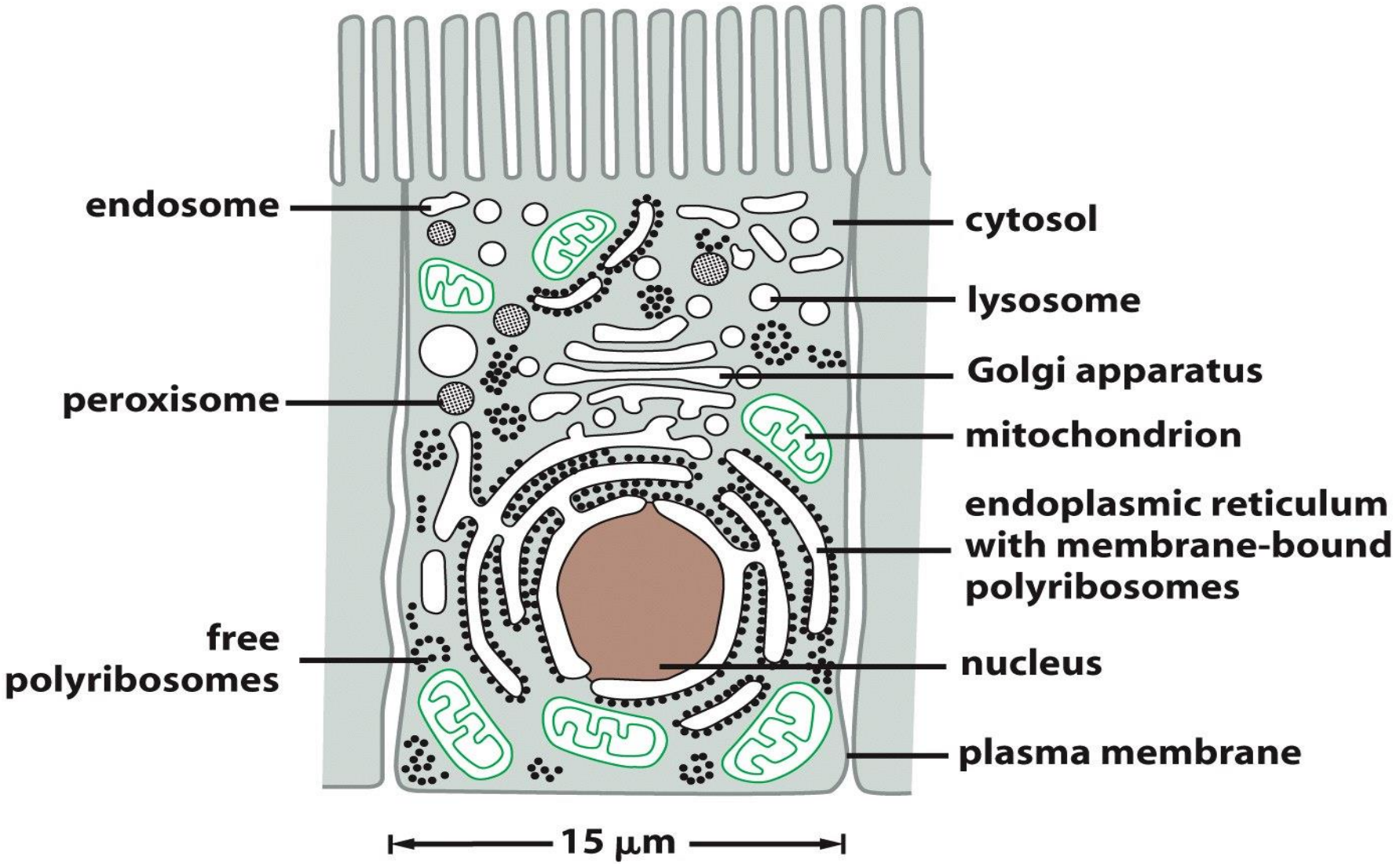
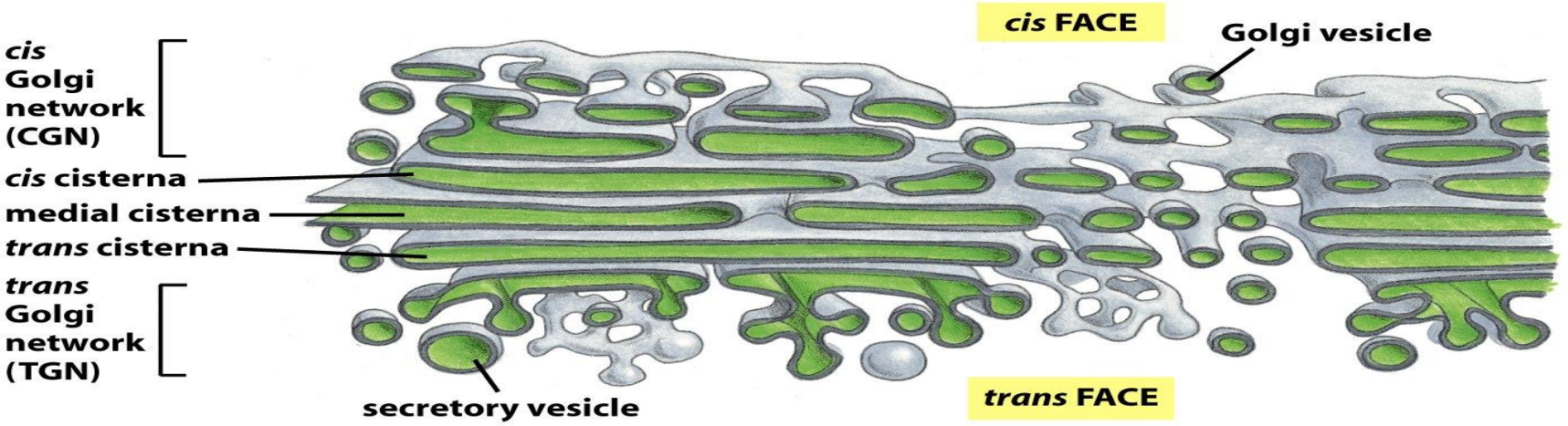
CELL BIOLOGY - 3

