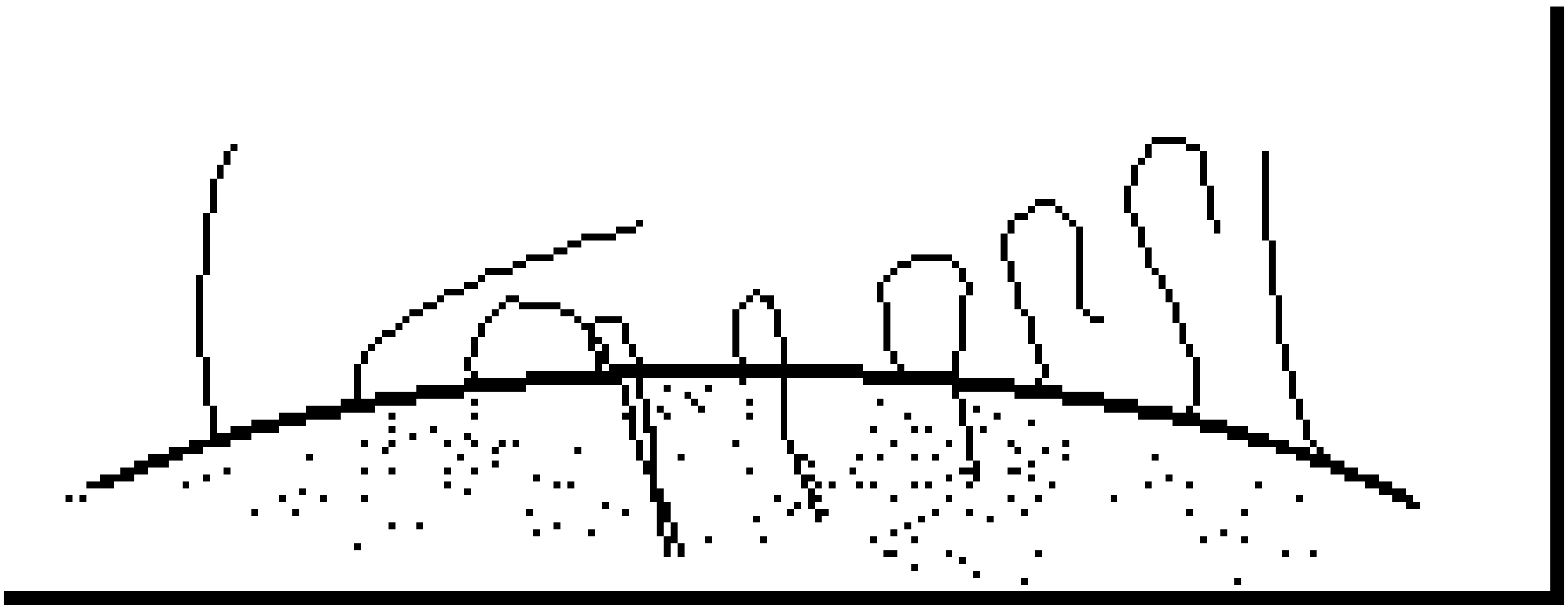
Sliding theory





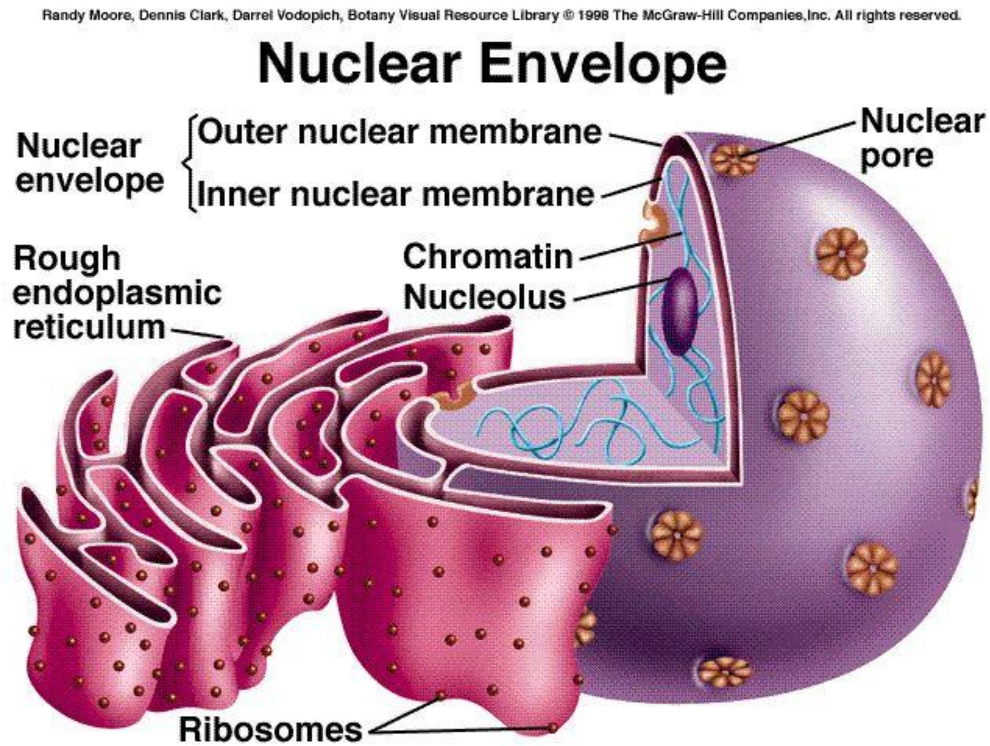
Sliding Theory

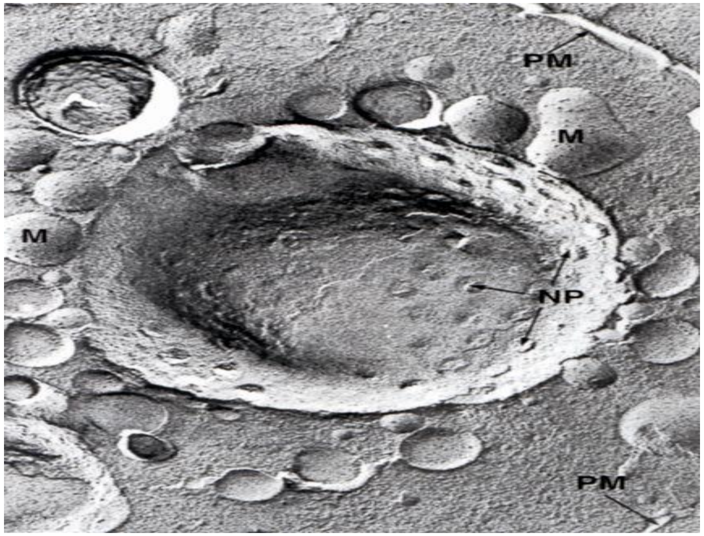


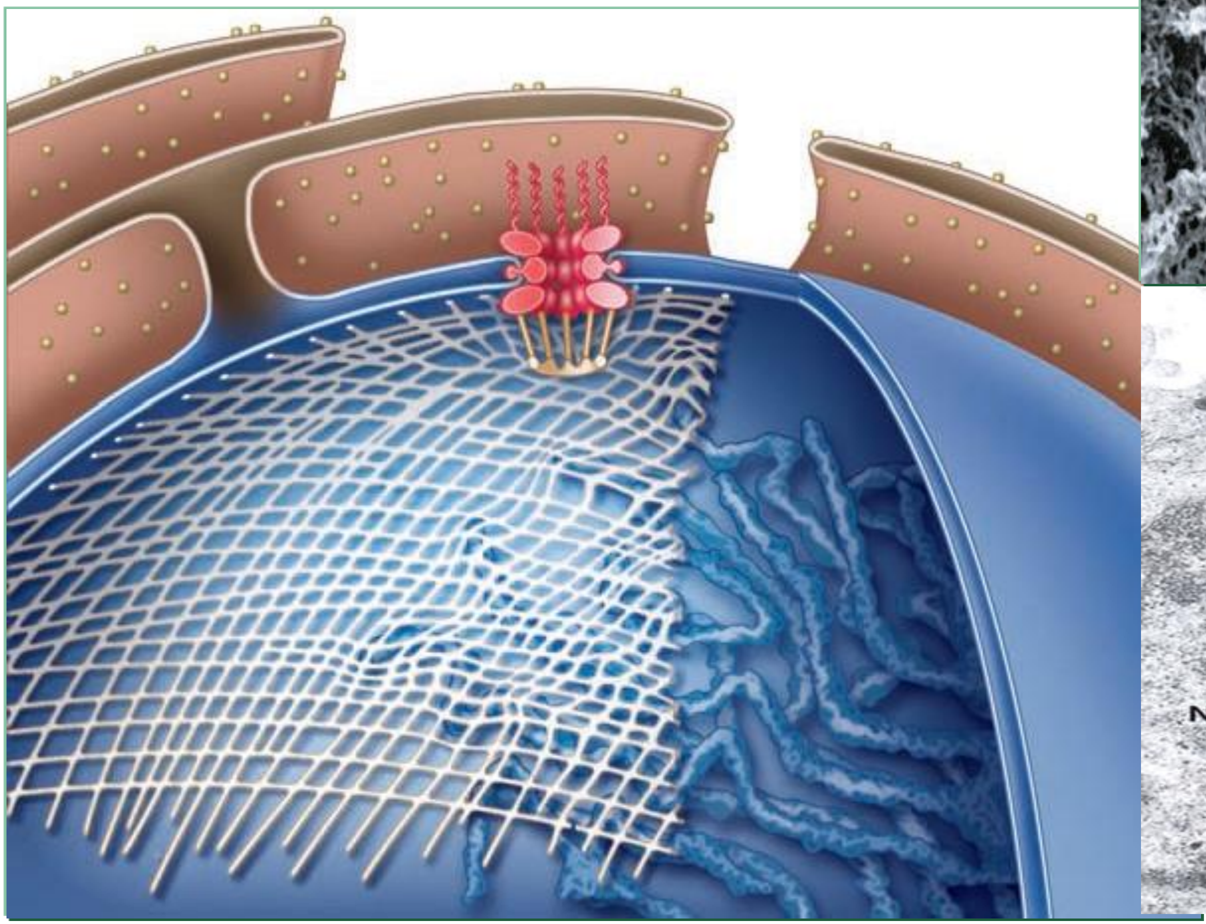
Nucleus

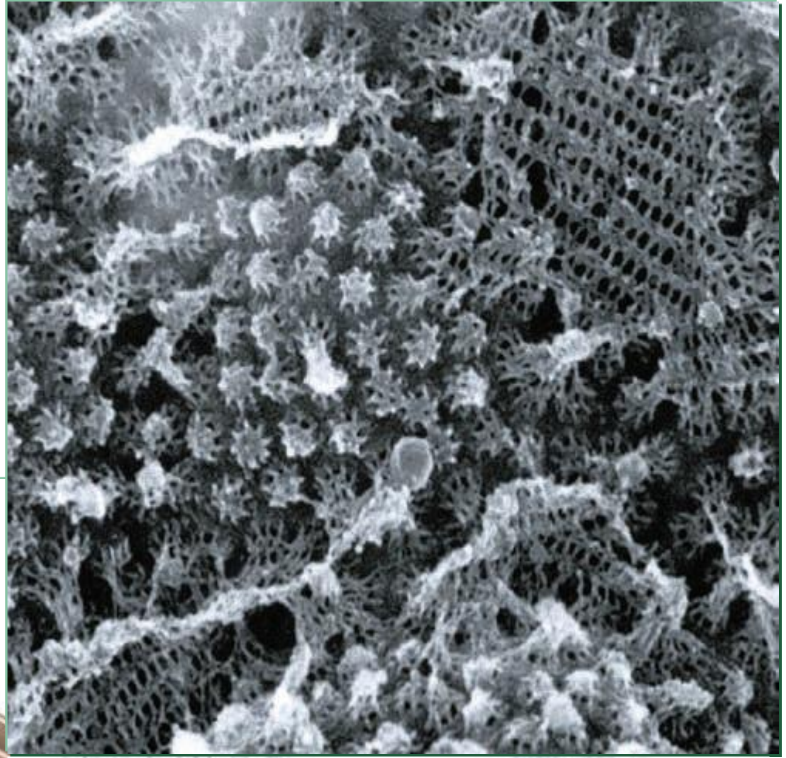
- Nuclear envelope
- Chromatin
- Nucleolus
- Nucleoplasm

