The cell III.

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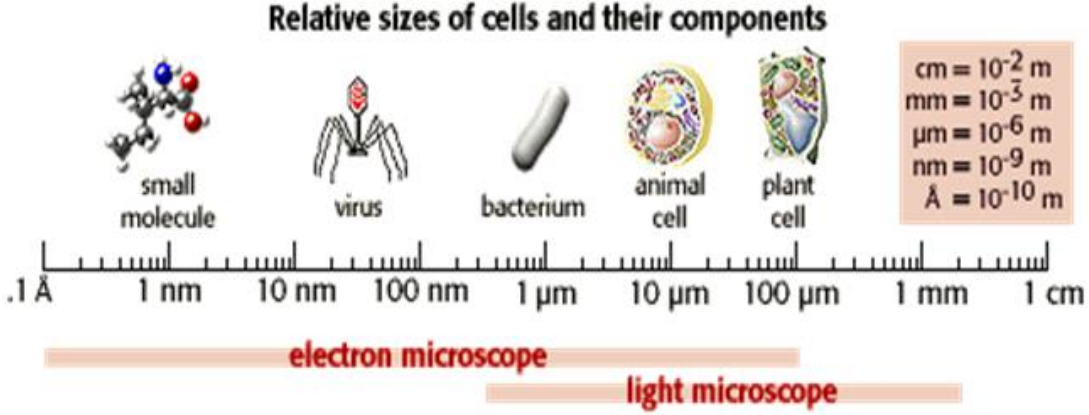
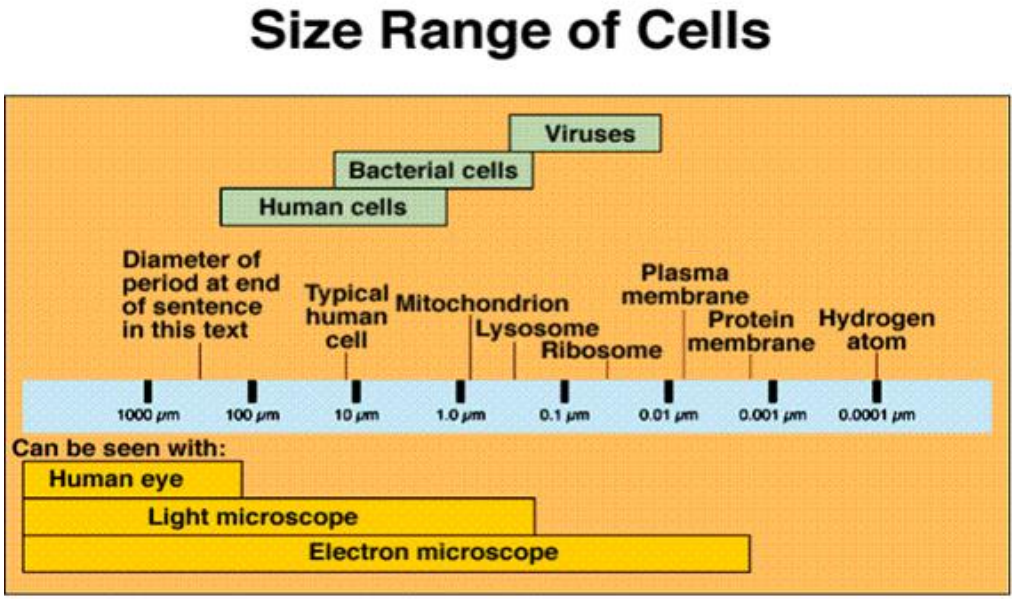


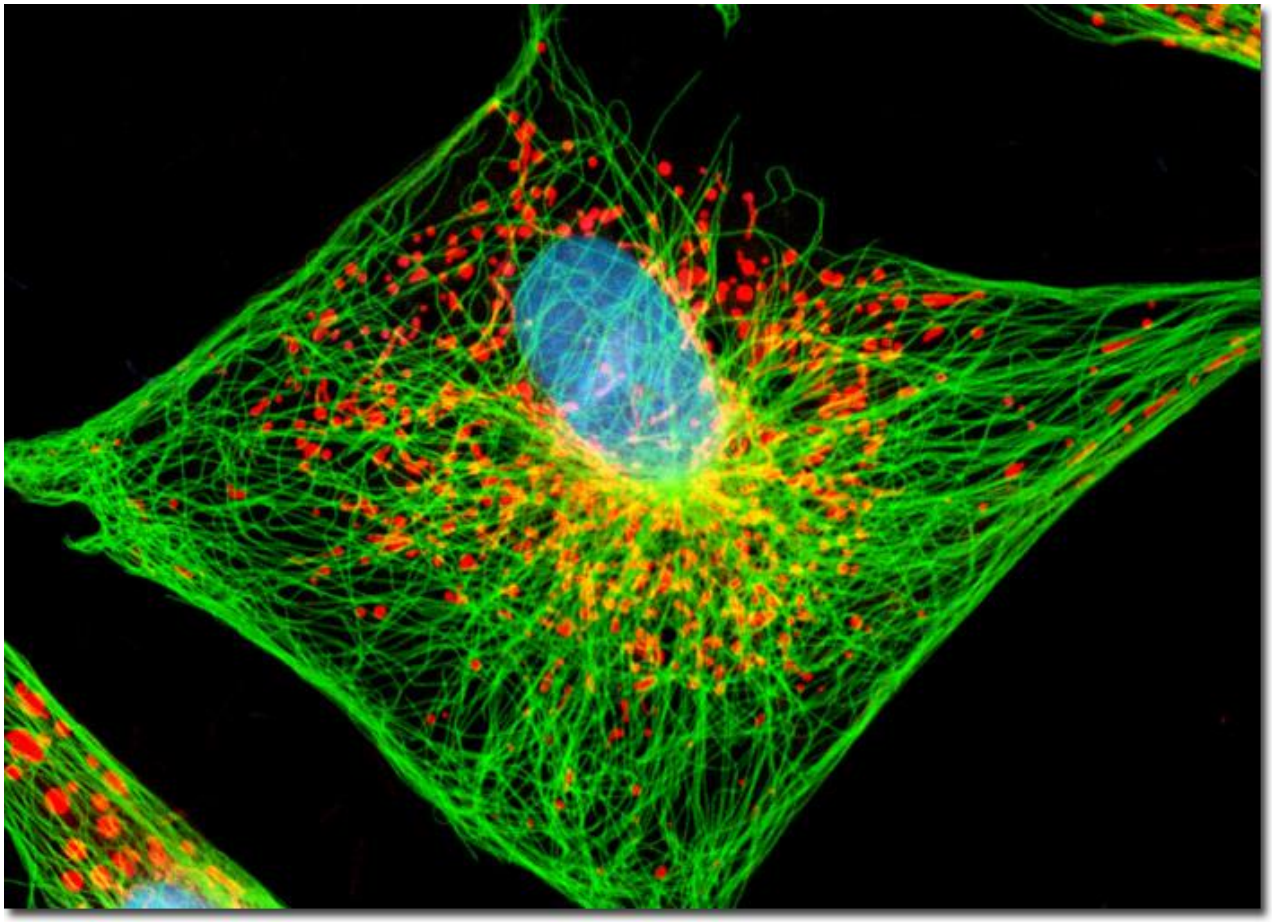
Size and Biology

- Biology is a visually rich subject
- many of the biological events and structures are smaller than the unaided human eye can see
- resolution of the human eye is about 100 µm



The structure of cells:

The cytoplasm and the cytoskeleton



Cytoplasm

- The cytoplasm is the part of a cell that is enclosed within the plasma membrane (between the cell mebrane and the nuclear membrane).
- This three-dimensional, jelly-like material
- In eukaryotic cells the cytoplasm contains organelles
- The cytoplasm is the site where most cellular activities occur eg. Metabolic reactions
- Contains mostly water 80 to 97% in different cells
- The dry component contains macromolecules: proteins, carbohydrates, nucleic acids, and lipids

Components

- The cytoplasm has four major elements: the cytosol, the cytoskeleton organelles and inclusions

Cytoplasm

Cytosol

- Is a fluid in which the other cytoplasmic elements are suspended.
- Makes up about 70 % of the cell volume and is composed of water, salts and organic molecules/ potassium, sodium, magnesium, calcium,iron/

Organelles

- Organelles are membrane-bound compartments within the cell that have specific functions.