Cellular Components

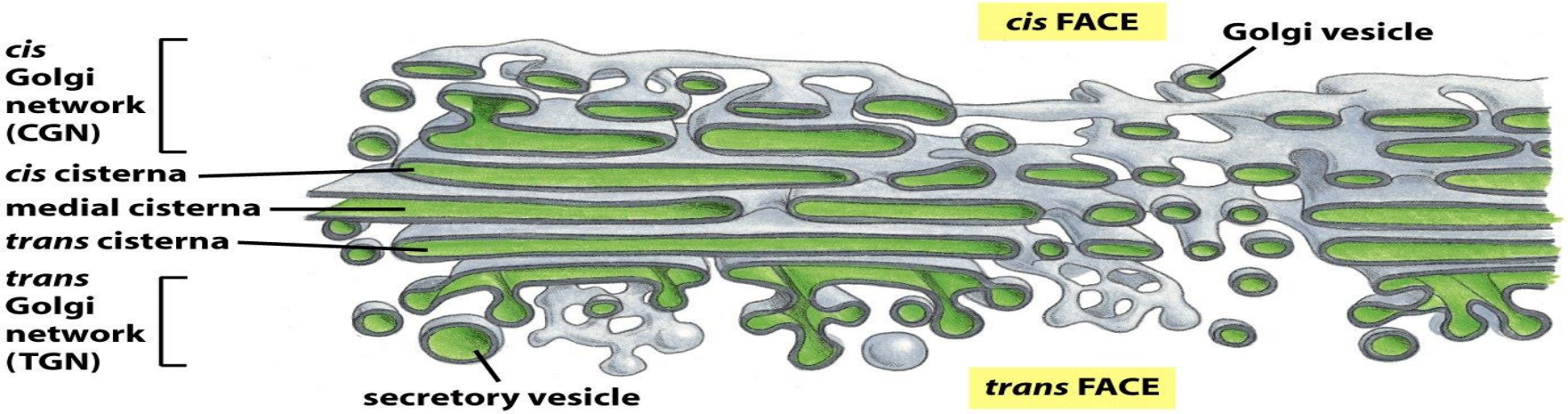


The Golgi Apparatus



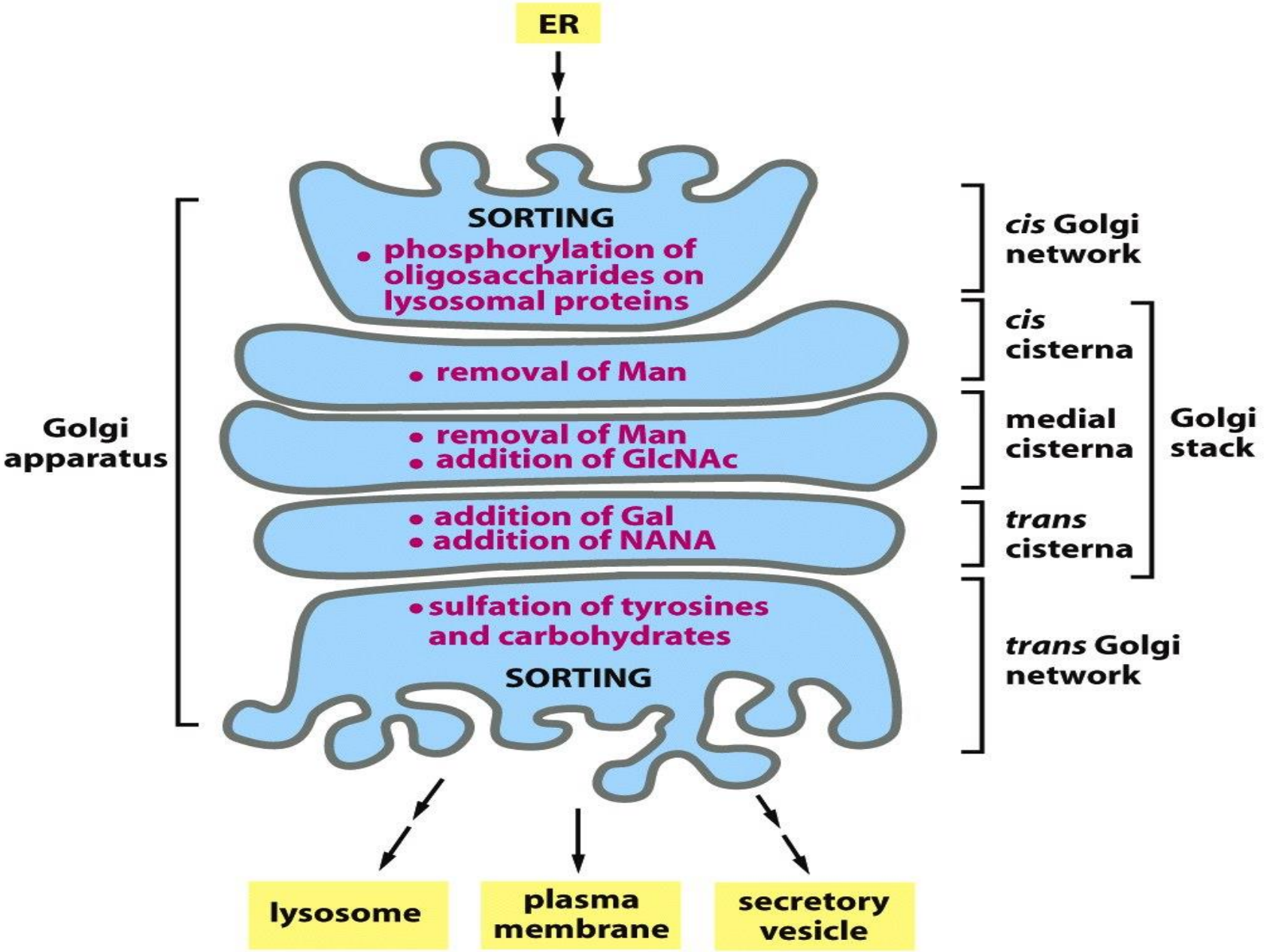
- Complex organelle present in eukaryotic cells – stack of flattened membrane enclosed compartments - called *cisternae*. *Golgi* stacks are linked with tubular connections – forming a single complex – Golgi apparatus - located near the nucleus and ER (endoplasmic reticulum) exit sites. In plant cells, hundreds of individual Golgi stacks may be dispersed throughout the cytoplasm.

- Proteins and lipids are transferred from the ER to Golgi complex - then modified, sorted and distributed by Golgi apparatus throughout the cell. Also, it is the site of cell wall polysaccharide synthesis in plants and extracellular matrix glycosaminoglycans synthesis in animals.



Two distinct faces – the *cis* face (entry face) and the *trans* face (exit face). Each face is composed of a network of interconnected tubular and cisternal structures – the *cis* Golgi network and the *trans* Golgi network.

Proteins and lipids enter the cis-golgi network (entry face) and after modification, exit from the trans-golgi network (exit face) – then distributed to cell surface or to other compartments (like lysosome, vesicles, etc.).


ER
SORTING
• phosphorylation of oligosaccharides on lysosomal proteins
• removal of Man
• removal of Man
• addition of GlcNAc
• addition of Gal
• addition of NANA
• sulfation of tyrosines and carbohydrates
SORTING
Golgi apparatus
cis Golgi network
cis cisterna
medial cisterna
trans cisterna
Golgi stack
trans Golgi network
lysosome
plasma membrane
secretory vesicle

Upon arrival in the CGN, proteins pass through the cis- Golgi network (CGN), before entering the first golgi processing compartment (cis cisterna).

They then move to the next compartment (medial cisternae) and finally to the trans cisterna, where glycosylation is completed.

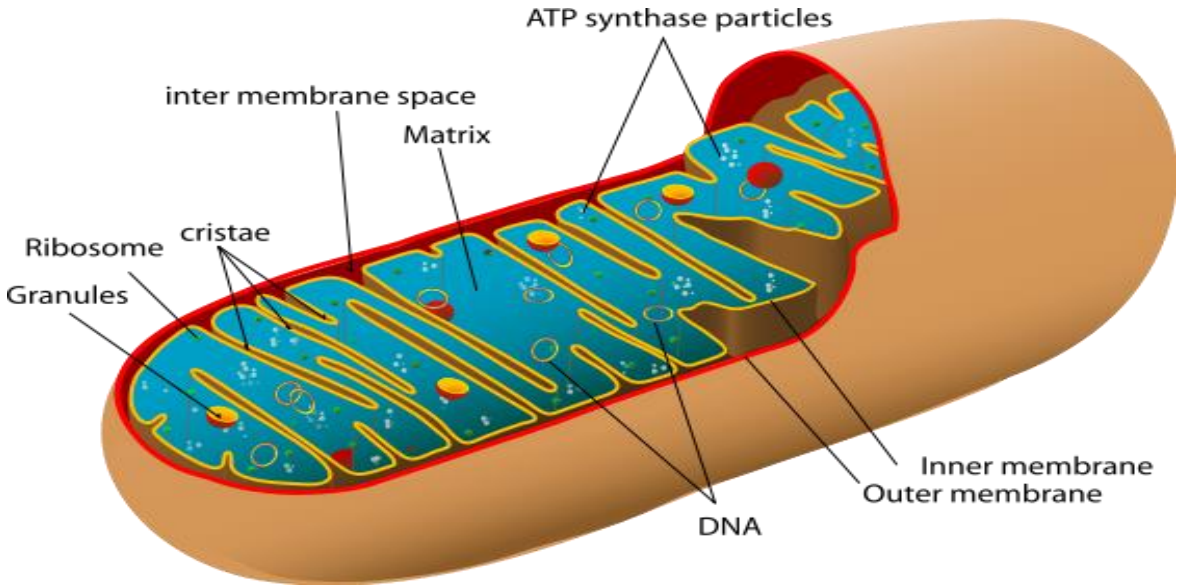
The trans-Golgi network (TGN), is the place where proteins are segregated into different transport packages and dispatched to their final destinations.

Proteins are modified in successive stages as they move from cisterna to cisterna across the stack, so that the stack forms a multistage processing unit.

Phosphorylation takes place in cis compartment, The removal of mannose residues and the addition of N-acetylglucosamine take place in the medial compartment.

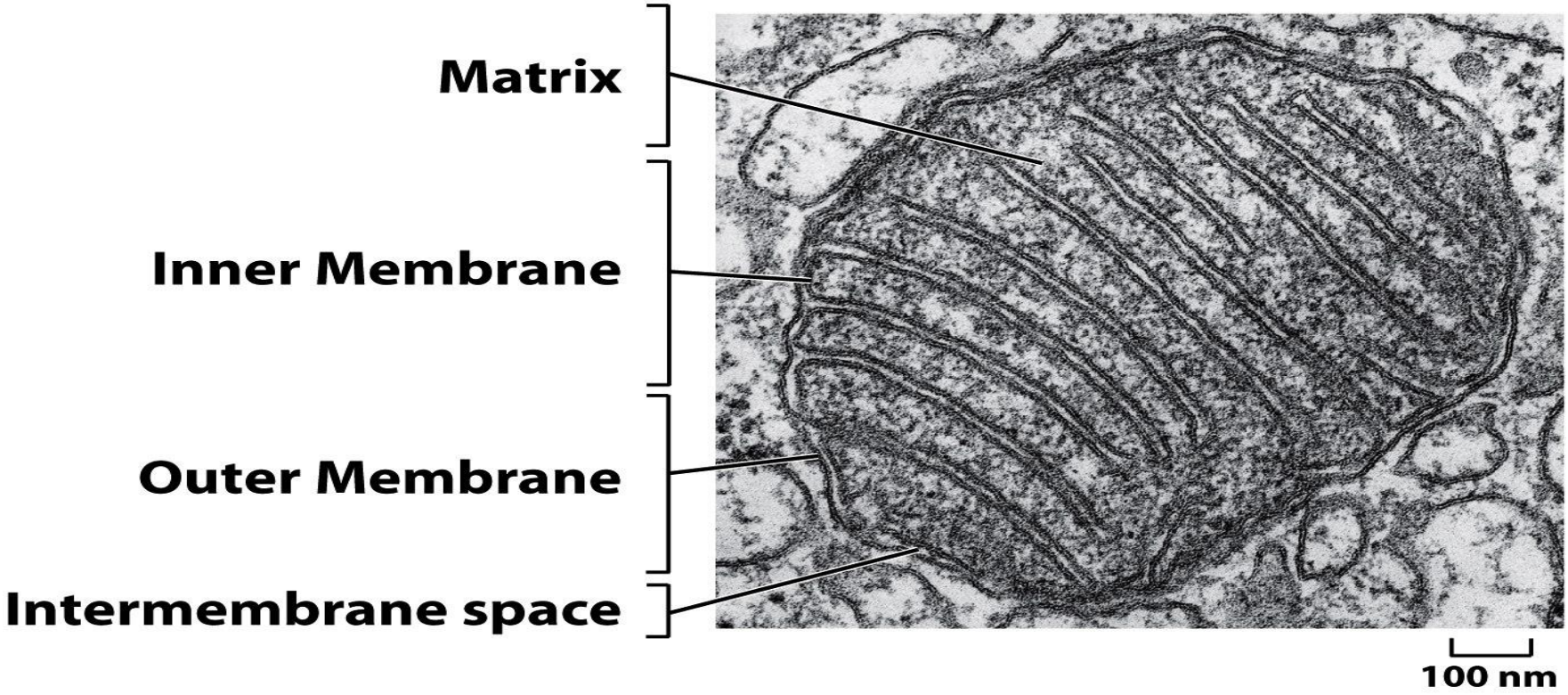
Addition of galactose and sialic acid (NANA – N acetyl neuraminic acid) in trans compartment. Sulfation and final packaging takes place in TGN.