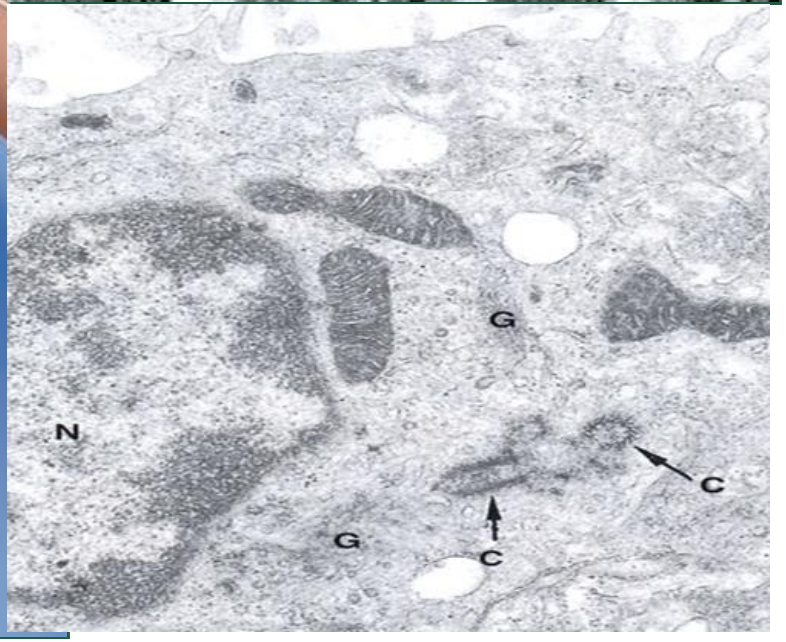




Lamins



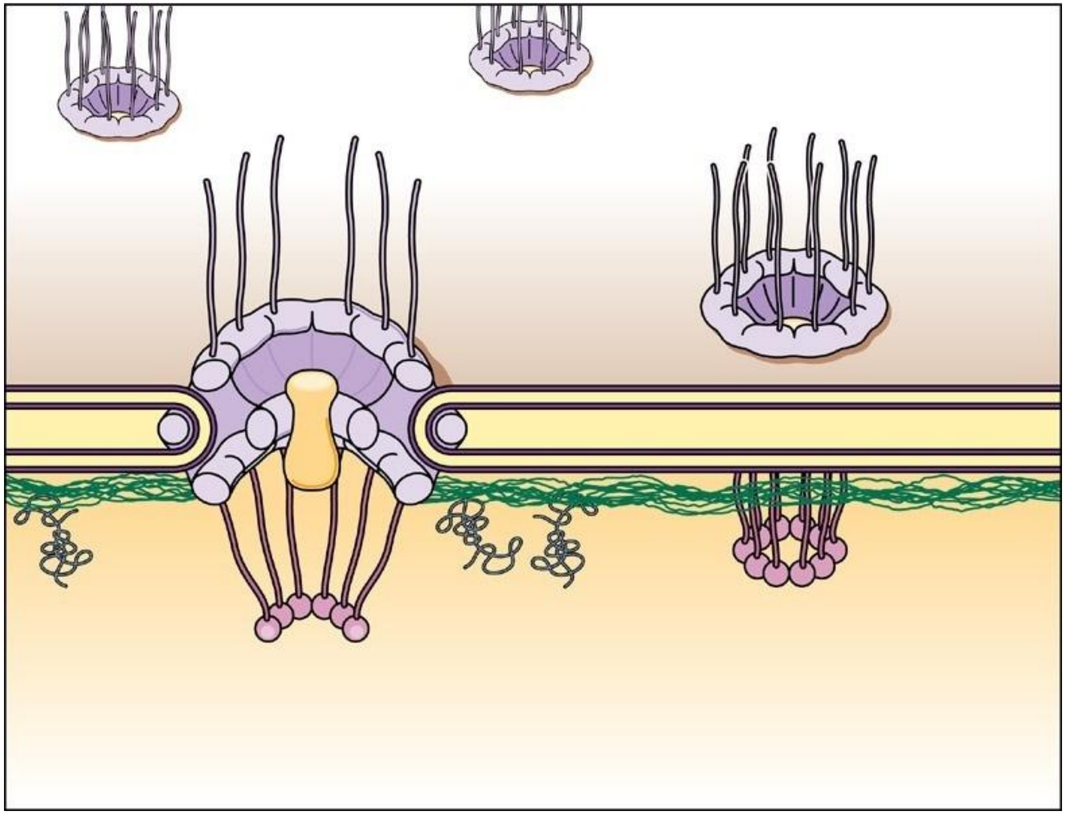


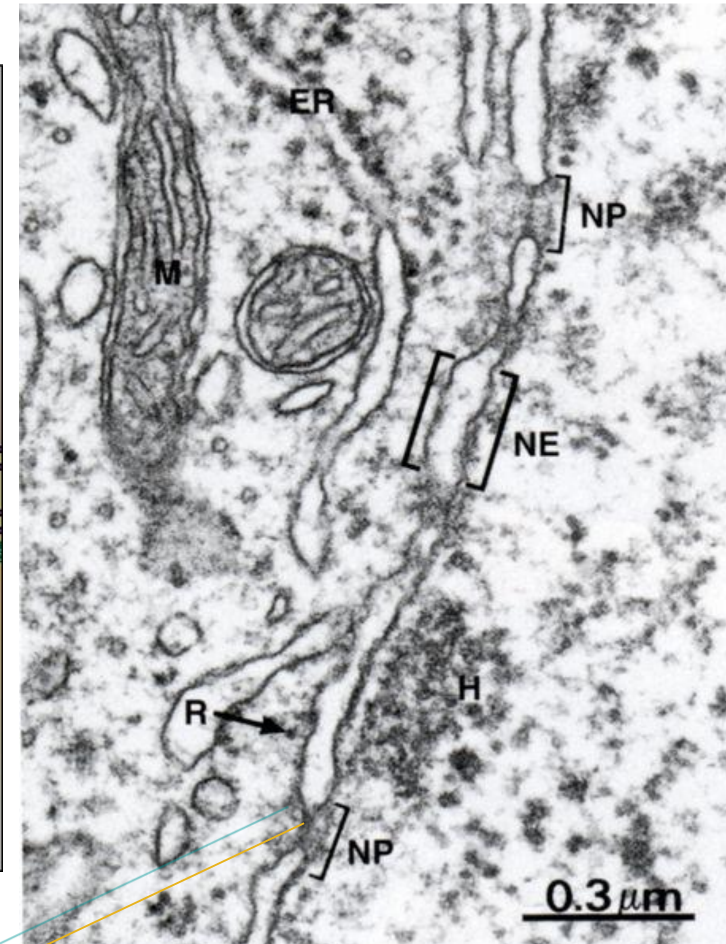


Laminopathy

- Leads to progeria or premature aging
- A disease due to mutation of the lamin A/C gene.

