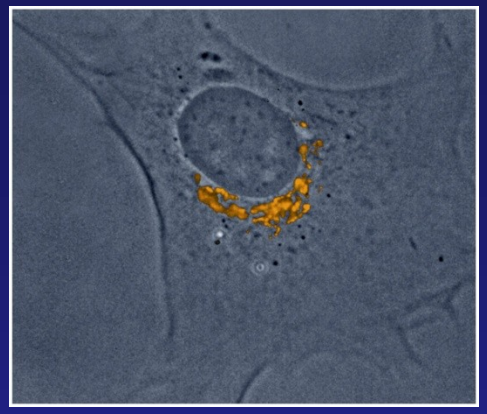
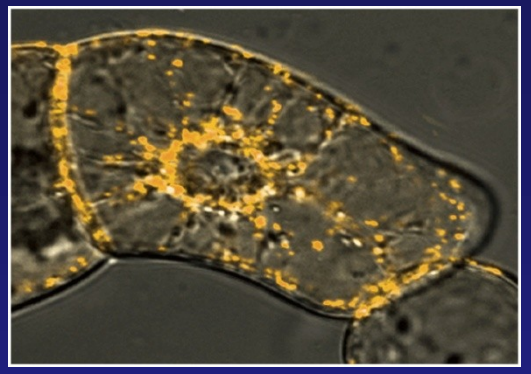


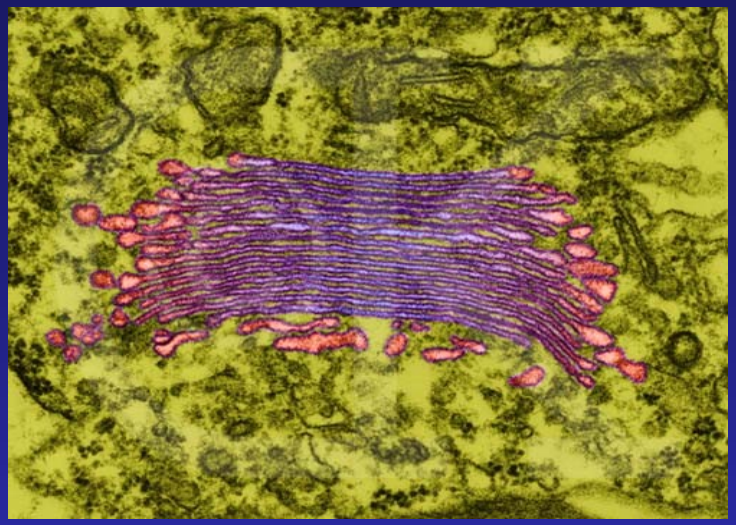
Golgi complex

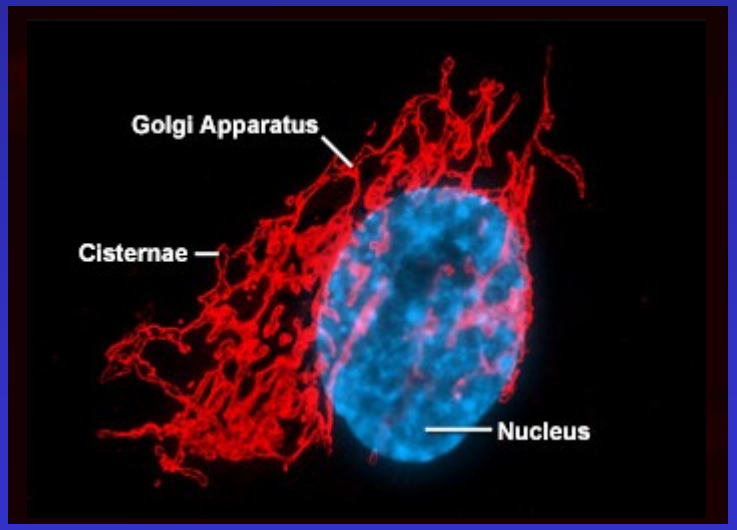


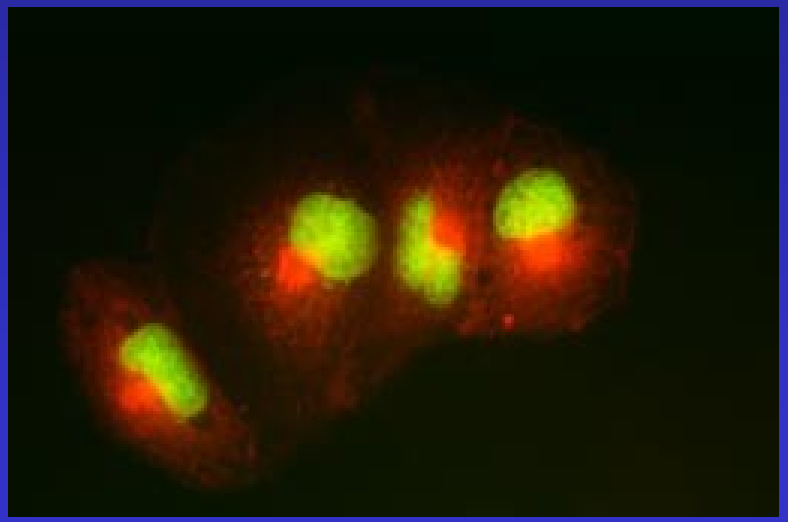
BIOLOGY, Faculty of Dentistry

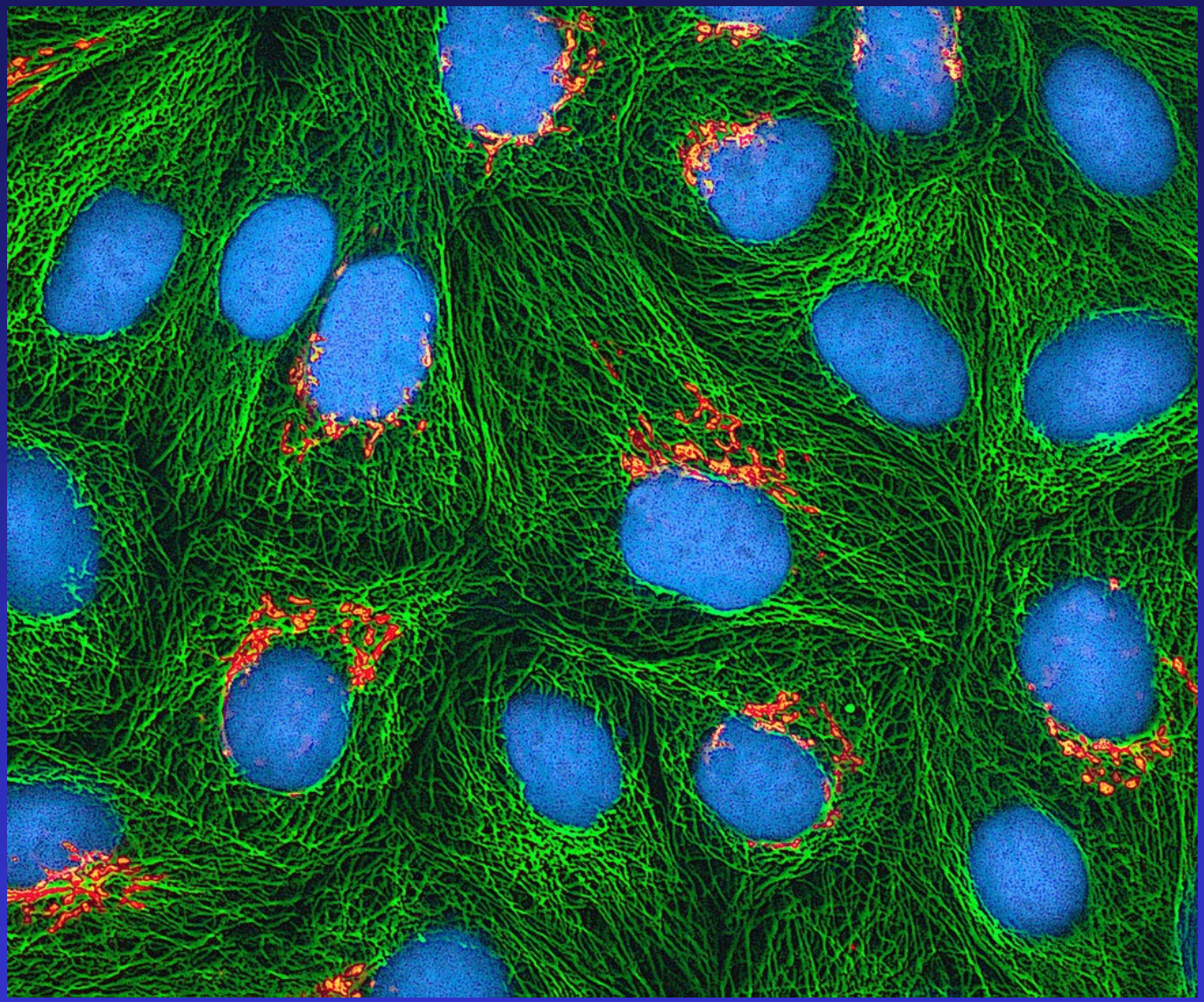
2023. 10. 03.

Prof. László KŐHIDAI, MD., PhD.
Department of Genetics, Cell- and Immunobiology
Semmelweis University




Golgi Apparatus
Cisternae
Nucleus



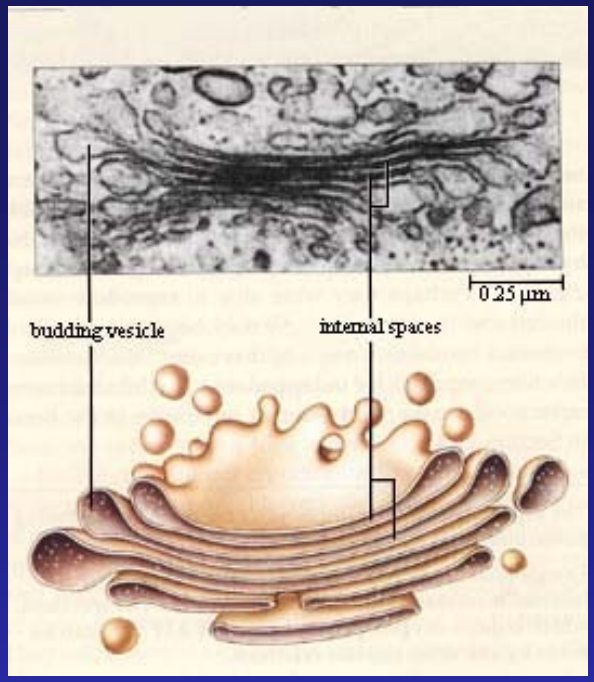


Multiphoton fluorescence image of cultured HeLa cells

Camillo Golgi
(1843-1926)

Nobel prize 1906

"internal reticular apparatus"



Structure

!

