

Vacuoles, lysosomes, peroxisomes and glyoxysomes



Vacuoles are organelles of eukaryotic cells (typical for plants, algae, fungi, and protozoa). They are covered by a biomembrane (**tonoplast**), which contains many transporters, ion channels, and pumps maintaining active substance exchange between the vacuole and cytosol.

Vacuoles are formed by a fusion of **vesicles coming from ER-GA**, and **endosomes**.

The vacuoles may contain: **salt solutions, saccharides, proteins, pigments;** and **sequestered toxic substances** (e.g. heavy metals).

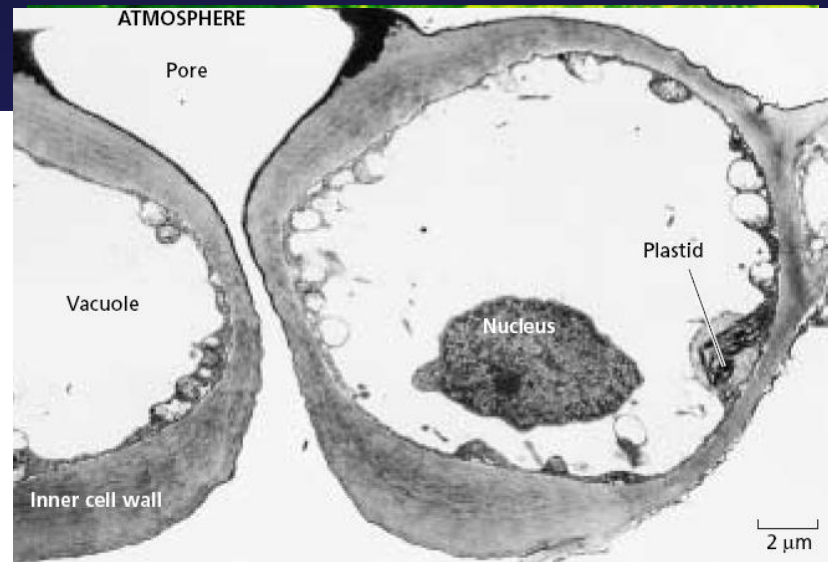
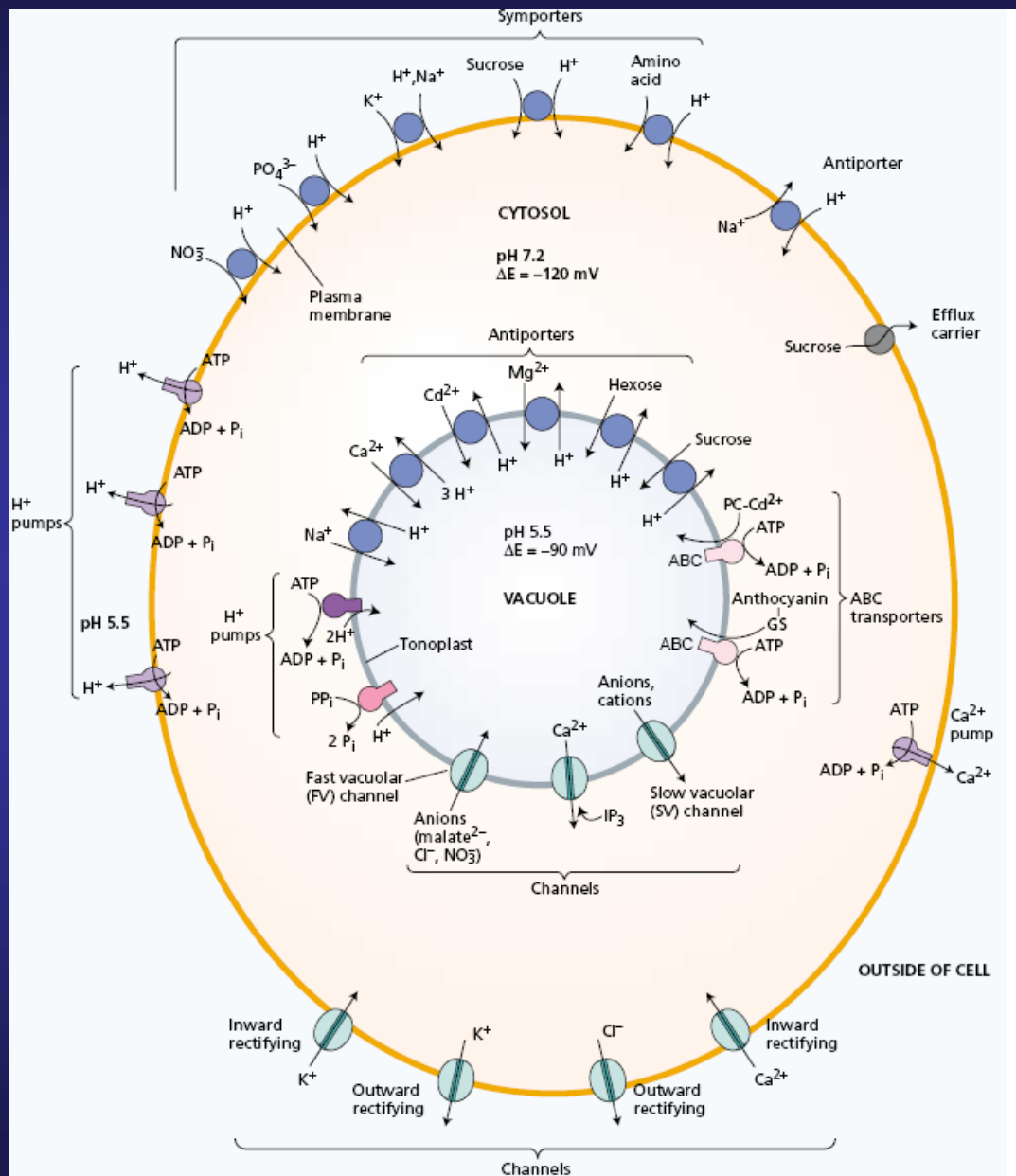
Vacuoles may **differ in size, content**, and thus fulfil **several functions**.