Mitochondria - the energy generating organelles



- **Stiff, elongated cylinder – diameter 0.5 to 1 um – resembling bacteria – energy converting organelle in eukaryotes – remarkably mobile and plastic organelle – can change their shape.**

- **Mitochondrion contains an outer membrane (OM) and an inner membrane (IM). Two separate compartments - the internal matrix and the intermembrane space – each compartment contains a unique collection of different proteins.**



- **The IM is highly convoluting (folded) – forming series of finger like infoldings – the cristae, that are projected into the matrix.**

- **The outer membrane (OM) is permeable to all molecules of 5000 daltons or less. OM contains *porin* proteins - a type of transport protein forming large aquous channels through the lipid bilayer of OM.**

- **Most of the molecules transported through OM can not cross the inner membrane (IM) to enter into the matrix. The IM is highly selective for some molecules.**

- **IM contains proteins with 3 types of functions: some carry out oxidation reaction in Electron transport chain; the ATP synthase enzyme - making ATP in matrix during respiration; and transport proteins that allow the passage of metabolites into and out of the matrix. IM is impermeable to ions and most small charged molecules.**

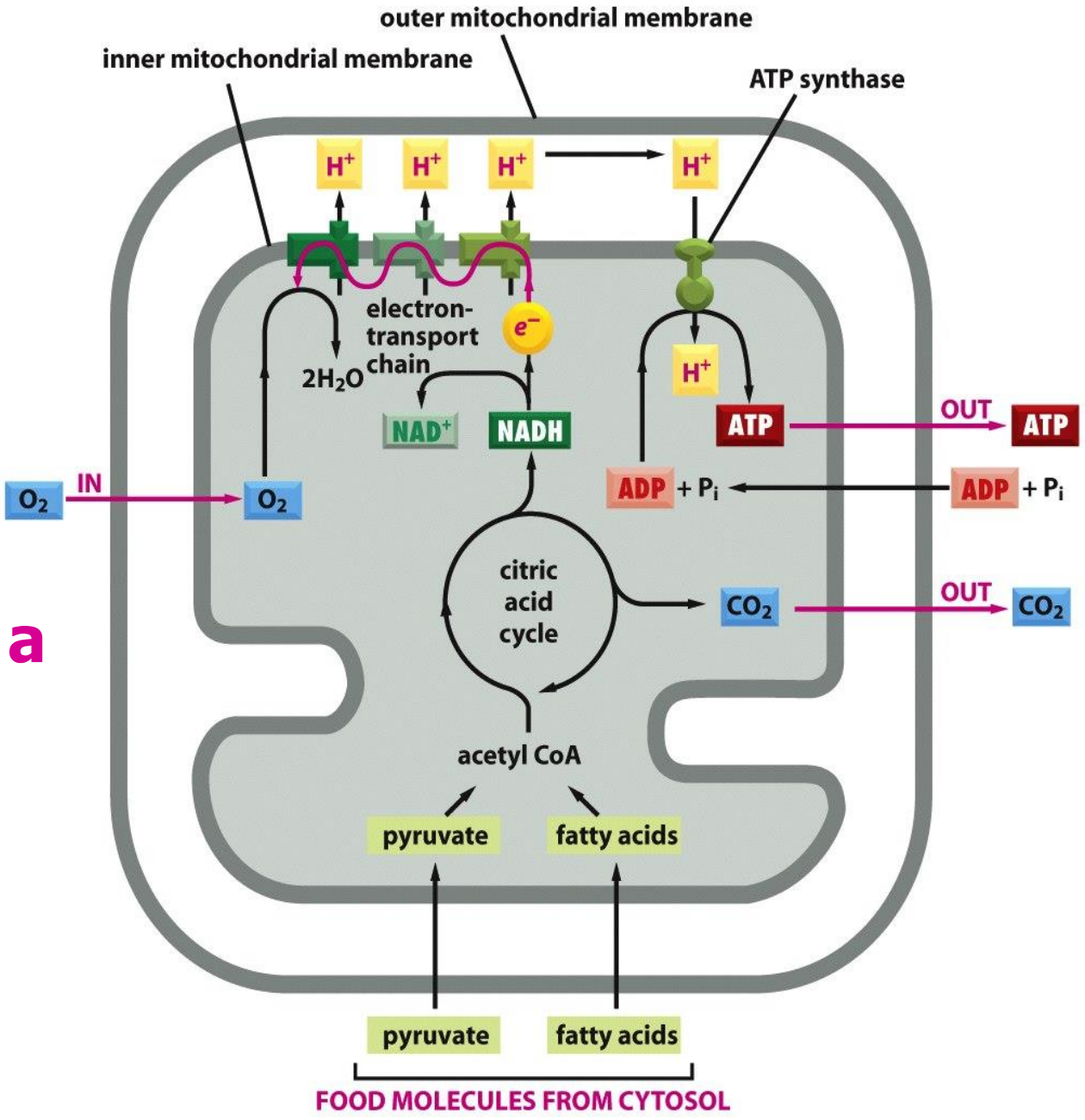
- **OM contains channel forming proteins – the porins ; and the enzymes for mitochondrial lipid synthesis and for processing lipid substrates. Also contains import receptor for mitochondrial proteins and enzymatic machinery for mitochondrial division and fusion.**

- **Intermembrane space contains the enzymes to phosphorylate other compounds using the ATP passing out of the Matrix.**

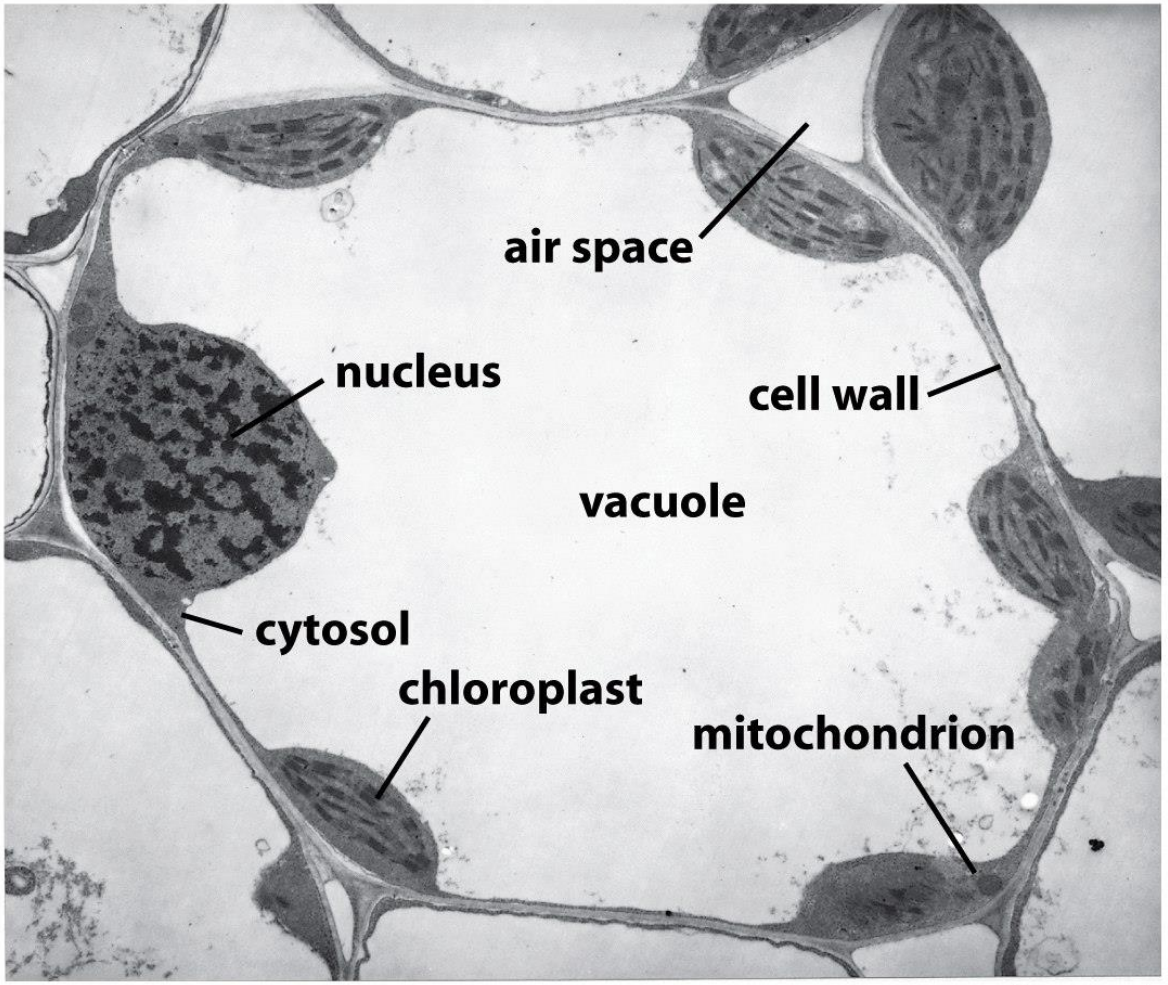
- **Matrix contains a highly concentrated mixture of hundreds of enzymes required for the oxidation of pyruvate and fatty acids and for the citric acid cycle during respiration.**