Nuclear envelope and pore

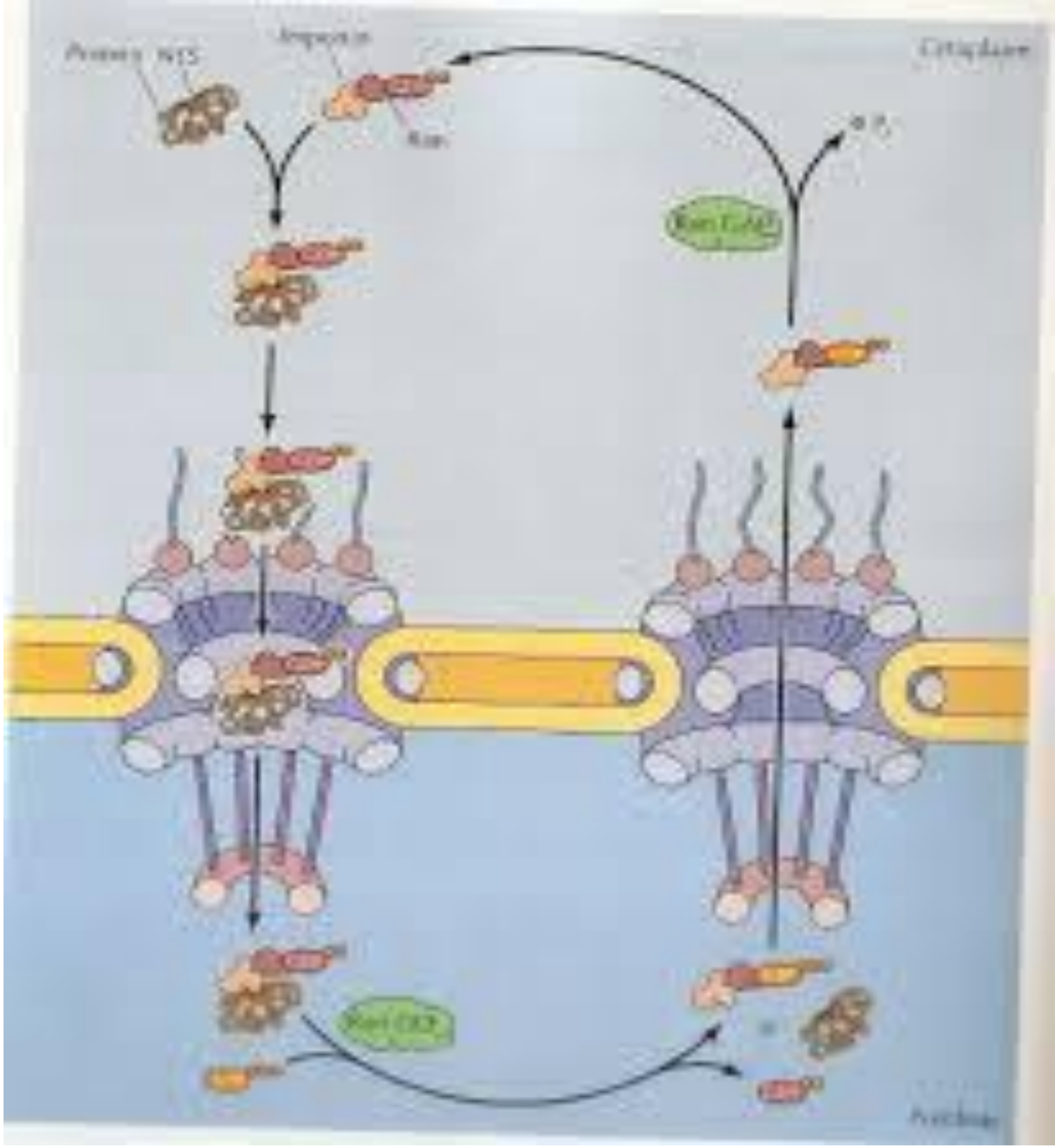




Nuclear pore

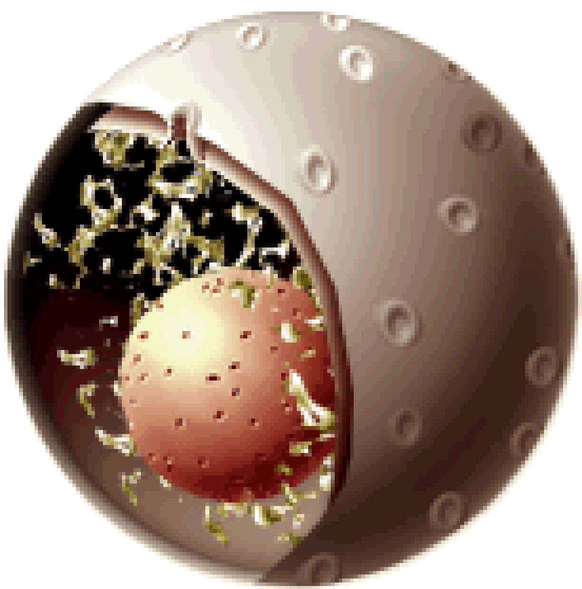
nucleoporins

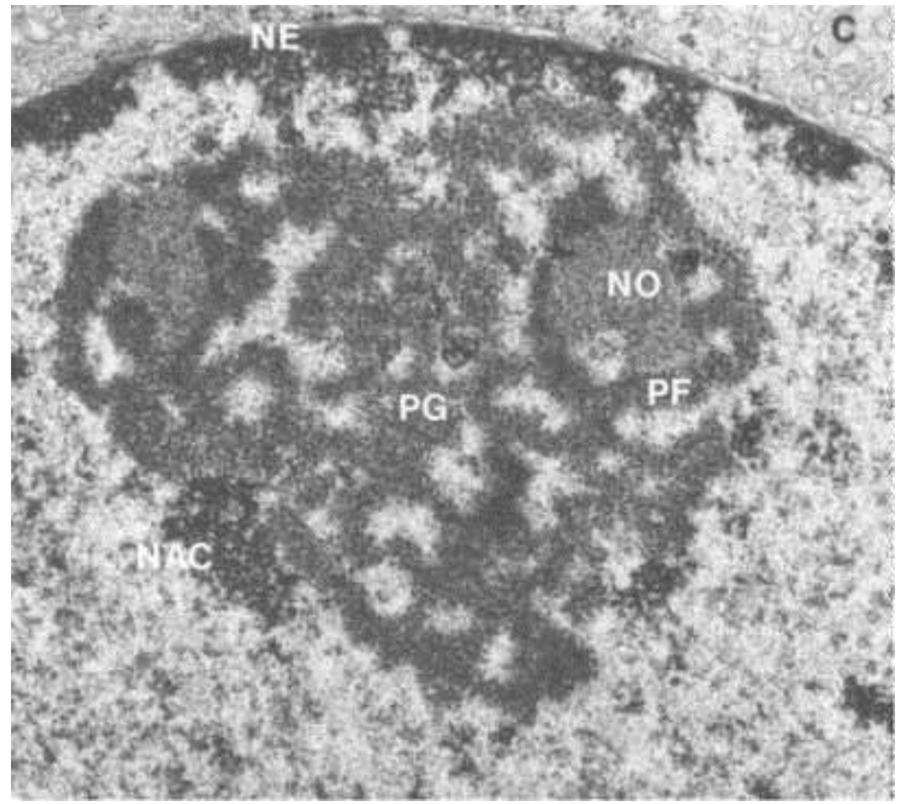
Importin and exportin



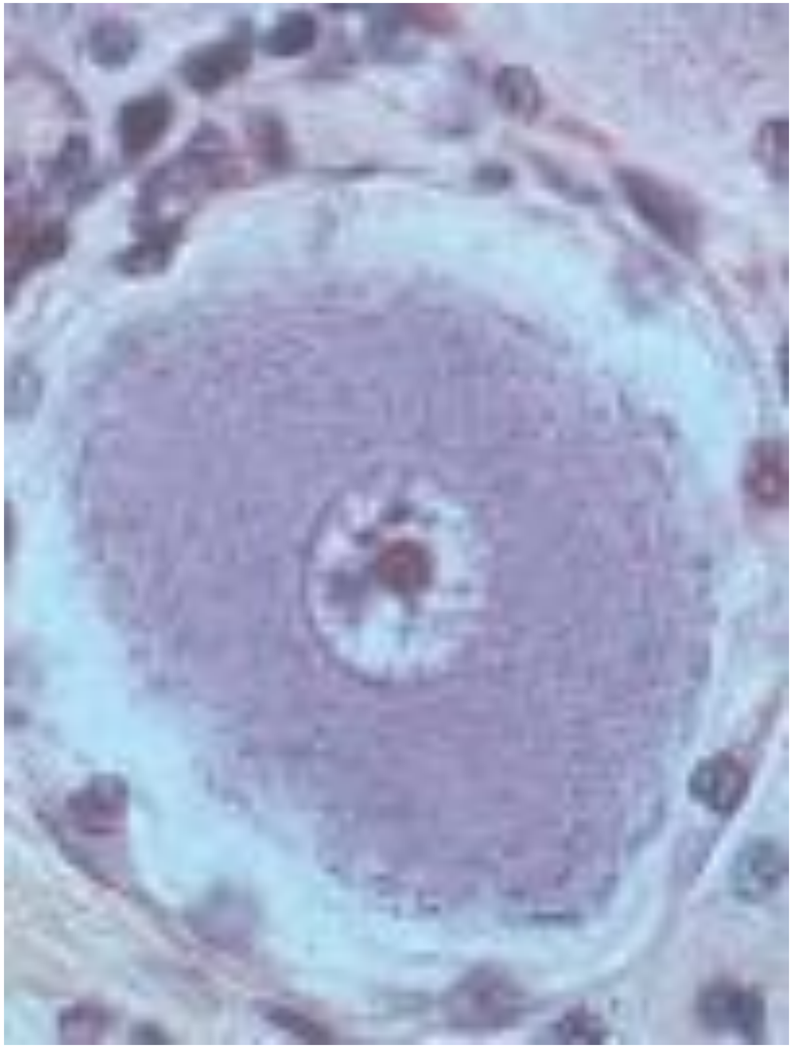
Nucleolus

- Nucleolar organizer
- Pars fibrosa
- Pars granulosa
- Nucleolar association chromatin



