The Cytoplasm

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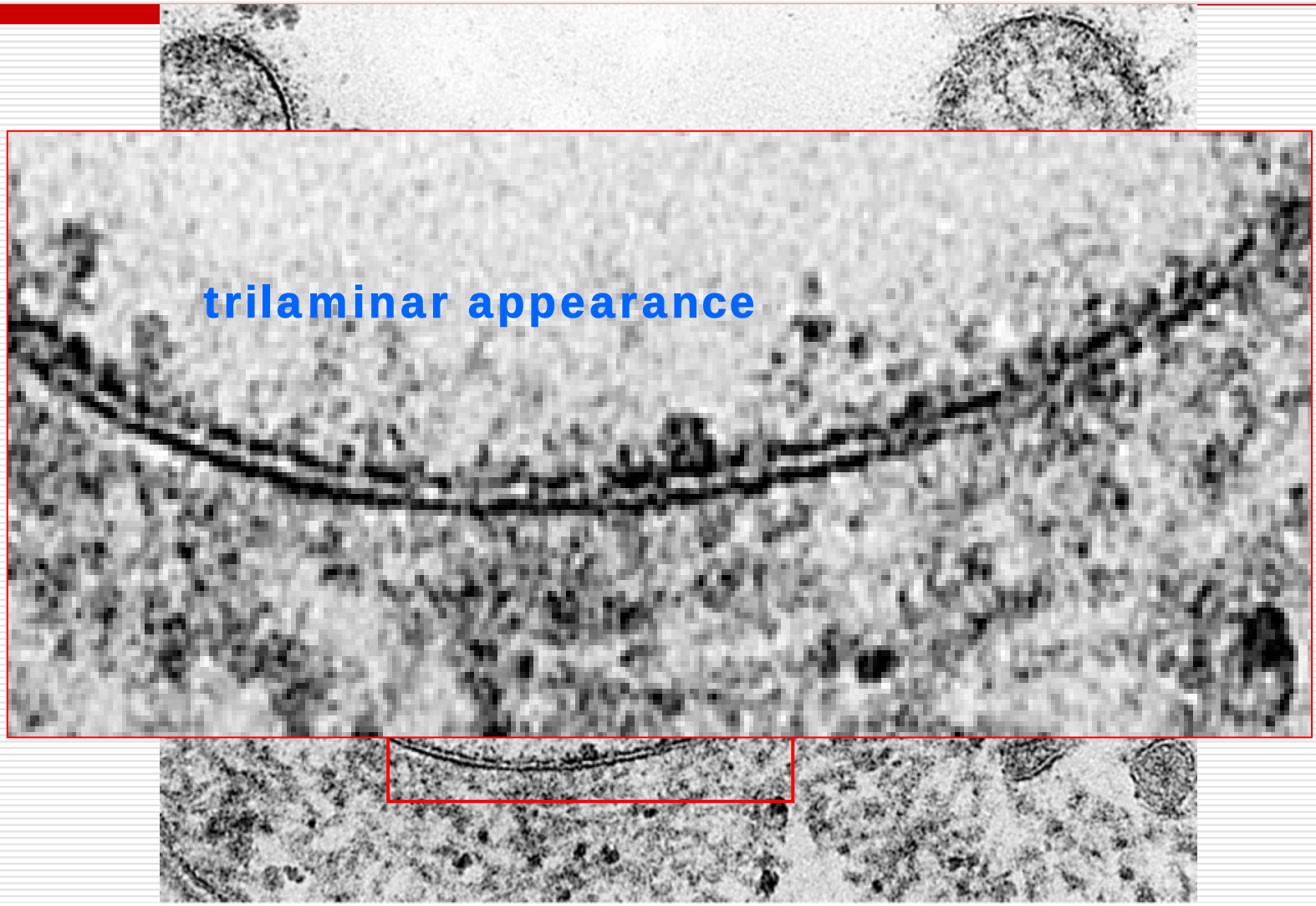
Cell components

- Cytoplasm
  - Plasma membrane
  - Organelles
  - Cytoplasmic deposits
  - Cytoskeleton
  - Cytosol (Matrix)
- Nucleus

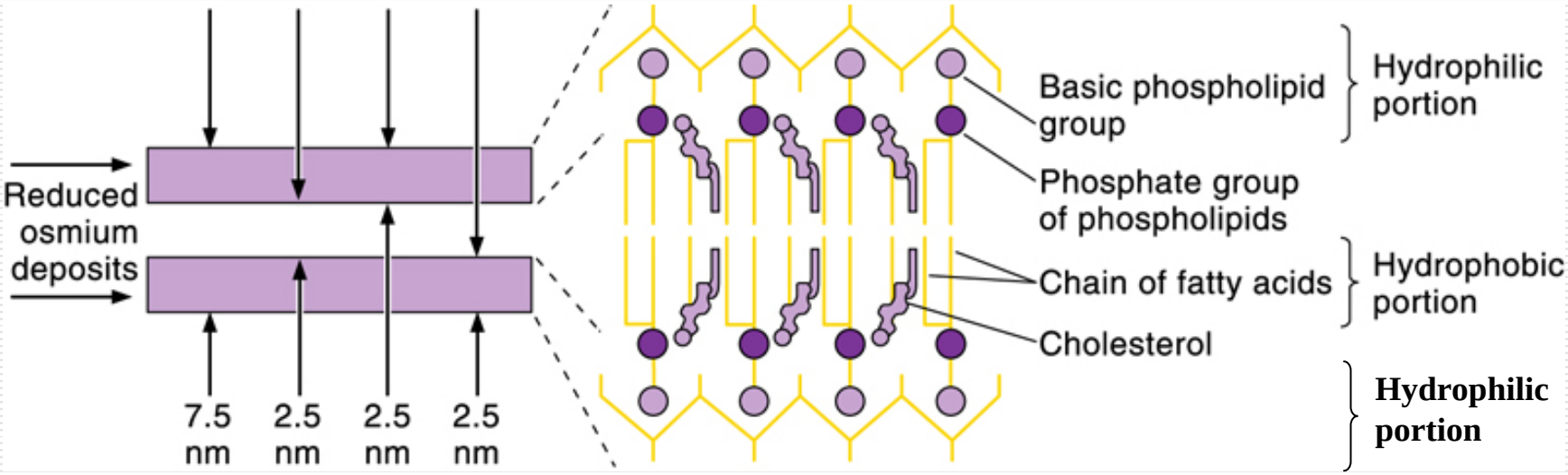
Plasma membrane

- Structure
  - Thickness:7.5nm~10nm
  - Unit membrane
  - Fluid mosaic model
- Main functions
  - Transmemebrane transport
  - Signal transmembrane transduction

Plasma membrane

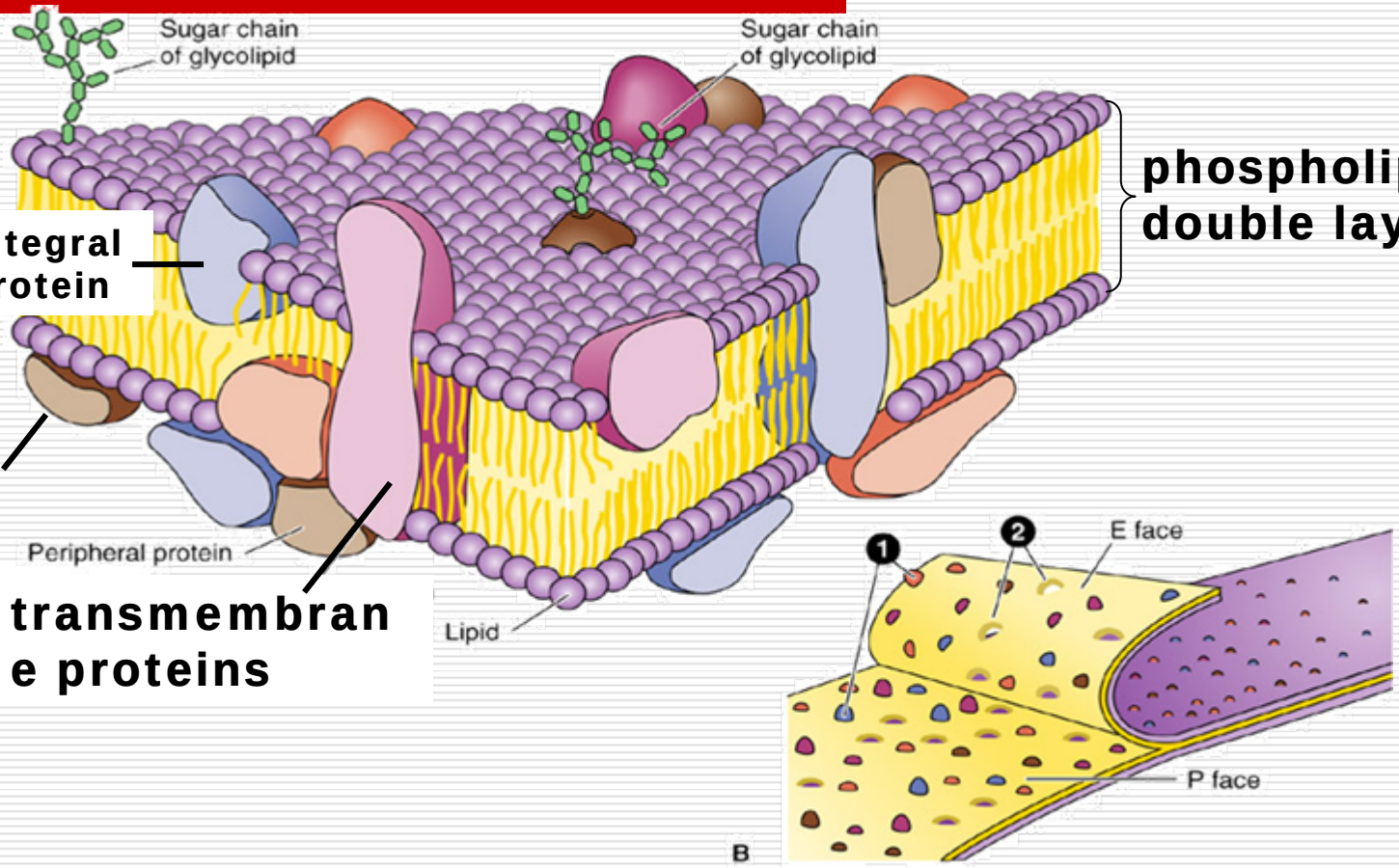


Plasma membrane



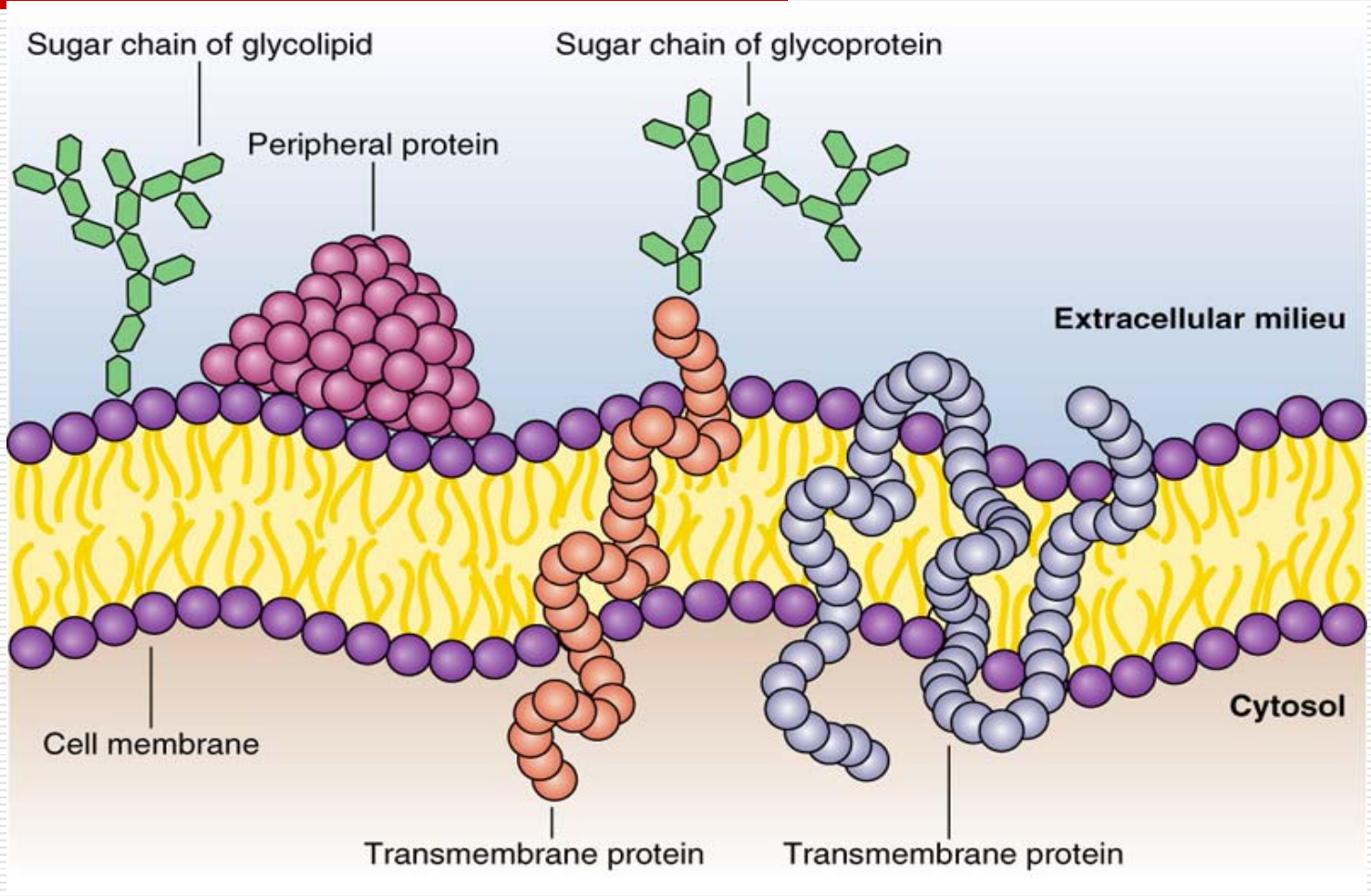
The ultrastructure and molecular organization of the cell membrane. The dark lines at left represent the two dense layers observed in the electron microscope.
Cholesterol breaks up the close packing of phospholipid chains, and makes the membrane more fluid.
The lipid composition of each half of the bilayer is different.

Plasma membrane



A: The fluid mosaic model of membrane structure.
B: Membrane cleavage occurs when cell is frozen and fractured into two parts along the hydrophobic interactions .

Plasma membrane



molecular structure of the plasma membrane.
one-pass and multipass transmembrane proteins, peripheral protein proteins are present mainly in the cytoplasmic face.