- **Matrix also contains several identical copies of mitochondrial DNA, special mitochondrial ribosomes, tRNAs and various enzymes required for mitochondrial gene expression.**

A summary of the energy generating metabolism in a mitochondrion

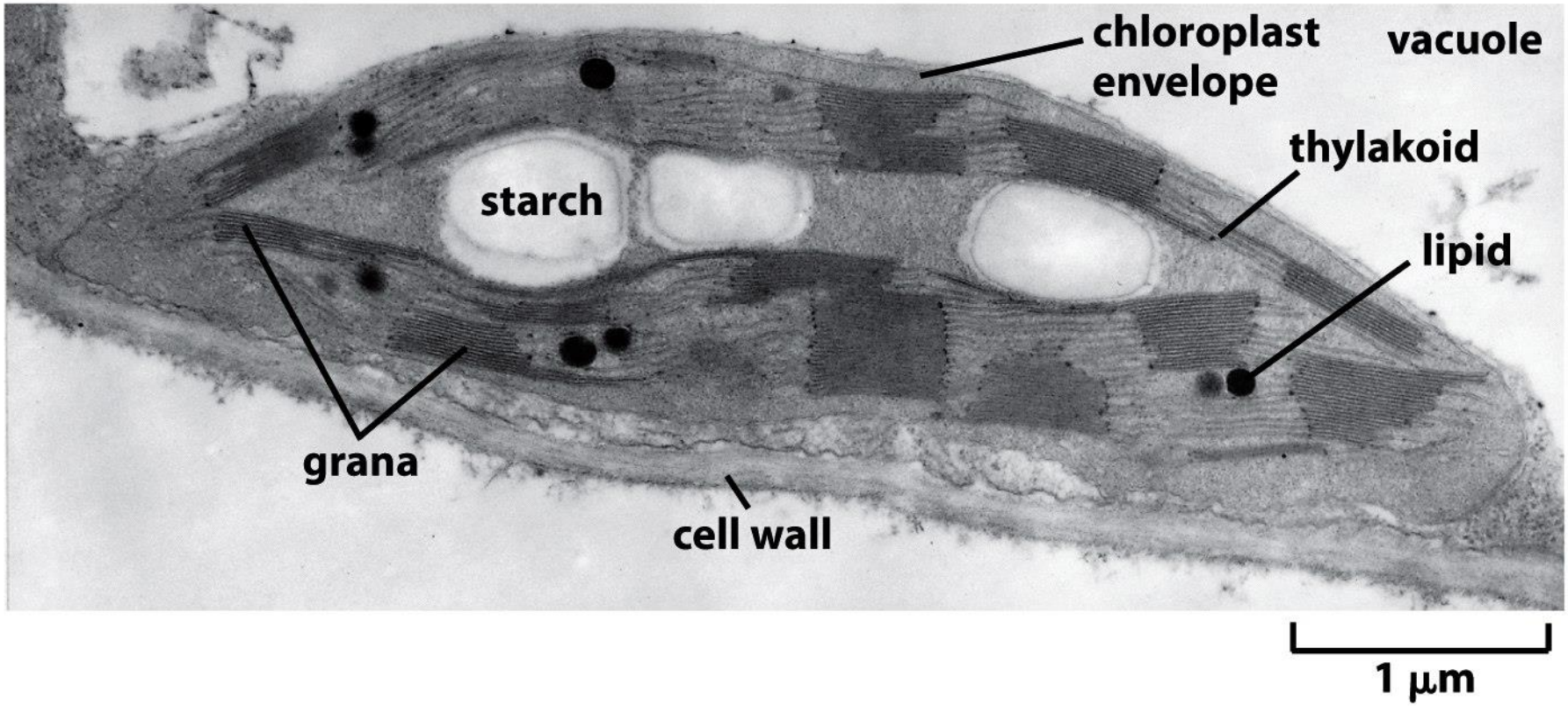


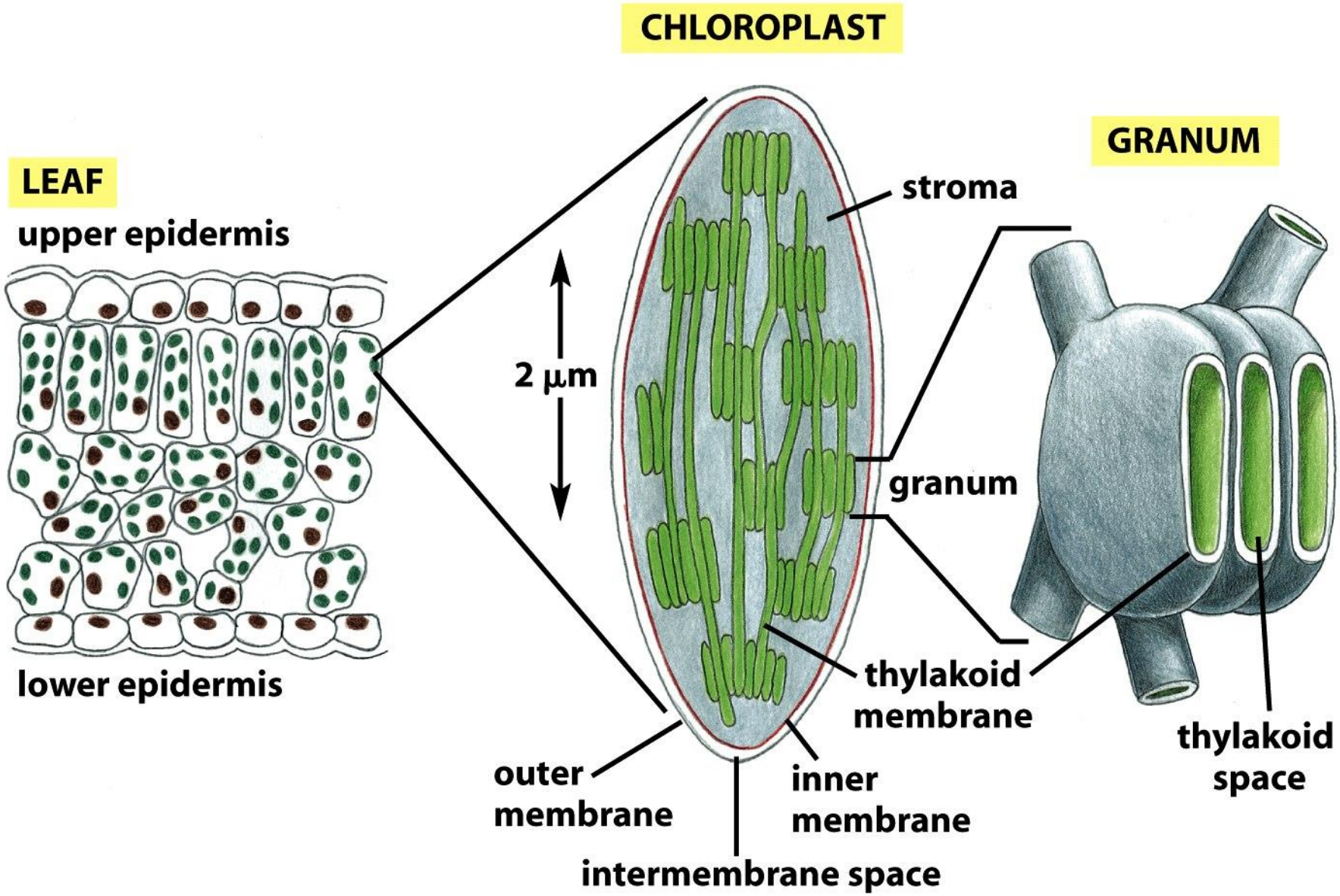
Chloroplast – organelle for photosynthesis