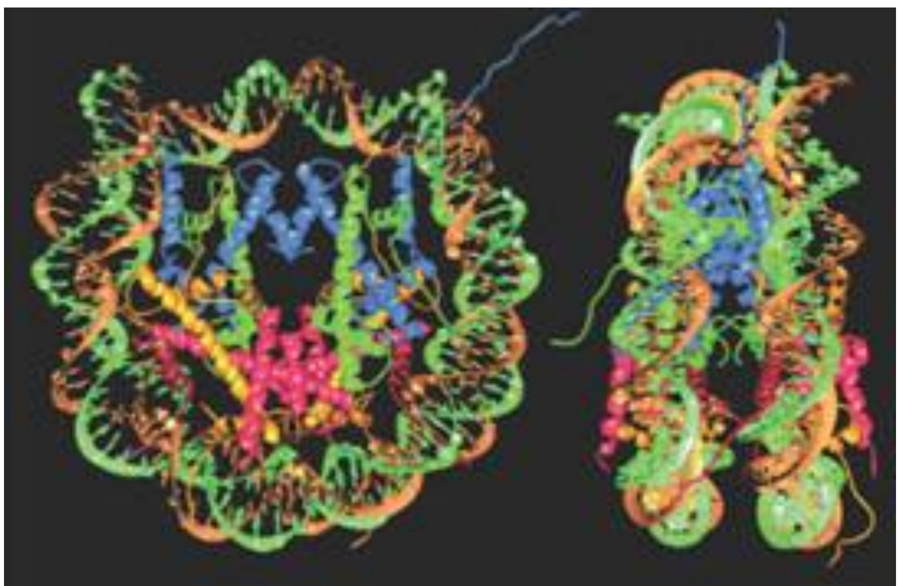


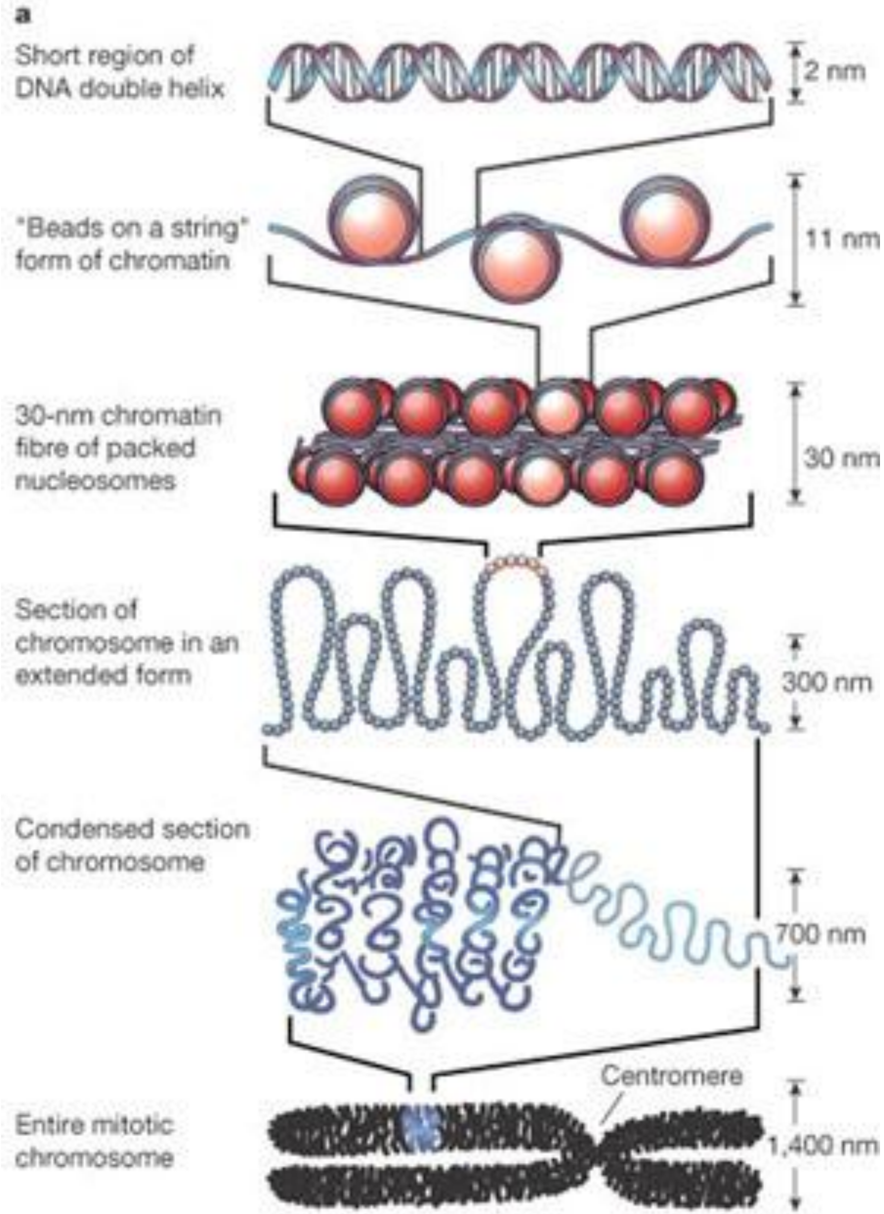
Nucleolus



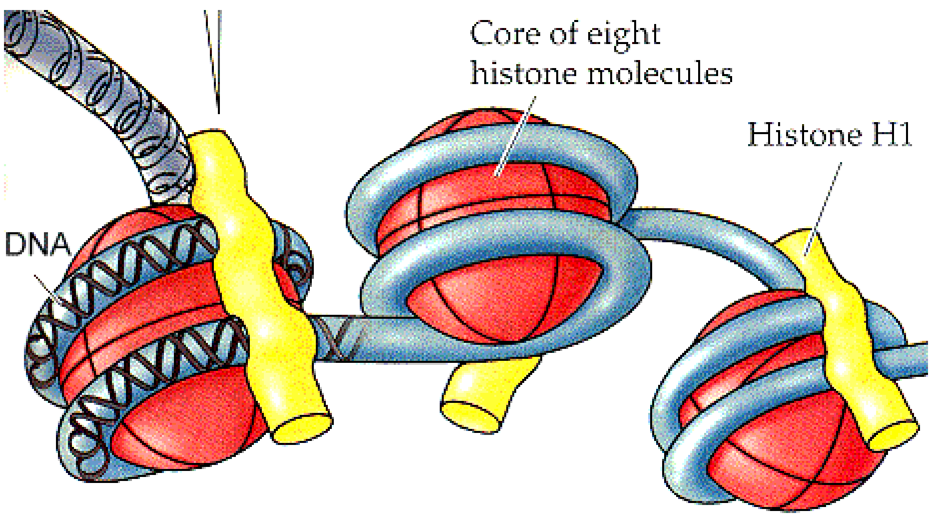
Chromatin

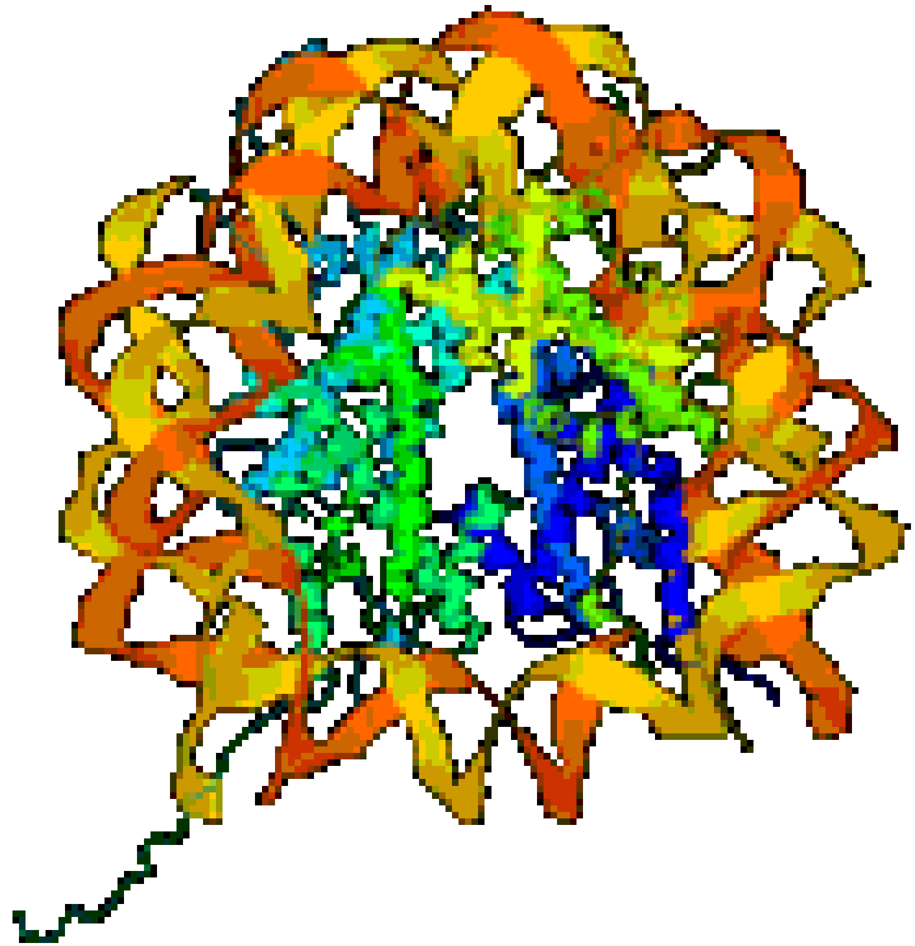
- Nucleosome
- Selenois
- Chromosome





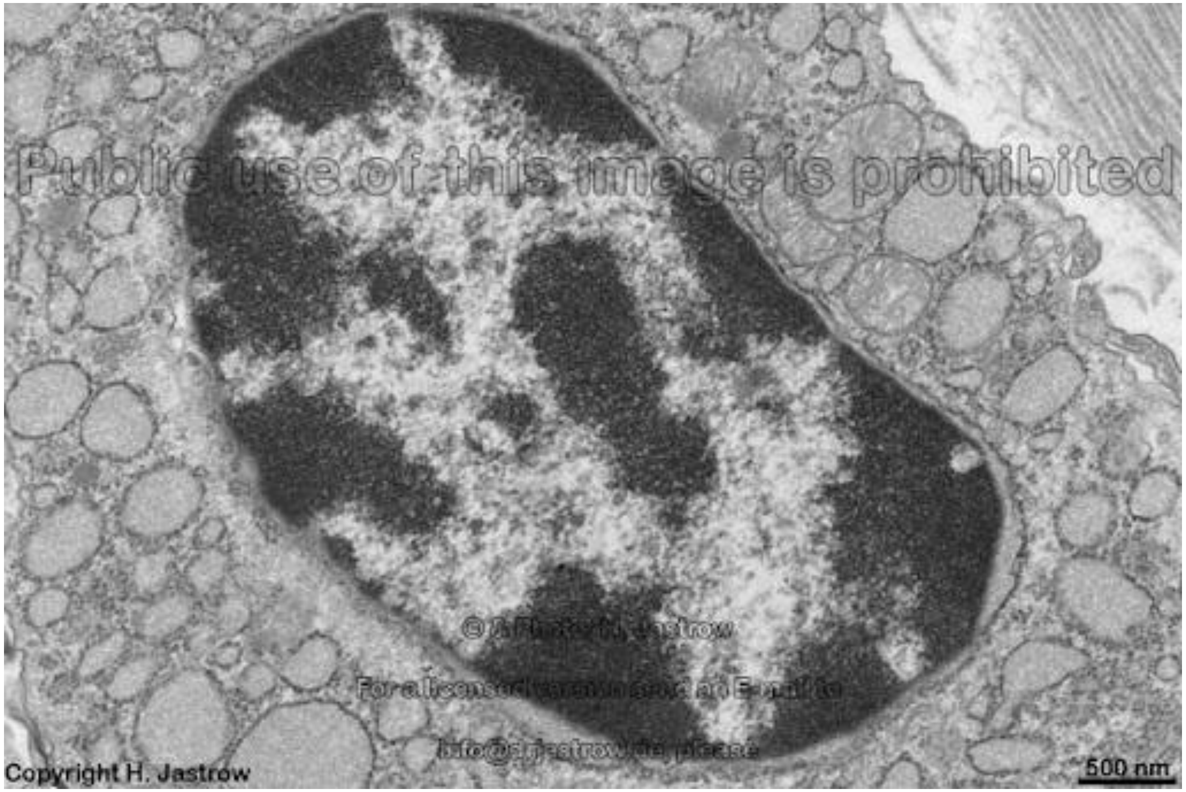
Nucleosome





Chromatin in electron microscopy

- Heterochromatin
- Euchromatin



Type of cell size

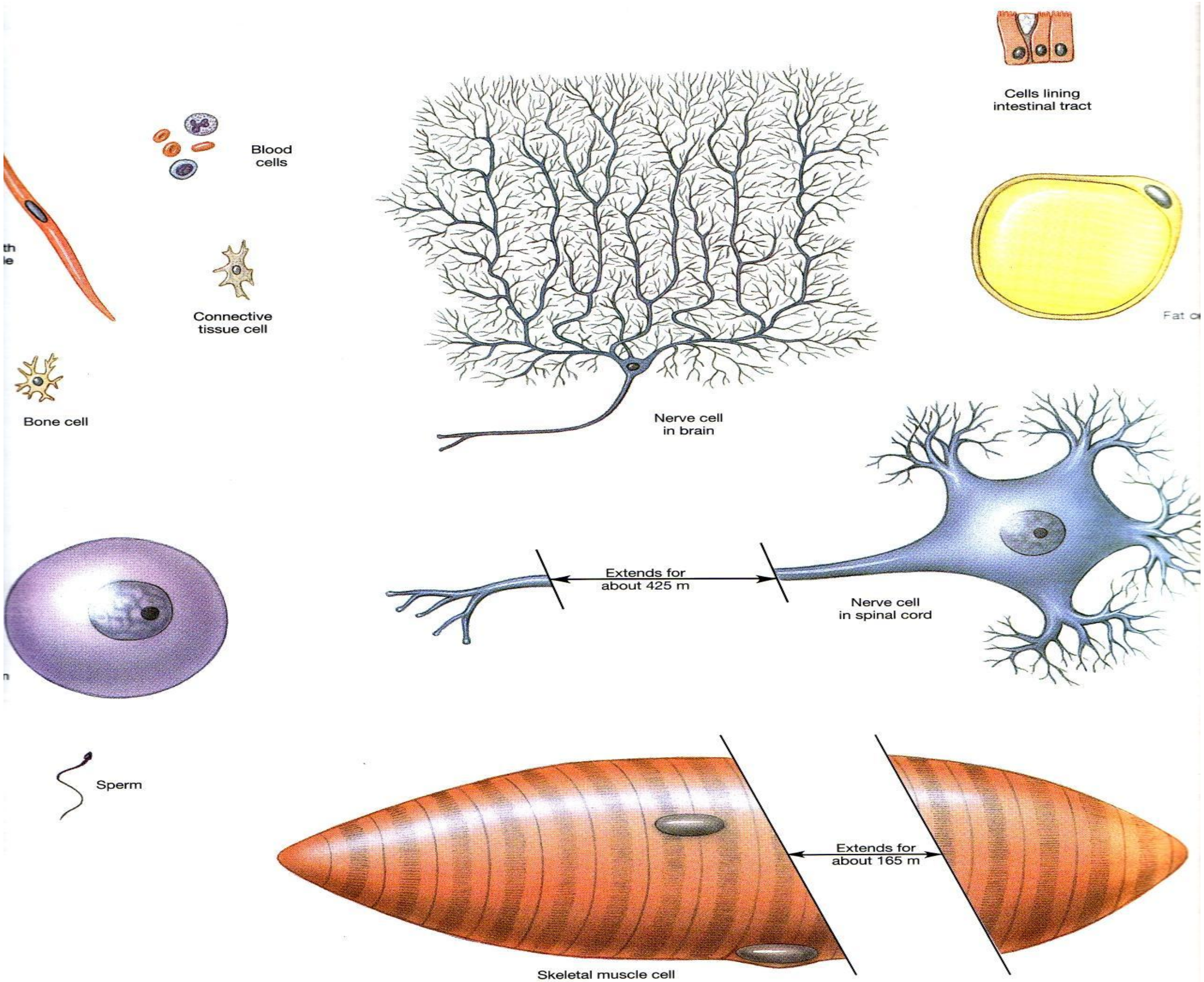