(1) Mitochondria

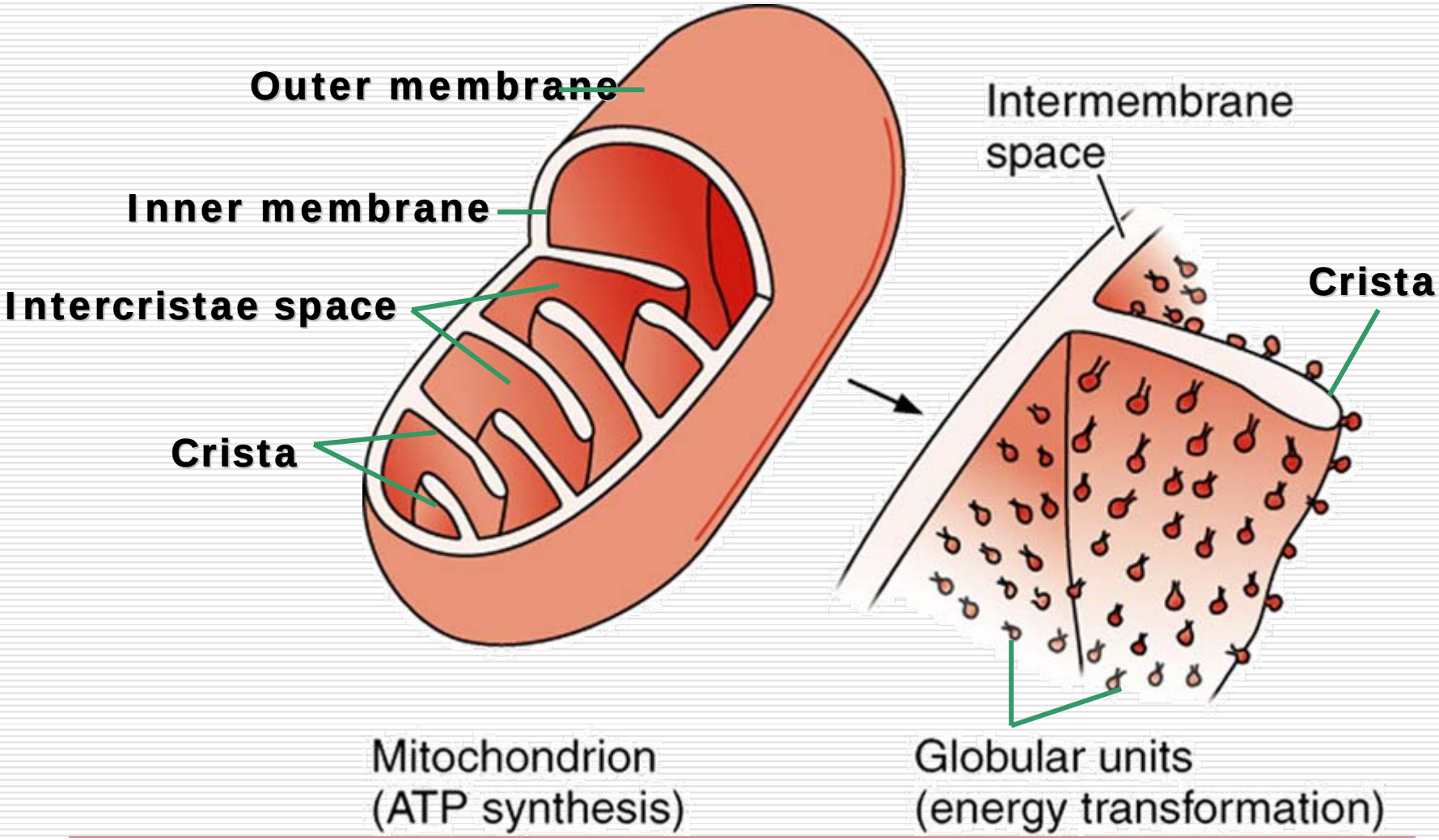
Structure

- Outer membrane
- Inner membrane
- Cristae: oxidative phosphorylation and electron transport system
- globular units: ADP to ATP
- Intermembrane space
- Intercristae space
- Matrix

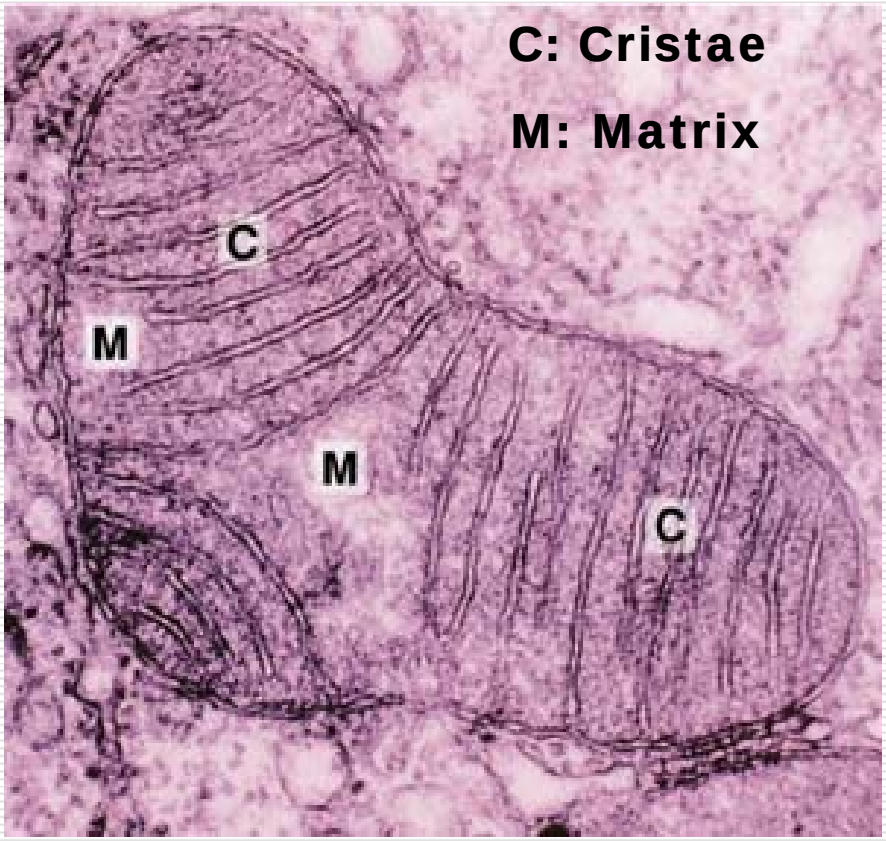
Function

- Transform the chemical energy of the metabolites present in cytoplasm into energy that is easily accessible to the cell.

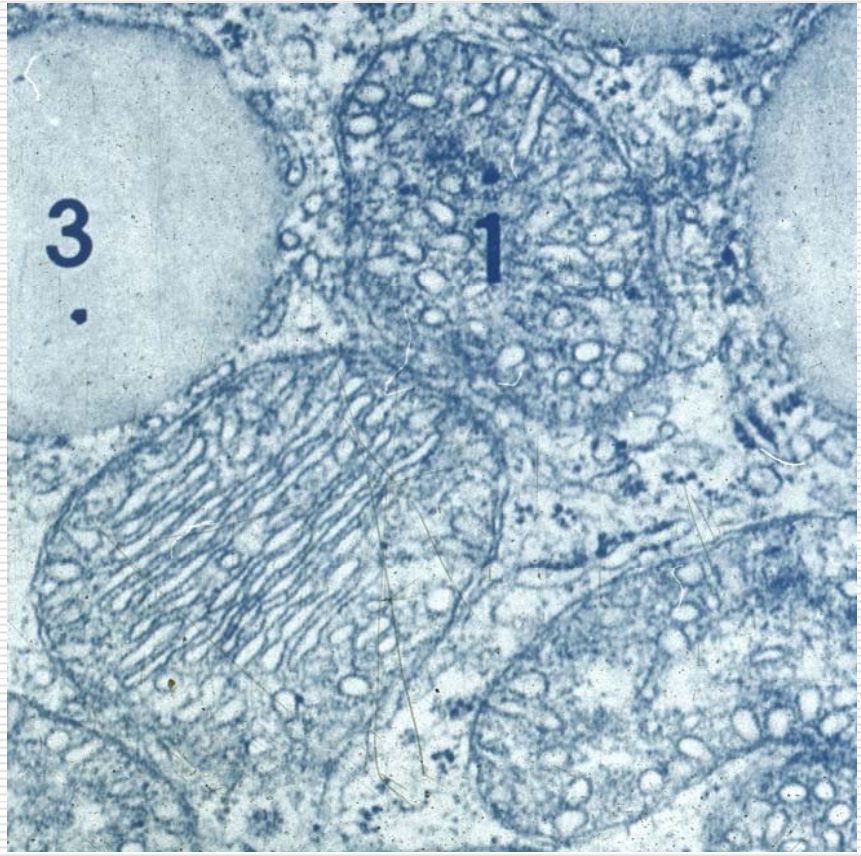
Mitochondria



Mitochondria



protein-secreting cell
flat, shelf-like cristae

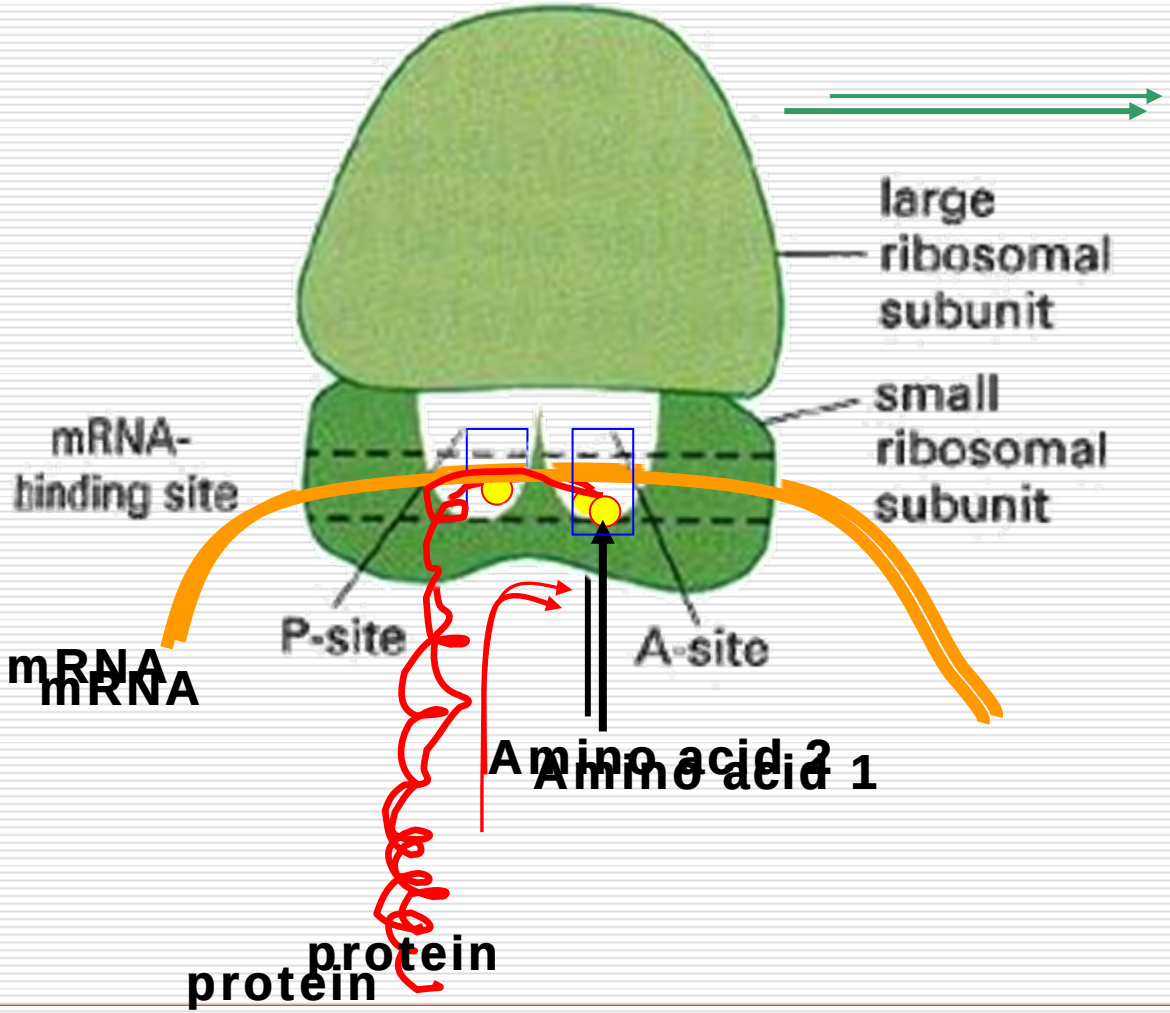


Steroid-secreting cell
tubular cristae

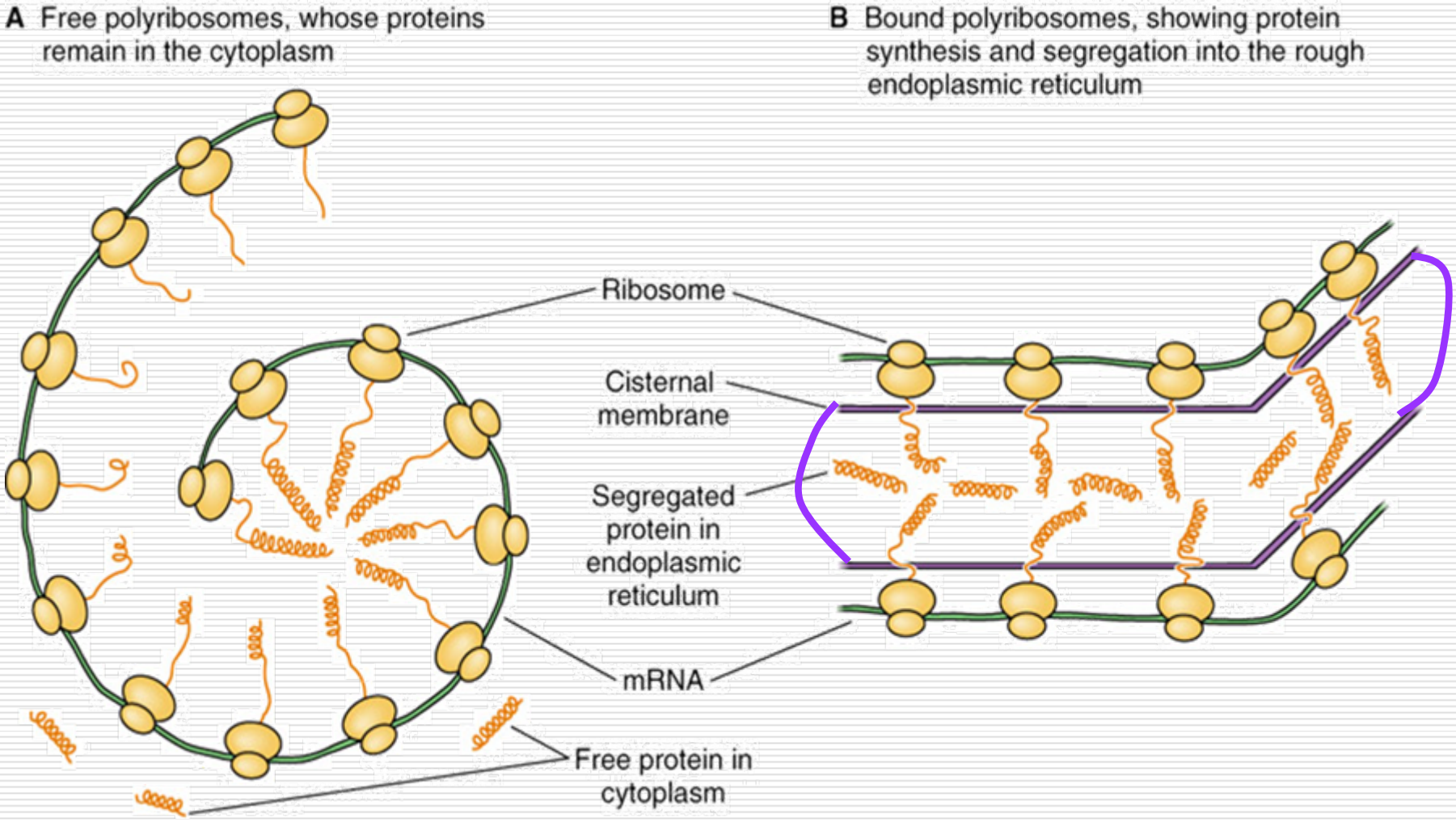
(2)Ribosomes

- Structure
  - Small electron-dense particles
  - Two different-sized subunits
  - Free ribosome (Polyribosome) & attached ribosome
  - Intensely basophilic
- Function
  - Take part in protein synthesis