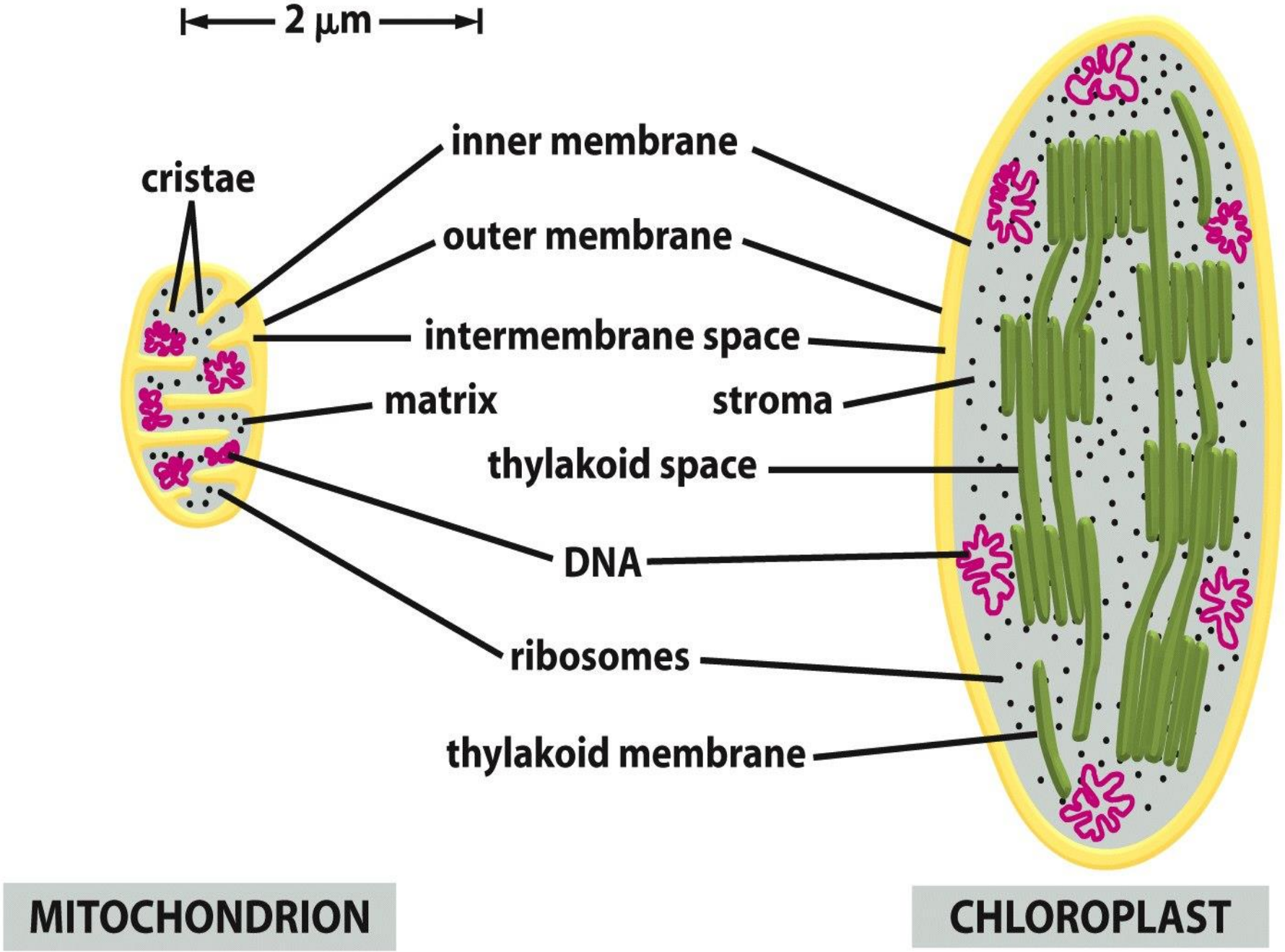


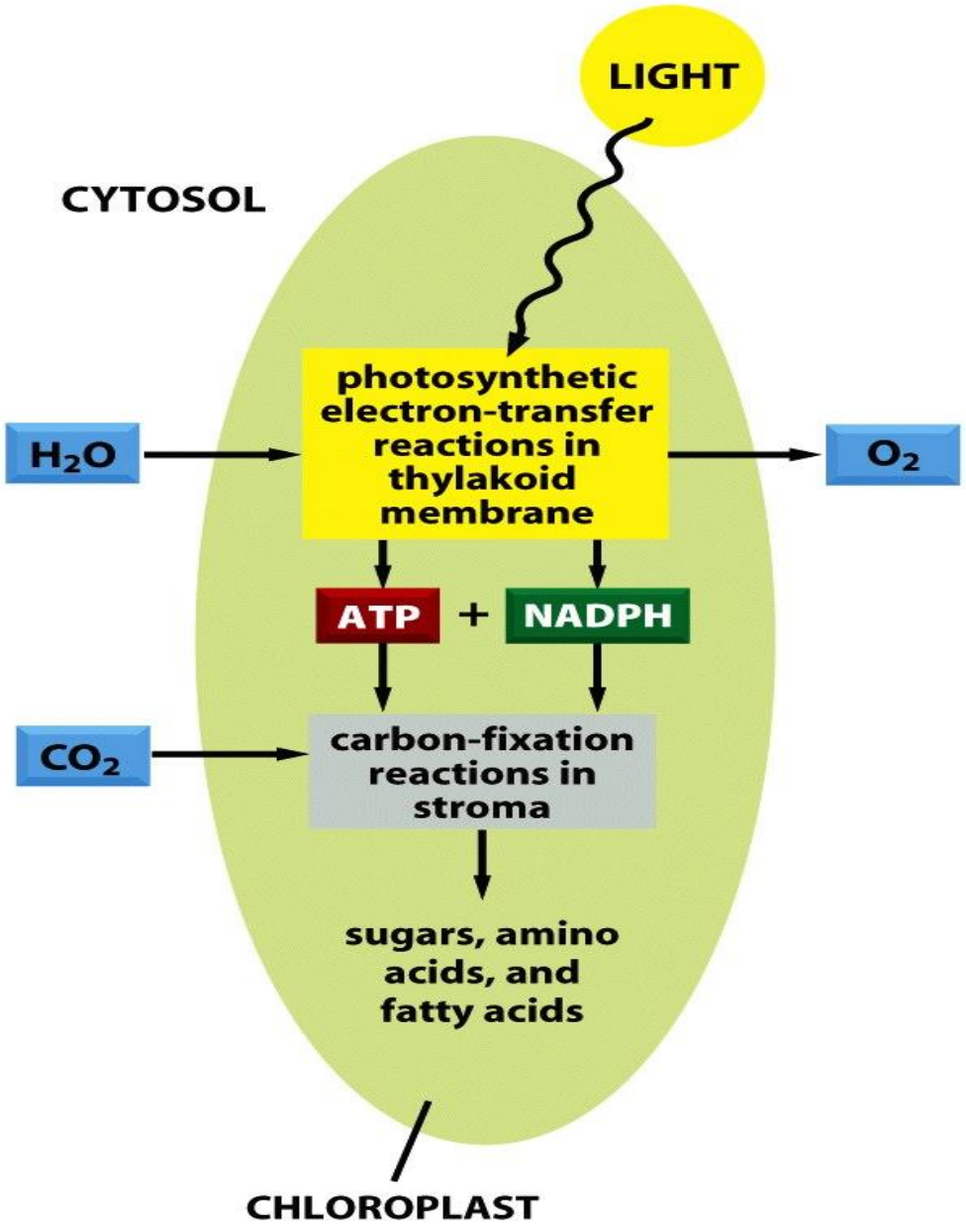
A PLANT CELL

Chloroplast – organelle for photosynthesis




CHLOROPLAST
LEAF
upper epidermis
lower epidermis
2 μm
stroma
granum
thylakoid membrane
outer membrane
inner membrane
intermembrane space
GRANUM
thylakoid space


2 µm
cristae
inner membrane
outer membrane
intermembrane space
matrix
stroma
thylakoid space
DNA
ribosomes
thylakoid membrane
MITOCHONDRION
CHLOROPLAST

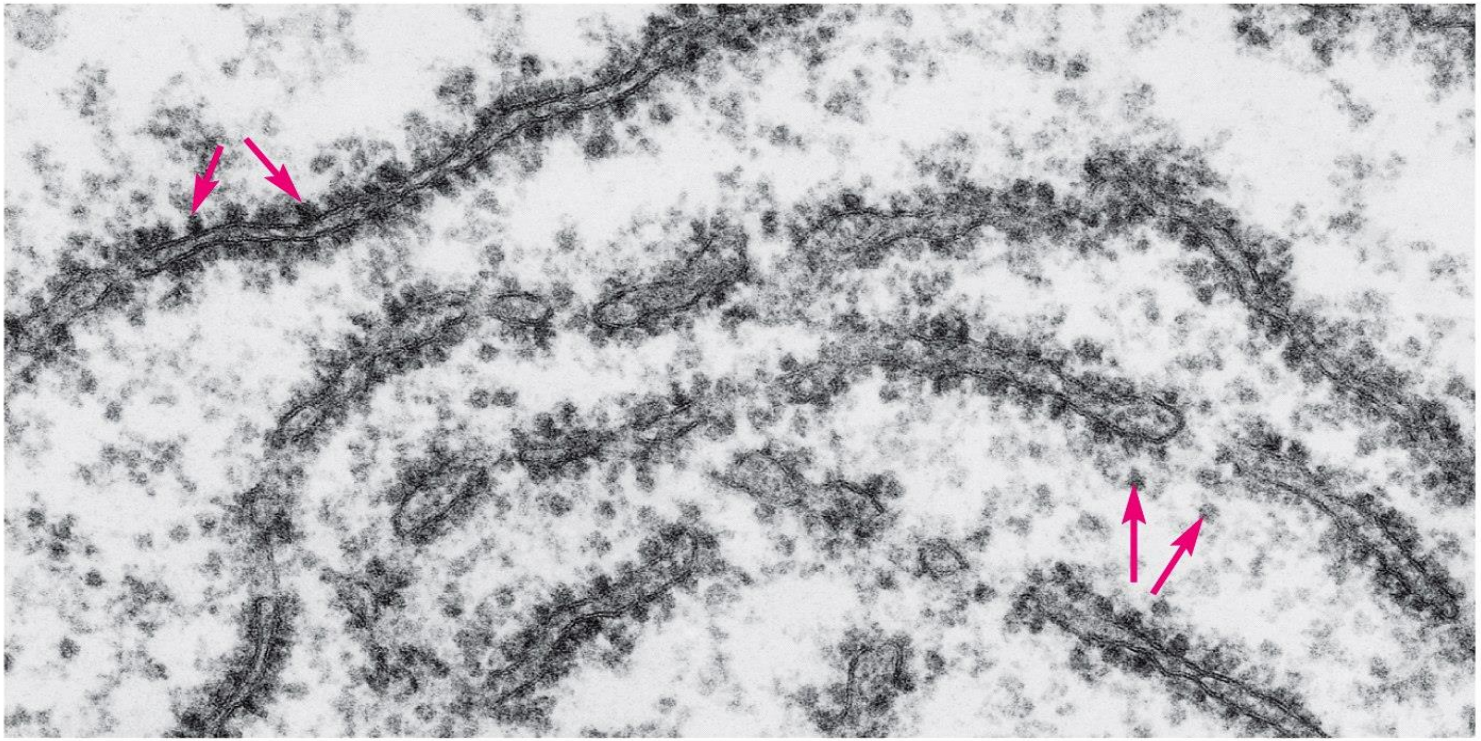


The reactions of photosynthesis in a chloroplast.