Cytoplasmic inclusions

- The inclusions are small particles of insoluble substances suspended in the cytosol
- calcium oxalate or silicon dioxide in plants
- granules of energy-storage materials such as starchs, glycogen in animal cells
- lipid droplets

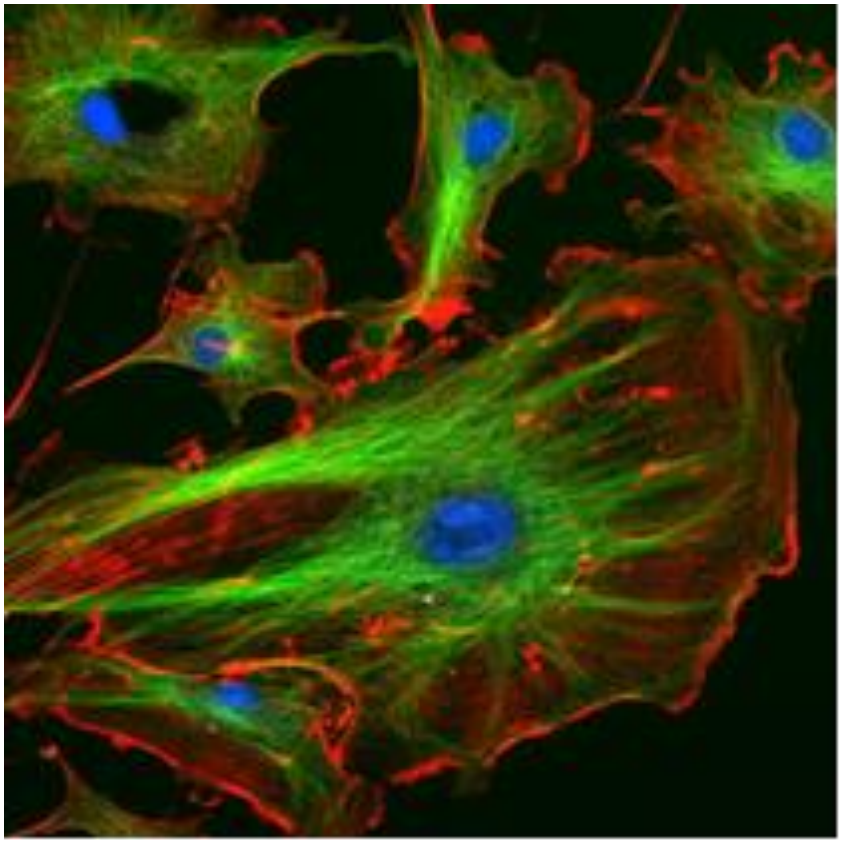
Cytoskeleton

Structure

- The cytoskeleton is present in all eukaryotic cells
- Eukaryotic cells contain three main kinds of cytoskeletal filaments: **microfilaments, intermediate filaments, and microtubules**.

Functions

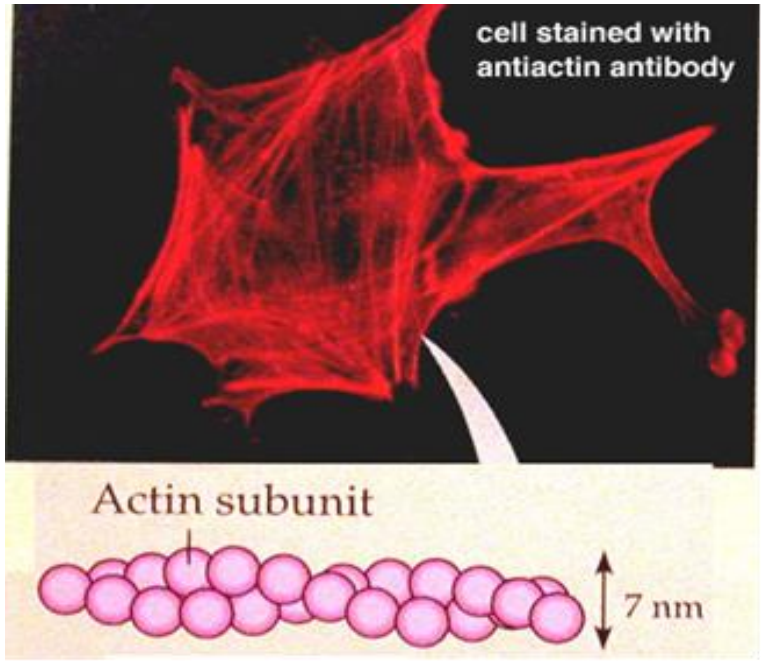
- determines cell shape
- Mechanical support
- drives active cell movements
- transport organells
- drives cell division
- Signaltransduction



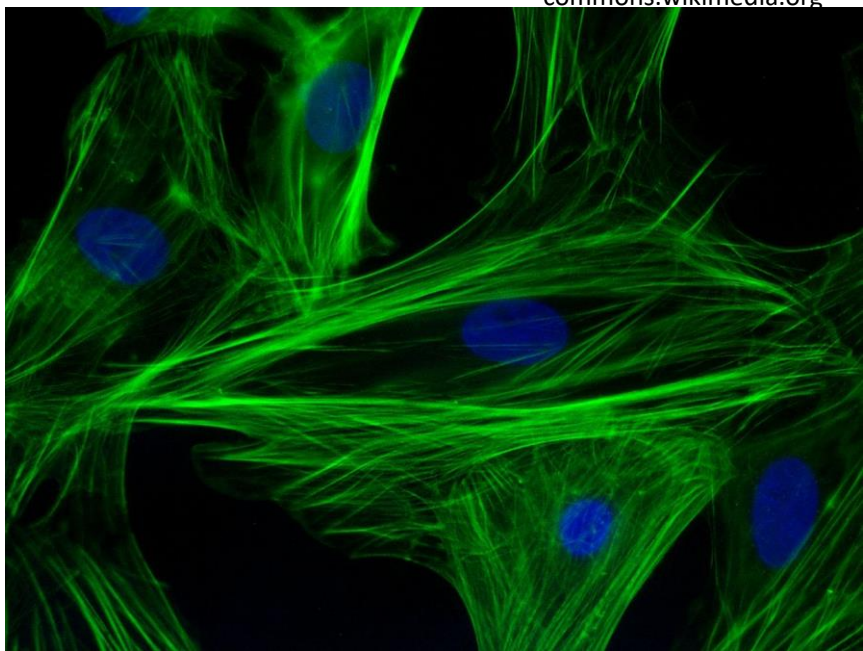
The eukaryotic cytoskeleton/actin, microtubules, nuclei/