The type of vacuole inside a cell depends on functional specialisation (differentiation) of the cell (or tissue, organ).

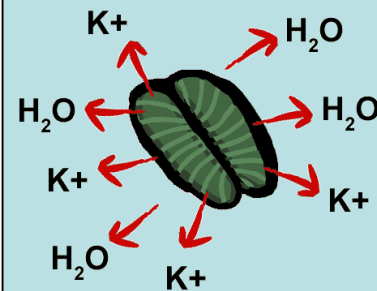
The vacuoles can differentiate into the **central vacuoles** (in parenchyma cells), **lytic vacuoles, storage vacuoles** (e.g. protein storage vacuoles), etc.

Central vacuoles (CV) are formed often by gradual **fusion of small provacuoles**. CV contain large amounts of osmotic active substances, and thus help to regulate **cell turgor**. Generally, the massive central vacuoles are typical for fully differentiated cells.

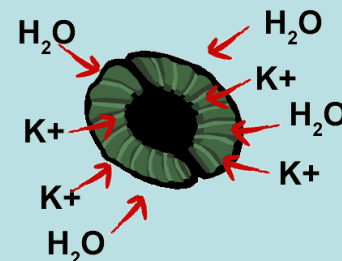




Closed Stomata

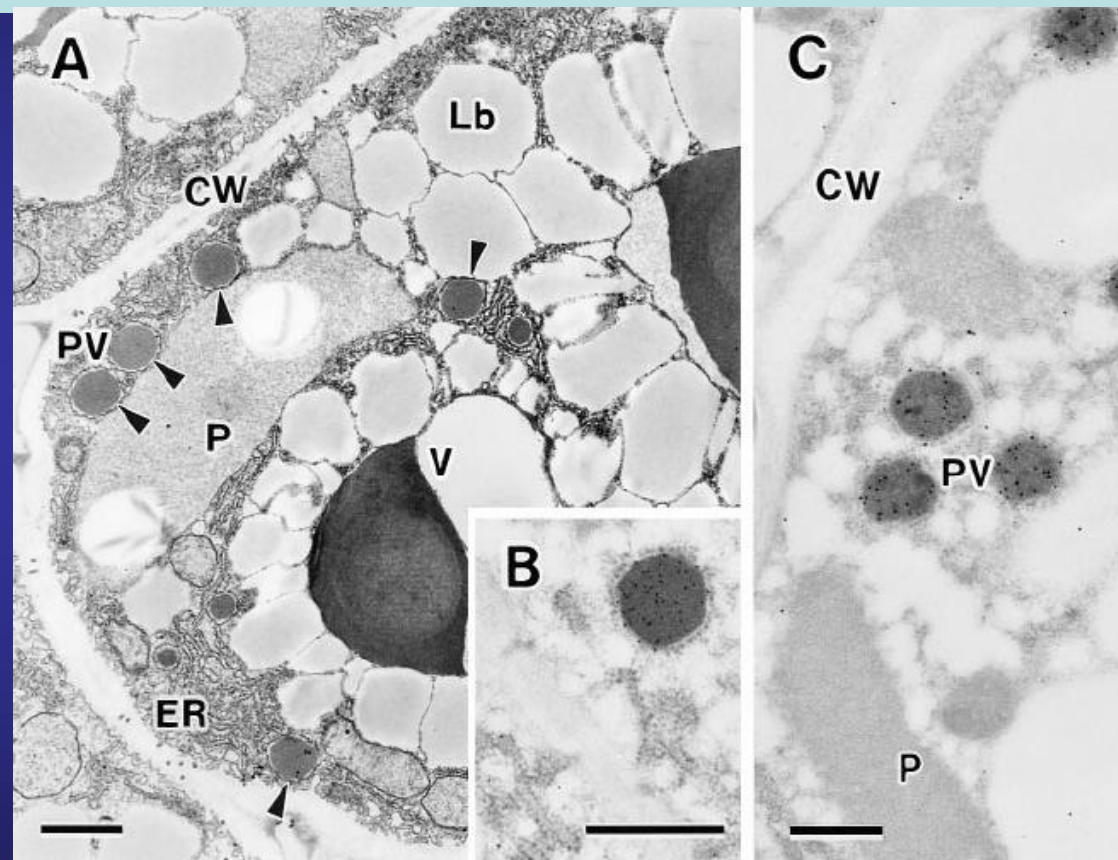


Open Stomata

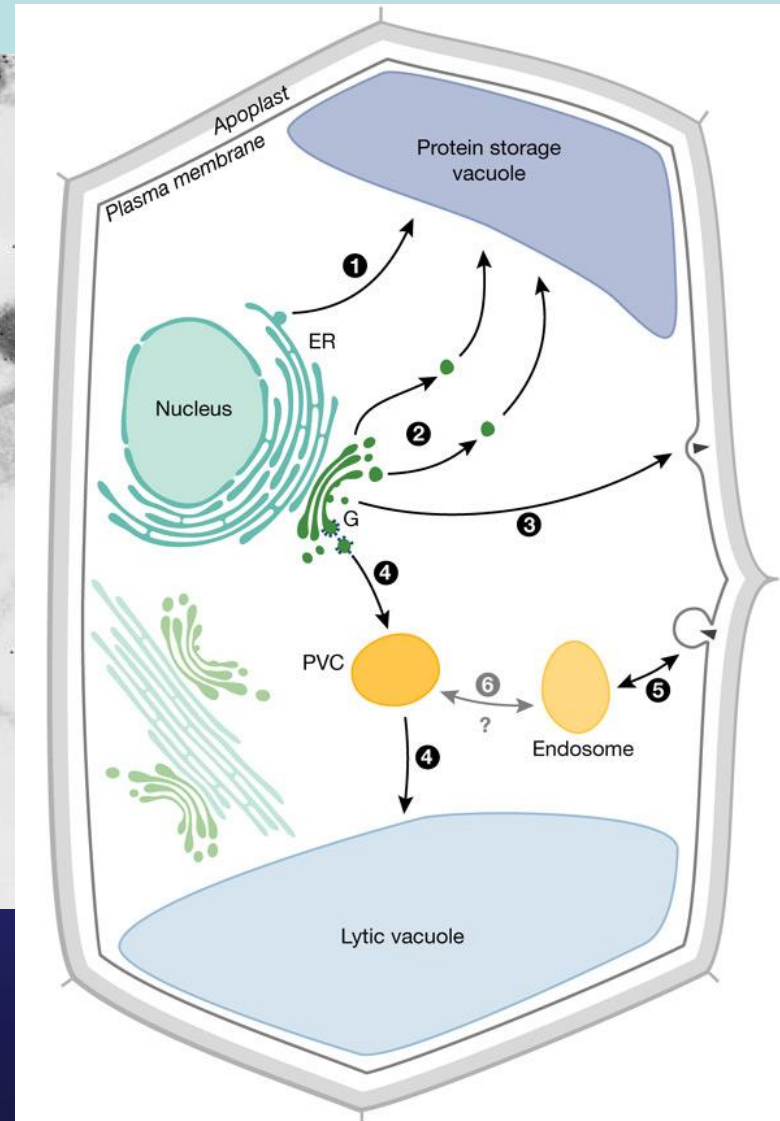


Vacuoles of stomata guard cells play important role in turgor regulation, and thus help to regulate the opening and closing of stomata.