Water is oxidized and oxygen is released in the photosynthetic electron-transfer reactions (light reaction),

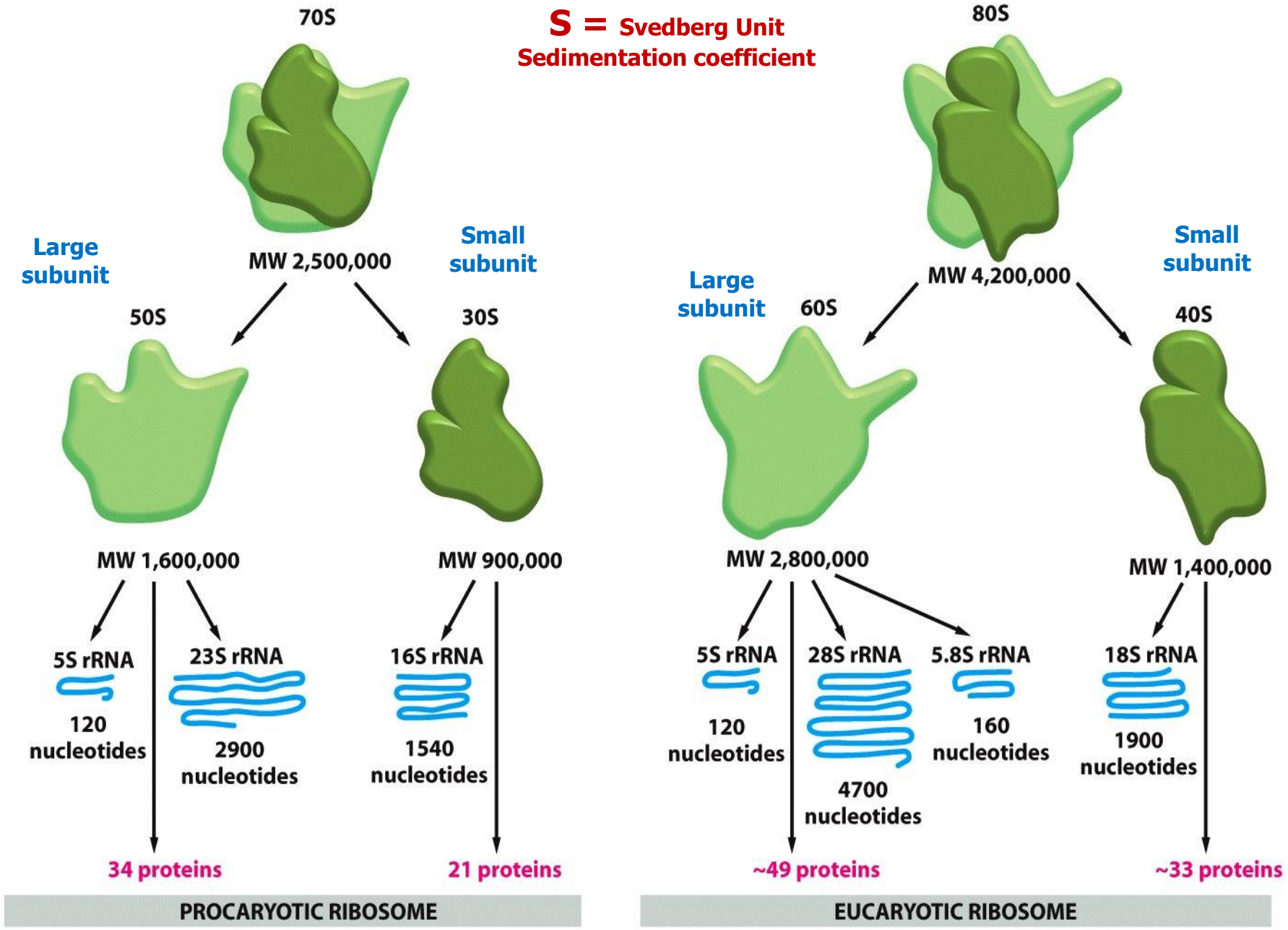
while carbon dioxide is assimilated (fixed) to produce sugars and a variety of other organic molecules in the carbon fixation reactions (dark reaction).

Ribosome – protein synthesis machinery



Many ribosomes are attached to the endoplasmic reticulum

S = Svedberg Unit
Sedimentation coefficient



Ribosome – protein synthesis machinery

Factor	Prokaryotes	Eukaryotes
large subunit	50S (23S and 5S rRNA) (35 proteins)	60S (28S, 5S, and 5.8S rRNA) (49 proteins)
small subunit	30S (16S rRNA) (21 proteins)	40S (18S rRNA) (33 proteins)
ribosome	70S	80S

- Ribosomes are made up of 2/3 rRNA and 1/3 protein
- Cells contain thousands of ribosomes

The Lysosome

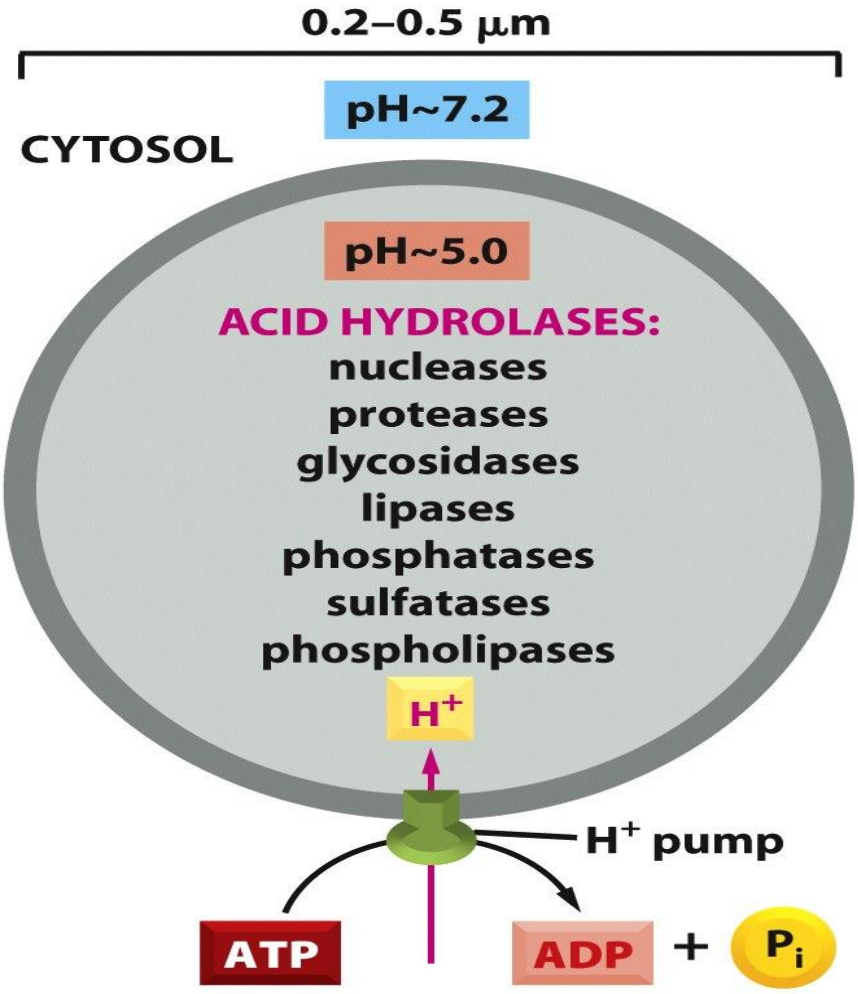
LYSOSOME

Membrane bound organelle in eukaryotic cells containing digestive enzymes active under acidic conditions. ATPase enzyme in the membrane pumps hydrogen ions into the lysosome, maintaining its lumen at an acidic pH.

Acid hydrolase enzymes break down waste materials and cellular debris.

Lysosomes digest excess or worn-out organelles, food particles, and engulf viruses or bacteria.

They can be described as the stomach of the cell as well as suicidal bag. They are found in animal cells, while their existence in yeasts and plants is disputed.



Lysosomes contain about 50 different degradative enzymes that can hydrolyze proteins, DNA, RNA, polysaccharides, and lipids.

All of the lysosomal enzymes are acid hydrolases, which are active only at the acidic pH (about 5) that is maintained within lysosomes.