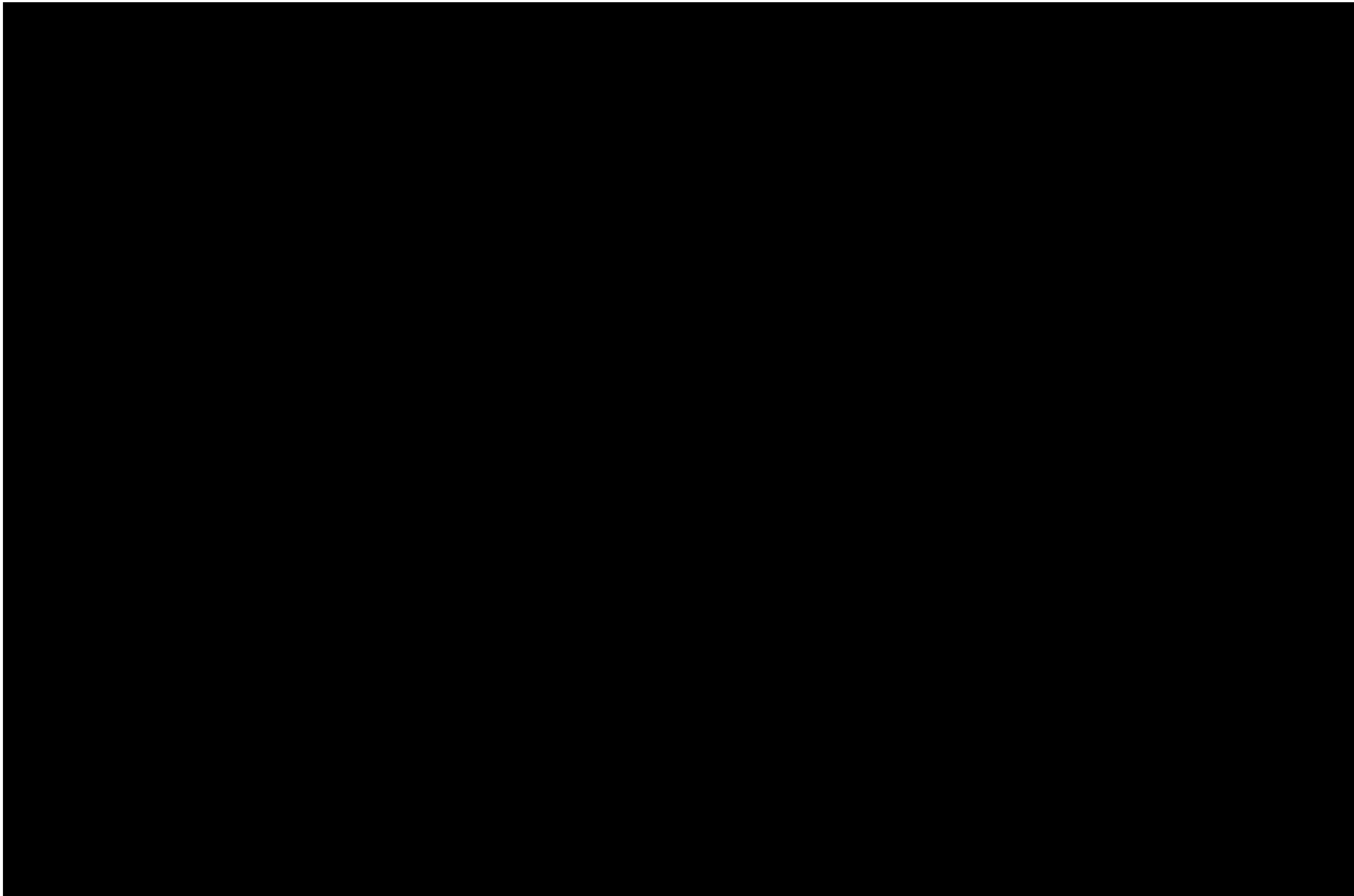
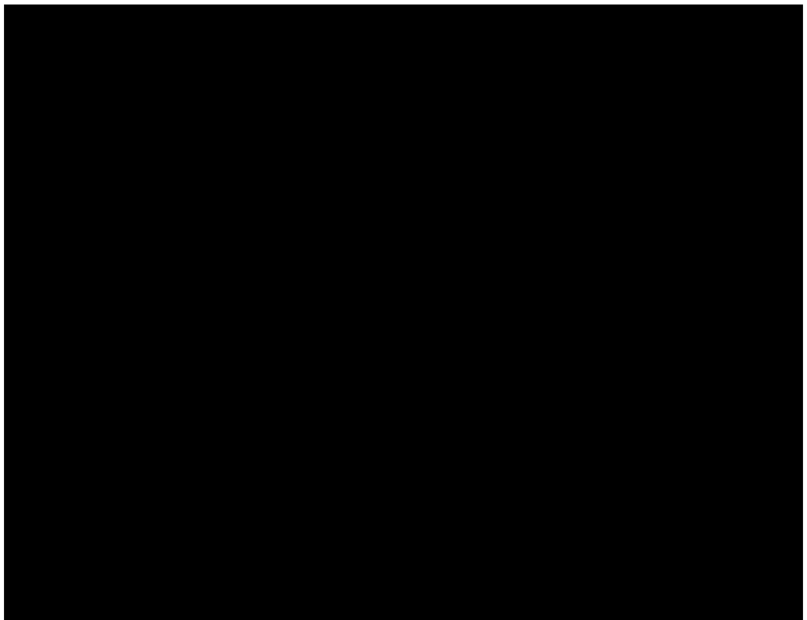


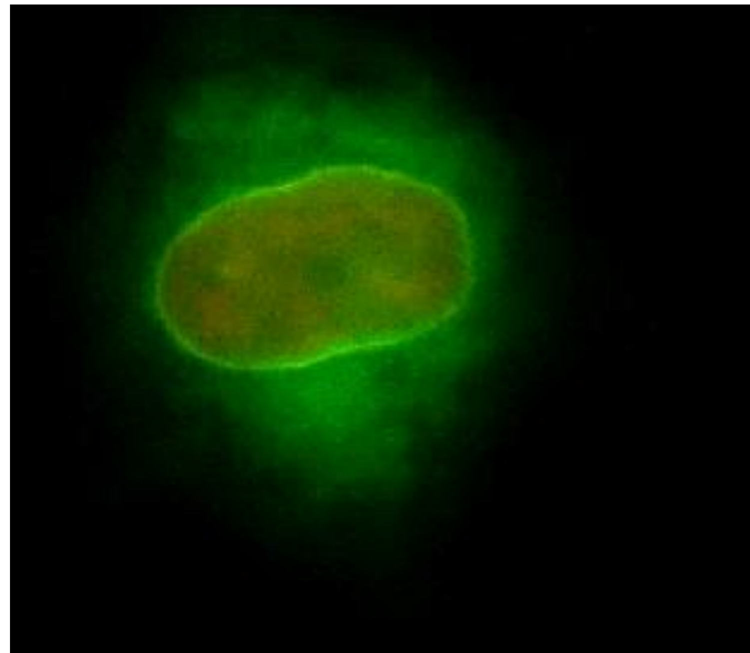
FIGURE 2-1c
The Diversity of Cells in the Human Body. The cells of the body have many different shapes and a variety of special functions. These examples give an indication of the range of forms and sizes; all of the cells are shown with the dimensions they would have if magnified approximately 500 times.