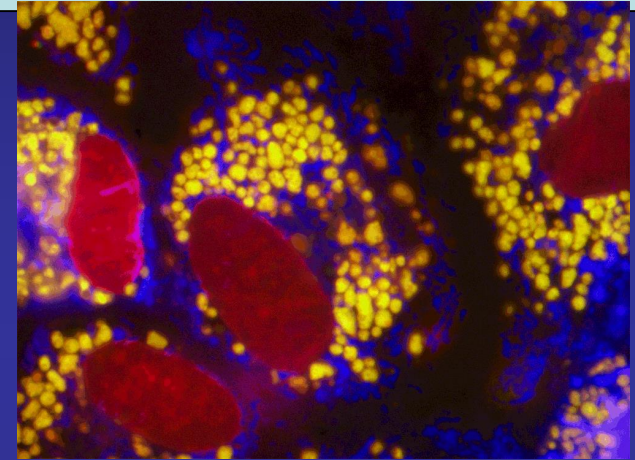
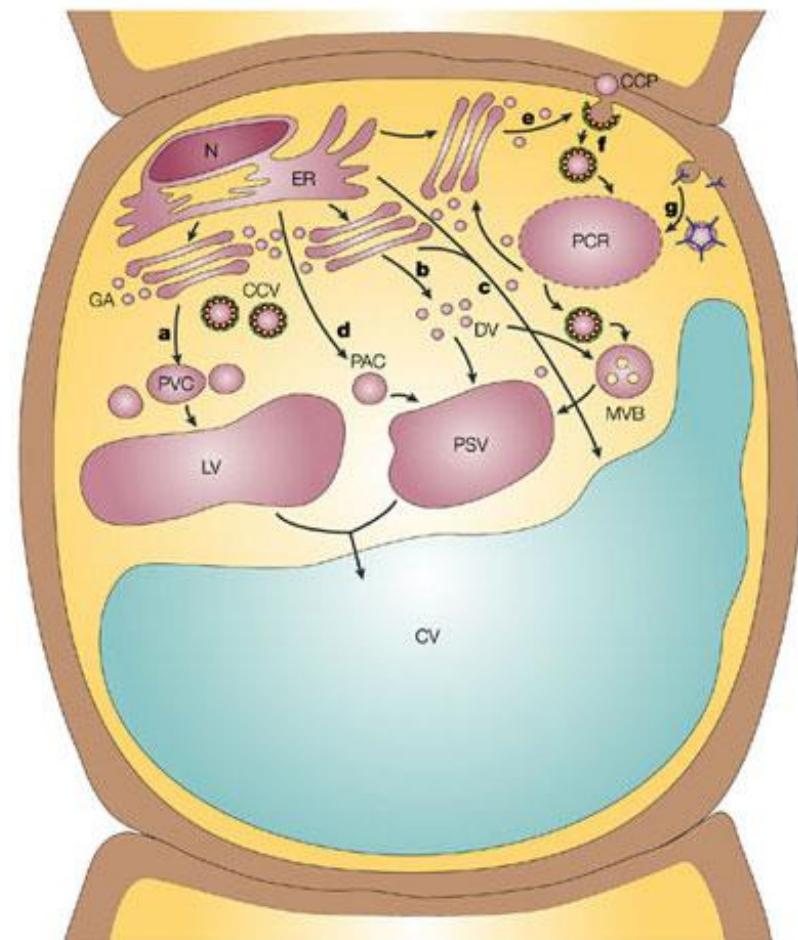
Specialised vacuoles may accumulate storage proteins (**protein storage vacuoles**, PSVs). Accumulated material in PSVs in case of need is degraded (proteases, peptidases, etc.), PSVs abolish and individual intermediate products are used in different metabolic pathways.



Immunogold electron microscopy



Lytic vacuoles accumulate a material with large amount of **hydrolytic enzymes**. In those vacuoles leads to **cleaving** and **degradation** of different **molecules** (proteins) and **cellular materials** (parts of dysfunction organelles) (**autolysis**). Lytic vacuoles are important **in degradation of whole protoplast** in a process of **programmed cell death** (PCD). Lytic vacuoles are functionally similar to lysosomes of animal cells.