Some important enzymes within lysosomes include:

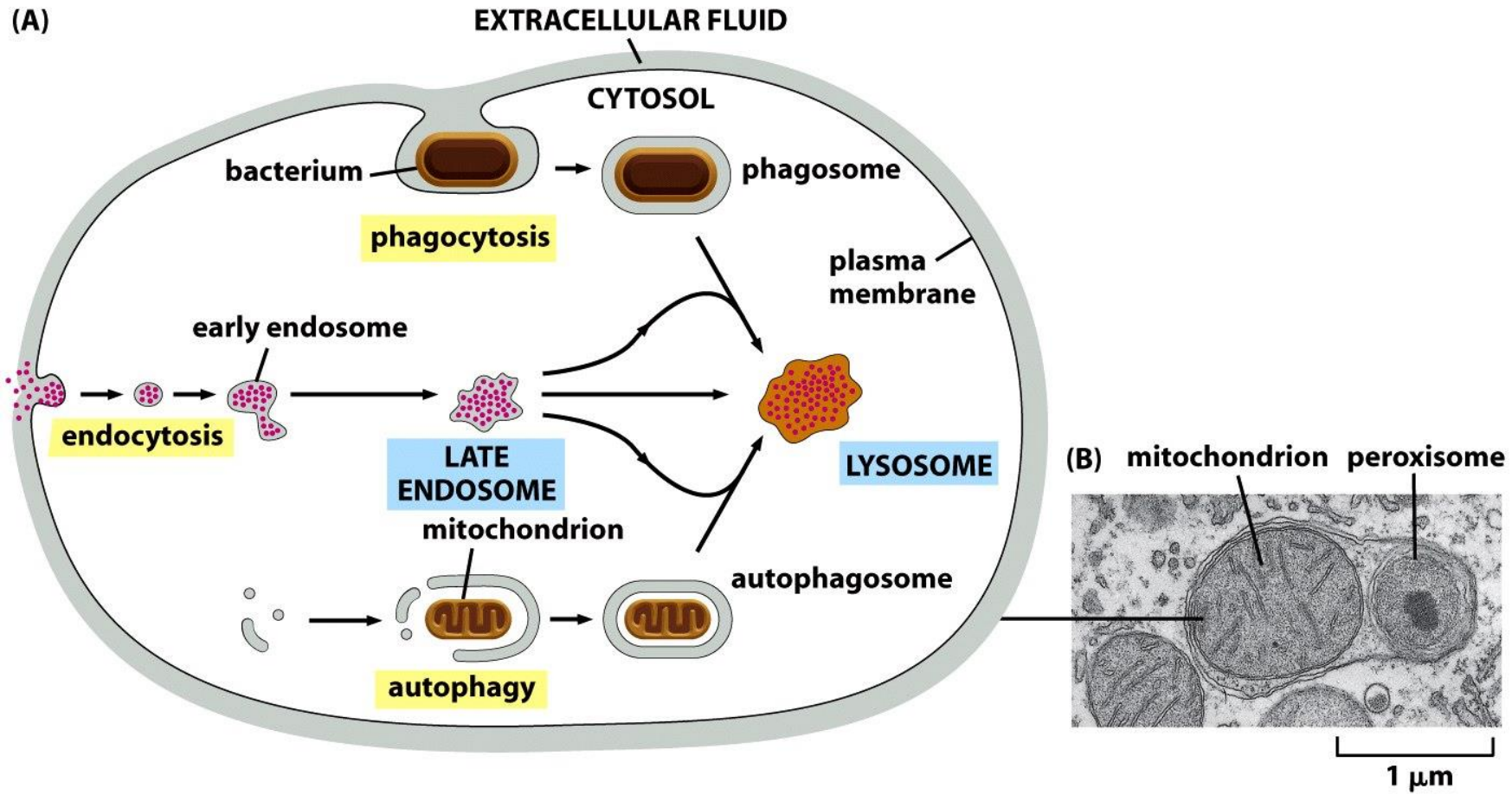
Lipase, which digests lipids

Amylase, which digests amylose, starch, and maltodextrins

Proteases, which digest proteins

Nucleases, which digest nucleic acids

The Lysosome



Three pathways to degradation in Lysosome

Peroxisome

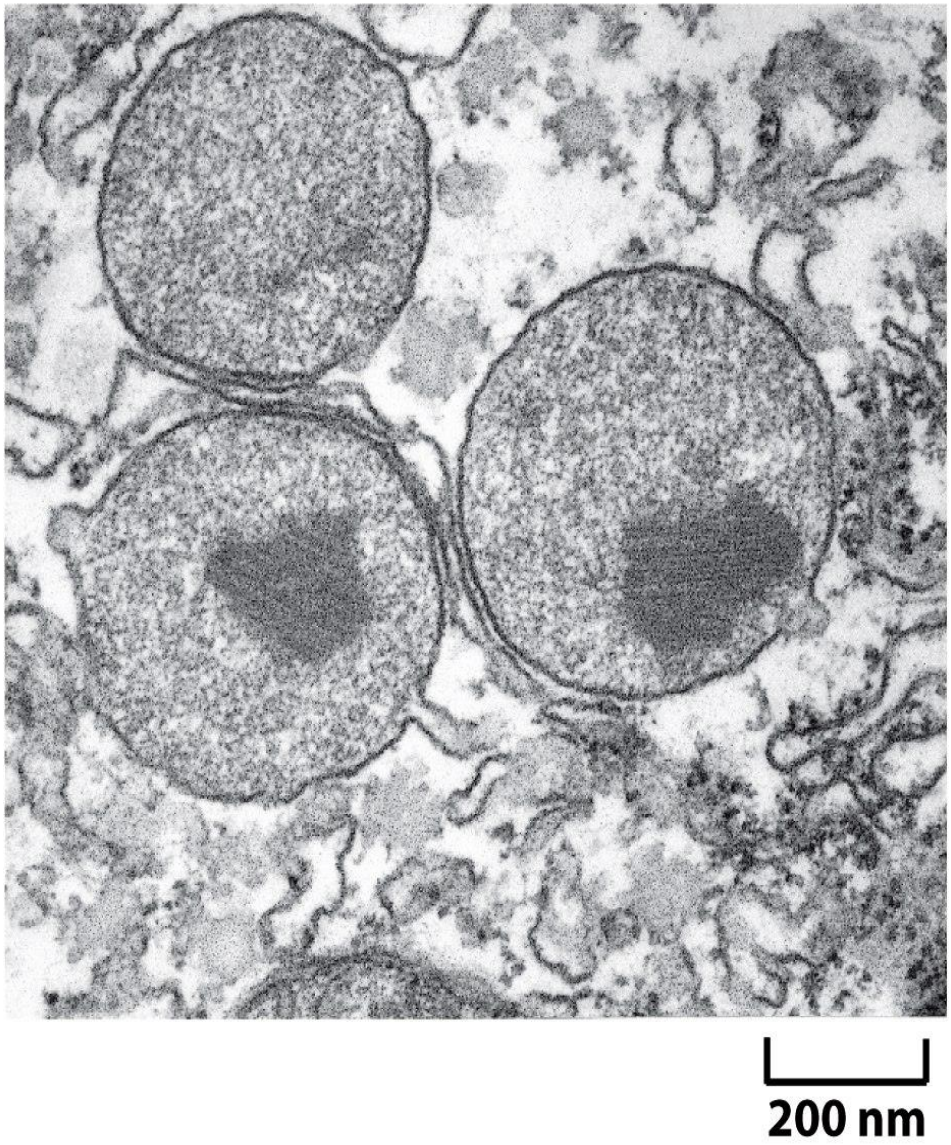
Single membrane bound organelle - present in all eukaryotic cell

Contain oxidative enzymes at high concentrations - catalase, urate oxidase, etc. Some times these enzymes form crystalized core.

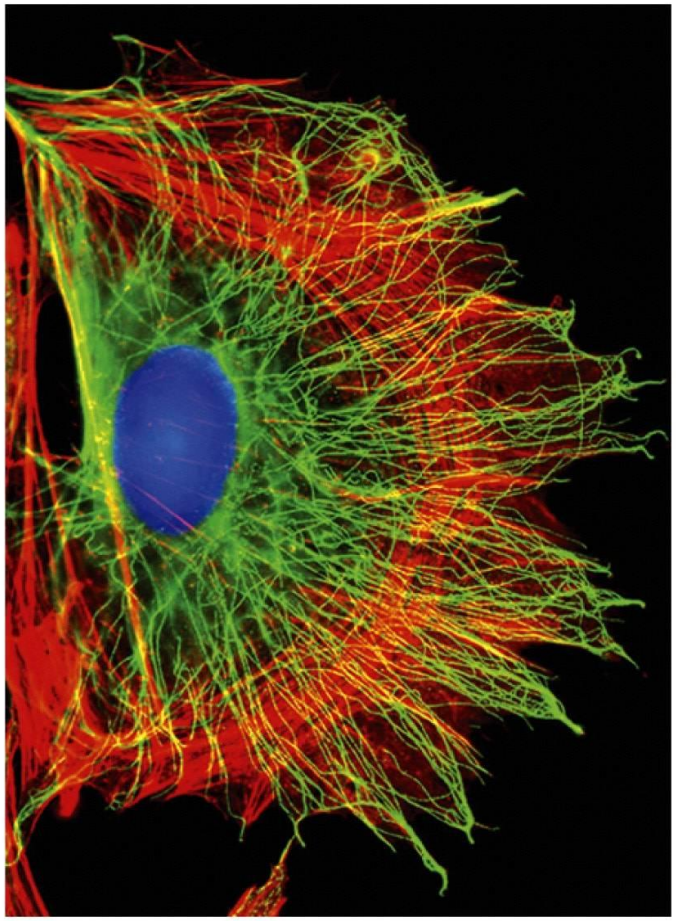
Major site of oxygen utilization – produce hydrogen peroxide. This is used for peroxidation reaction.