- Saccules
- Tubules
- Vesicles

structural-functional unit: **dictyosome** 4-6 saccles

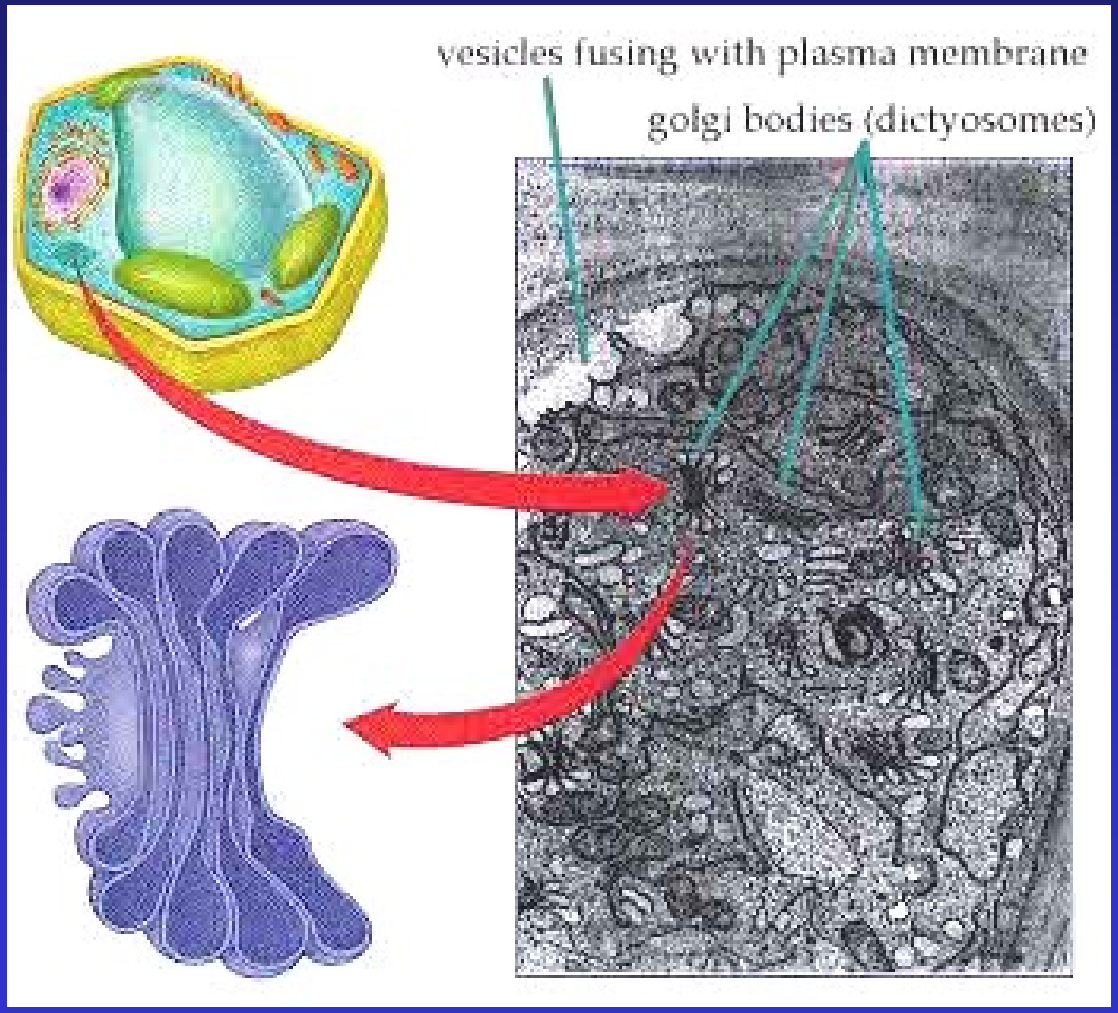
the structure is polarized into sub-compartments

cis Golgi → *medial Golgi* → *trans Golgi*

cis Golgi network (CGN)

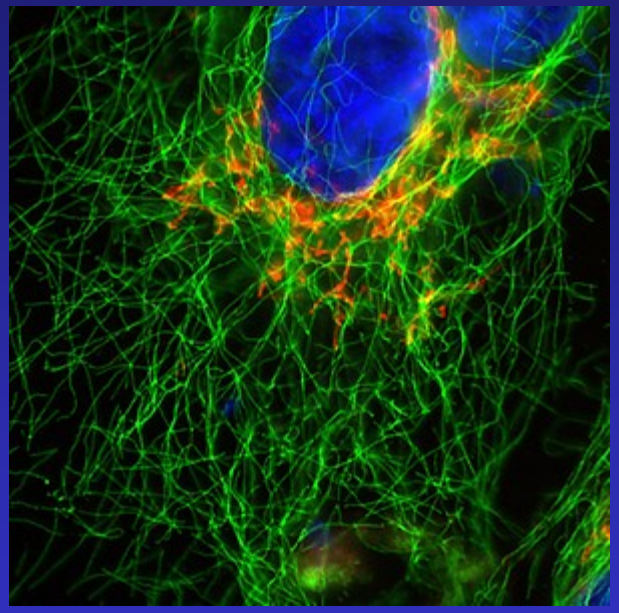
trans Golgi network(TGN)

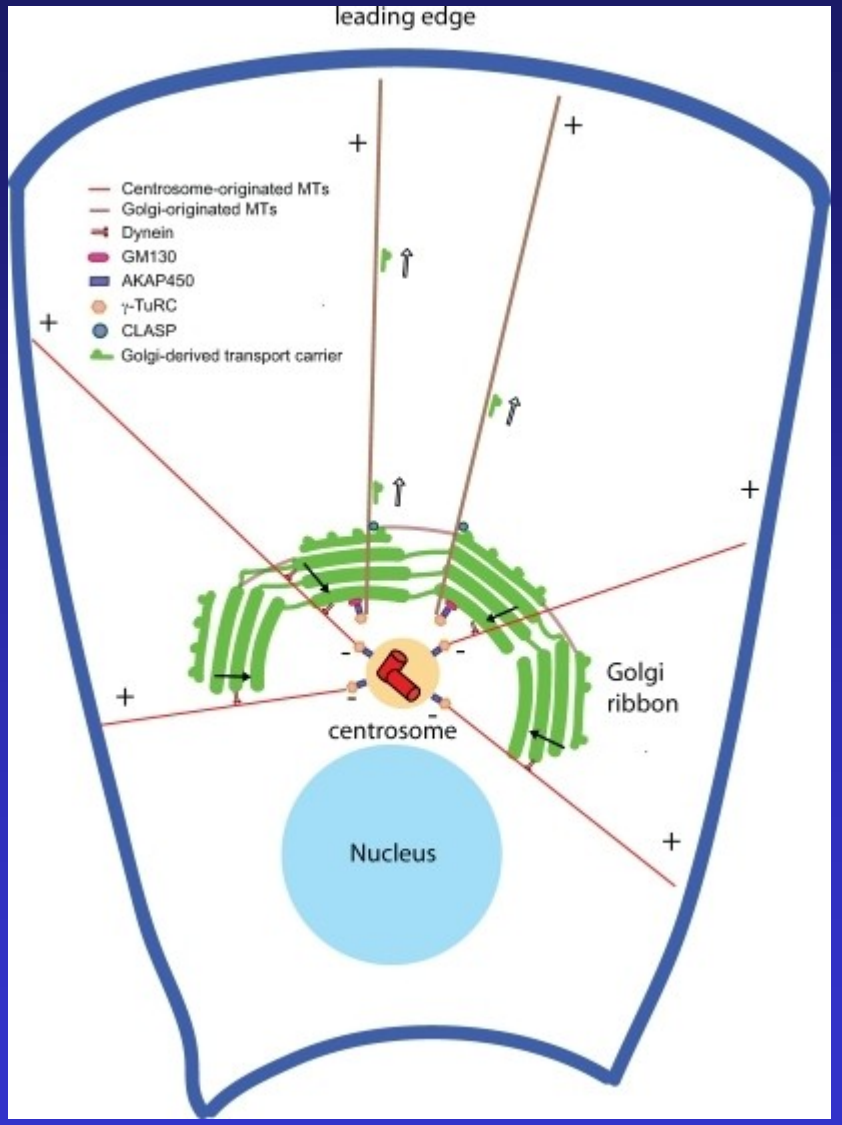
Dictyosomes of the plant cells



Synthesis of complex polysaccharides of the cell wall (hemicellulose, pectins)