Anatomy of the Lysosome

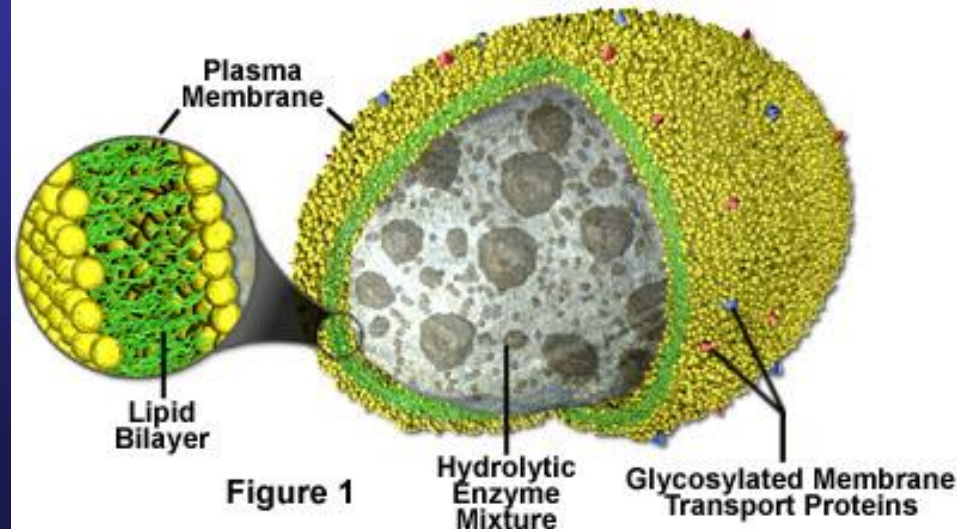
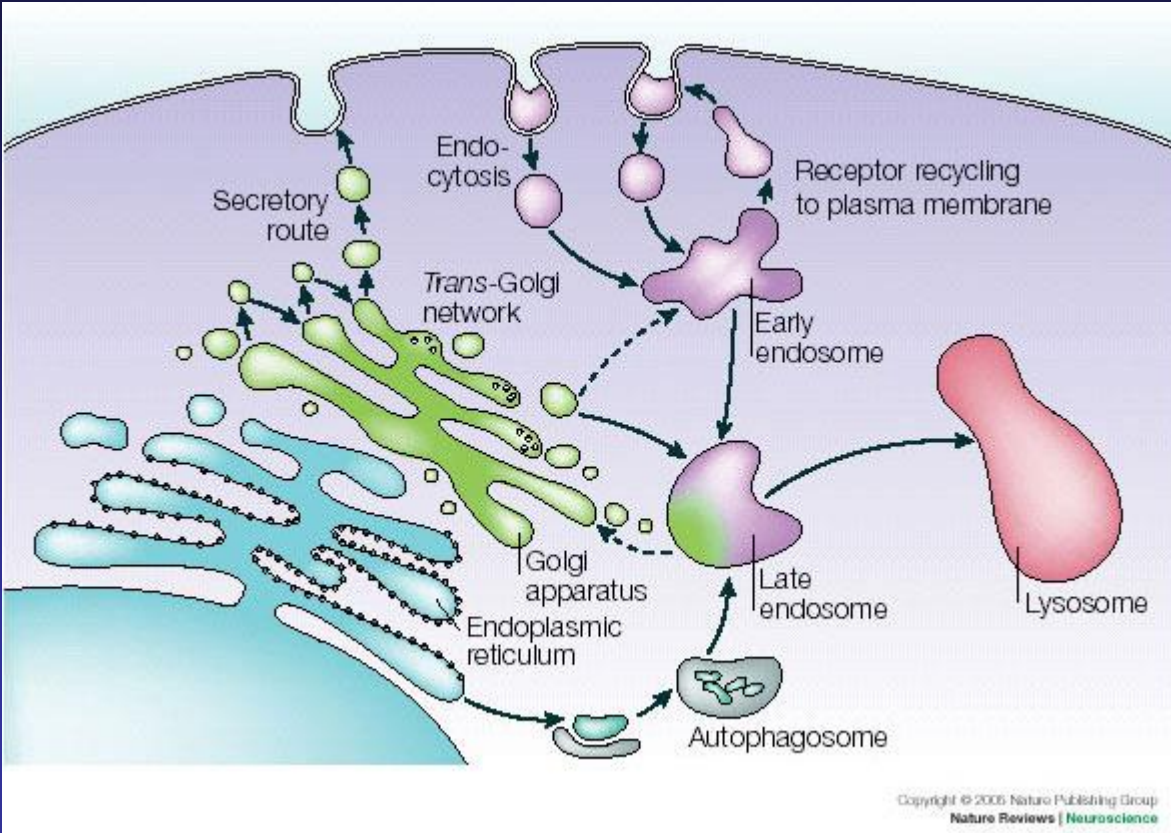


Figure 1



Lysosomes are formed by a fusion of hydrolytic enzymes containing vesicles – they may be derived either from GA or from late endosomes. Lysosomal enzymes are active in acidic environment – **acid hydrolases**.

Primary lysosomes may fuse with late endosomes – thus form **secondary lysosomes**.

Lysosomal Enzymes

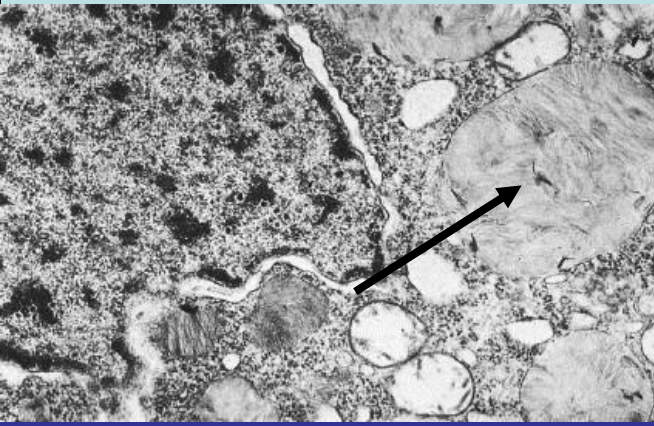
- Phosphate esters: acid phosphatase
- Nucleases: DNase, RNase
- Protein digesting enzymes: collagenase, cathepsins, other proteases
- Carbohydrate digesting enzymes: β -glucosidase, hexosaminidase A, α -mannosidase, α -fucosidase, sialidase, etc.
- Lipid digesting enzymes: sphingomyelinase, esterases

Lysosome enzymes are transported specifically into the late endosomes, or lysosomes!

Autophagy – degradation of an own cell material.