Microfilaments

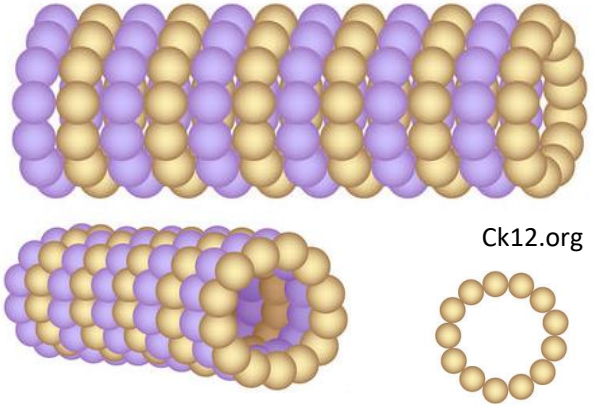
- Made of actin proteins (most abundant cellular protein)
- 3-7 nm in diameter (smallest type)
- 2 possibilities for organization:
  - ➢Actin bundles in the cytoplasm
  - ➢Actin network eg. under the cell membrane
- Capable of dynamic changes → cell shaoe chaneg, cell movement
- Muscle cells: contraction by myosin proteins
- Intracellular transport by myosin also
- participation in some cell-to-cell or cell-to-matrix junctions
- important for cytokinesis



commons.wikimedia.org



Microtubules

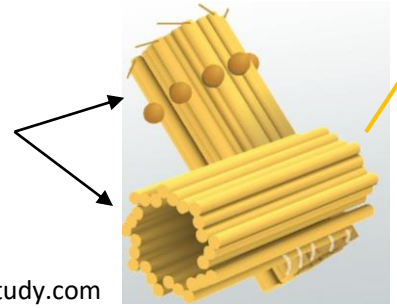


Ck12.org

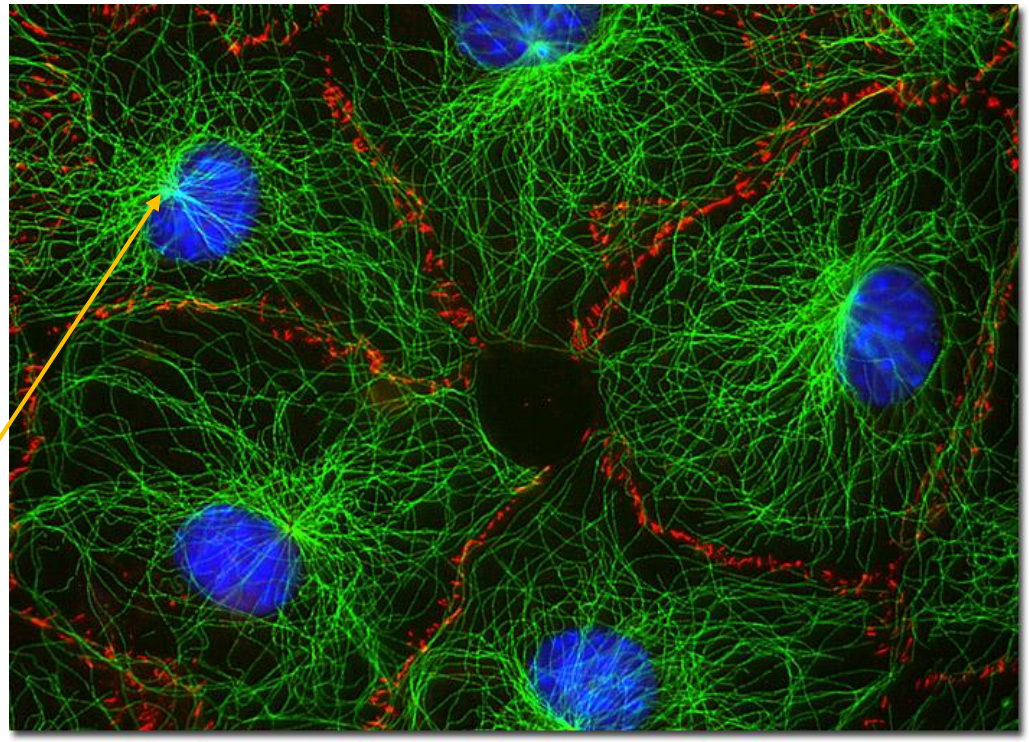
- Diameter: 20-25 nm (largest type)
- Made of tubulin proteins
- Globular monomers → dimers → tube-like structure
- Their center is the centrosome composed of 2 centrioles
- They are dynamic, important in cell division (eg. movement of chromosomes as components of the mitotic spindle)
- intracellular transport
- ciliae and flagellae
- synthesis of the cell wall in plants

centrosome

centrioles



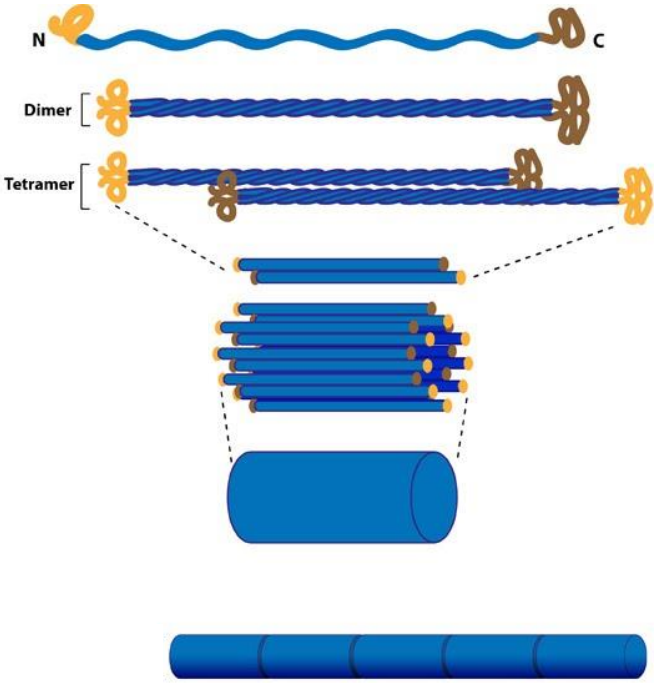
Study.com



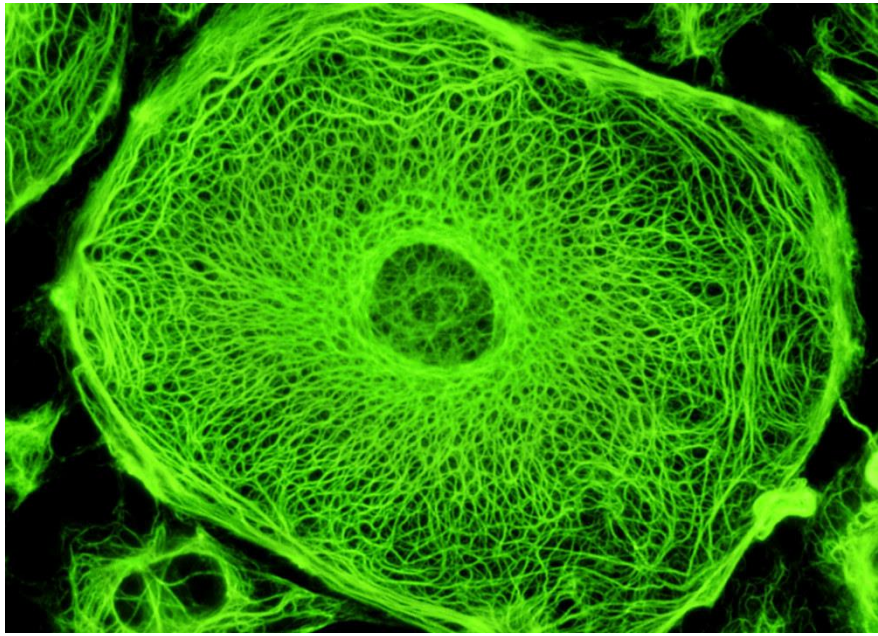
https://people.maths.bris.ac.uk/~matbl/images/mousefibroblasts.jpg