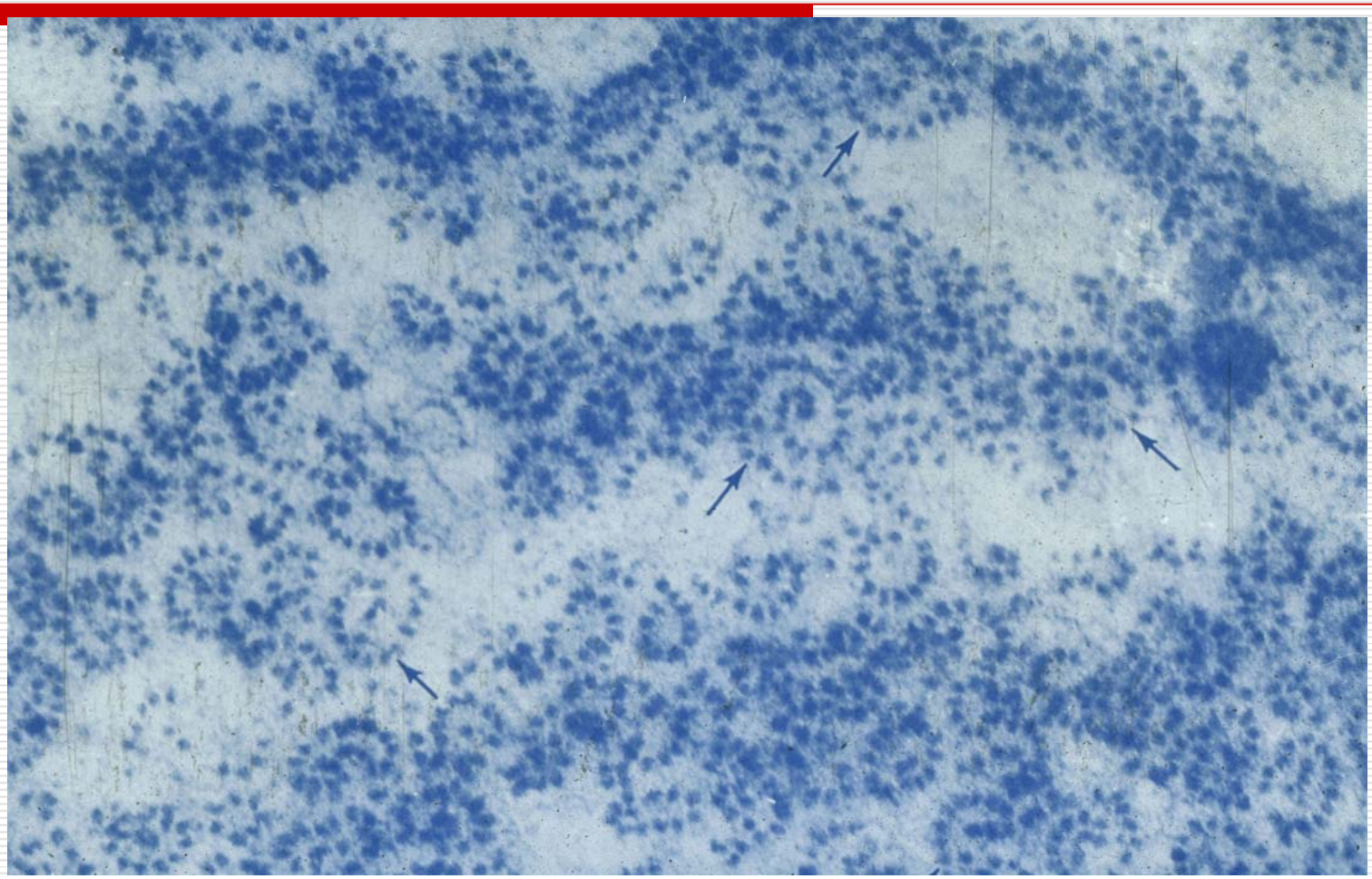
Ribosomes


large
ribosomal
subunit
small
ribosomal
subunit
mRNA-
binding site
P-site
A-site
mRNA
mRNA
Amino acid 2
Amino acid 1
protein
protein

Ribosomes


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

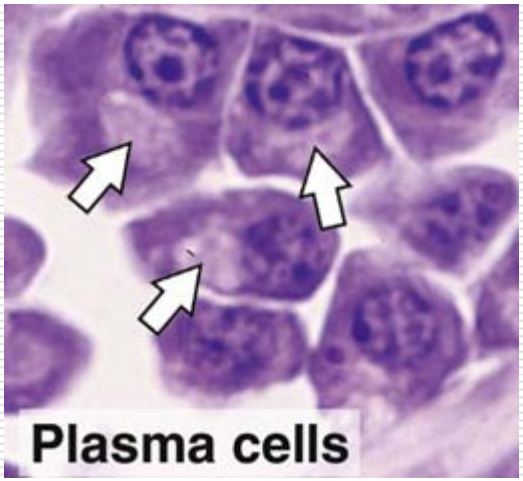
Ribosomes

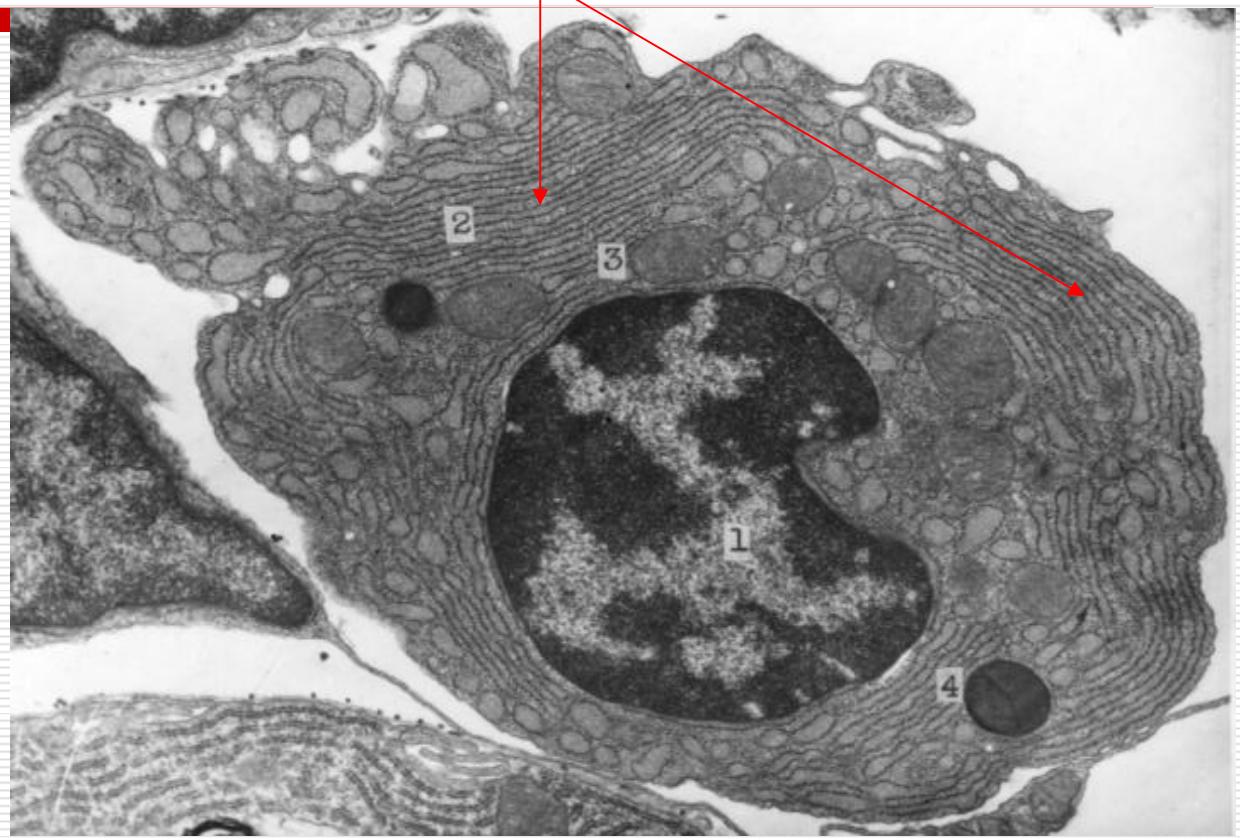


More polyribosomes like curves and few single free ribosomes

attached ribosomes on the cytoplastic surface of endoplasmic reticulum

Layers of Endoplasmic reticulum with attached ribosomes





Because of developed attached ribosomes in cytoplasma, plasma cells is stained blue or basophilic in HE staining.

(3)Endoplasmic Reticulum (ER)

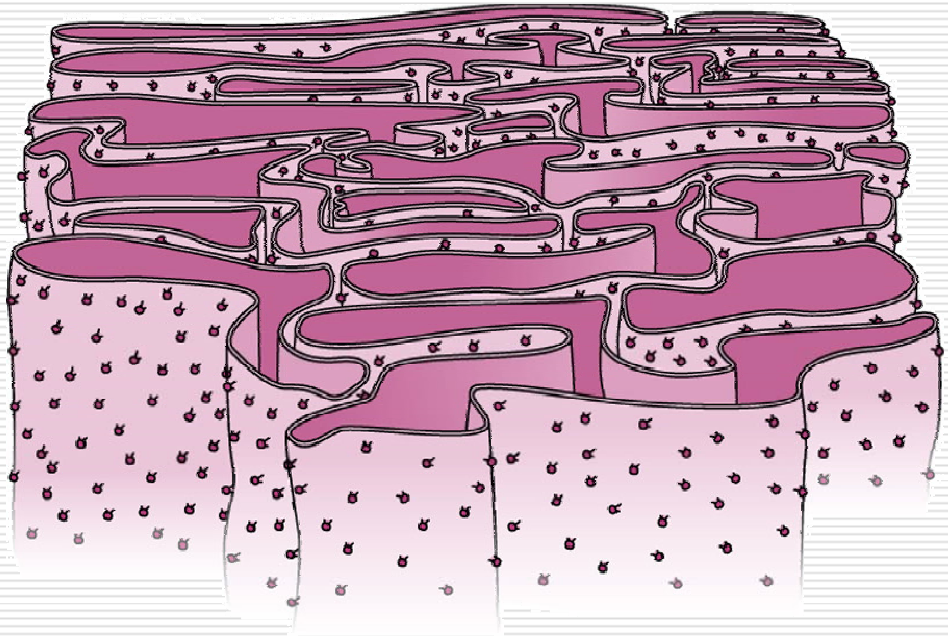
- Connecting and branching channels made by a continuous membrane
- Classification
  - Rough Endoplasmic Reticulum (RER)
  - Smooth Endoplasmic Reticulum (SER)

Rough Endoplasmic Reticulum (RER)

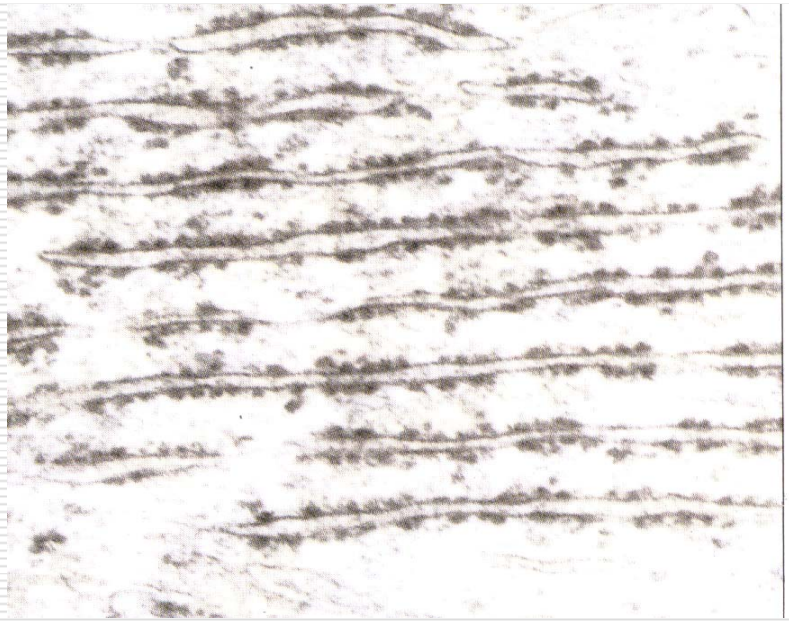
- Distribution: cells specialized for protein secretion
- Structure
  - Saclike and parallel stacks of flattened cisternae
  - Polyribosomes on the cytosolic surface
- Function
  - synthesiz proteins
    - Intracellular storage (eg, in lysosomes)
    - intracellular storage of proteins for export (eg, in pancreas)
    - a component of other membranes (eg, integral proteins)
  - Post-translational modifications of newly formed polypeptides

Rough Endoplasmic Reticulum (RER)

3-D



2-D



Saclike and parallel stacks of flattened cisternae
Polyribosomes on the cytosolic surface
It should be kept in mind that the cisternae appear separated in sections made for electron microscopy, but they form a continuous tunnel in the cytoplasm.