Conclusion





21-1



21-3

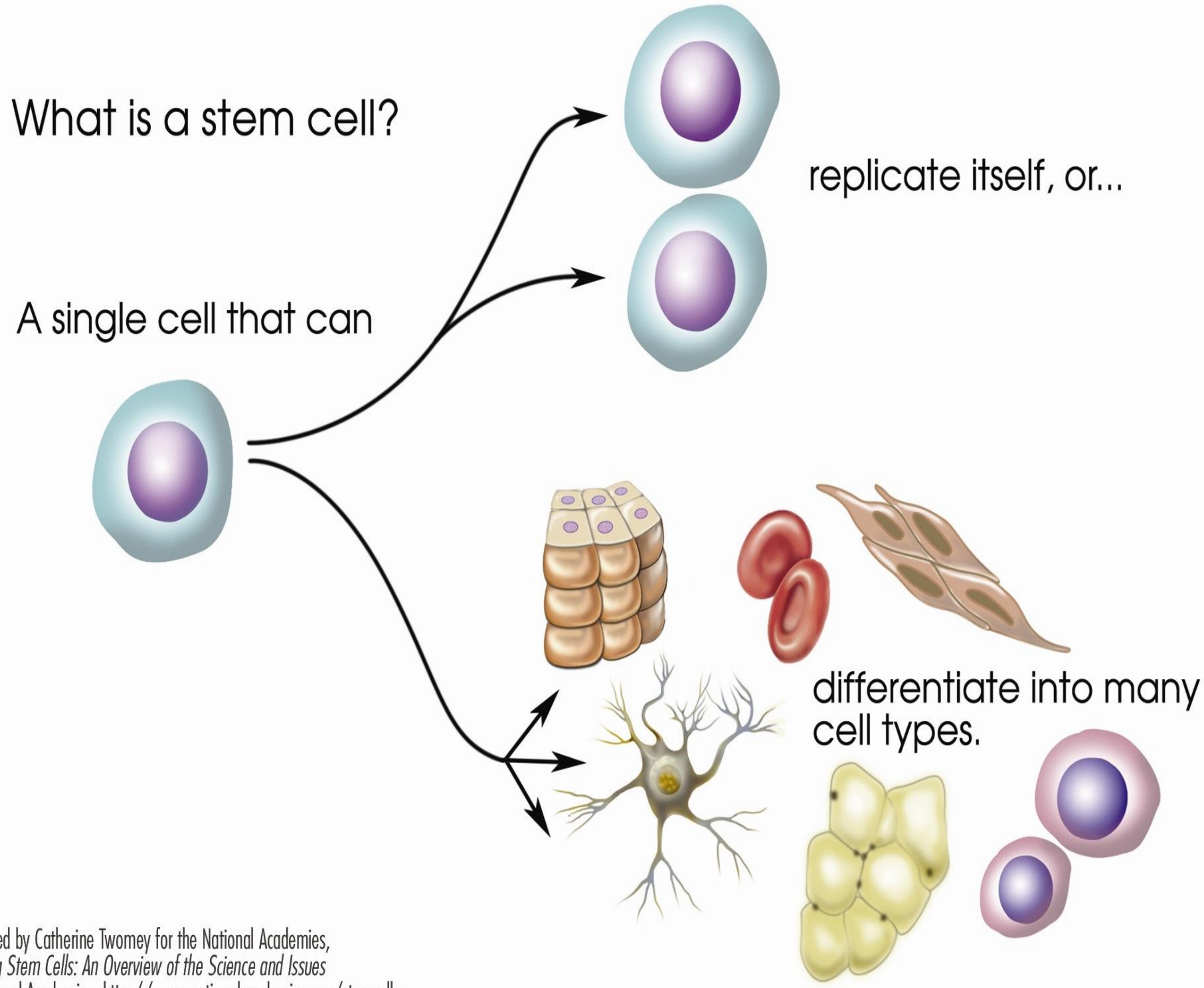
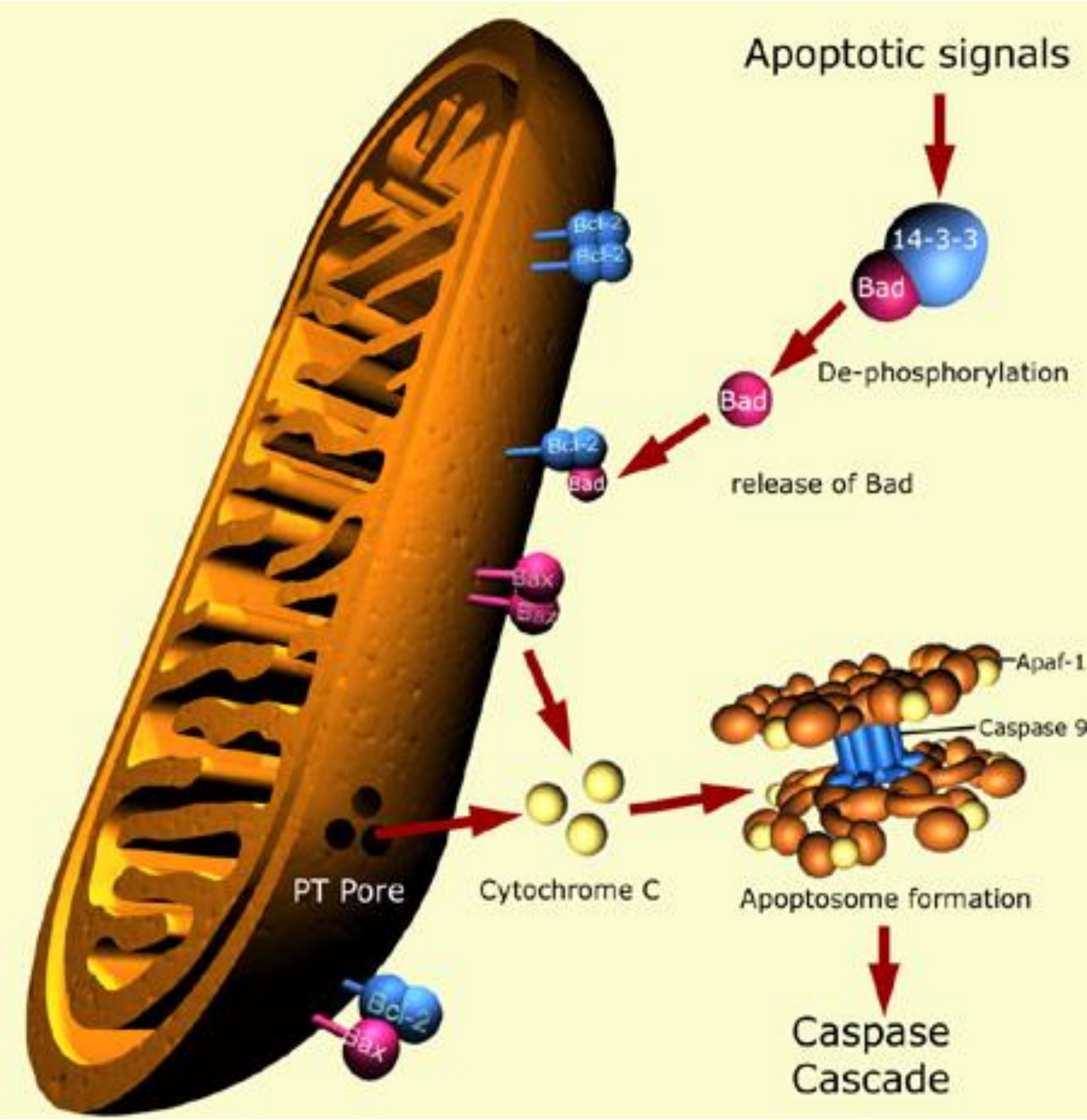


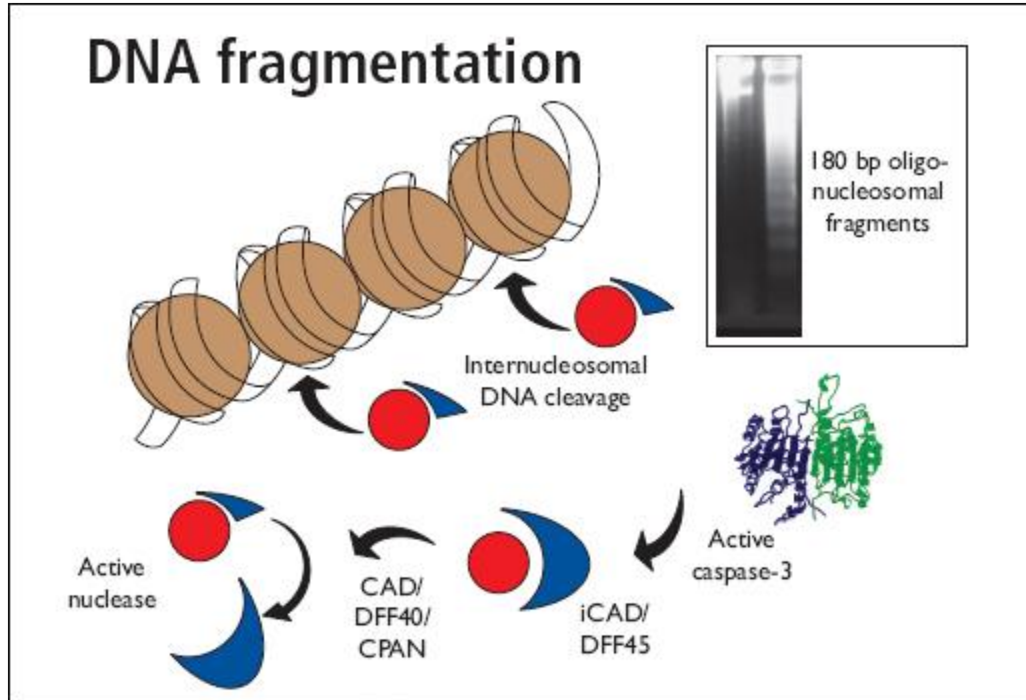
Image prepared by Catherine Twomey for the National Academies, *Understanding Stem Cells: An Overview of the Science and Issues* from the National Academies, http://www.nationalacademies.org/stemcells. Academic noncommercial use is permitted.