Relation to the cytoskeleton





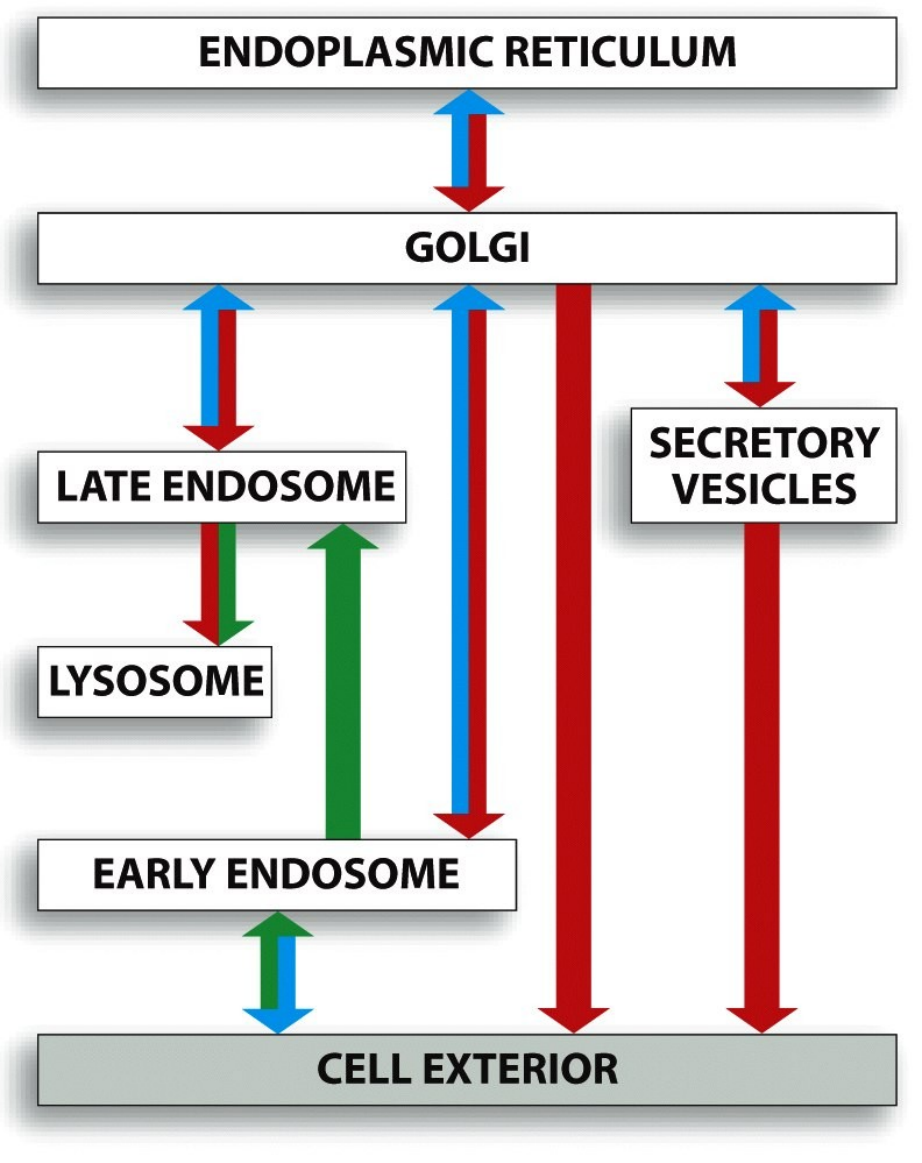
Main functions

!

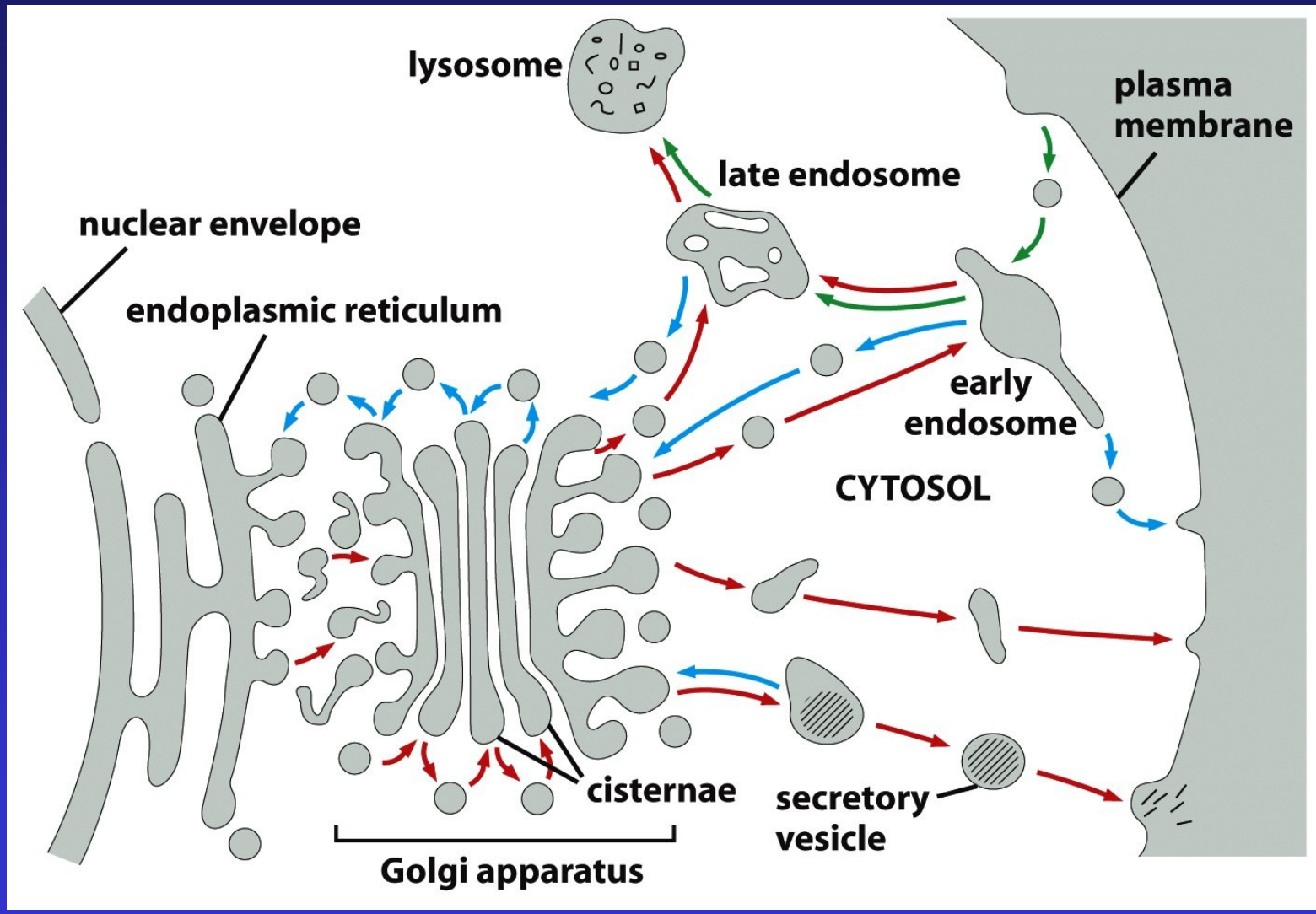
- transport
- sorting
- transformation
- membrane wrapping