Intermediate filaments

- Diameter: 10nm
- organize the internal 3D structure of the cell in a stable fashion
- They are less dynamic, more stable
- anchoring organelles
- participate in some cell-cell and cell-matrix junctions
- There are more than 50 types of proteins composing intermediate filaments (ie. They are tissue specific)
- Keratins, cytokeratin, →epithelial cells
- vimentin→connective tissue, smooth muscle cells
- desmin→striated and heart muscle
- peripherin→peripheral neurons
- neurofilaments→central nervous system
- lamins→nucleus (in all cells): serving as structural components of the nuclear lamina



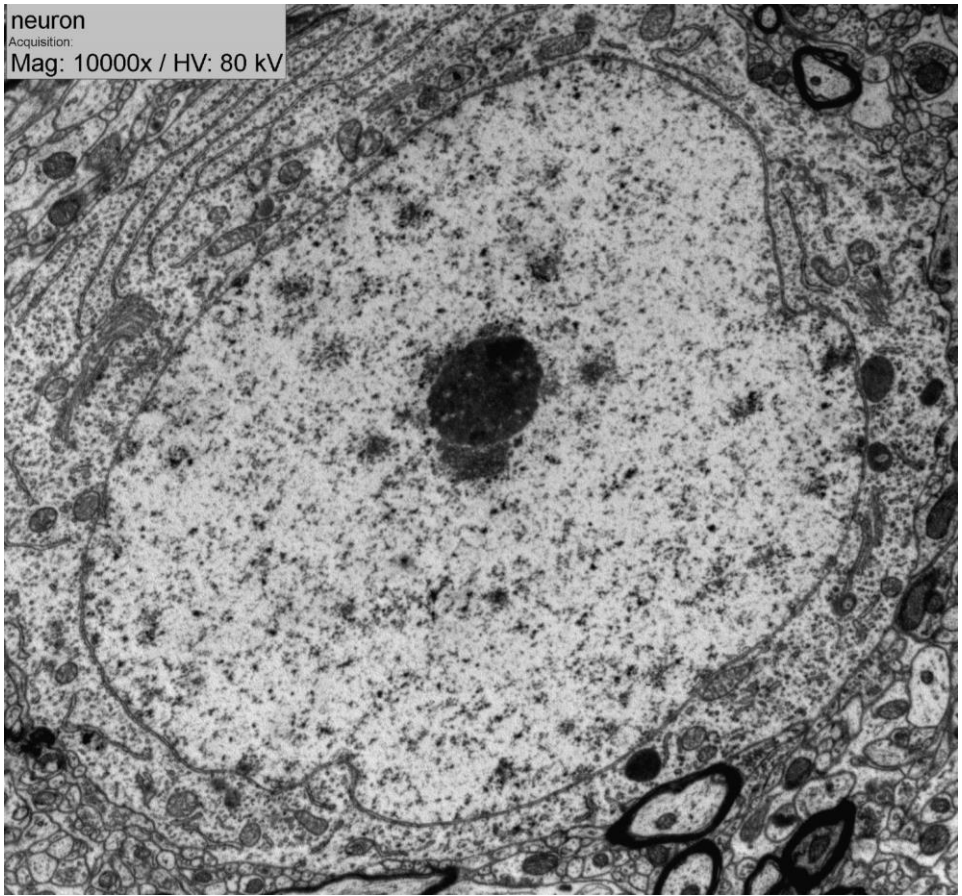
www.mechanobio.info



microscopyu.com

The structure of cells:

The ER, Golgi-apparatus, vesicles and lysosomes

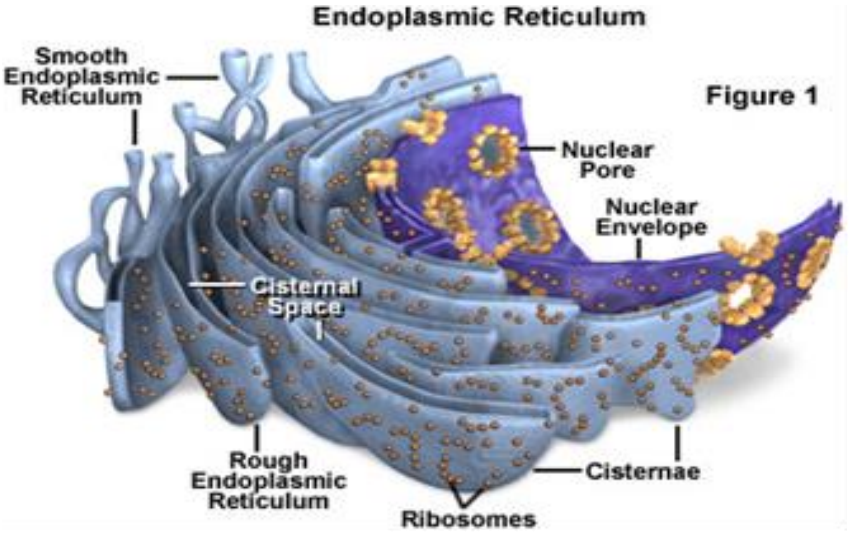


Endoplasmic reticulum

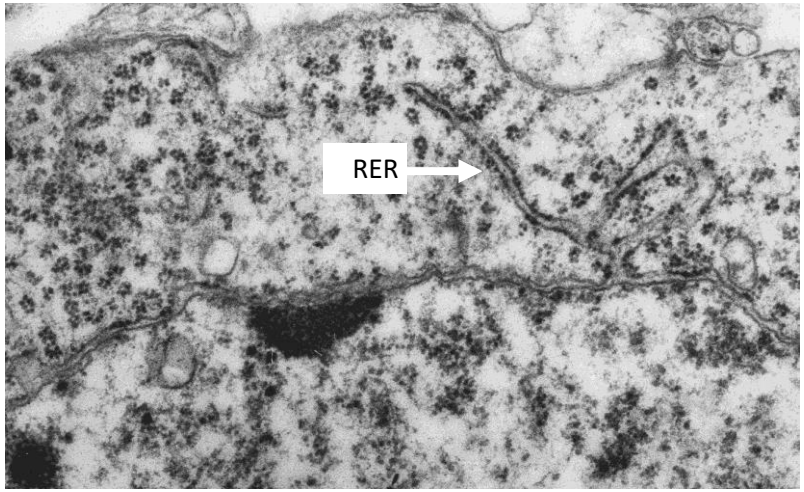
- is an interconnected network of tubules, vesicles, and cisternae within cells.
- is part of the endomembrane system.
- Is connected to the outer nuclear membrane