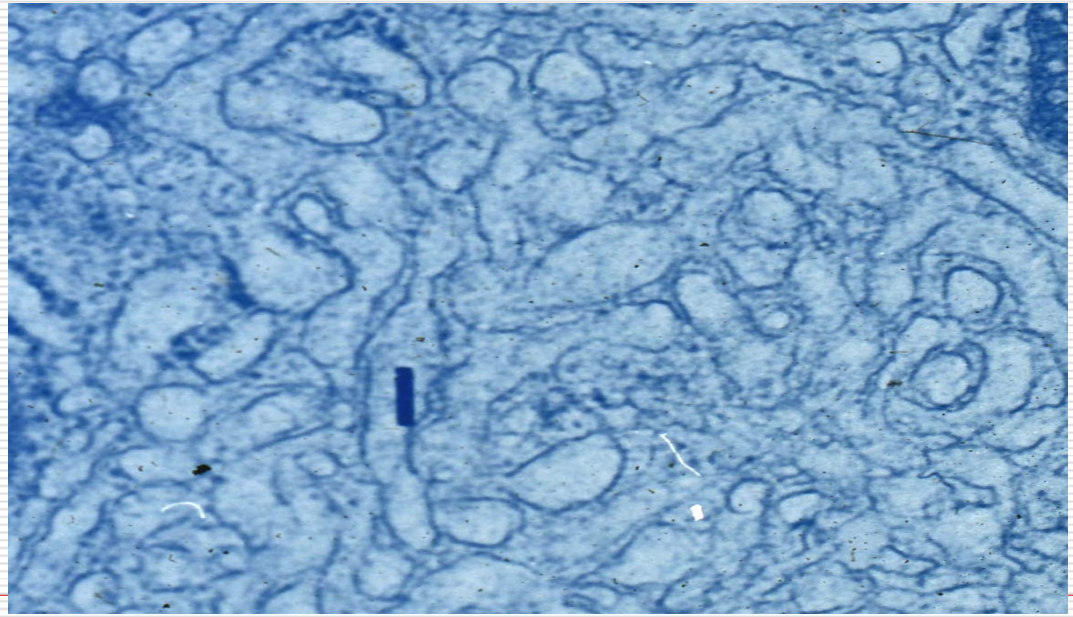
Smooth Endoplasmic Reticulum (SER)

- **Structure**
  - Appear smooth and lacks polyribosomes
  - Cisternae are tubular or vesicle
- **Function**
  - Synthesizes phospholipids for cell membranes
  - Participates in synthesis of steroid hormones
  - Participates in neutralizing noxious substances
  - Participates in the utilization of glucose
  - Participates in the contraction process in muscle cells (Sarcoplasmic reticulum)

Endoplasmic Reticulum

3-D

2-D

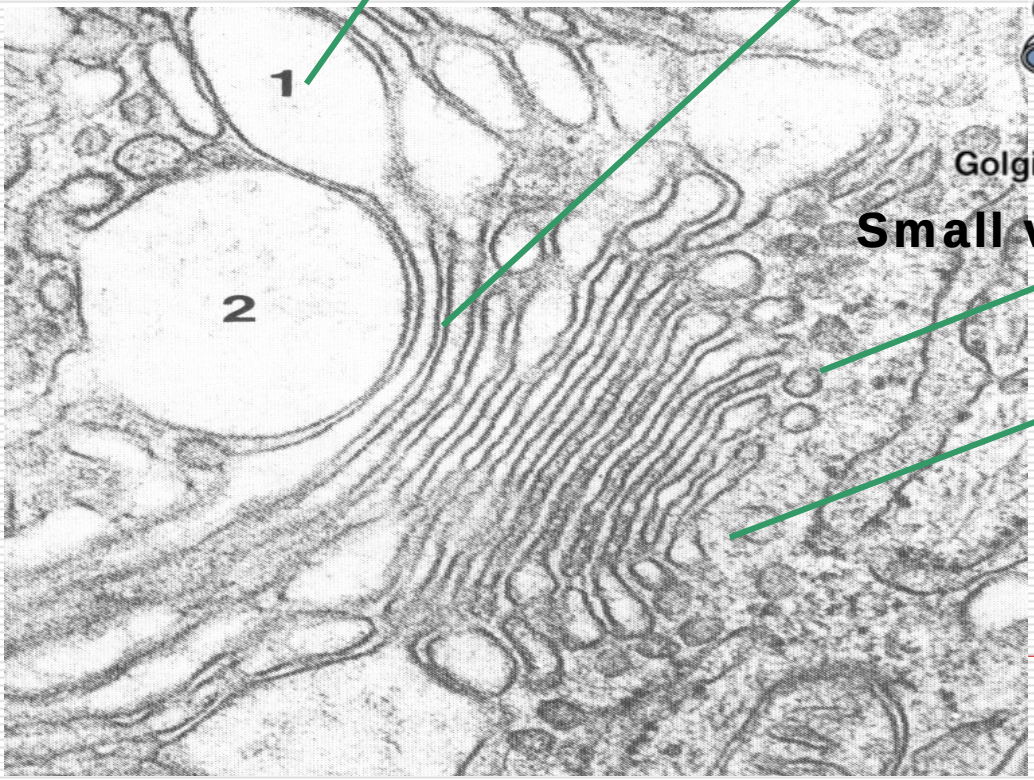


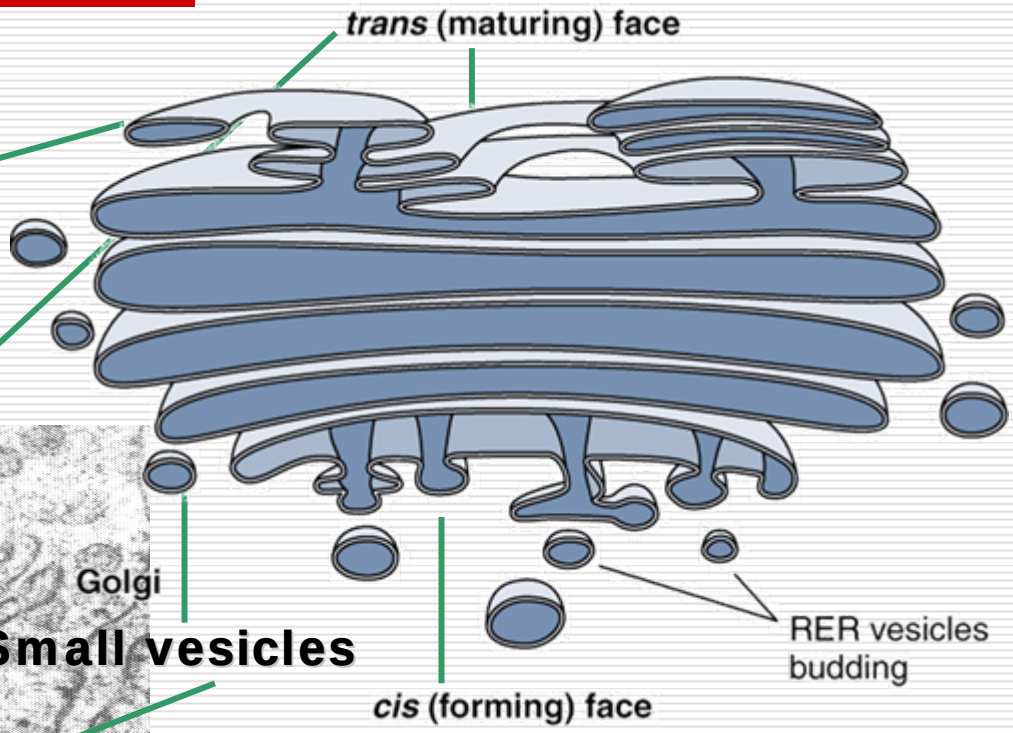
The cisternae of SER are tubular and more likely to appear as vesicles in different shapes and sizes.

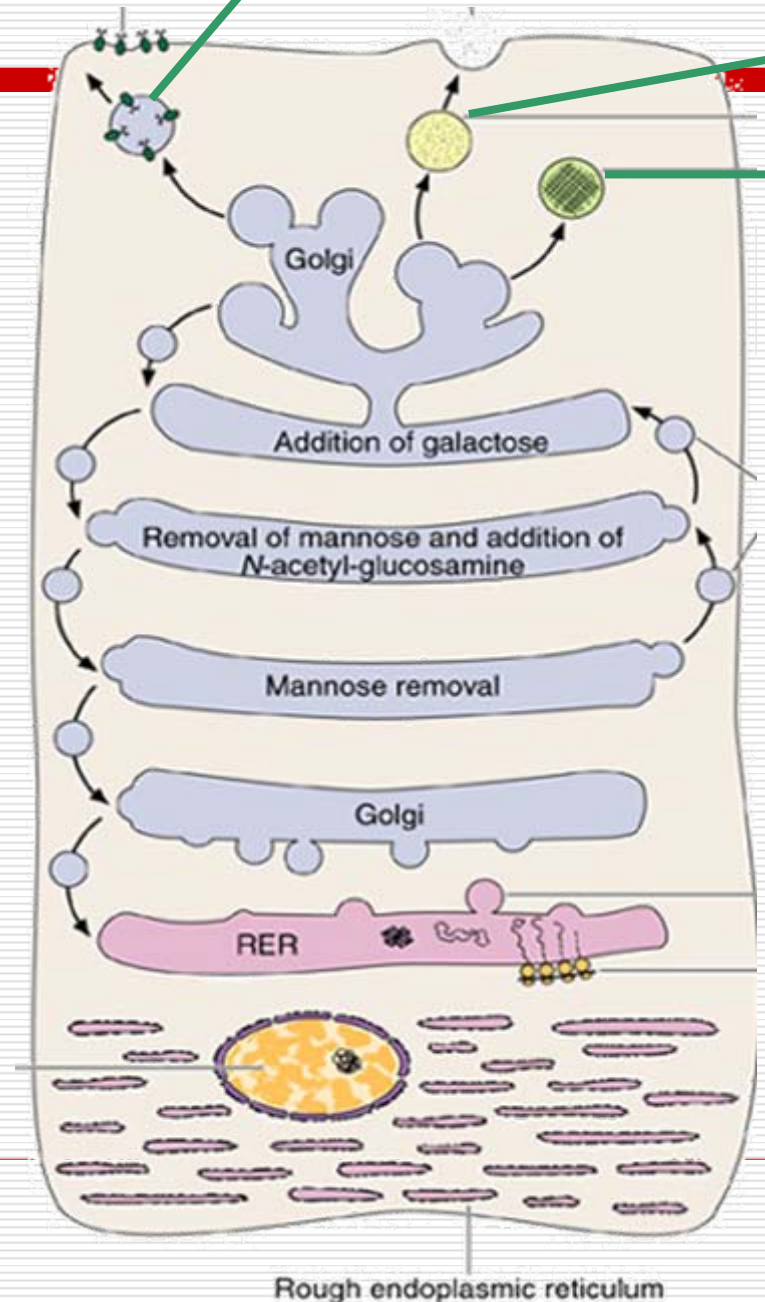
(4) Golgi Complex (Golgi Apparatus)

- **Structure**
  - Small vesicles (Transport vesicles)
  - Golgi cisternae
    - Forming, convex, or cis face
    - Maturing, concave, or trans face
  - Large vacuoles (Condensing vacuoles)
- **Functions**
  - Initiates packing, concentration, and storage of secretory products.
  - Participates in post-translational modifications and limited proteolysis of proteins.

Golgi Complex (Golgi Apparatus)







Near the cis face of Golgi complex, the RERs bud off small vesicles (transport vesicles) that shuttle newly synthesized proteins to the Golgi complex for further processing. The molecules are released from the Golgi trans face in larger vesicles to constitute secretory vesicles, lysosomes, or other cytoplasmic components.

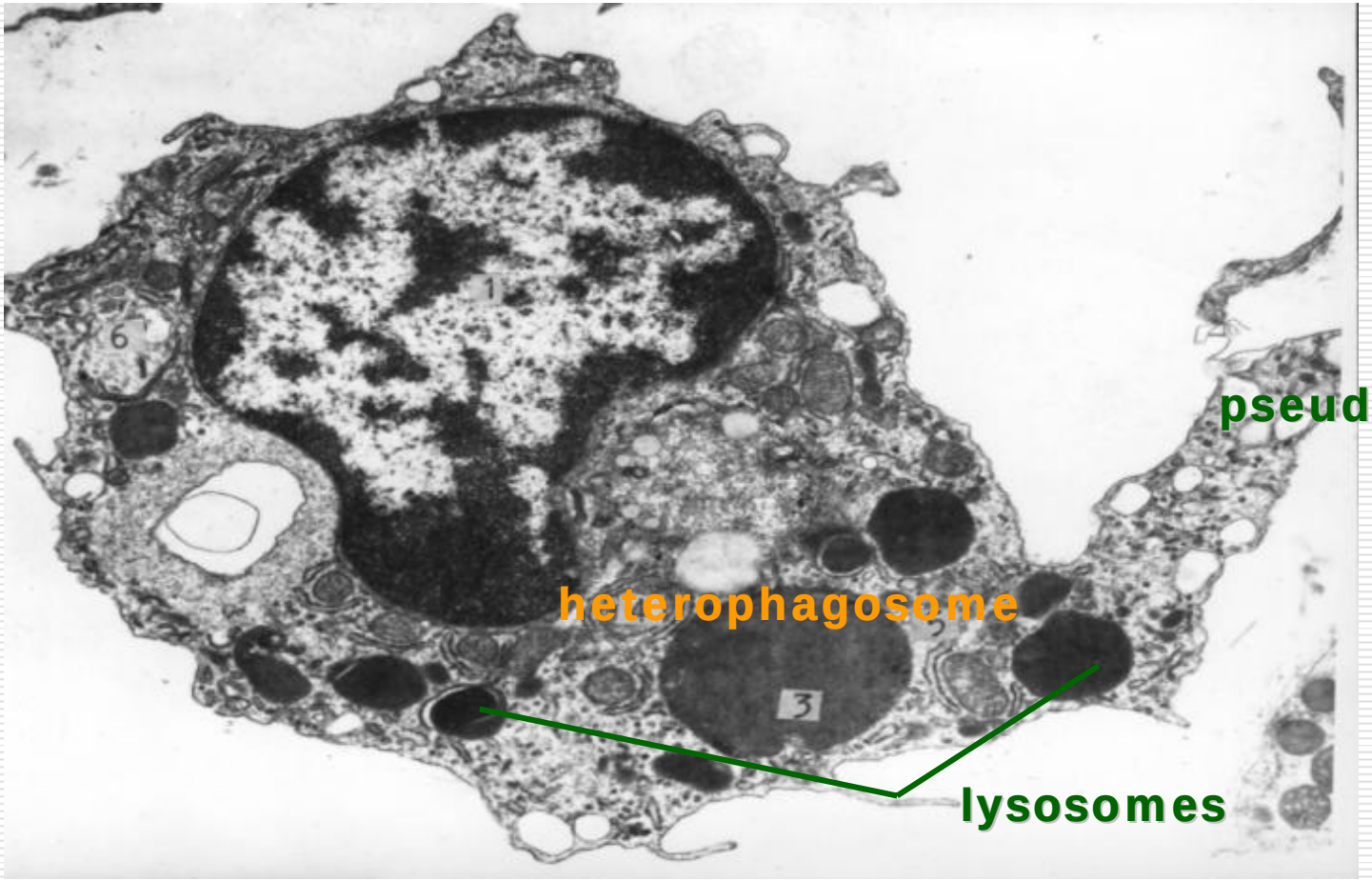
(5) Lysosomes

- **Structure**
  - electron-dense, spherical, membrane-limited vesicles
  - hydrolytic enzymes
- Function: intracytoplasmic digestion
- Origin:
  - Enzymes are synthesized and segregated in RER, modified and packaged in Golgi complex