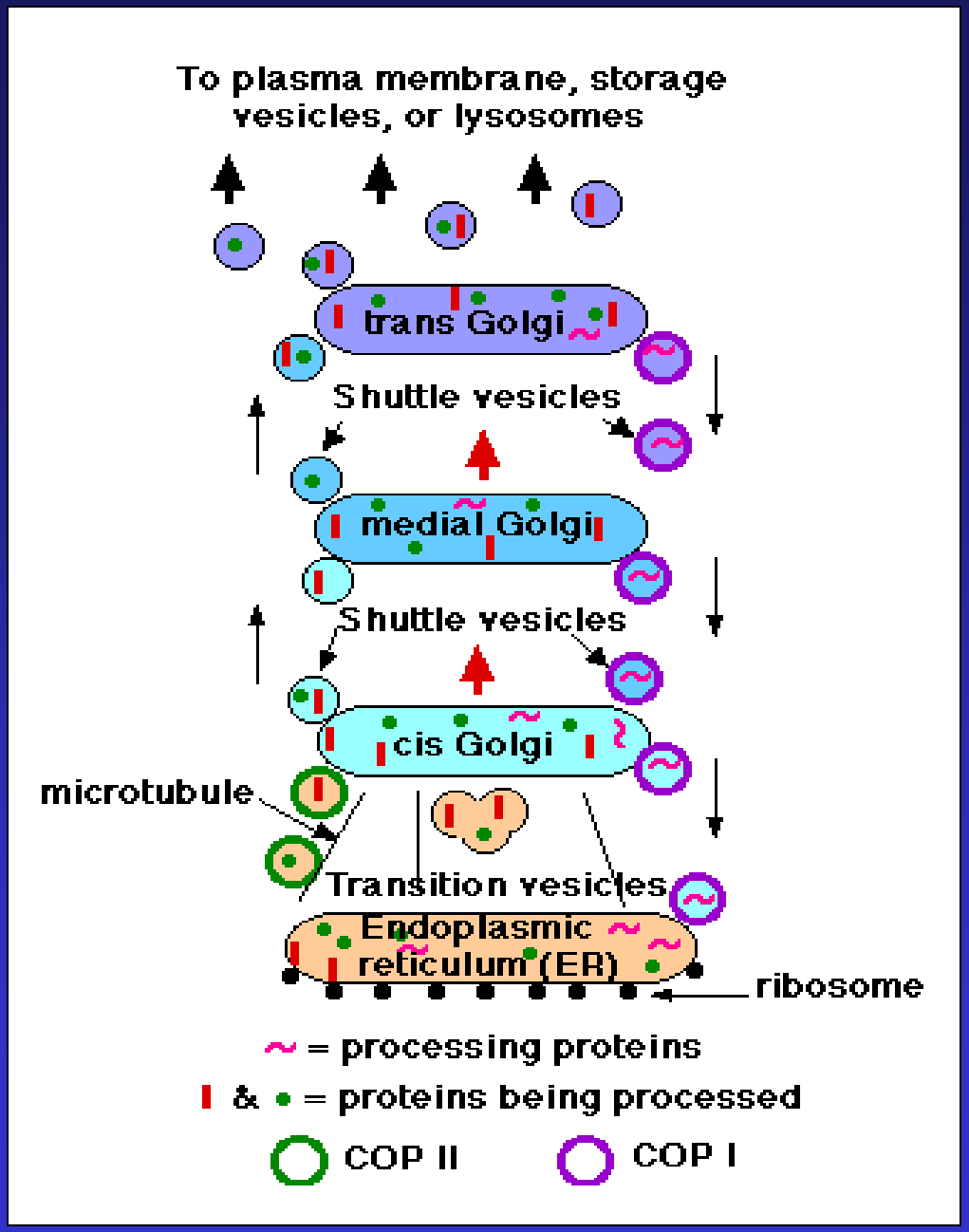
Golgi – „Traffic manager" of the cell

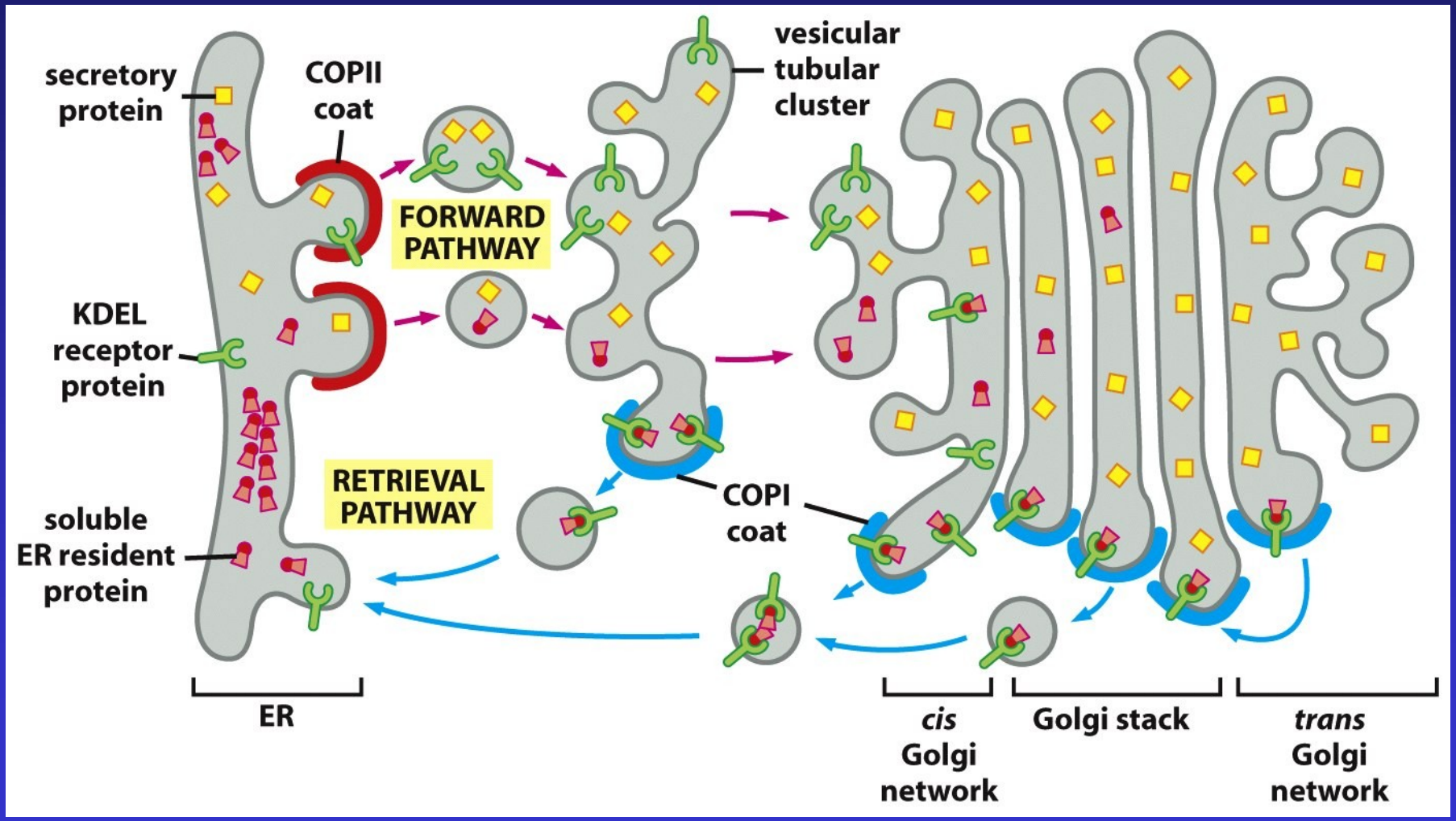
!

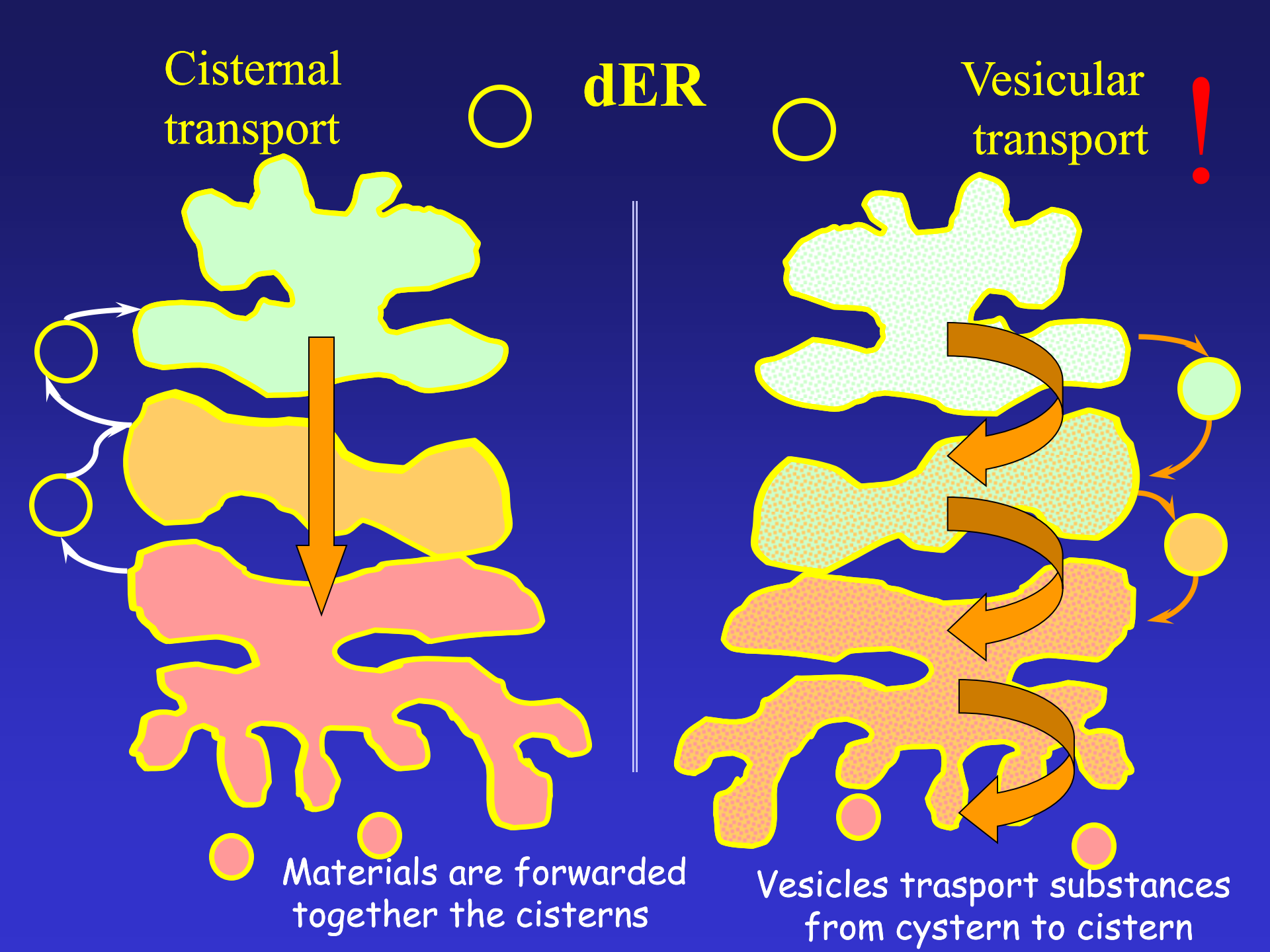


Main pathways going in and out Golgi !




To plasma membrane, storage vesicles, or lysosomes
trans Golgi
Shuttle vesicles
medial Golgi
Shuttle vesicles
cis Golgi
microtubule
Transition vesicles
Endoplasmic reticulum (ER)
ribosome
~ = processing proteins
I & • = proteins being processed
COP II
COP I


secretory protein
COPII coat
vesicular tubular cluster
FORWARD PATHWAY
KDEL receptor protein
RETRIEVAL PATHWAY
COPI coat
soluble ER resident protein
ER
cis Golgi network
Golgi stack
trans Golgi network


Cisternal transport
dER
Vesicular transport
!
Materials are forwarded together the cisterns
Vesicles trasport substances from cystern to cistern

CGN

!

- the peptides arrive from the ER in vesicles
- they are N-glycosilated
- no sorting in the ER

Bidirectional transport of proteins:

- soluble, *endogeneous proteins of the ER* recycled in transport vesicles - **retention signal** is required

- sorting and transport of **lysosomal enzymes**

Sorting and modification of lysosomal enzymes

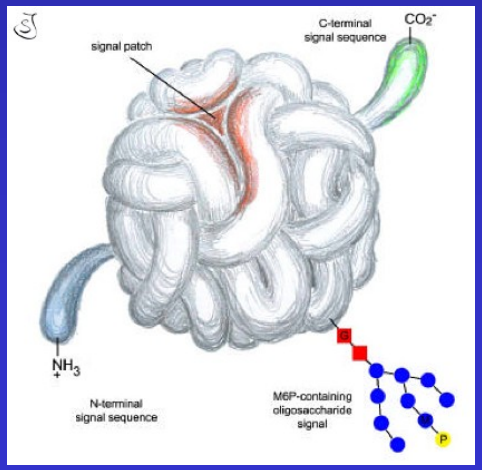
!