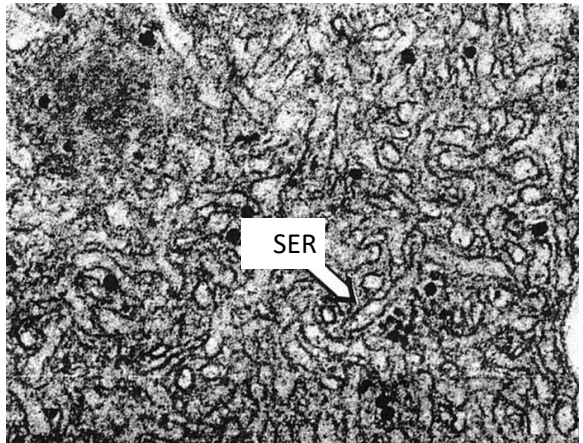
Structure

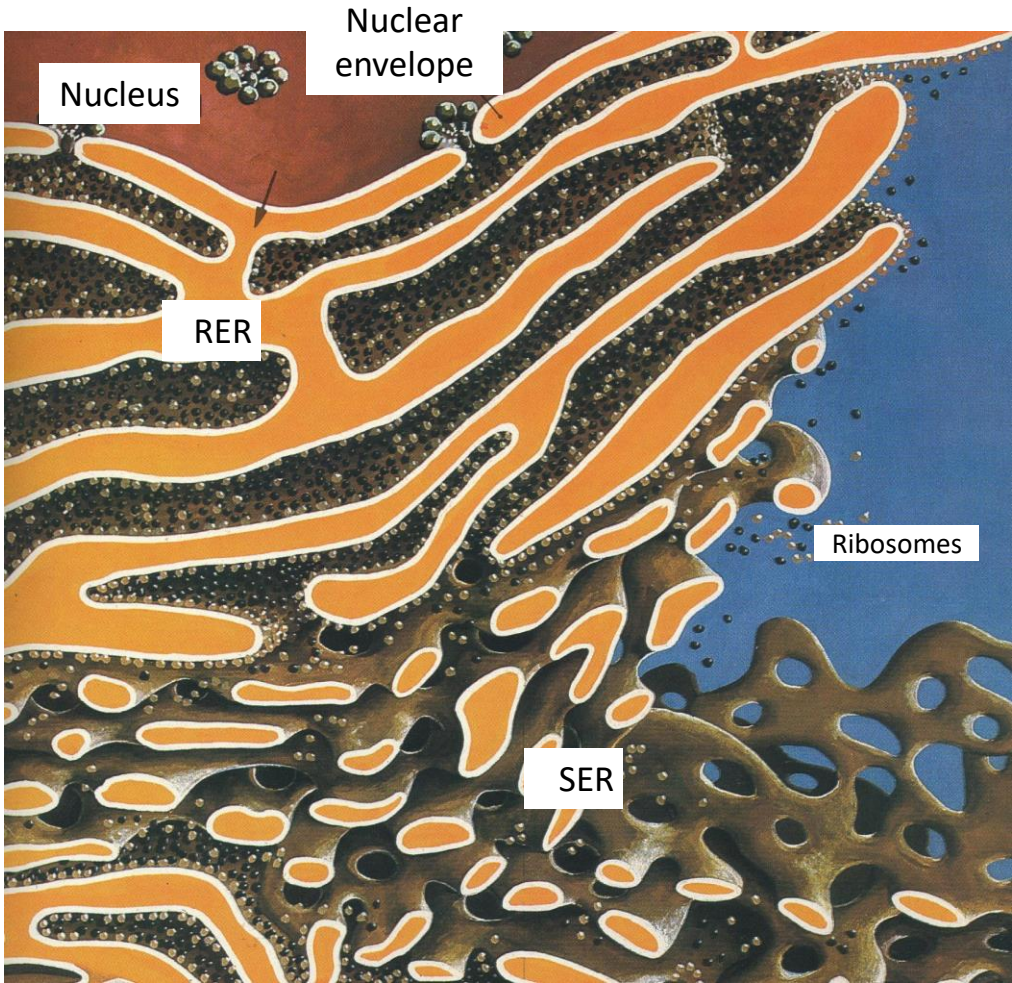
- is an extensive membrane network of cisternae held together by the cytoskeleton.
- cisternal space (or lumen) enclosed by a phospholipid membrane from the cytosol.



- Types
  - rough endoplasmic reticulum
  - smooth endoplasmic reticulum /sarcoplasmic reticulum/





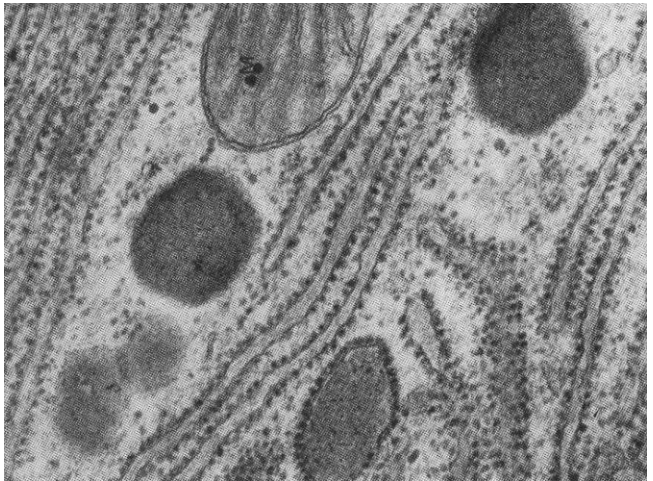


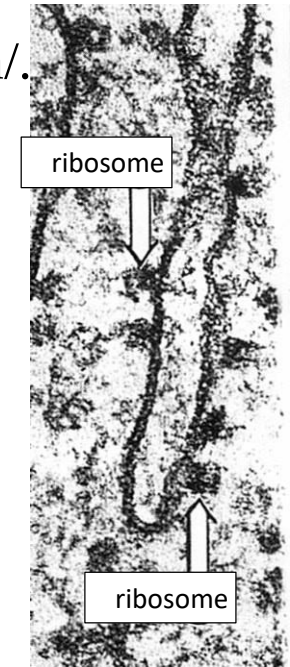
Rough endoplasmic reticulum

The surface is studded with ribosomes giving it a "rough" appearance

Key functions of the RER:

- Protein synthesis: proteins of the cell membrane, secretory, lysosomes, Golgi, ER
- Protein maturation (processing)
  - Stabilization of conformation/folding/: chaperone proteins
  - Glycosylation: attachment of oligosaccharides / N-linked glycosylation/.
  - Disulfide bond formation and rearrangement
- Quality control of proteins





Smooth endoplasmic reticulum

There are no ribosomes on the surface

Key functions of SER:

- synthesis of lipids eg. phospholipids and steroids
- regulation of calcium concentration (Ca^{2+}storage)
- drug detoxification – biotransformation (cytochrome P450 enzyme system)