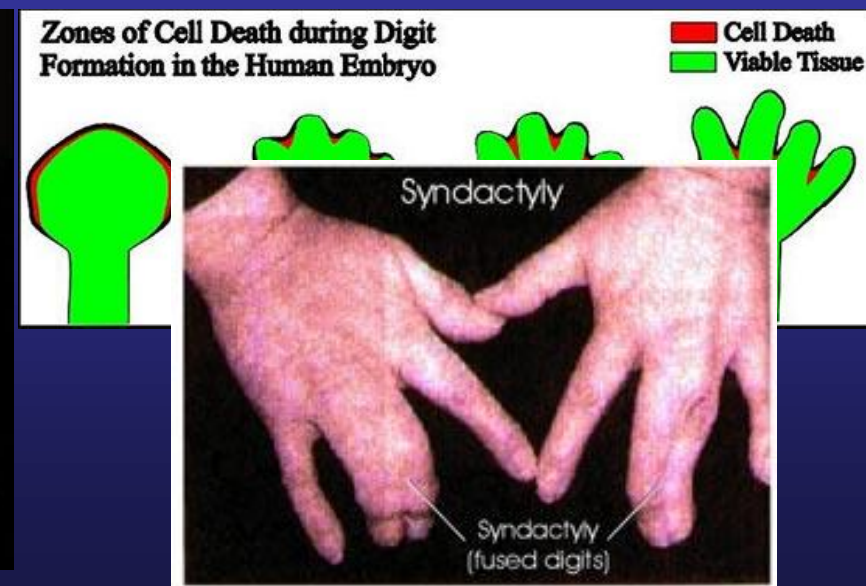
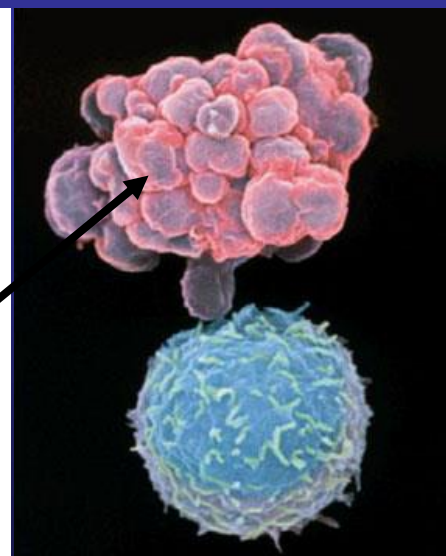
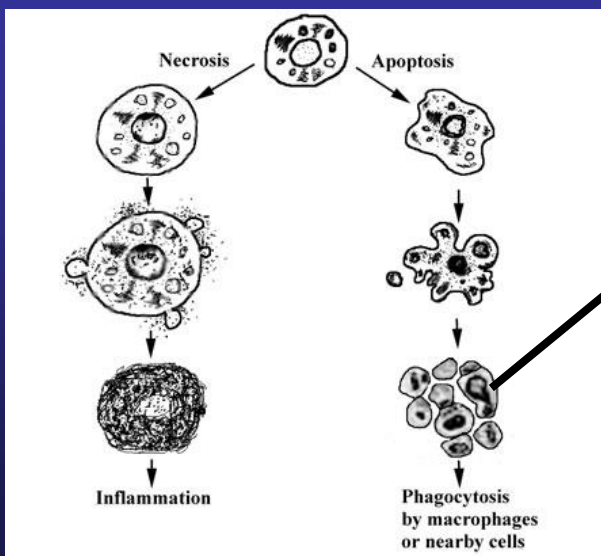
Mistakes of function or correct transport of lysosome enzymes may result in development of serious diseases!