Mannose-6-phosphate (M-6-P) signaling:

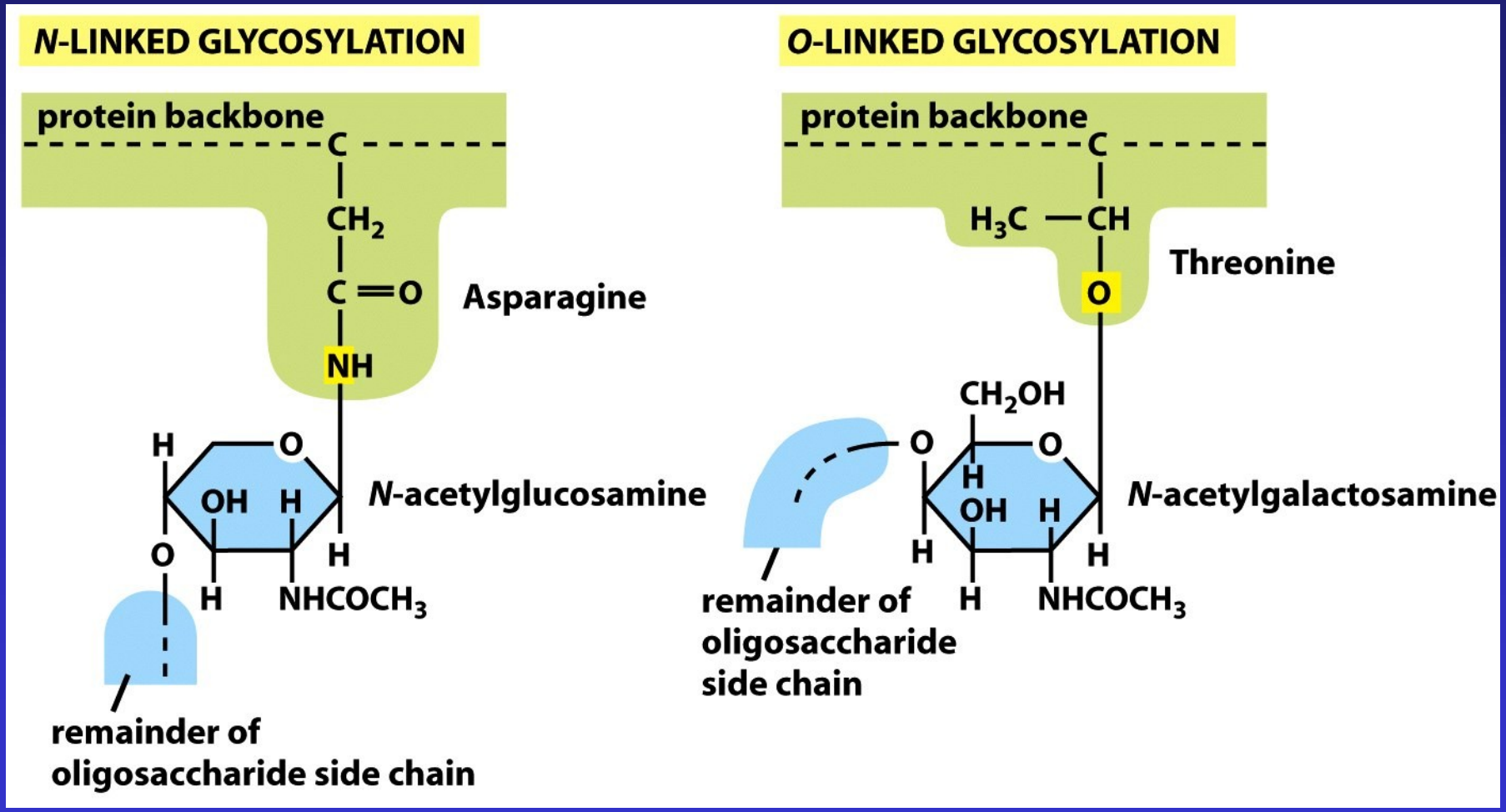
- based on the recognition of **lysosomal hydrolases**
- recognition of the "***signal patches***" (proper 3D combination of amino acids) is required
- main working enzyme: GlcNAc-phosphotransferase

Phosphorylation of the mannoses:

- promotes the **sorting** of these enzymes
- **prevents the further modifications**



N- and O- glycosylation



Glycosilation in the Golgi

!

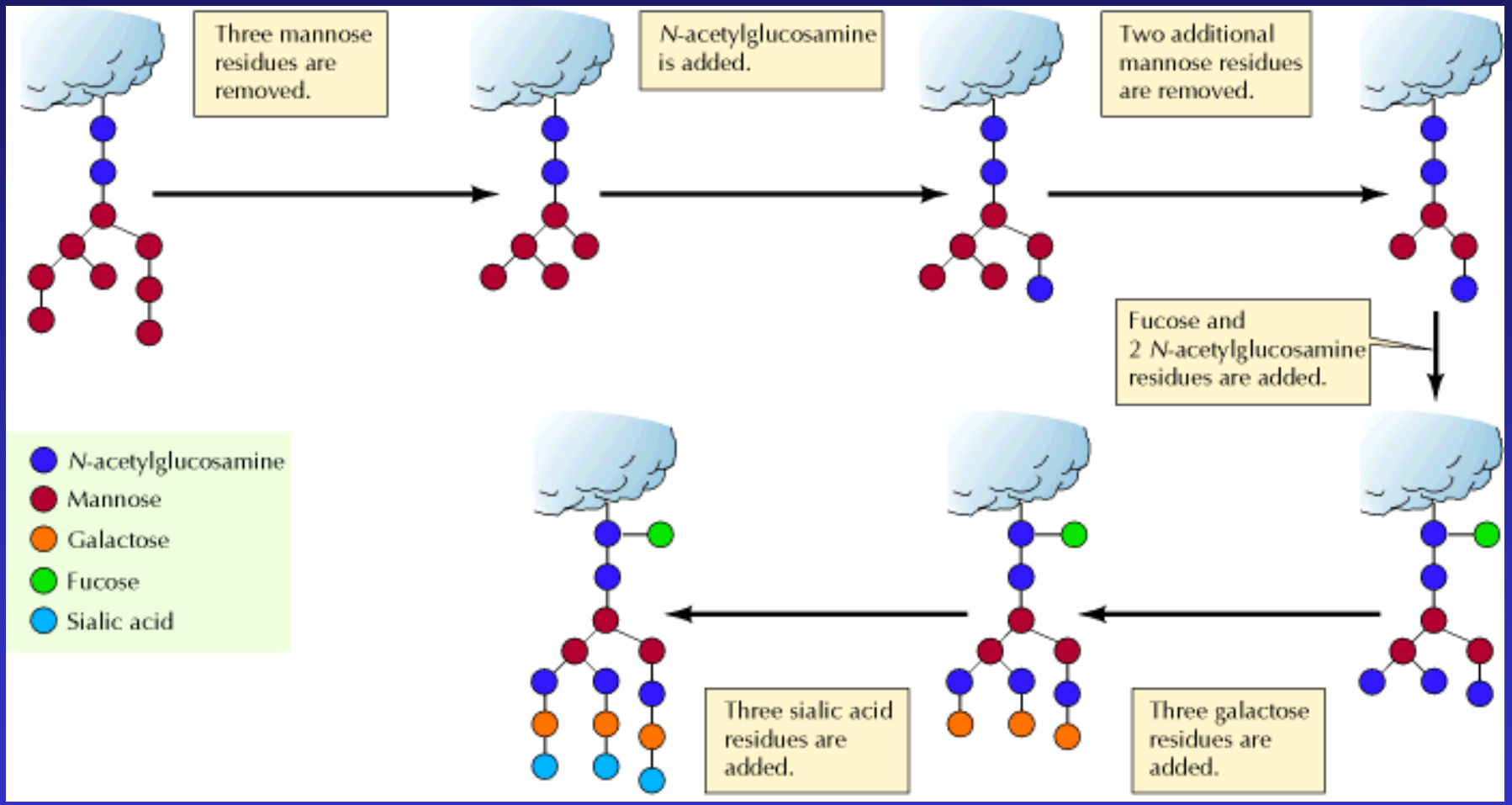
Modifications on the *N-glycosilation* pattern

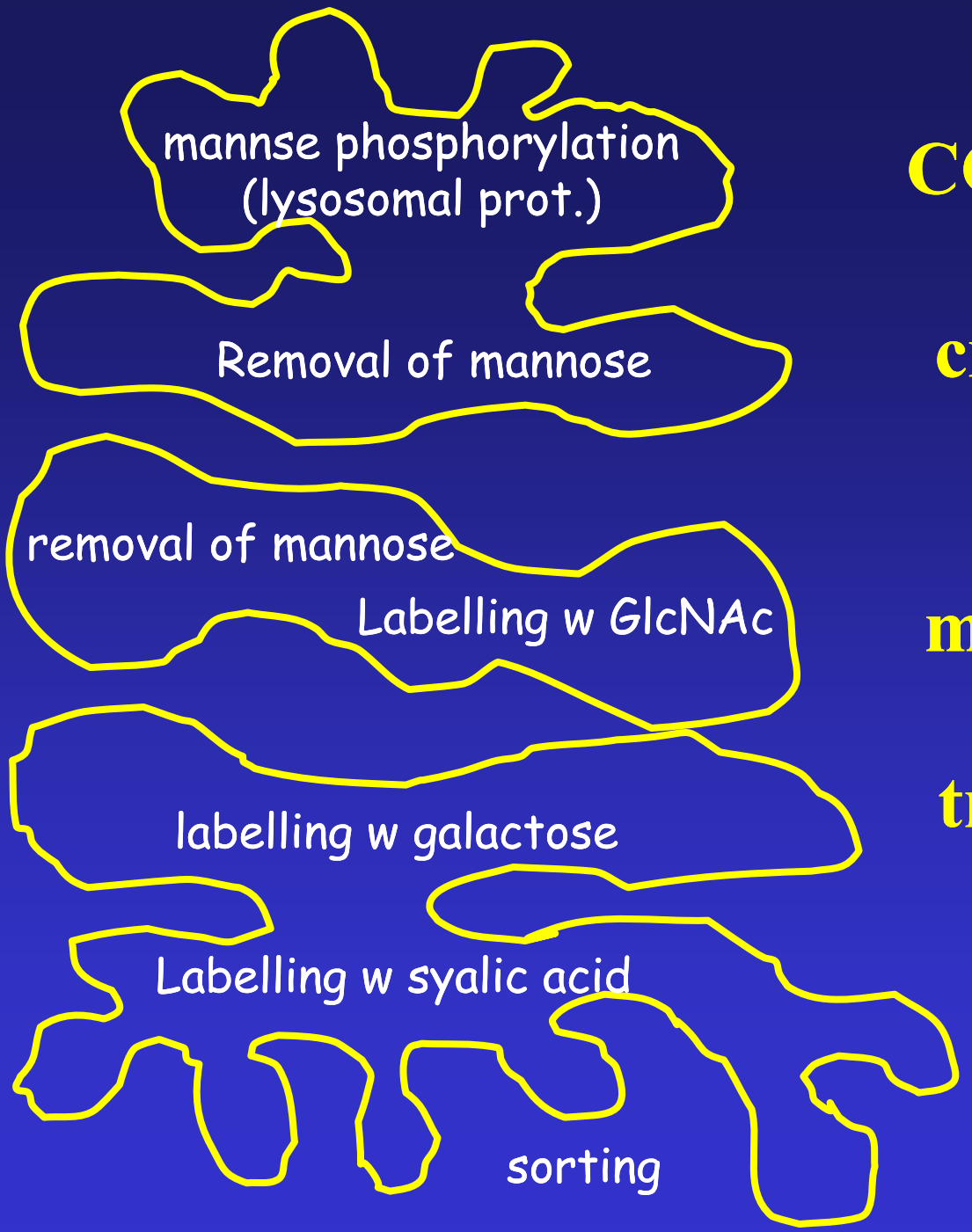
- **cis-Golgi**:
  mannose-type oligosaccharides
  complex oligosaccharides