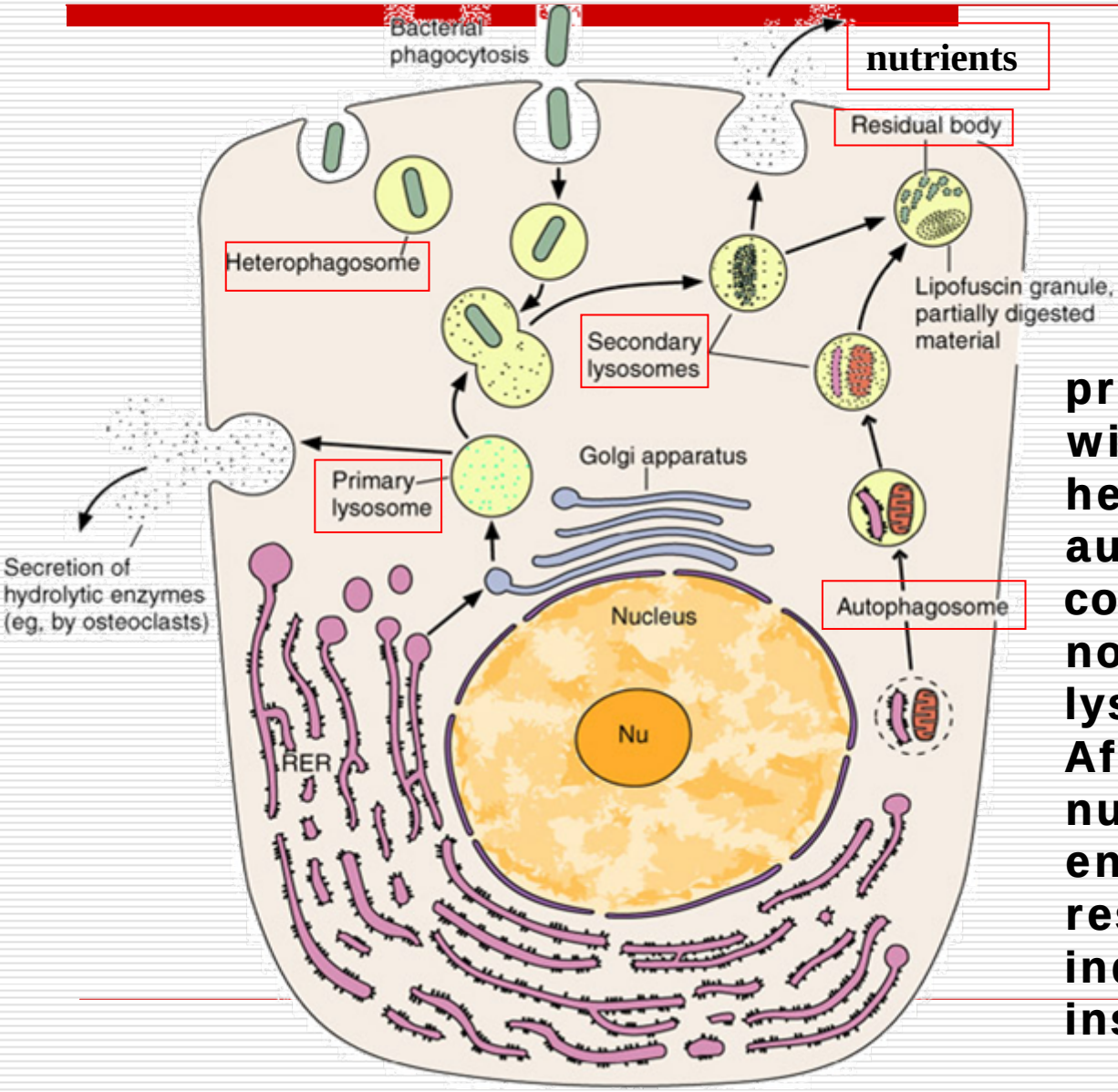
Lysosomes

- **Functions**
  - **cells exhibiting phagocytic activity**
  - **Digest material taken into the cell from its environment**
  - **Concern the turnover of cytoplasmic organelles**
- **Structure**
  - **Primary lysosomes**
  - **Secondary lysosome**
  - **Residual bodies (lipofuscin, or age pigment)**

Lysosomes



There are many lysosomes in macrophage.

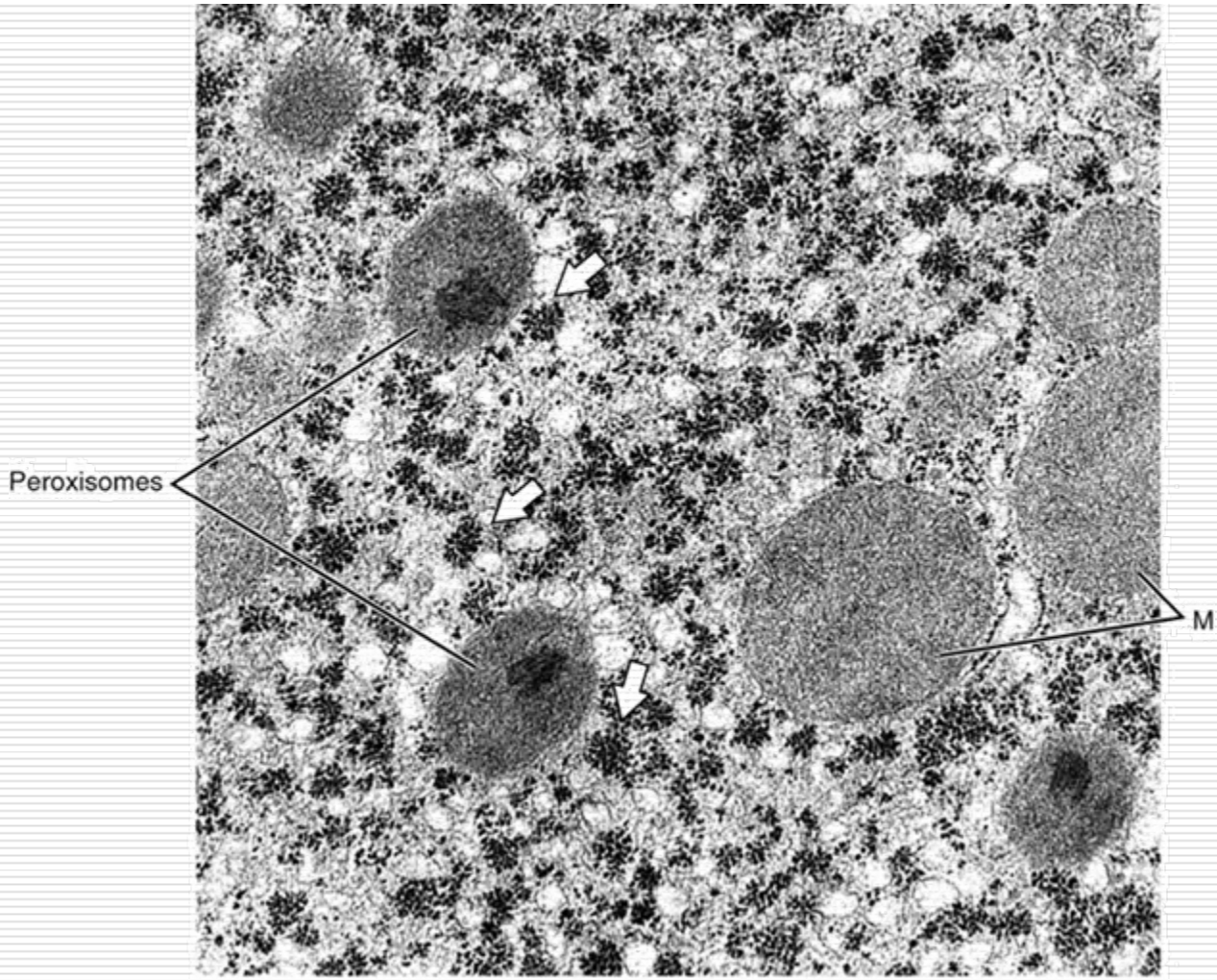


primary lysosome fuses with the membrane of heterophagosome or autophagosomes. The composite structure is now termed secondary lysosome.
After digestion, nutrients diffuse and enter the cytosol.
residual bodies with indigestible compounds inside are retained.

(6) Peroxisomes or Microbodies

- **Structure characteristics**
  - Spherical membrane-limited organelles with dense core
  - Contain catalase and peroxydase
- **Function**
  - Eliminate hydrogen peroxide and peroxidate ($2H_2O_2 \rightarrow 2H_2O+O_2$; 2RO2→2HO+O2)
  - Degrade toxic molecules in liver and kidney
  - Participate in lipid metabolism
  - Formation of bile acid and chelosterol

Peroxisomes

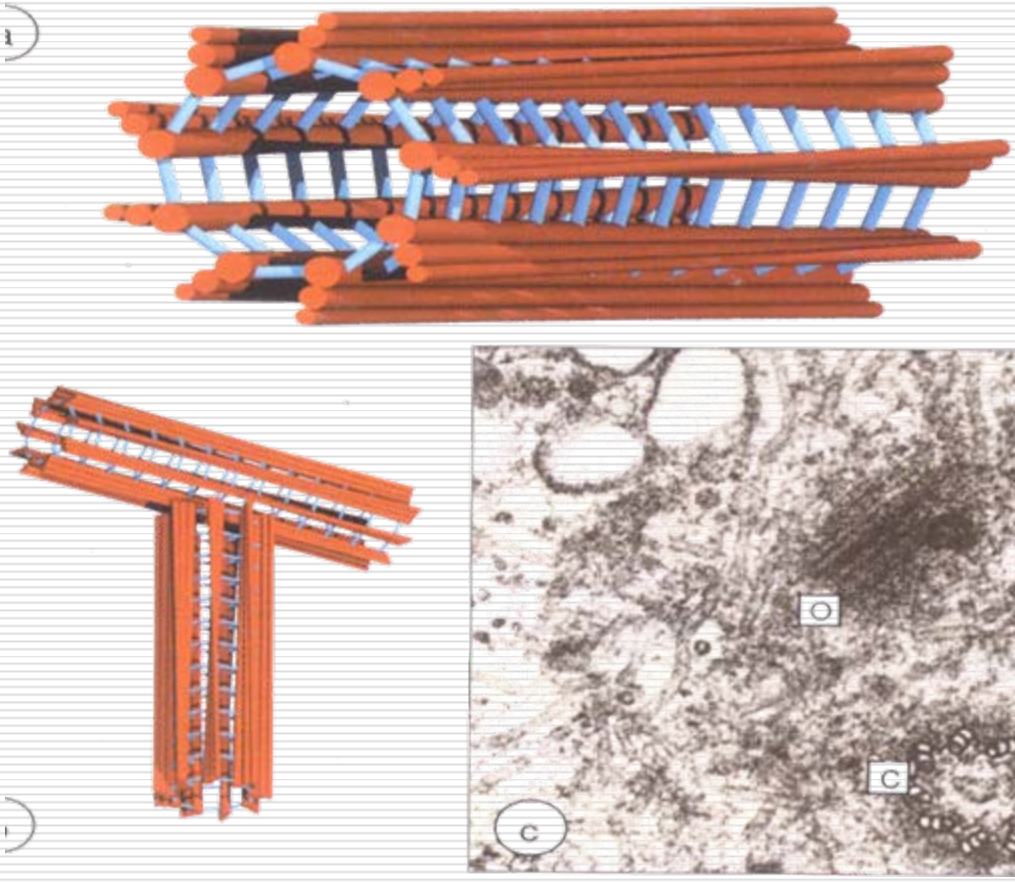


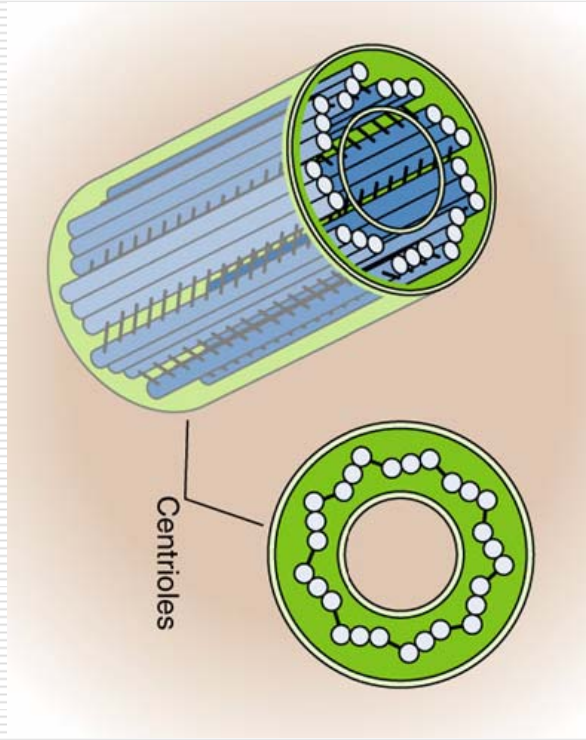
Round membrane-limited organelles with dense core

(7) Centrosome

- two centrioles at right angles
- **Centriole:**
  - cylindrical structures;
  - nine sets of microtubules arranged in triplets.
- **Function**
  - responsible for forming the mitotic spindle

Centriole & Centrosome



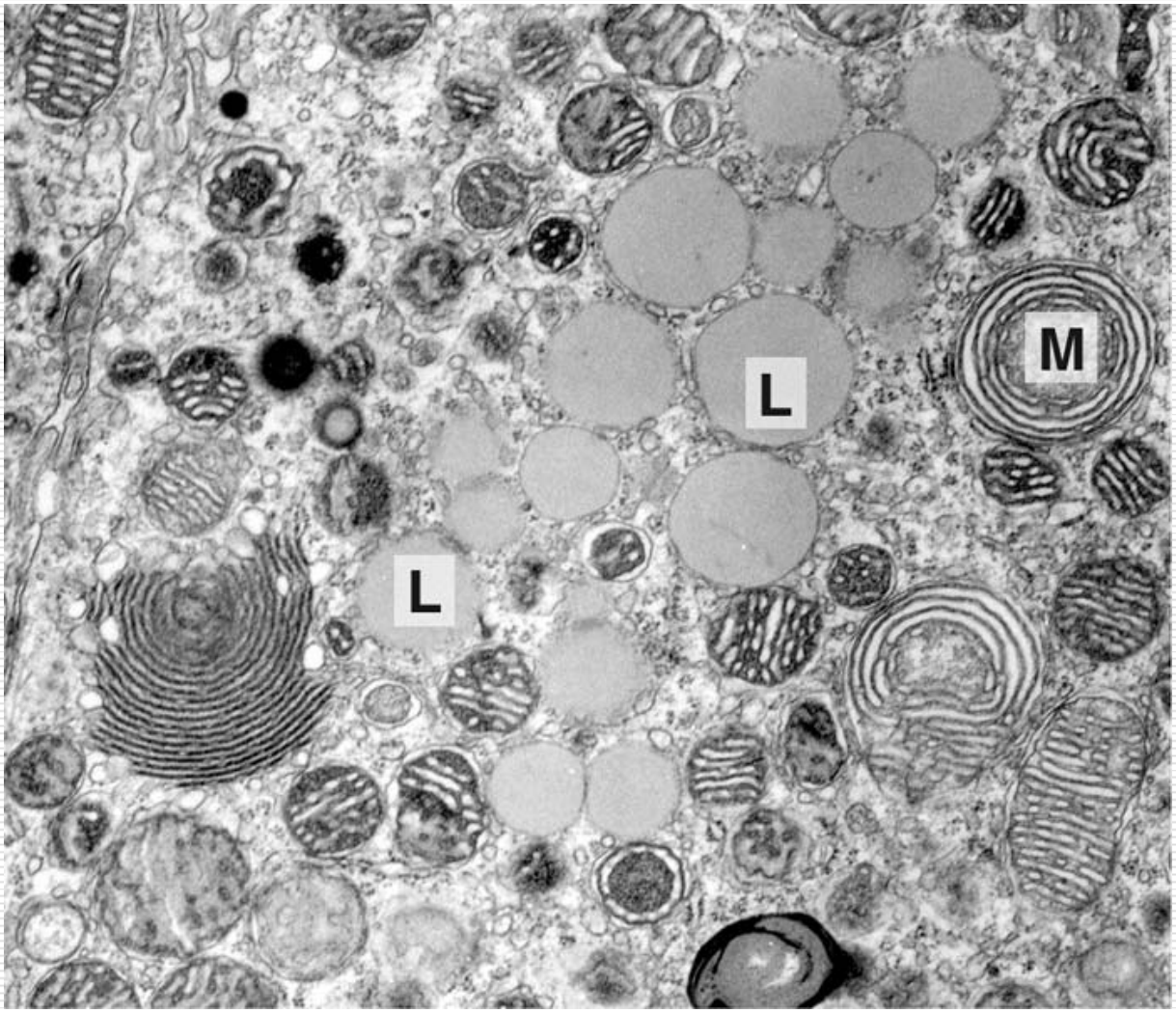


Centriole shows nine sets of microtubules arranged in triplets. Centrosome is made of a pair of centrioles surrounded by a granular material