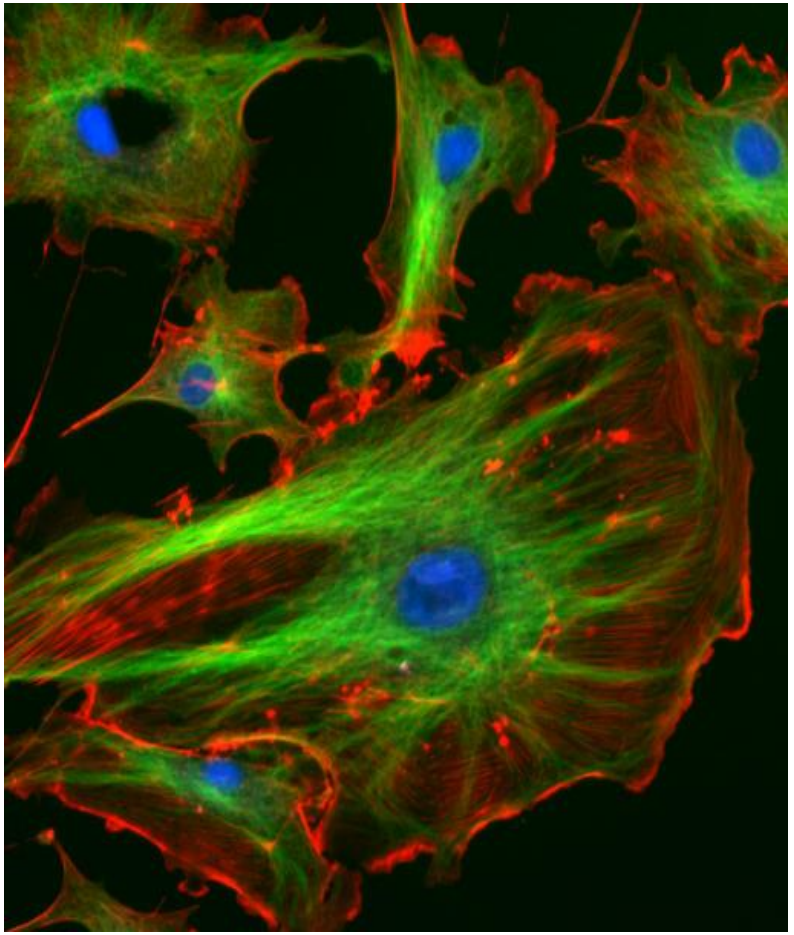
Peroxisomes detoxify various toxic molecules like phenols, alcohols, formaldehyde, etc.

A major function – oxidation of fatty acid molecules – beta oxidation.

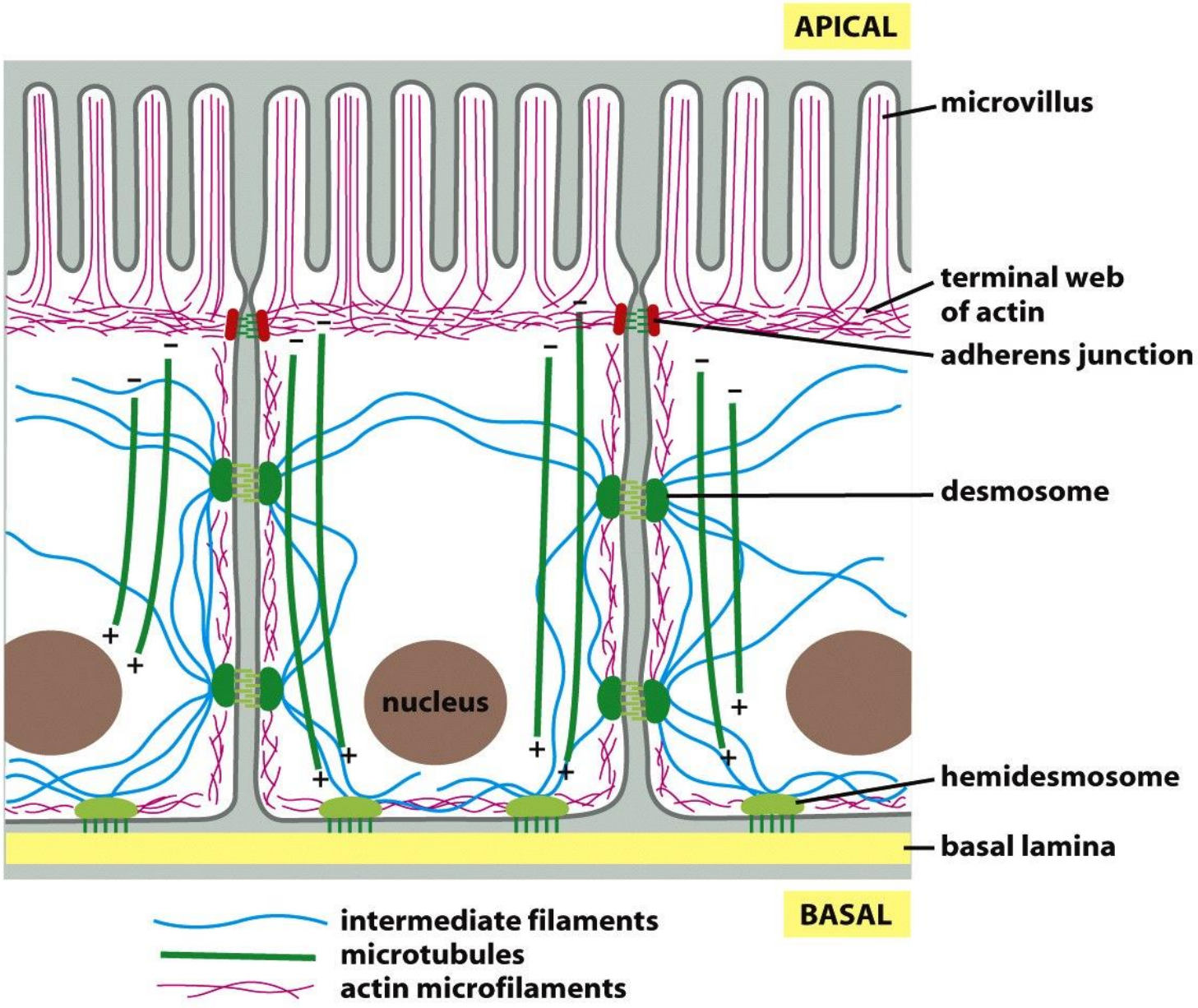


Cytoskeleton - **network of protein filaments in the cytoplasm of eukaryotic cell that gives the cell shape and the capacity for directed movement**



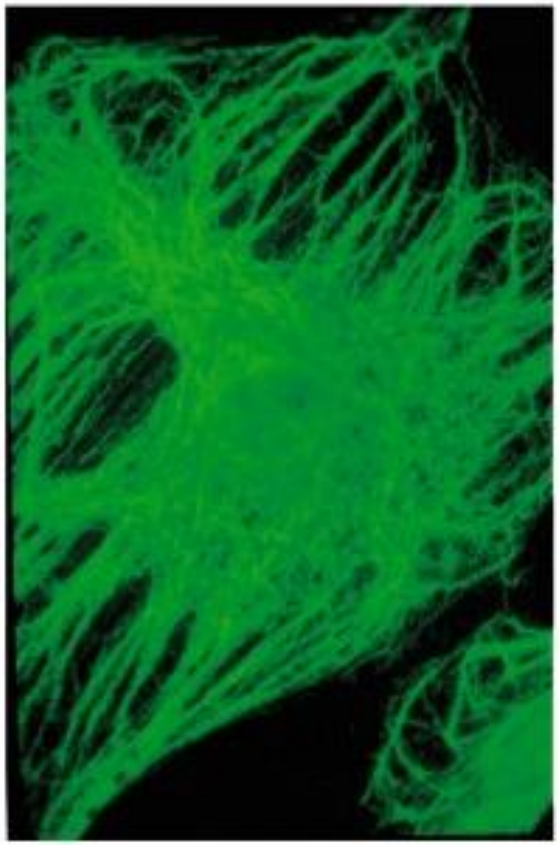


Cytoskeleton

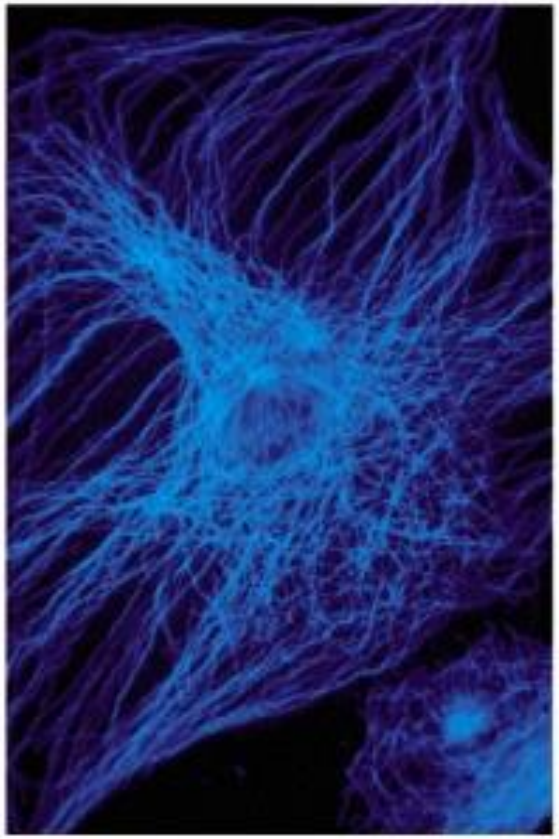


Cytoskeleton

(a) Intermediate filaments (vimentin)



(b) Microtubules (tubulin)



(c) Microfilaments (actin)

Cellular Organization