- **TGN**:
  substitution with **sialic acids** - negatively charged

O-glycosilation:

- takes place mainly in the *medial- and trans-Golgi*
- sidechains of Ser and Thr are glycosilated





CGN

cis-Golgi

medial-Golgi

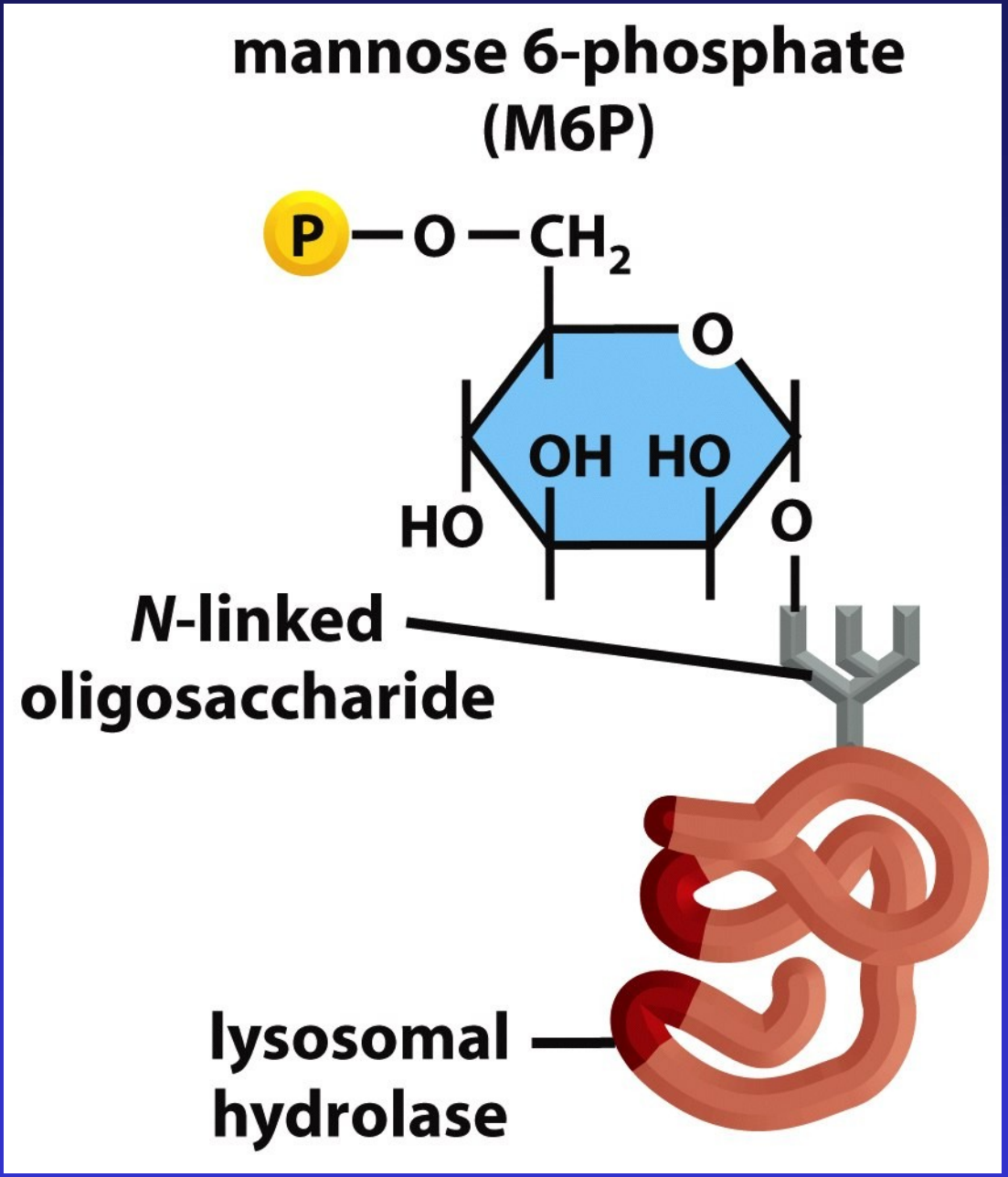
trans-Golgi

TGN

!

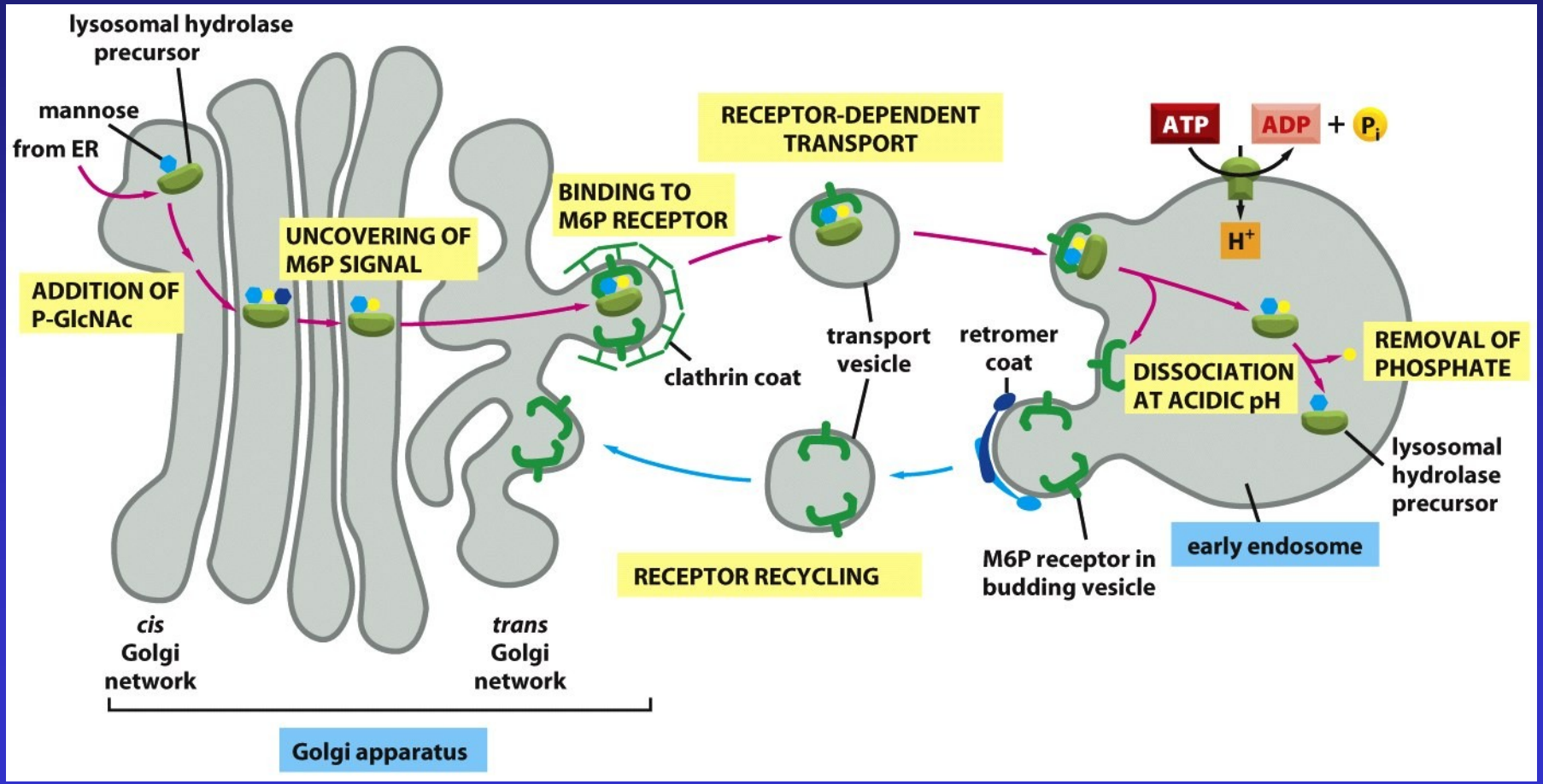
!

Structure of M-6-P

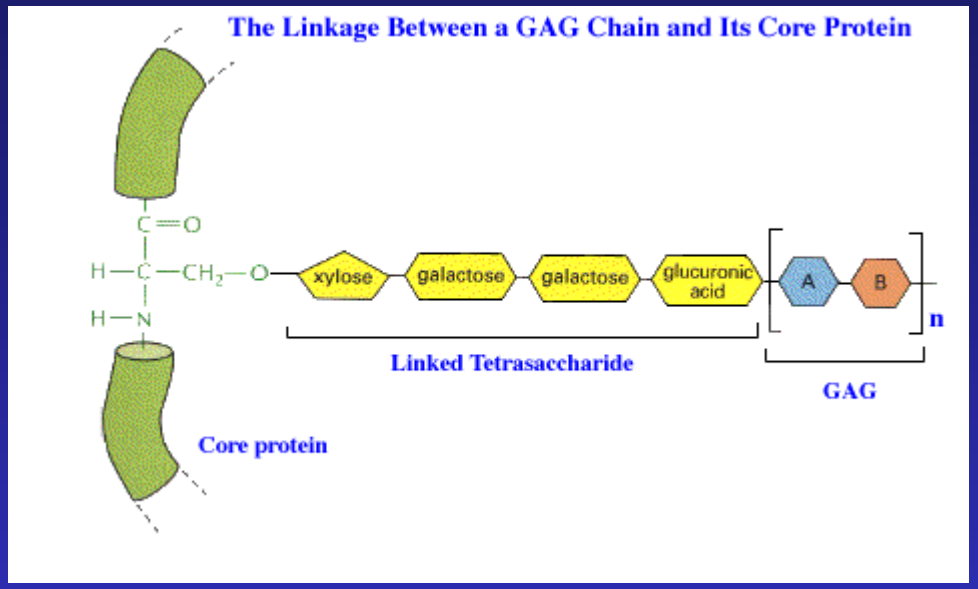


Significance of M-6-P labelling

!