Cytoplasmic deposits

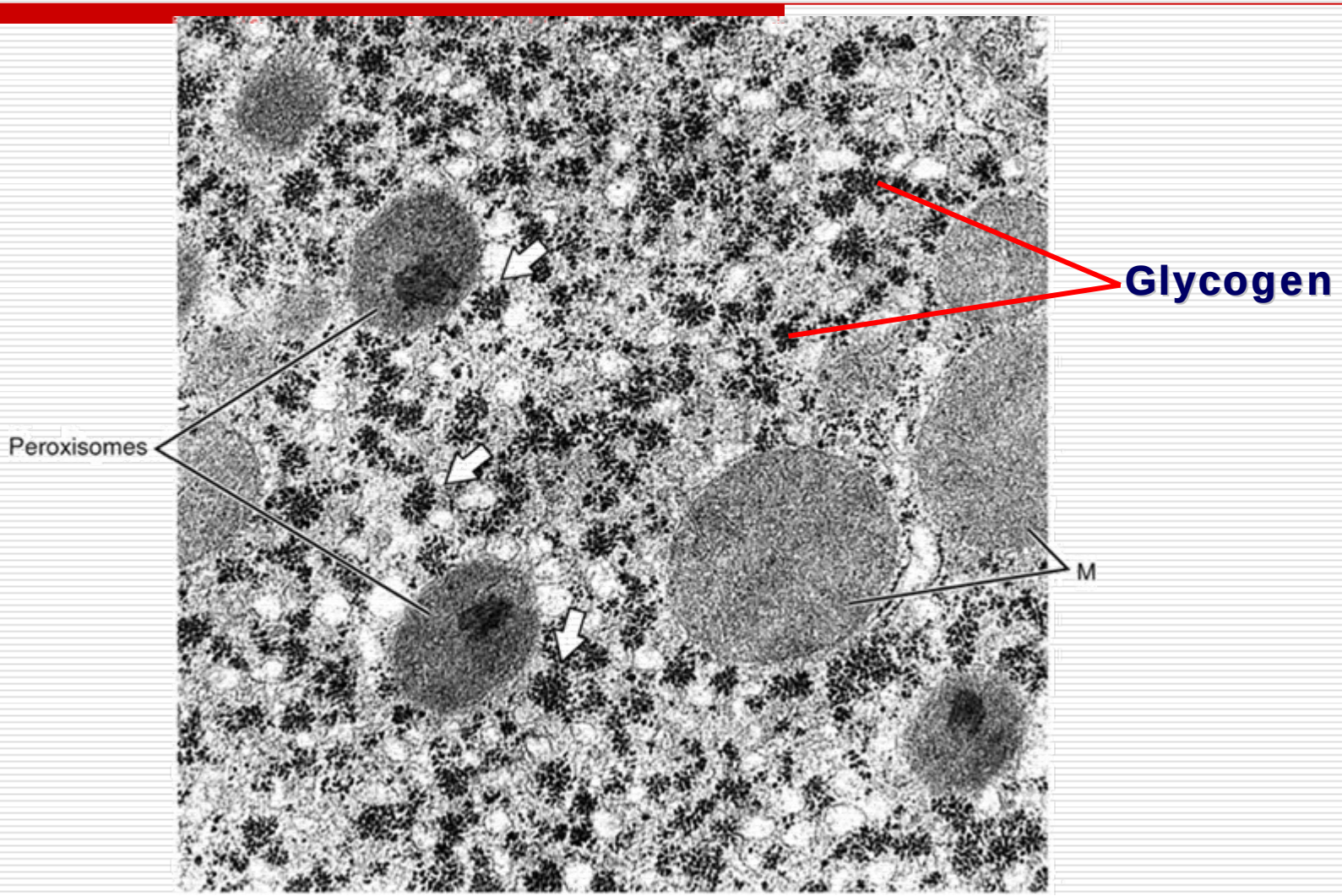
- Lipid droplets
- Glycogen deposits
- Secretory granules or secretory vesicles
- Pigments (Lipofuscin)

Lipid droplets

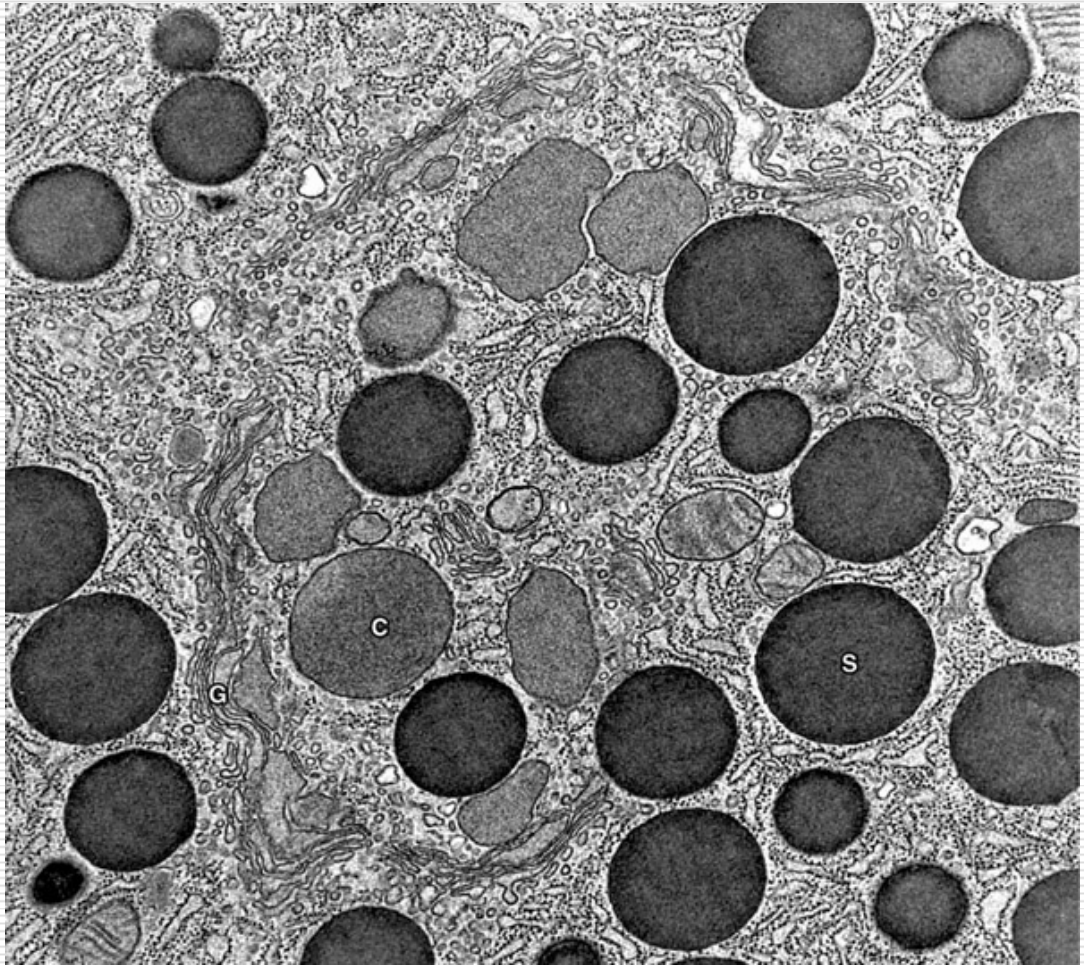


Lipid droplets without membrane are different in size and electron lucent.

Glycogen deposits



Glycogen granules aggregate together, without limited-membrane, like flowers.



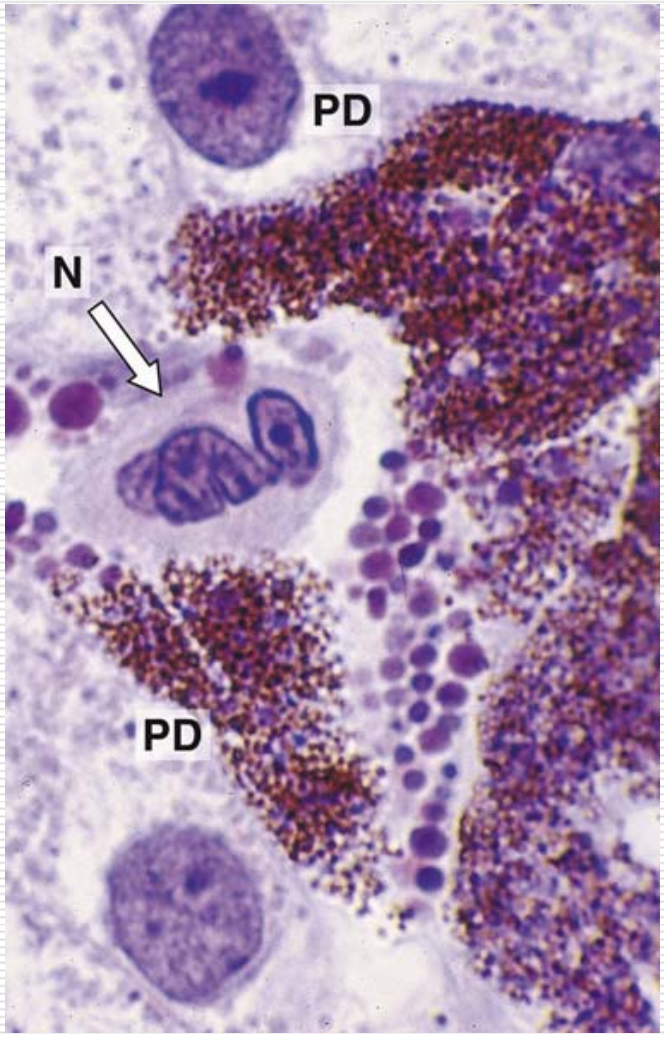
S : secretory granules with limiting-membrane

electron dense

C : condensing vacuoles

G : Golgi complex

Age pigments



Brown age pigments in cells

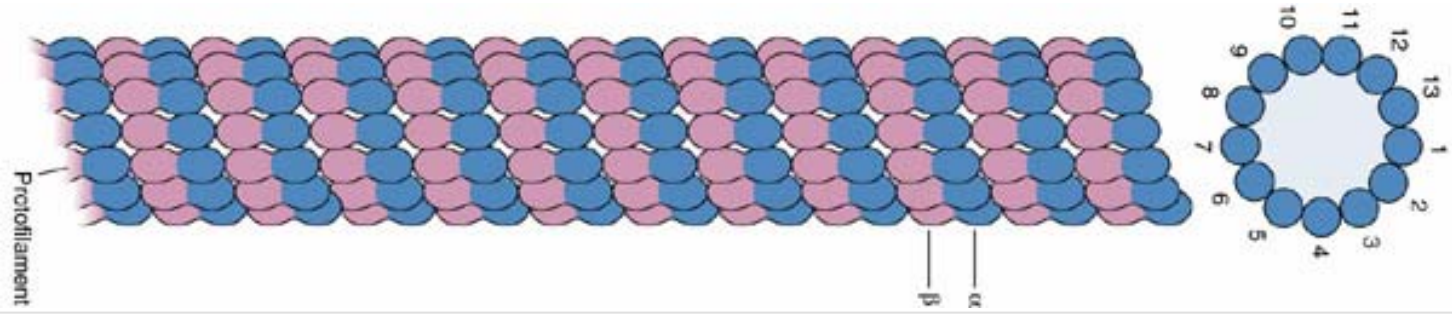
Brown age pigments on face

Cytoskeleton

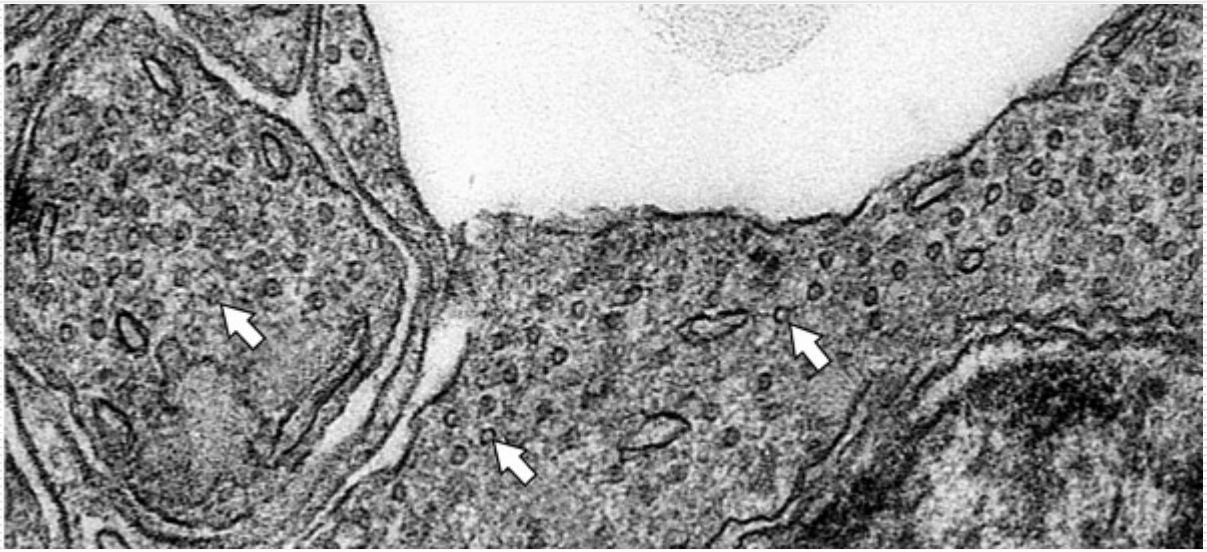
- Structure components
  - Microtubules
  - Actin filaments (microfilaments)
  - Intermediate filaments
- Functions
  - Provide for the shaping of cells
  - Play an important role in the movements of organelles and intracytoplasmic vesicles
  - Participate in the movement of cells

Structure of microtubules

- Tubular, outer diameter of 24 nm, a dense wall 5 nm thick , a hollow core 14 nm wide.
- heterodimer: α and β tubulin molecules.
- 13 tubulin units organized into a spiral in one turn.
- grow from microtubule-organizing centers