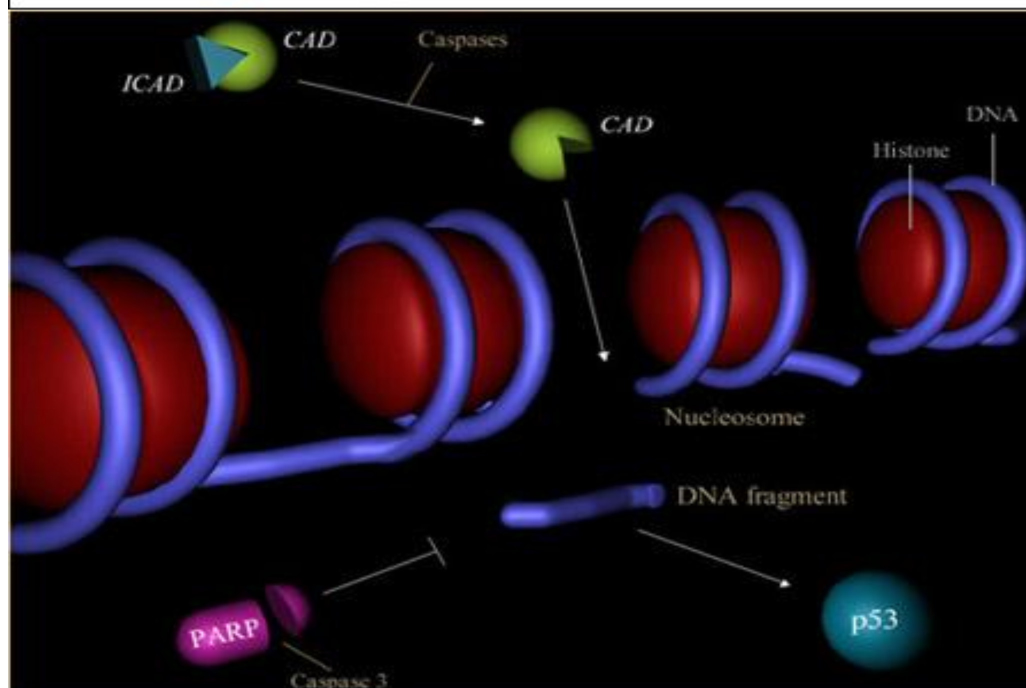
Apoptosis

- Loss of mitochondrial function and caspase activation

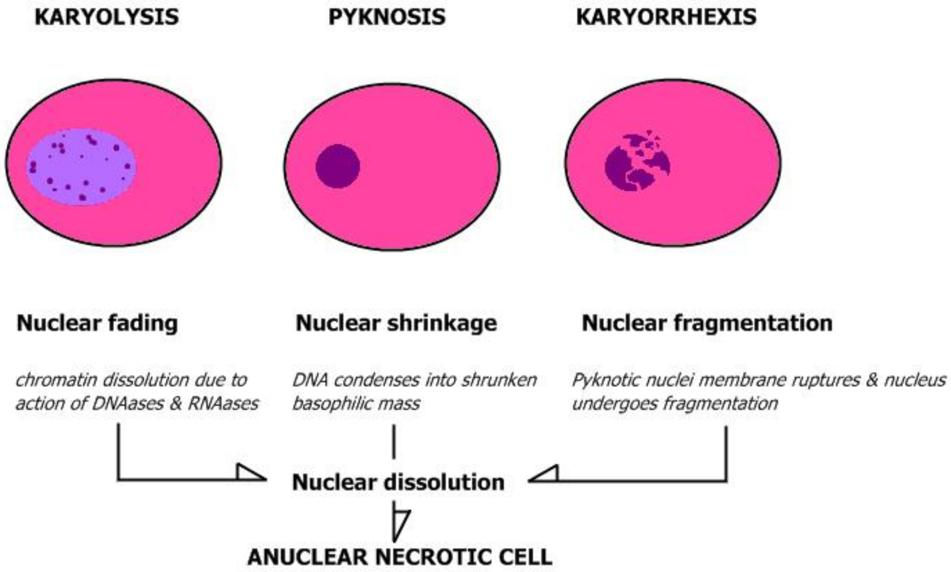


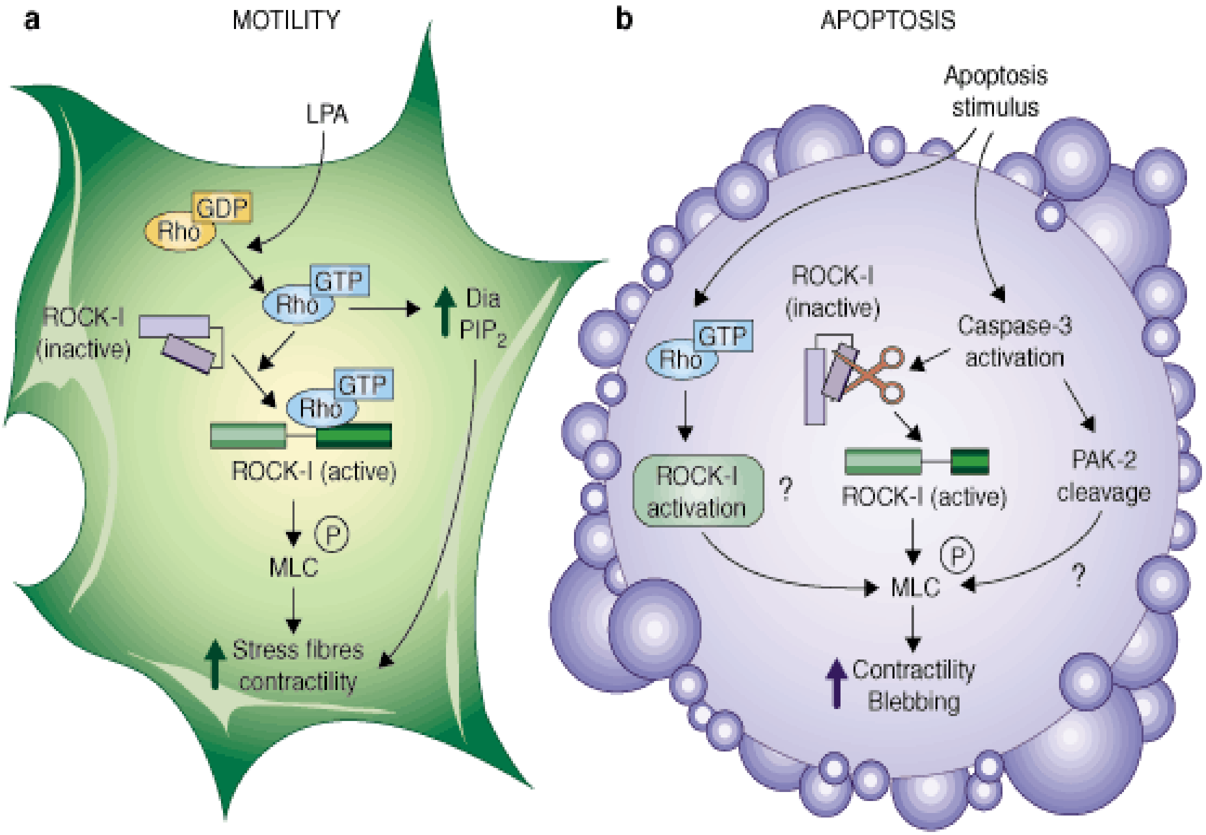
- Fragmentation of DNA: Endonucleases





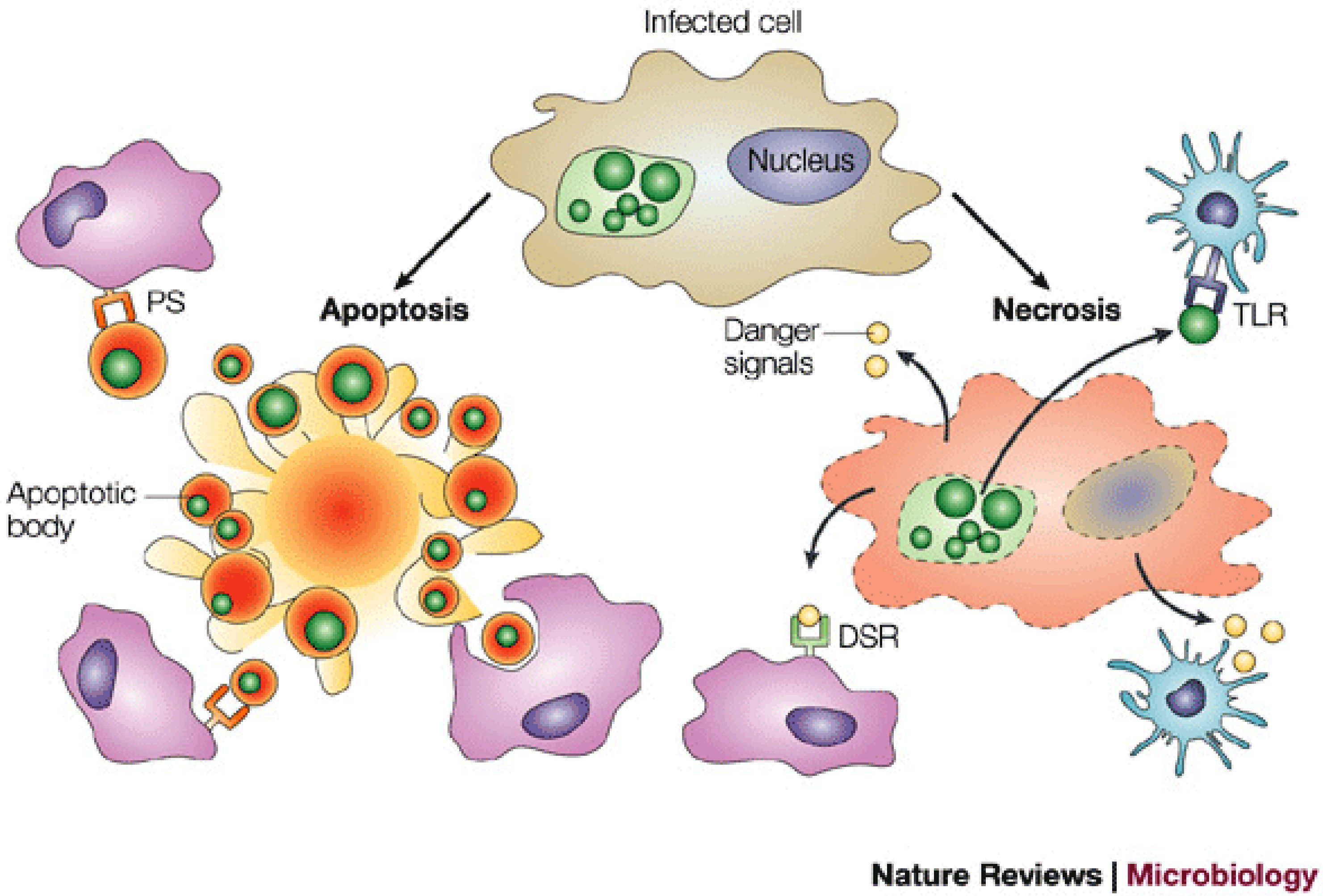
- Shrinkage of nuclear and cell volumes
- Cell membrane changes