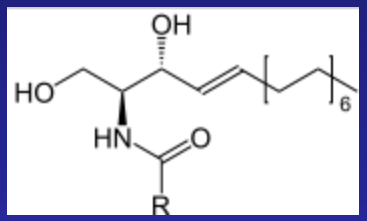


Other modifications



- glucose-amino-glycane (GAG) chains
- sulphatation (proteoglycanes, Tyr res. of peptides) - TGN
- proteolytic modifications - secretion vesicle

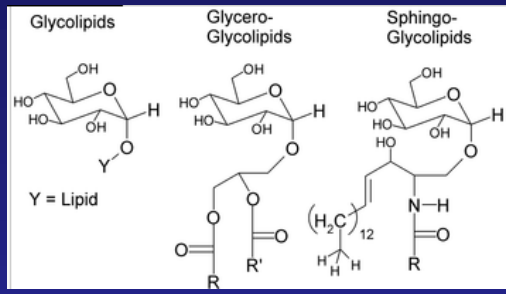
Synthesis of lipids in the Golgi

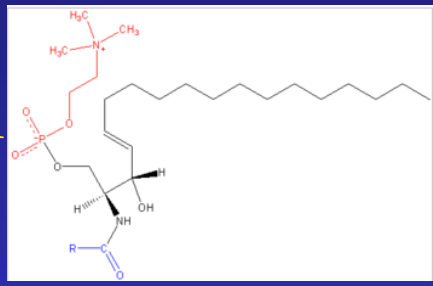


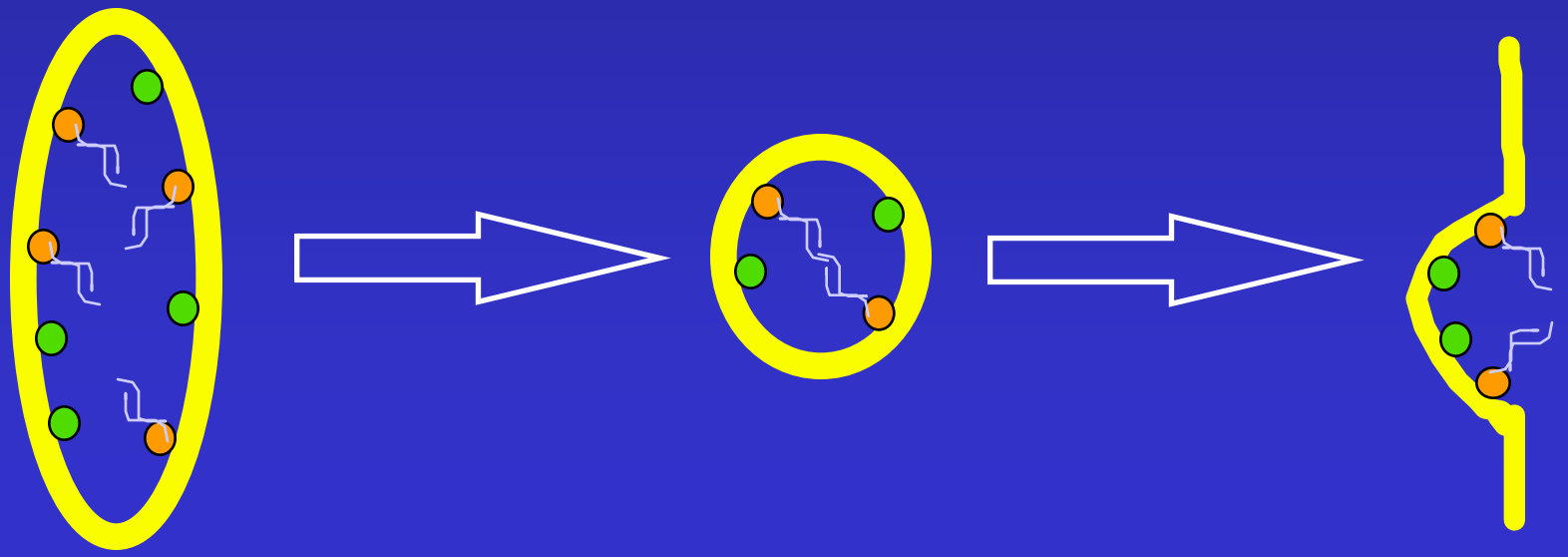
ceramide

glycolipids

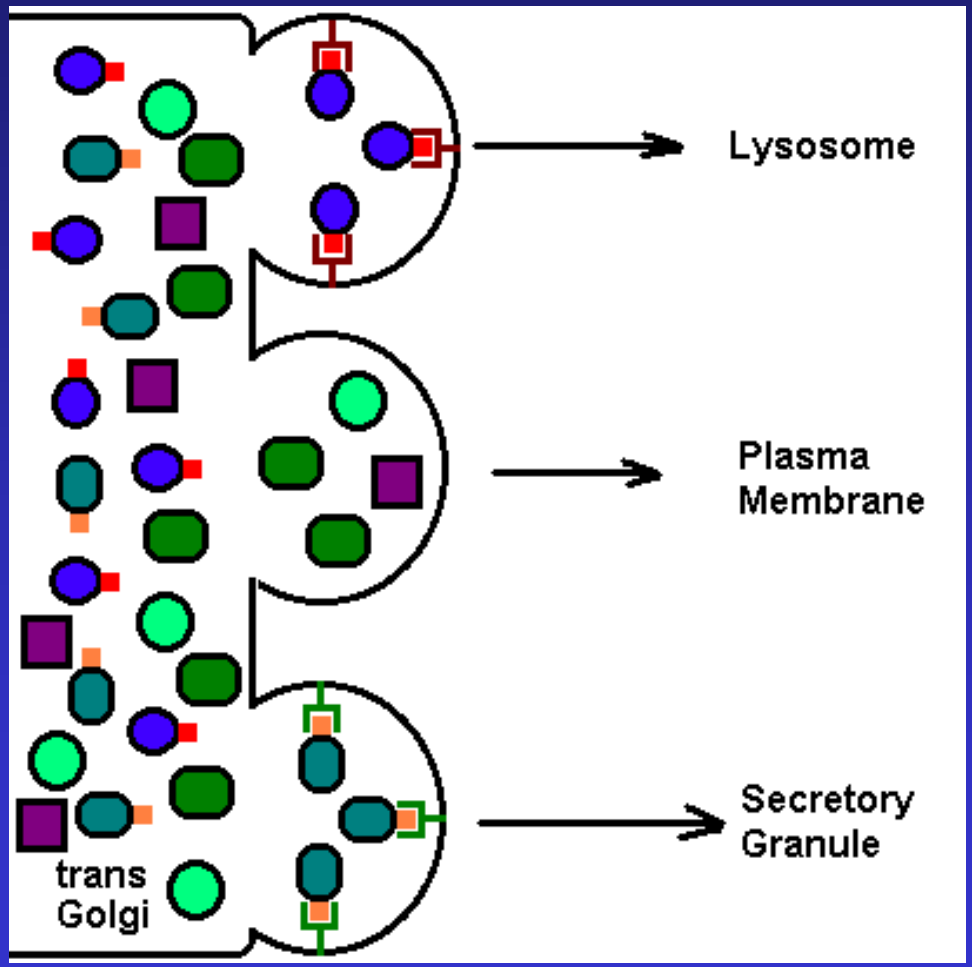
sphingomyelin







Main transport pathways from TGN



Main transport pathways from TGN

!

- endosomal-lysosomal compartment
  via transport vesicles - **M-6-P receptors**

- surface membrane - secretion
  constitutive secretion - transports **lipids** and **peptide** components of the surface membrane and the extracellular matrix

- exocytosis
  regulated secretion

Modifications of secretory vesicles

!

- selective aggregation - TGN
- further modifications and sorting

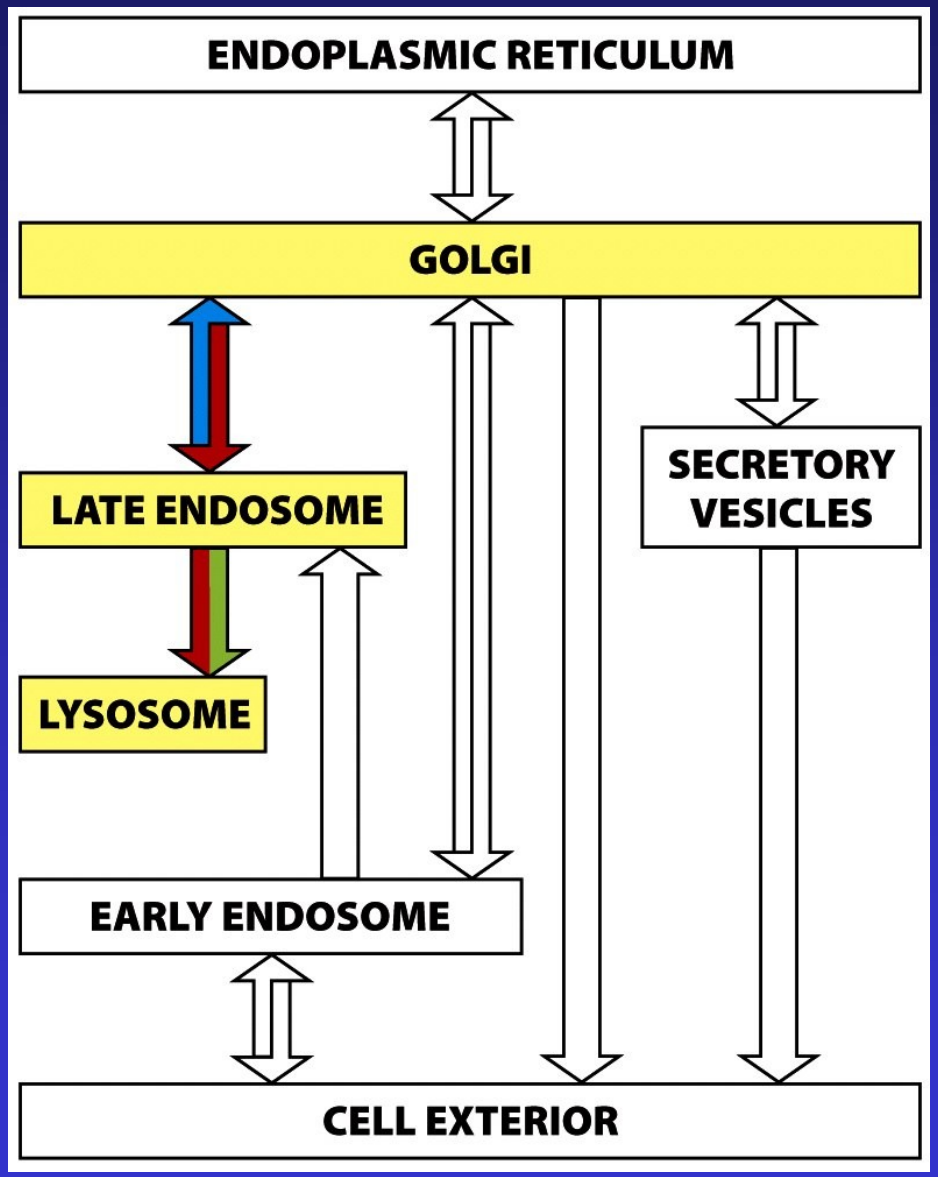
  inactive precursor - active enzyme or hormone