Sarcoplasmic reticulum

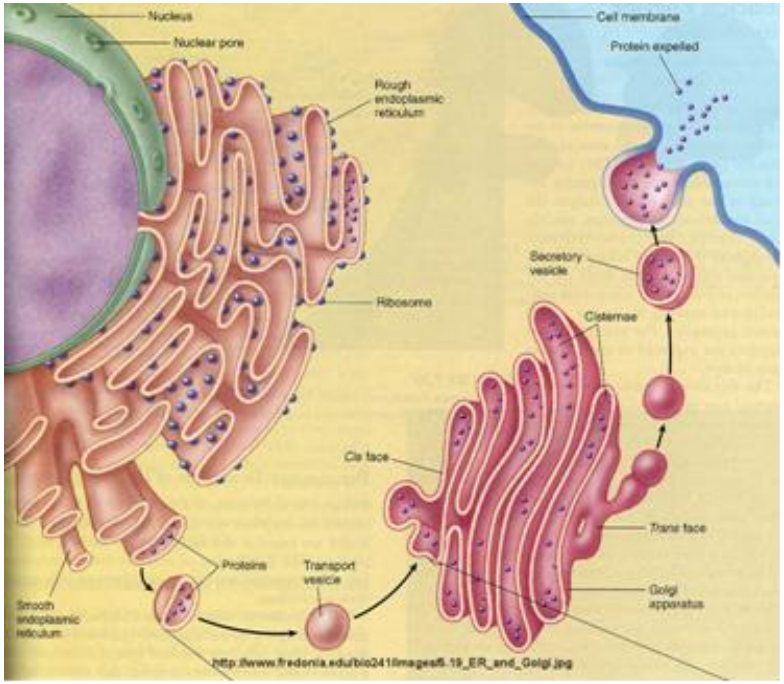
- is a special type of smooth ER
- found in smooth and striated muscle
- contains large stores of calcium/ sequesters and releases it when the muscle cell is stimulated/
- role in the contraction of muscle, by electrical stimulation

Golgi apparatus

The Golgi apparatus also called the Golgi body, Golgi complex

It was identified in 1898 by the Italian physician Camillo Golgi

Is part of the endomembrane system

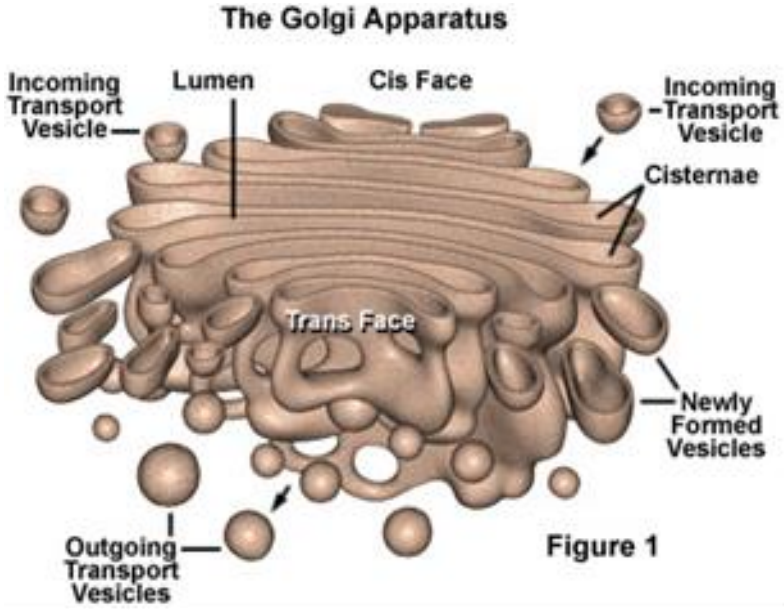


Structure

- The Golgi is composed of membrane-bound stacks known as cisternae
- The cisternae stack has five functional regions: the cis-Golgi network, cis-Golgi, median-Golgi, trans-Golgi, and trans-Golgi network.

Function

- Maturation, packaging and sorting of proteins /lysosomal, membrane, secretory/
- Glycosylation: attachment of oligosaccharides/ O-linked glycosylation→ form a signal sequence which determines their final destination, for example: mannose-6-phosphate- lysosomal proteins/



Vesicle

Structure

- Is a small, intracellular, membrane-enclosed sac
- Is separated from the cytosol by a phospholipid bilayer/ one phospholipid bilayer, →*unilamellar* vesicles, more→*multilamellar*/
- Vesicles can fuse with the plasma membrane to release their contents outside of the cell or also fuse with other organelles within the cell.

Functions: store, transport, or digest cellullar products and waste

Types of vesicles:

- **Transport vesicles**

Transport vesicles can move molecules between locations inside the cell, e.g., proteins from the

rough endoplasmic reticulum to the Golgi apparatus.

- **Secretory vesicles**

contain materials to be excreted from the cell

Vesicle coat: clathrin, COPI, COPII

Vesicular transport

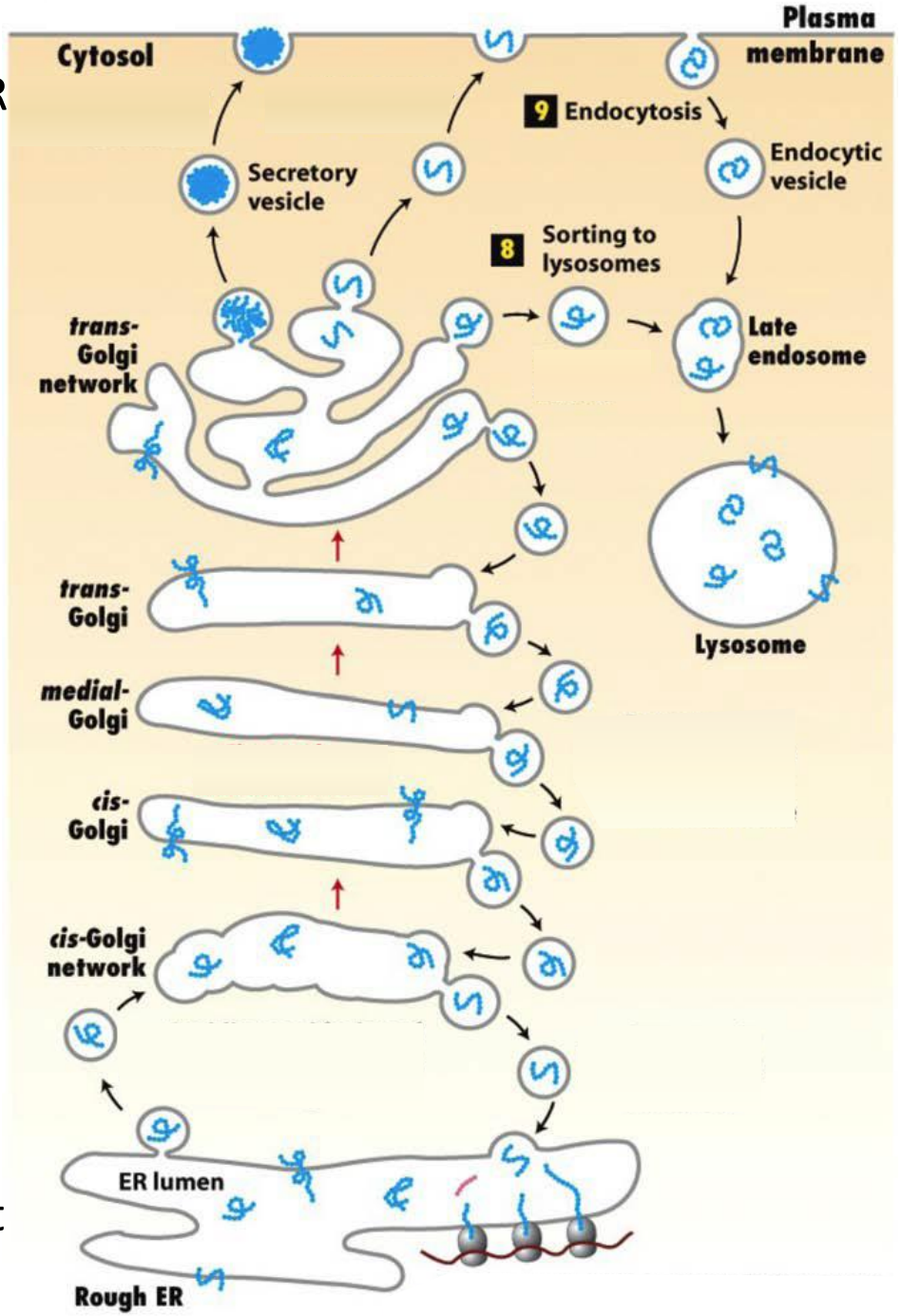
- Between RER, Golgi, cell membrane, SER transport (of eg. proteins) is carried out by vesicles
- Along main pathways:

➢ endocytosis→endocytic pathway: materials are taken up from outside of the cell:

  - Phagocytosis (eg. engulfing bacteria)
  - Pinocytosis (taking up solutions, „cell drinking")
  - Receptor-mediated endocytosis (eg. Uptake of LDL particles)

Endocytosis → endosome → merging with primary lysosomes → secondary lysosome (or alternatively storage, exocytosis)

➢ Secretory pathway → exocytosis (secretion): transport of materials into the extracellular space: RER → transport vesicle → Golgi-apparatus → transport (secretory-) vesicle → exocytosis

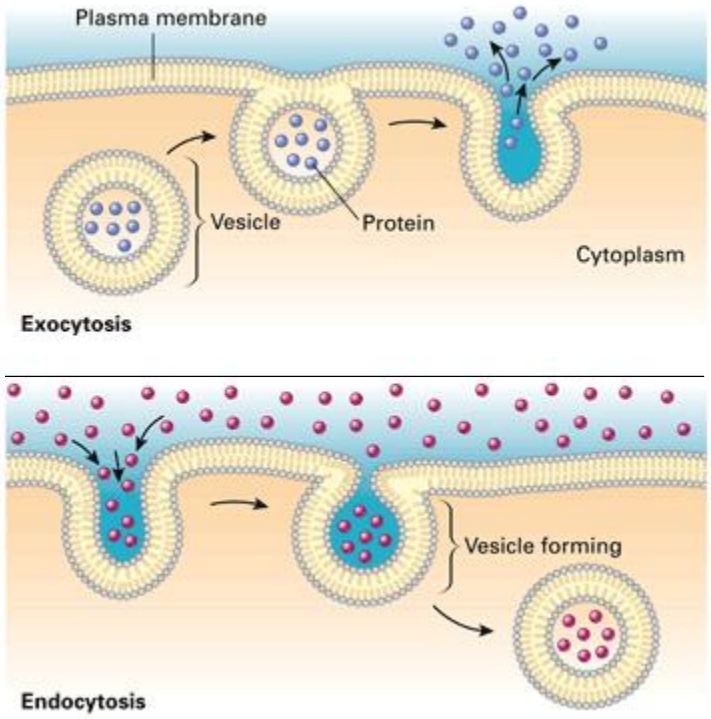


https://d1yboe6750e2cu.cloudfront.net

- *Endocytosis*: uptake of extracellular material in vesicles, which are formed from the cell membrane

  -phagocytosis, pinocytosis, receptor mediated endocytosis

- *Exocytosis*: Fusion of the membrane of a secretory vesicle with the cell membrane, excretion of content of the secretory vesicle.