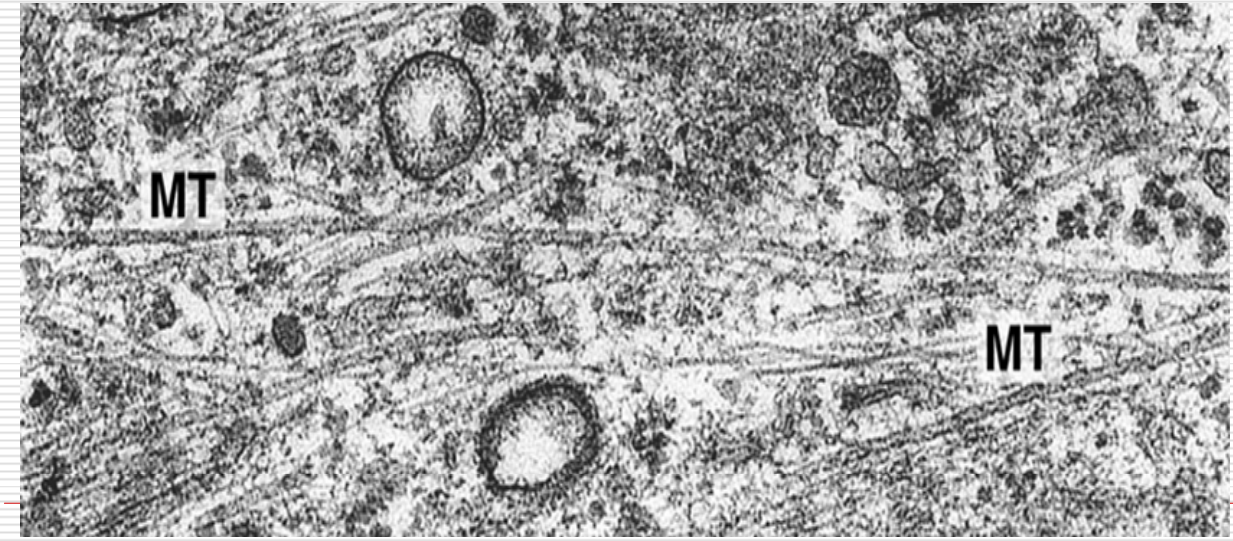


Microtubules



Transverse section

Aggregated small rings



Longitudinal section

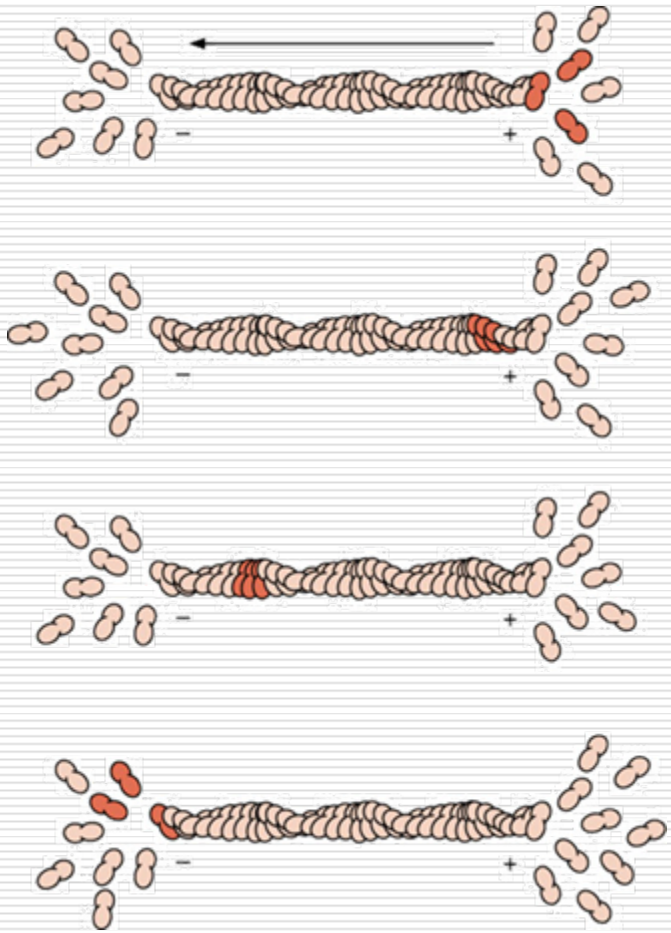
Long and thin tubules

Functions of microtubules

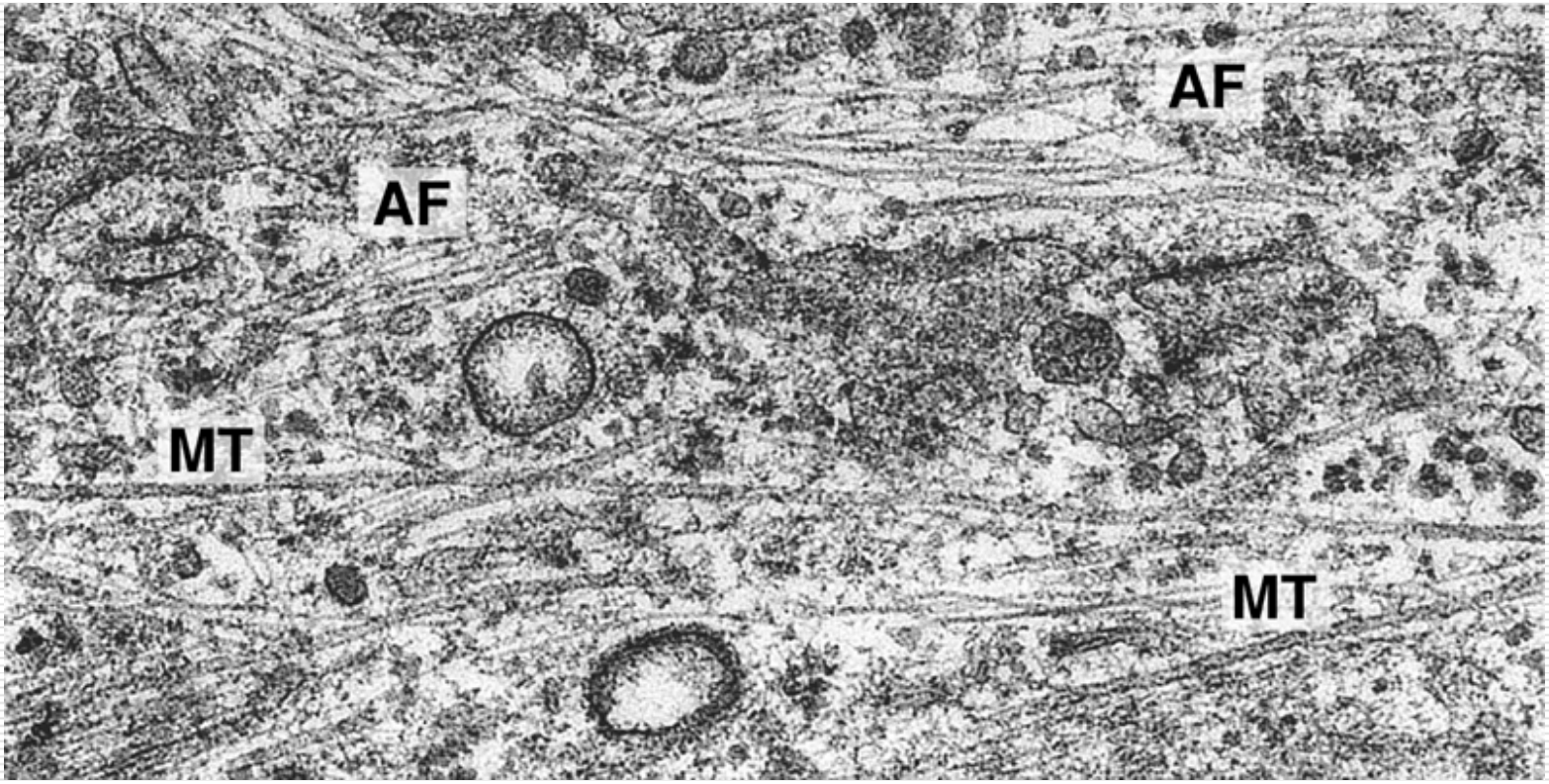
- keep cell's shape
- intracellular transport of organelles and vesicles.

Microfilaments (Actin filaments)

- **Structure**
  - About 5~7nm in diameter
  - globular subunits
  - double-stranded
- **Function**
  - maintain the shape of cell
  - contraction, movement, mitotic division



Microtubules & Microfilaments



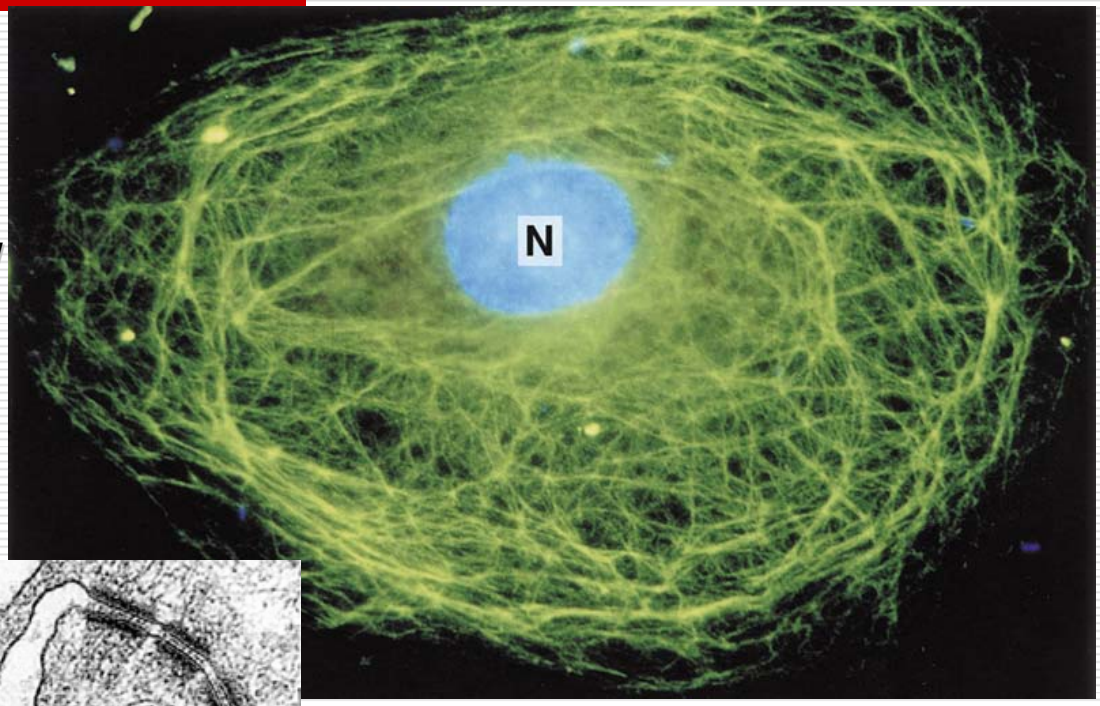
Microfilaments are much thinner than microtubules.

Intermediate Filaments

- diameter of 10-12 nm.
- keratin filaments: epithelial cells
- desmin filaments: muscle cells
- vimentin filaments: fibroblasts, mesenchymal cells
- Neurofilaments: neurons
- neuroglial filaments: astrocytes

Intermediate Filaments

immunofluorescence: desmin filaments（yellow meshwork）in decidual cell



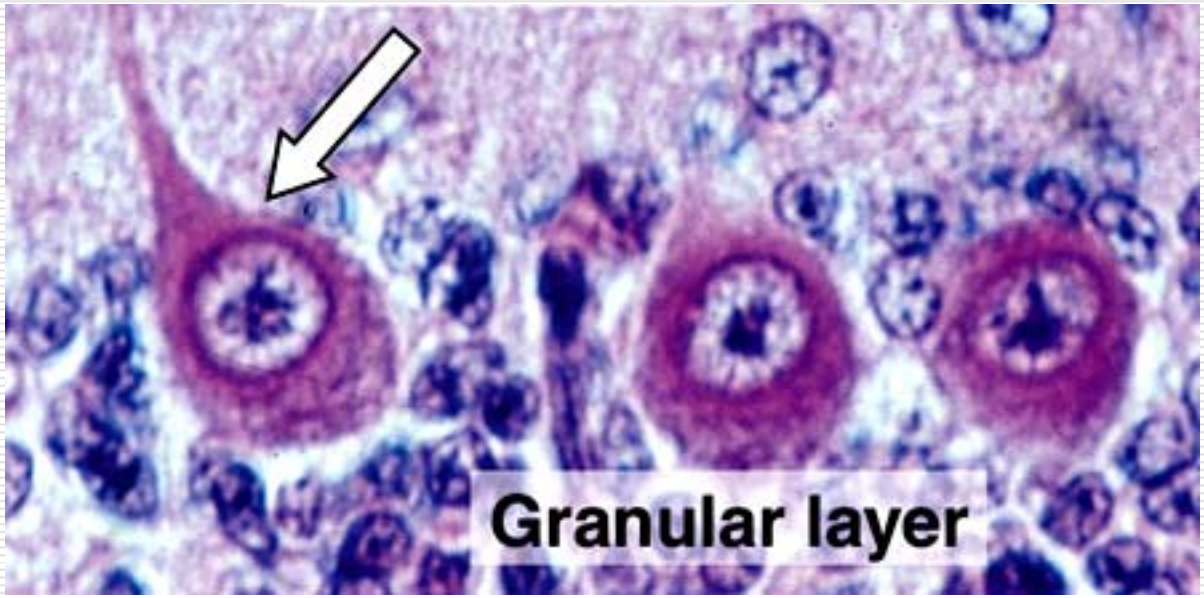
EM: keratin filaments （bundle of thin threads） in epithelial cell

Cytosol

- Components
  - Water
  - Enzymes to synthesize and decompose molecules
  - Machinery to synthesize proteins
- Functions
  - Coordinate the intracellular movements of organelles
  - Provide a framework for the organization of enzyme and substrates

Overview of nucleus

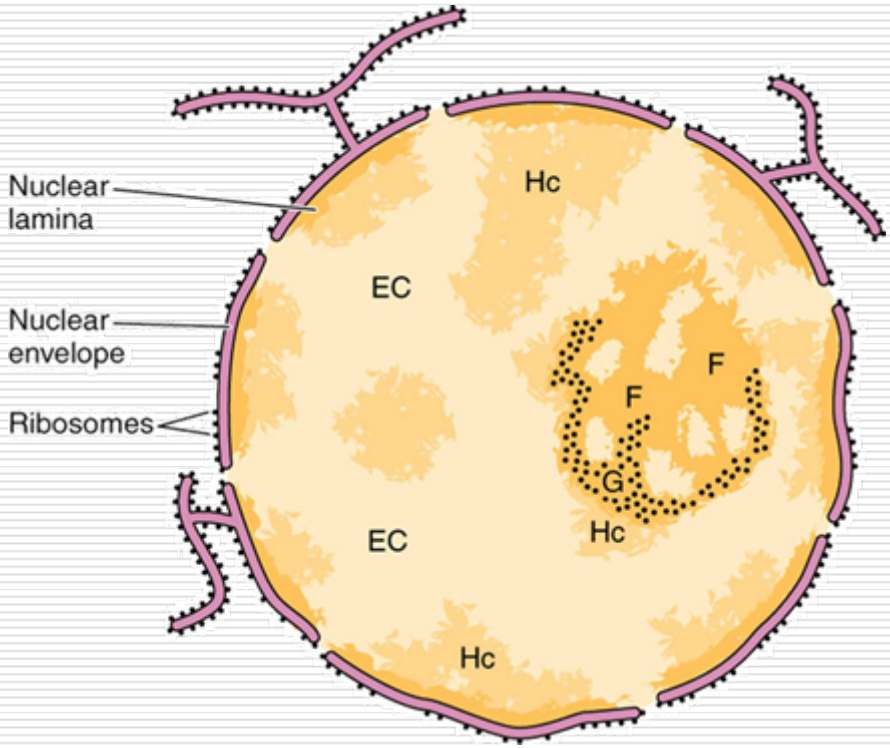
- intense basophilic in HE section
- replicate DNA
- synthesize and process RNAs



A basophilic nucleus with a developed nucleolus is located in the center of the acidophilic cytoplasm.