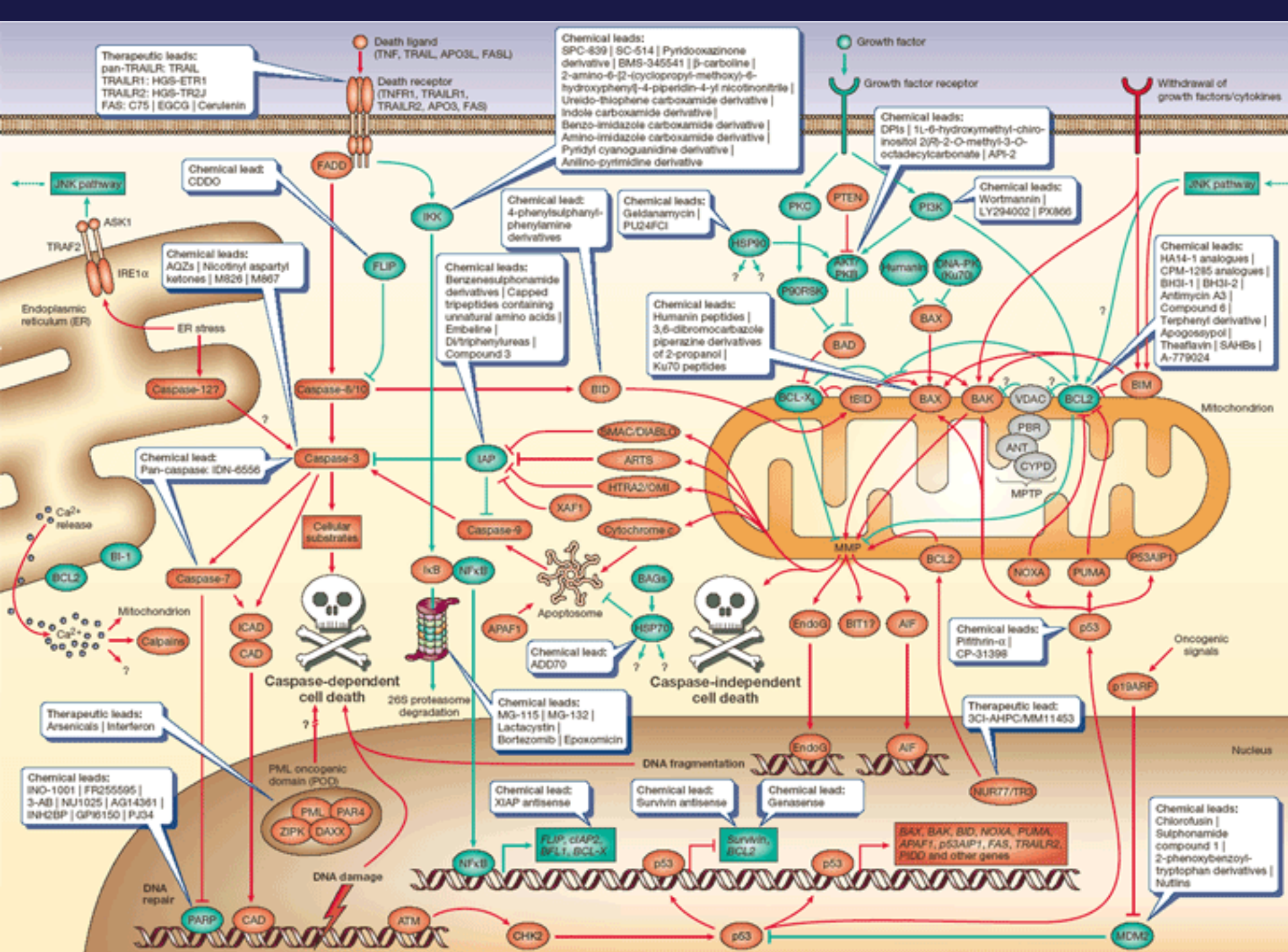
Lysosomal storage diseases



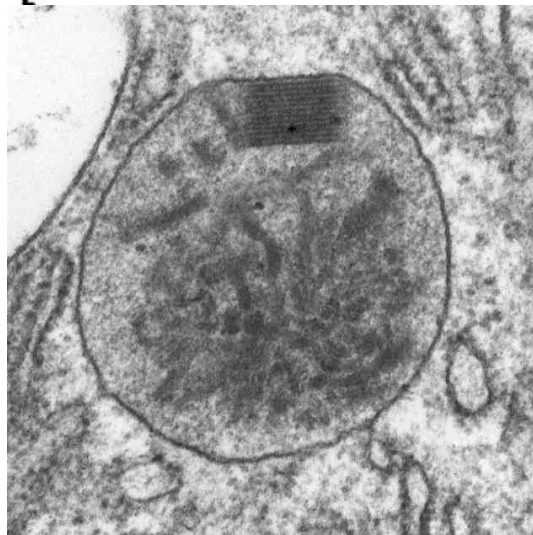
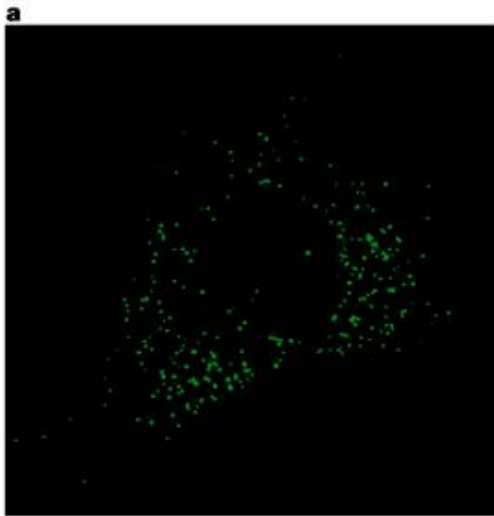
Tay-Sachs disease:
lysosomes of neural cells do not degrade gangliosides; it leads to neurodegenerative disease.

Controlled release of some lysosome proteins (cathepsins) is crucial for correct initiation of apoptosis.