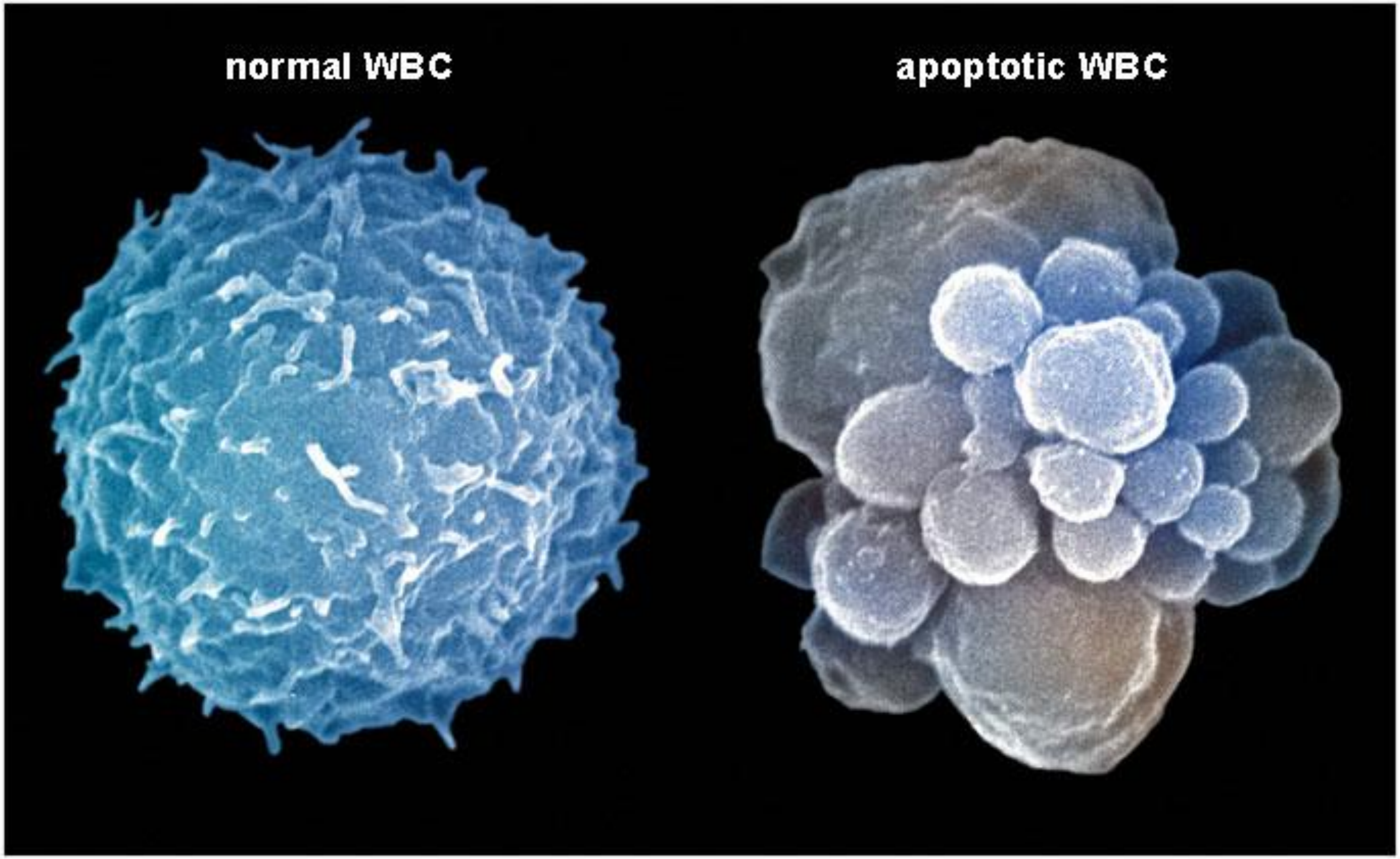


apoptotic bodies

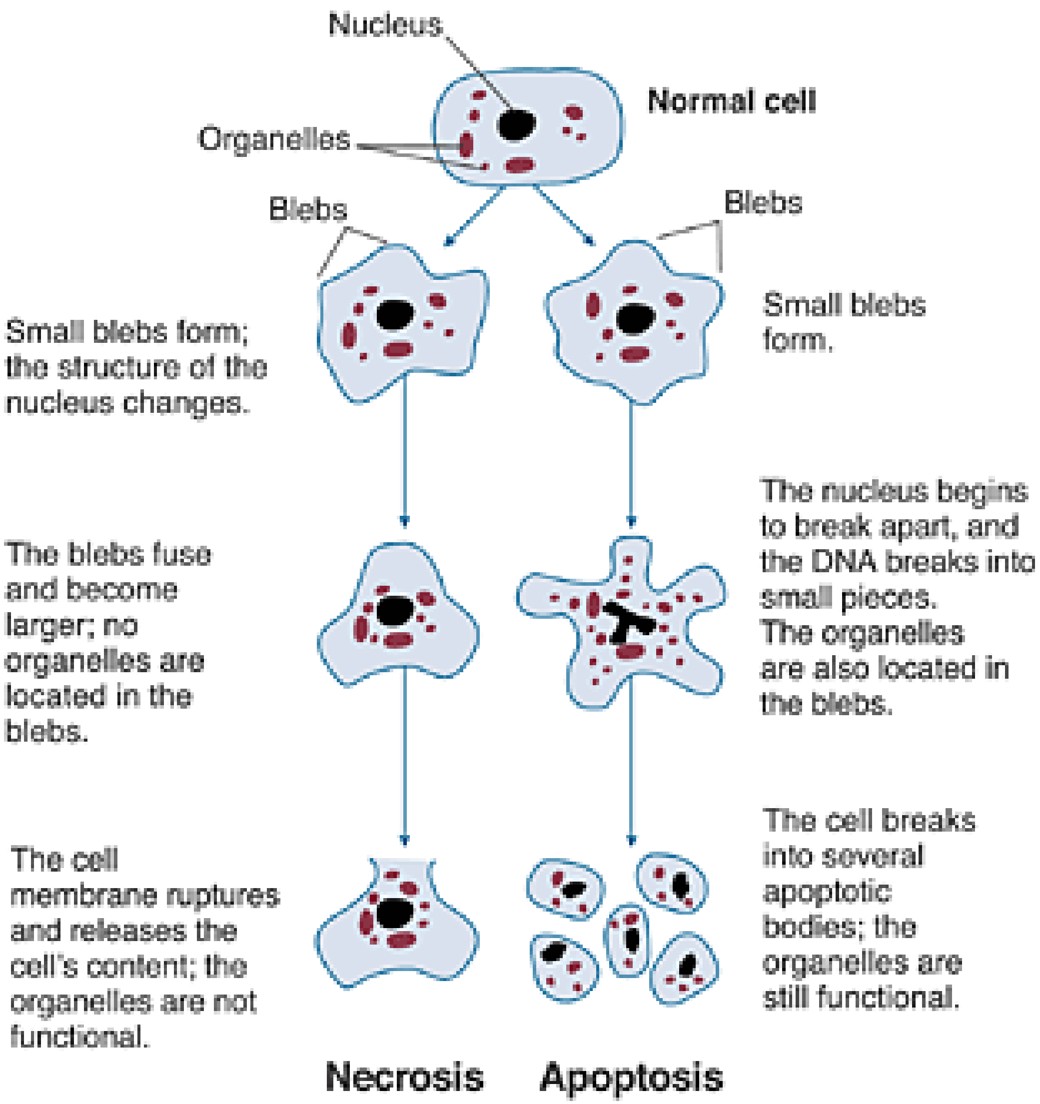
Newly exposed phospholipids on these bodies induce their phagocytosis



Apoptotic cell



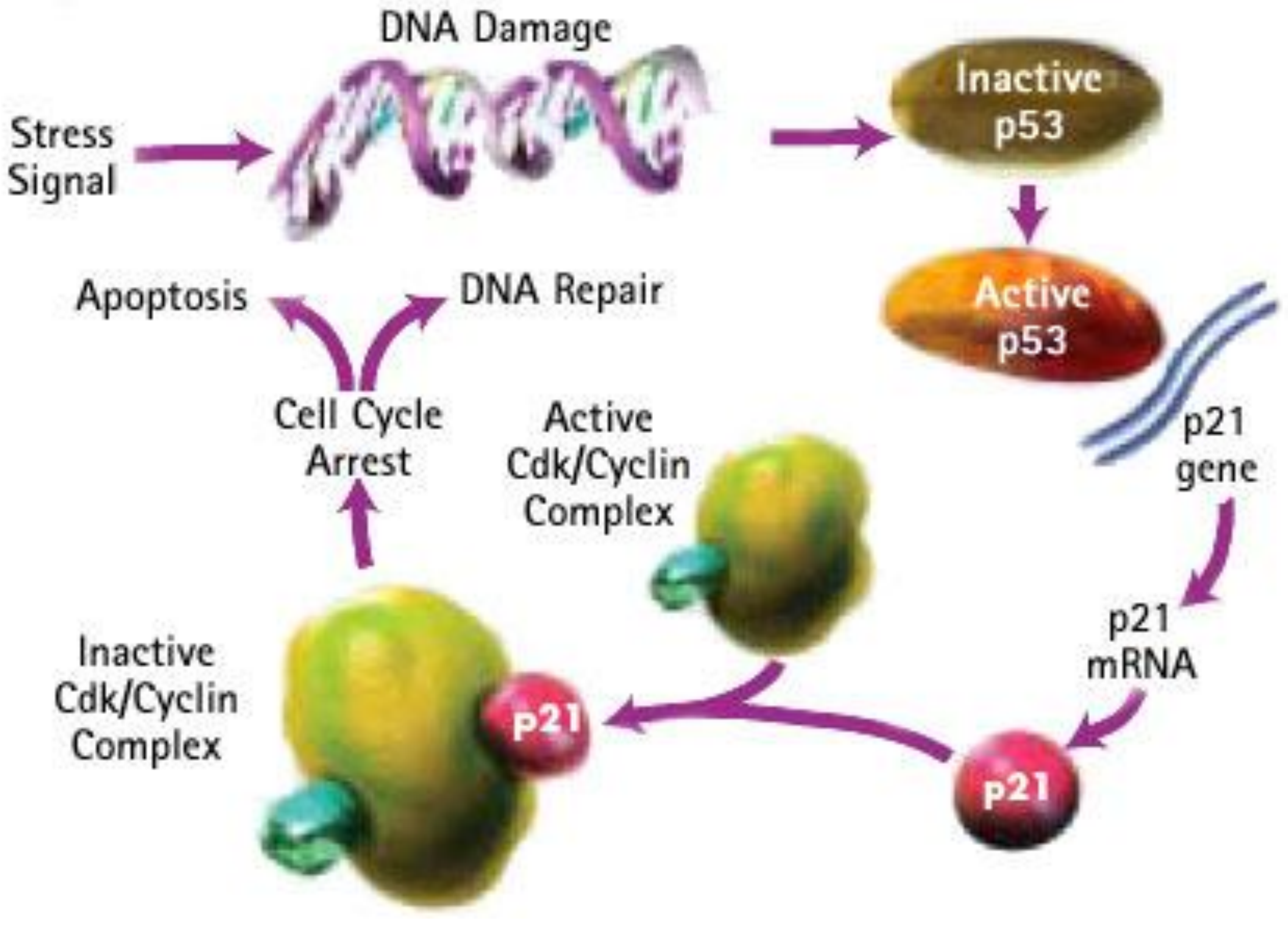
Comparison of the necrosis with apoptosis



Regulation of cell cycle

- Growth factor
- Repair factor (P53)
- Maturing promoting factor
- Protoncogens

Role of P53 in apoptosis




HIV
virion
gp41
gp120
CD4
CCR-5