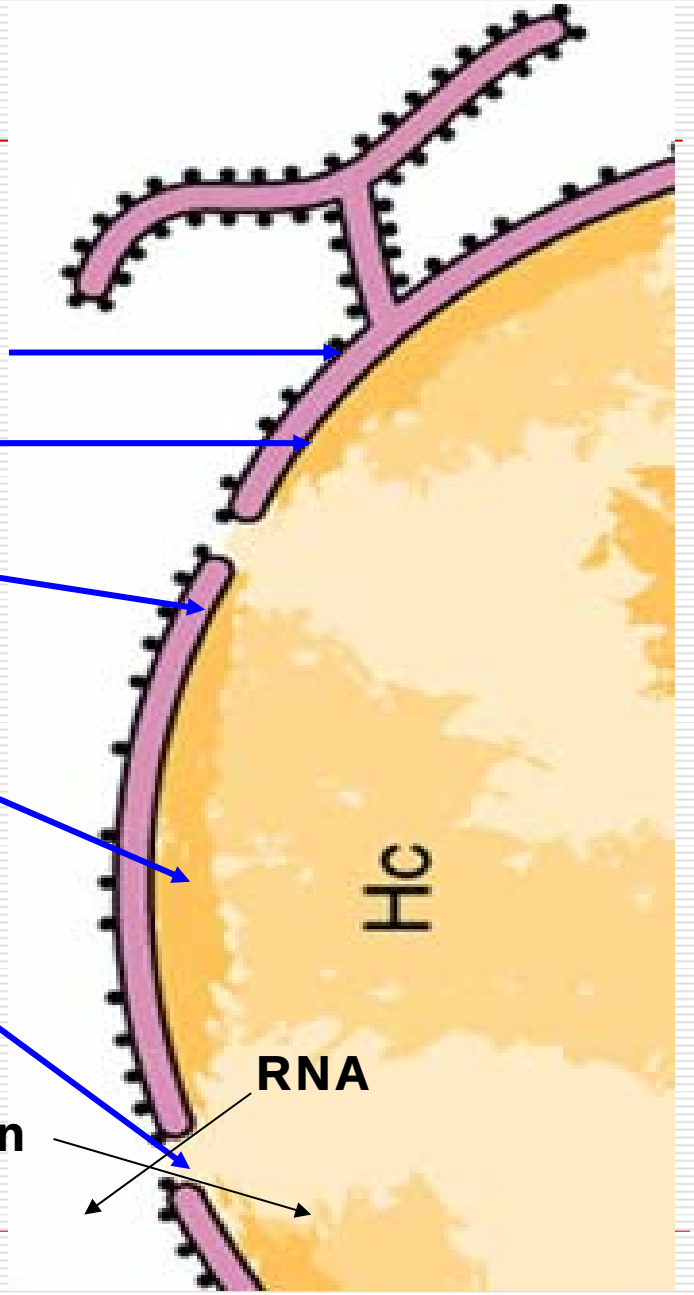
Nucleus

- **Main components**
  - **Nuclear envelope**
  - **Chromatin**
  - **Nucleolus**
  - **Nuclear matrix**

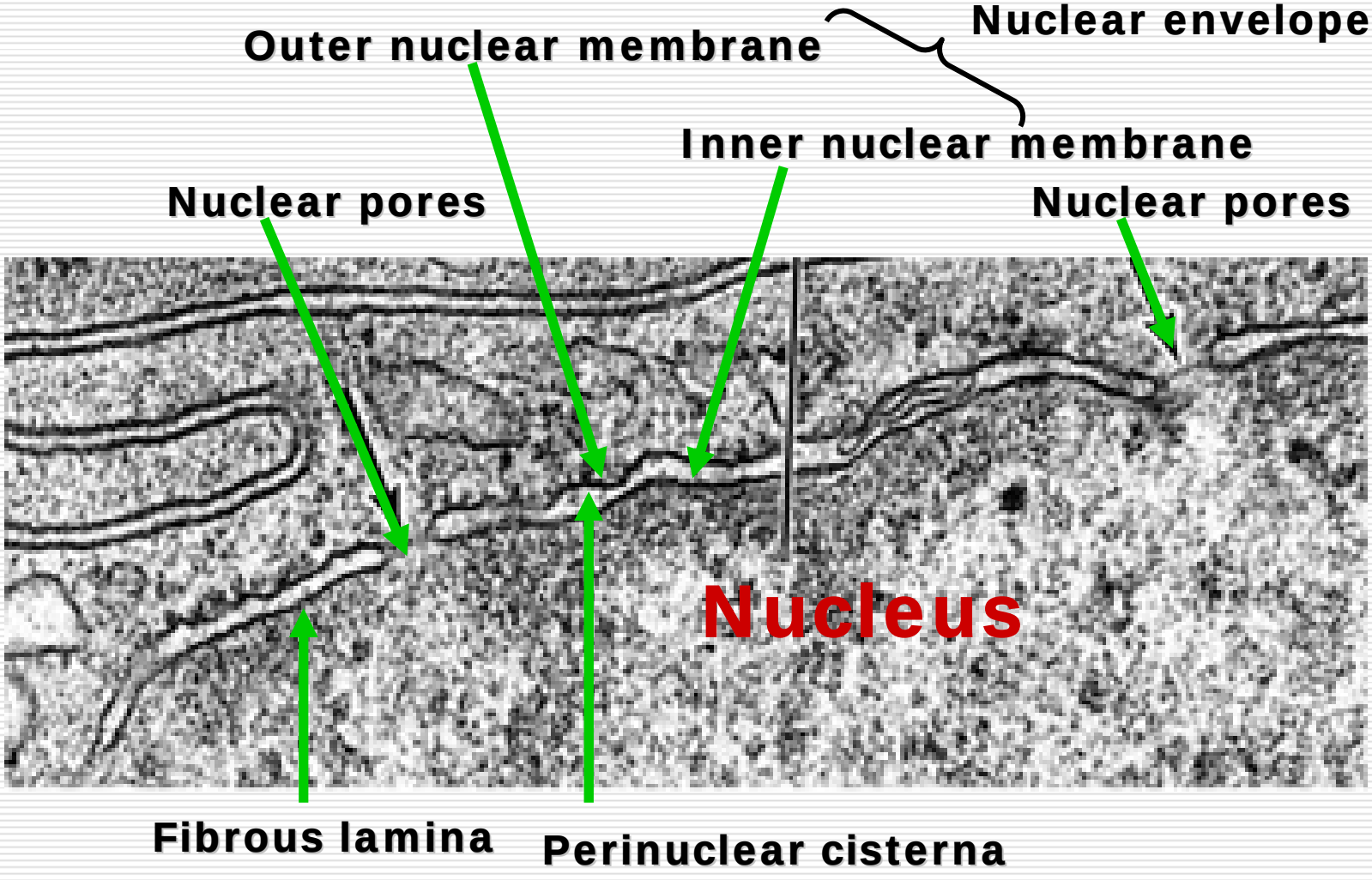


Nuclear Envelope

- Outer nuclear membrane
- Inner nuclear membrane
- Perinuclear cisterna
- Fibrous lamina
- Nuclear pores



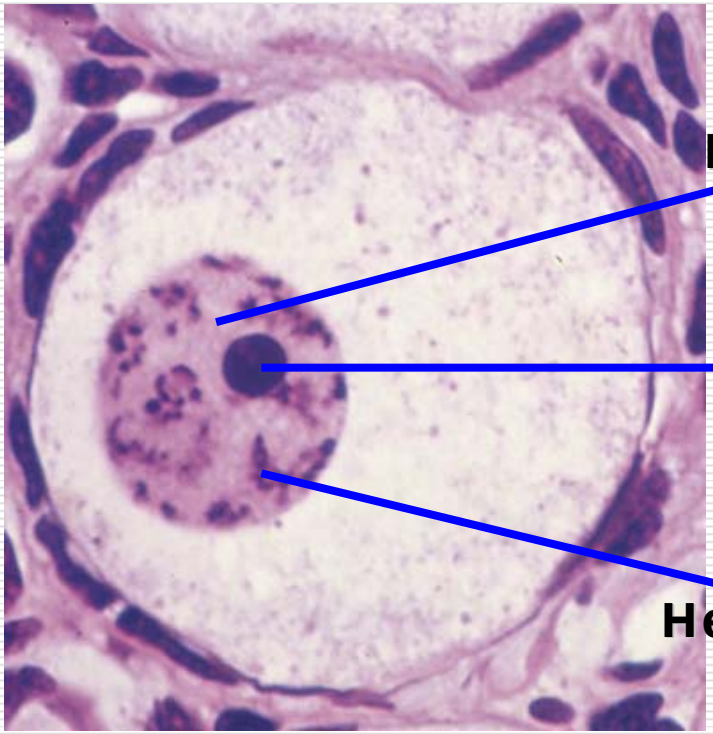
Nuclear Envelope



Chromatin

- Components
  - DNA & Proteins
- Classification
  - Heterochromatin: inactive cells
    - LM: basophilic clumps
    - EM: coarse granules
  - Euchromatin: active cells
    - LM: lightly stained basophilic areas
    - EM: finely dispersed granular material

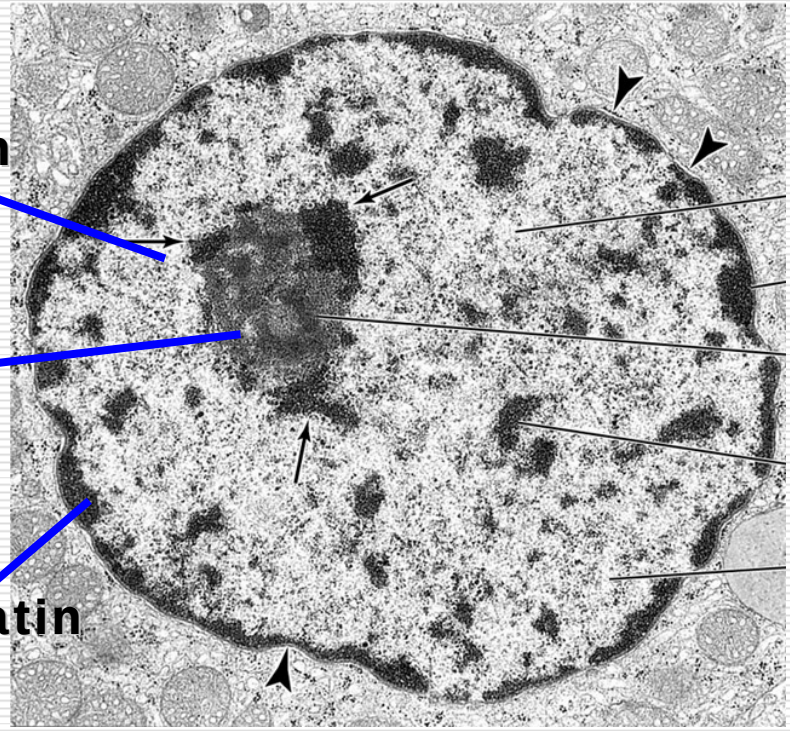
Nucleus



Euchromatin

Nucleolus

Heterochromatin

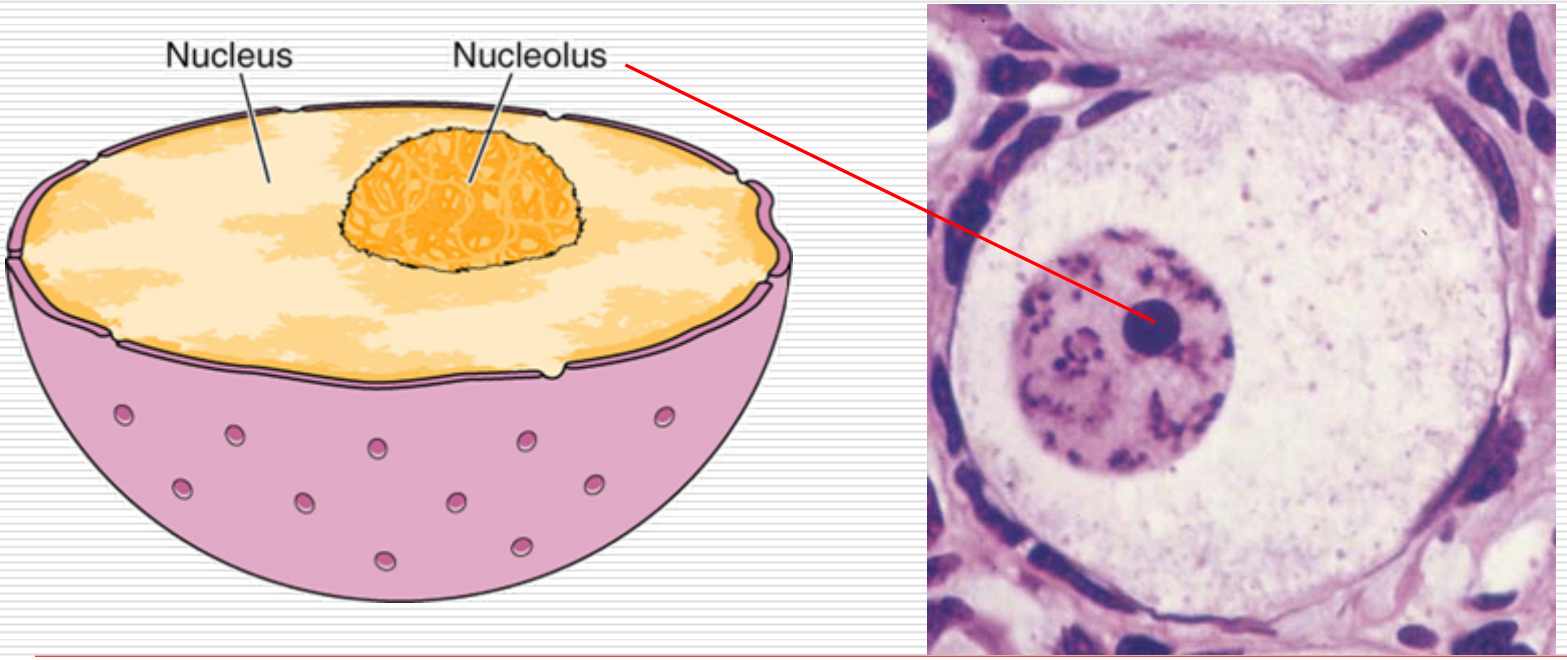


HE staining

EM

Nucleolus

- Spherical structure
- Rich in rRNA and protein (forming ribosomes)
- Basophilic when stained with H & E
- larger and more in protein-secreting cells



HE staining

Nuclear matrix

- between the chromatin and the nucleoli
- nuclear hyaloplasm
  - water, ions and enzymes
- Nucleoskeleton
  - 3D meshwork
  - proteins
  - connects with nuclear fibrous lamina
  - protein base to which DNA loops are bound

Summary

- **Master the structure and function of mitochondrion , polyribosome , RER , SER, Golgi complex , lysosome, microbody, cytoskeleton and nucleus.**
- **Understand the structure components of plasma membrane and the concept of unit membrane.**