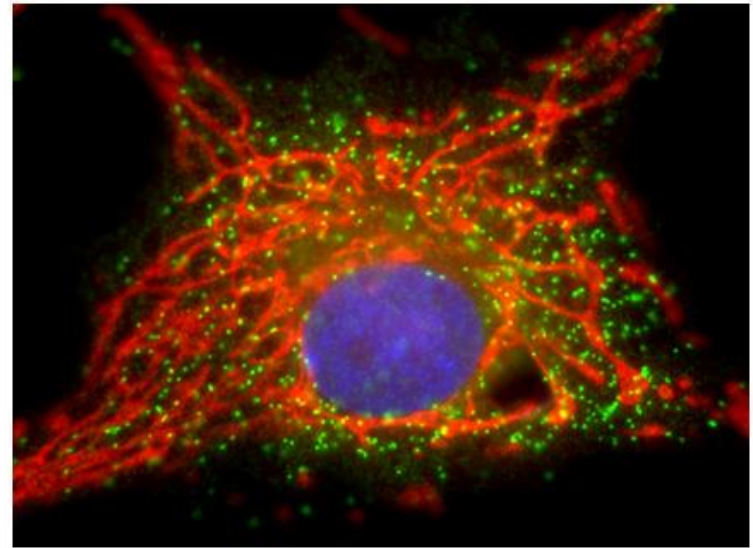




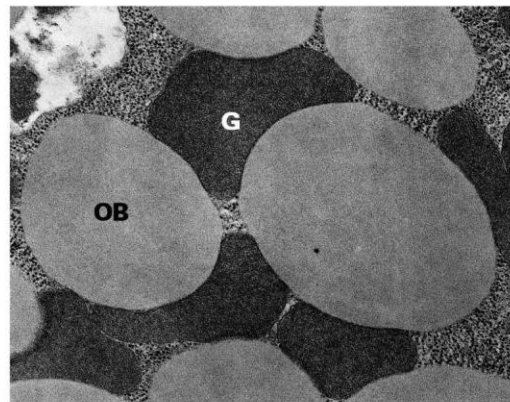
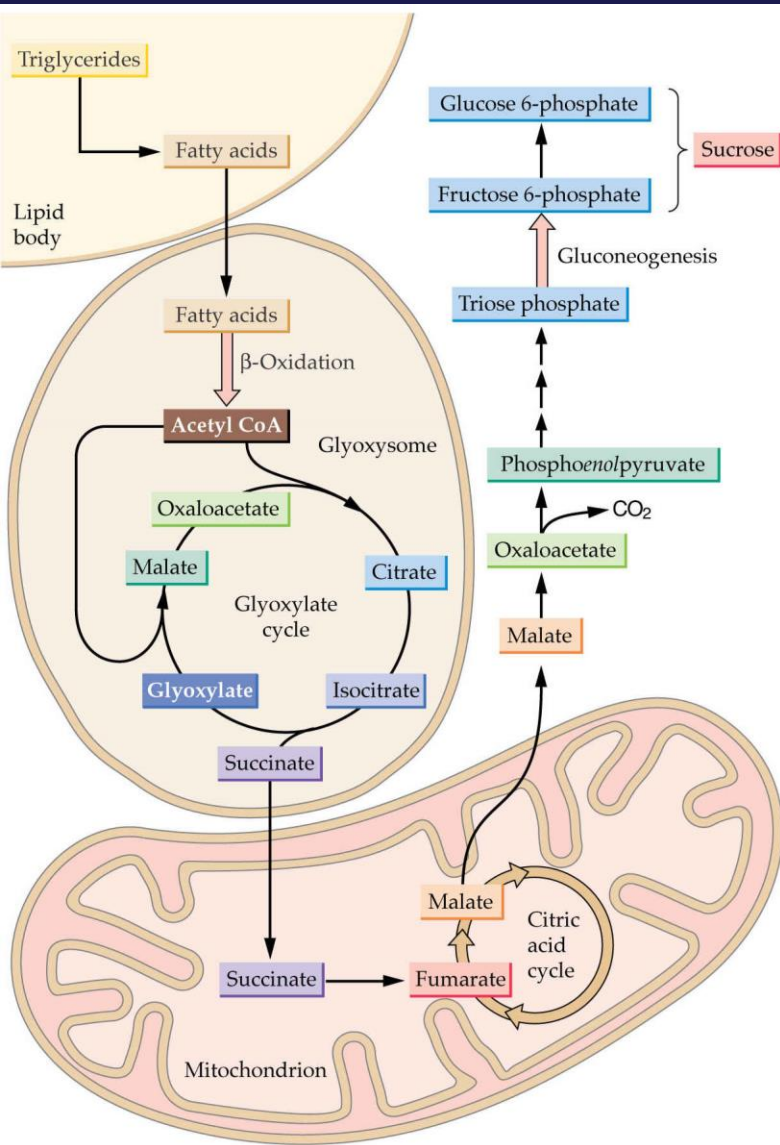
Peroxisomes are organelles/microbodies (0,2 – 1 μm) of eukaryotic cells with large amount of oxidative enzymes (**peroxidases, katalase, etc.**). Many enzymes of peroxisomes are synthesized in the cytosol (specific transport). Those enzymes help to oxidise fatty acids, metabolise H_2O_2 , synthesise precursors of biosynthetic pathways, synthesise myelin, photorespiration, degradation purines, etc.



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Peroxisomes (as the other organelles as well) is possible to visualise after marking them with a specific protein (marker). Visualisation of individual organelles in combination with additional pharmacological and genetical experiments may help to explain the function of those organelles.



Glyoxysomes are organelles/microbodies (0.5 – 1.5 μm) in plant cells (predominantly in plant seeds) with large content of oxidative enzymes for β -oxidation of fatty acids, and glyoxylate cycle (isocitrate lyase and malate synthase).

They are involved in the oxidation of stored lipids, thus produce carbon and energy for a growth, conversion of fatty acids onto the glucose precursors for biosynthetic pathways, etc.