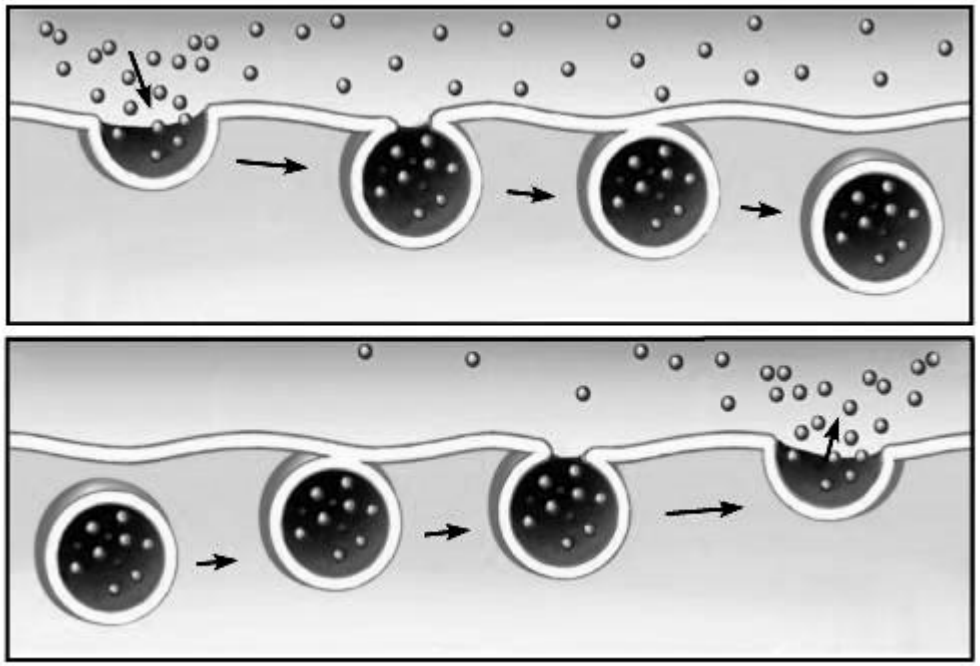
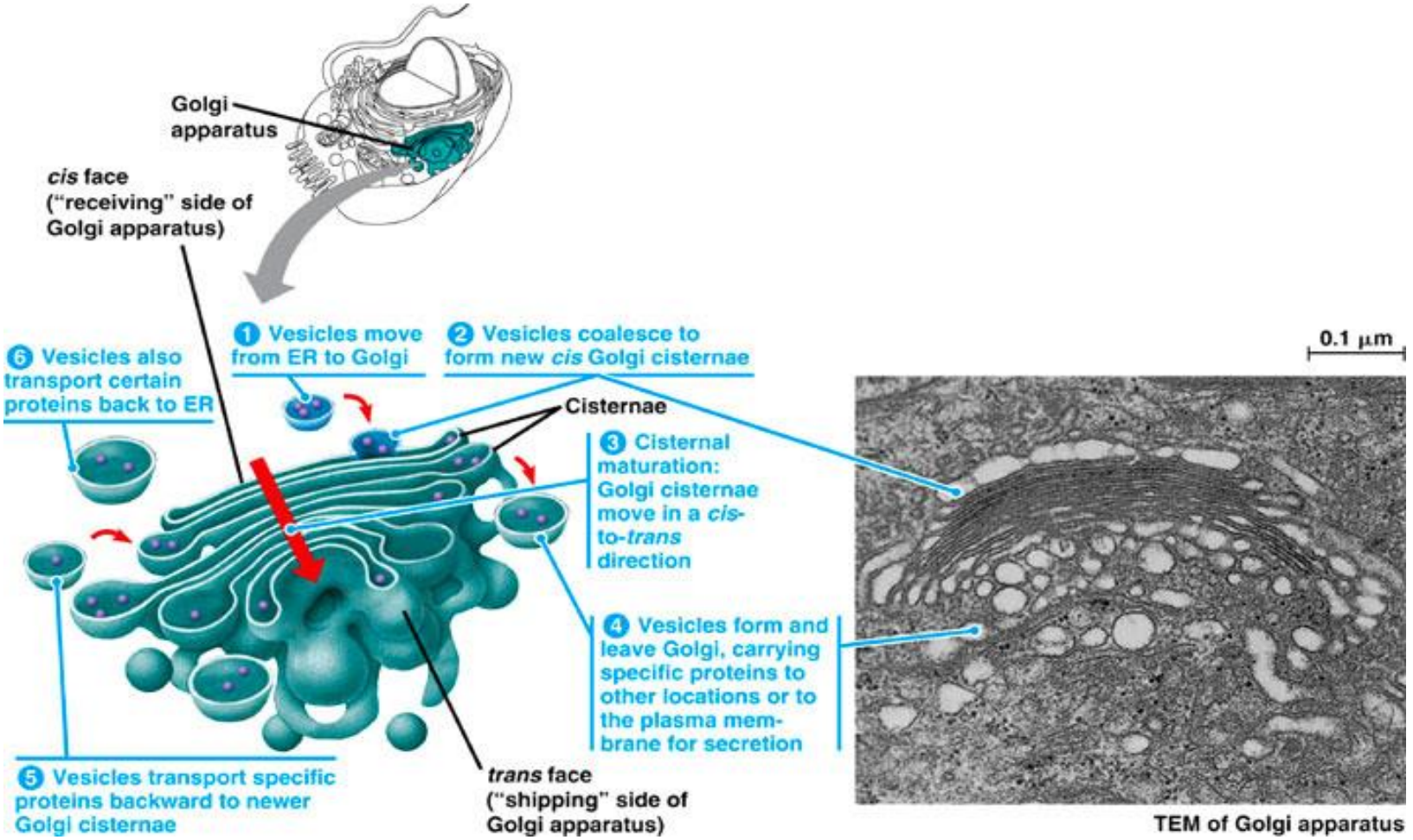
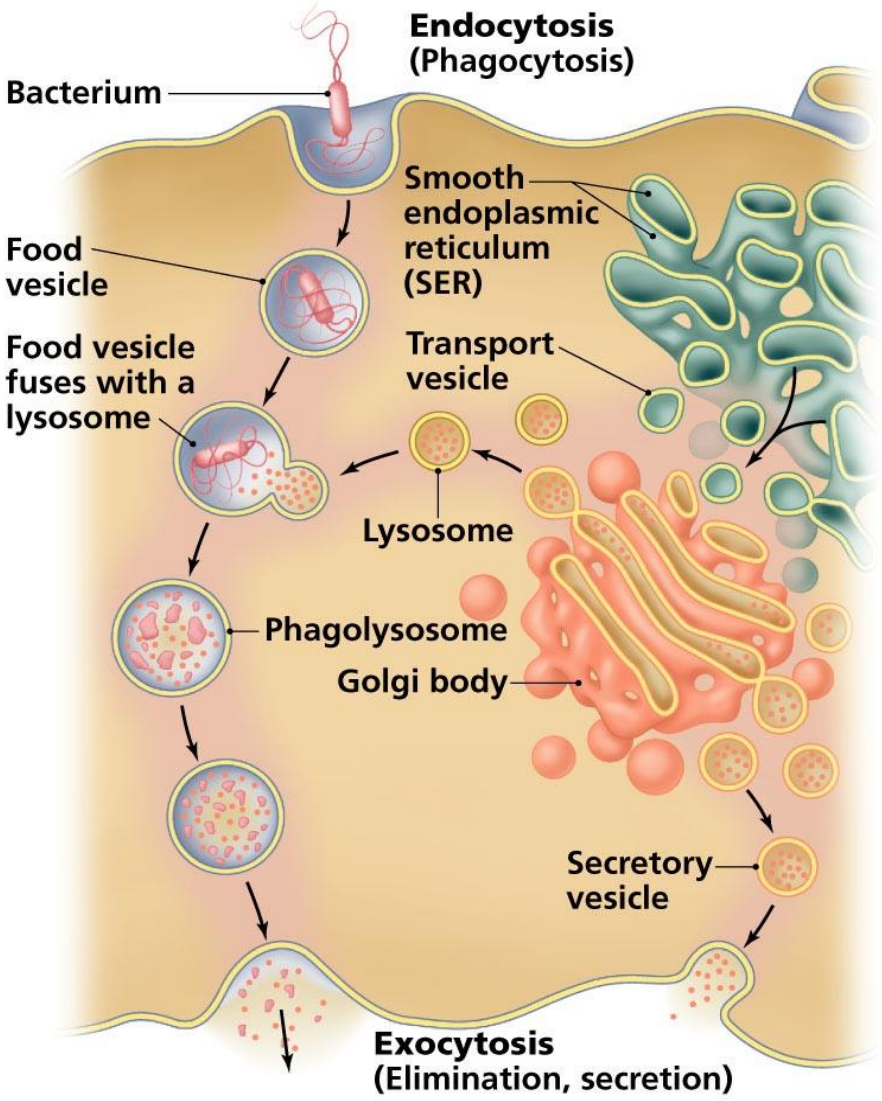


figure: http://www.kscience.co.uk

Vesicular transport: Golgi



Endocytosis, exocytosis



Lysosome

- The name derives from the Greek words *lysis*(destruction) and *soma*(body)
- Lysosomal enzymes are synthesized in the RER, sent to the Golgi, creat the vesicels
- They digest worn-out organelles, food particles, and phagocyted viruses or bacteria.

Size: varies from 0.1–1.2 μm

Structure: specialized vesicle surrounded by a single membrane

- **Types:**
- Primary lysosomes: contain digestive enzymes
- Secondary lysosomes: contain digestive enzymes + the digested material

Enzymes: acid hydrolases

Functions: digestion of macromolecules from phagocytosis, endocytosis, autophagy

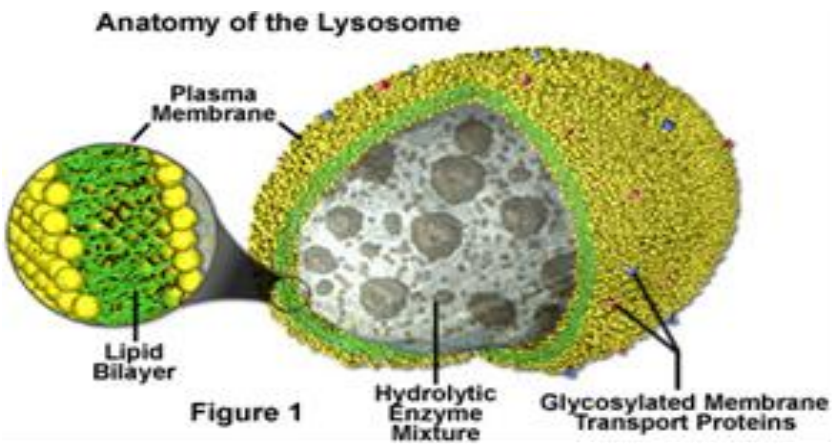


Figure 1

Peroxisomes:

- vesicle, often crystalline structure in the middle
- Contains many enzymes
- involved in production and elimination of hydrogen peroxide
- Breakdown and synthesis of different materials (e.g. lipids)

http://faculty.une.edu/com/abell/histo/histolab2.htm