  (e.g. preproinsulin - proinsulin - insulin)
- concentration - loss of water
- hydratation - e.g. proteoglygans
- uptake some cytoplasmatic substances e.g. histamine

Formation of the acrosome

- Acrosome is a large lysosome and found in **sperm**
- It contains **enzymes** e.g. hyaluronidase, acid phosphatase…
- During the sperm differantiation **several small vesicles** (primary lysosomes) are formed from Golgi
- thesmall vesicles are **fused to form a single large lysosome - acrosome**

Main pathway going out the Golgi



Alternative pathways

!

- some molecules do not synthesized on the rER
  (e.g. interleukin 1α and 1β - IL1α-IL1β,
  basic fibroblast growth factor-bFGF)

- these molecules transported by ABC-transporters

- other roles of the alternative pathway:
  - elimination of toxic proteins
  - regulation of protein concentrations in cytosol

Defects of sorting mechanism !

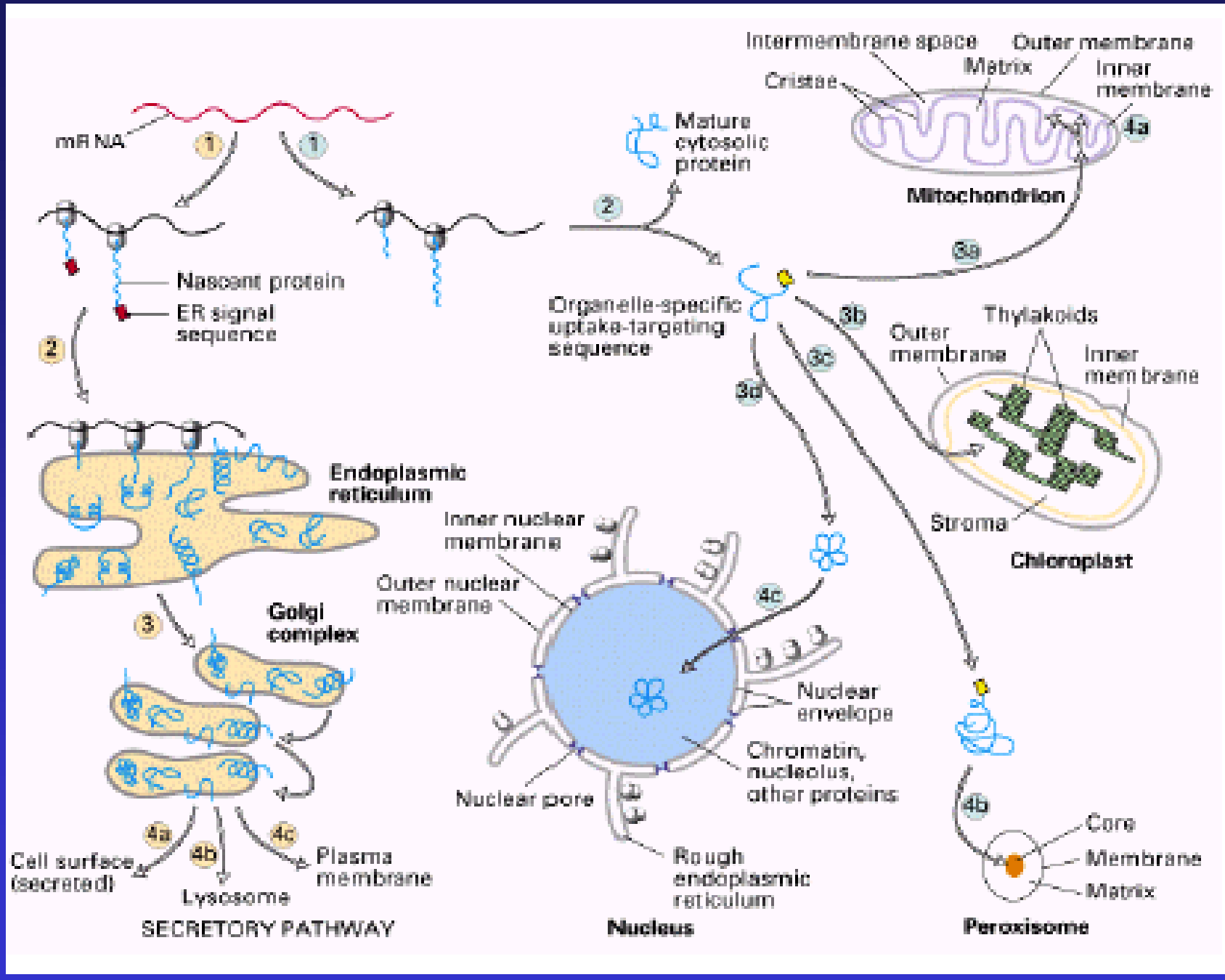
lysosomal enzymes do not enter the late endosomes

BUT

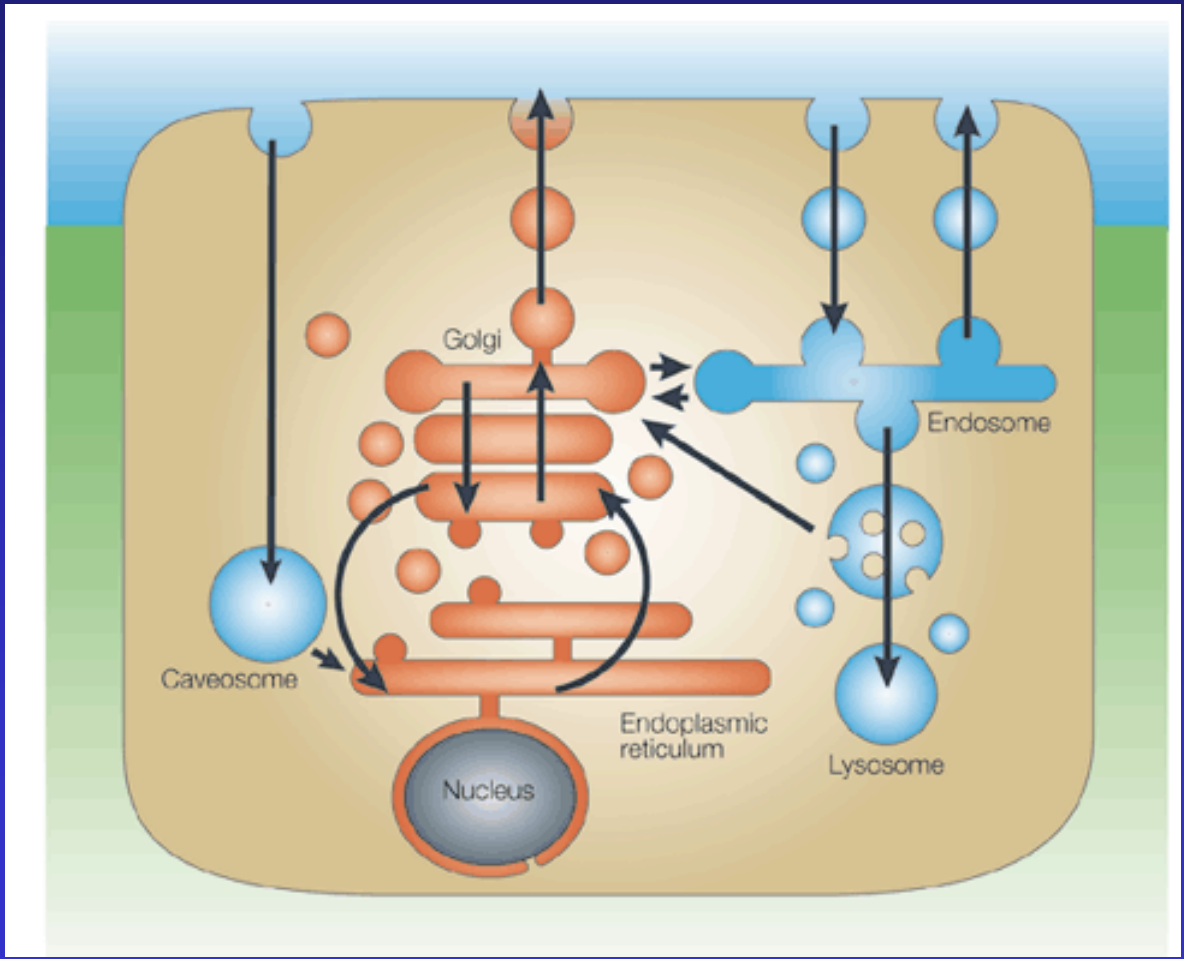
enzymes enter the constitutive secretory pathway and released

I (=inclusion) cell disease:

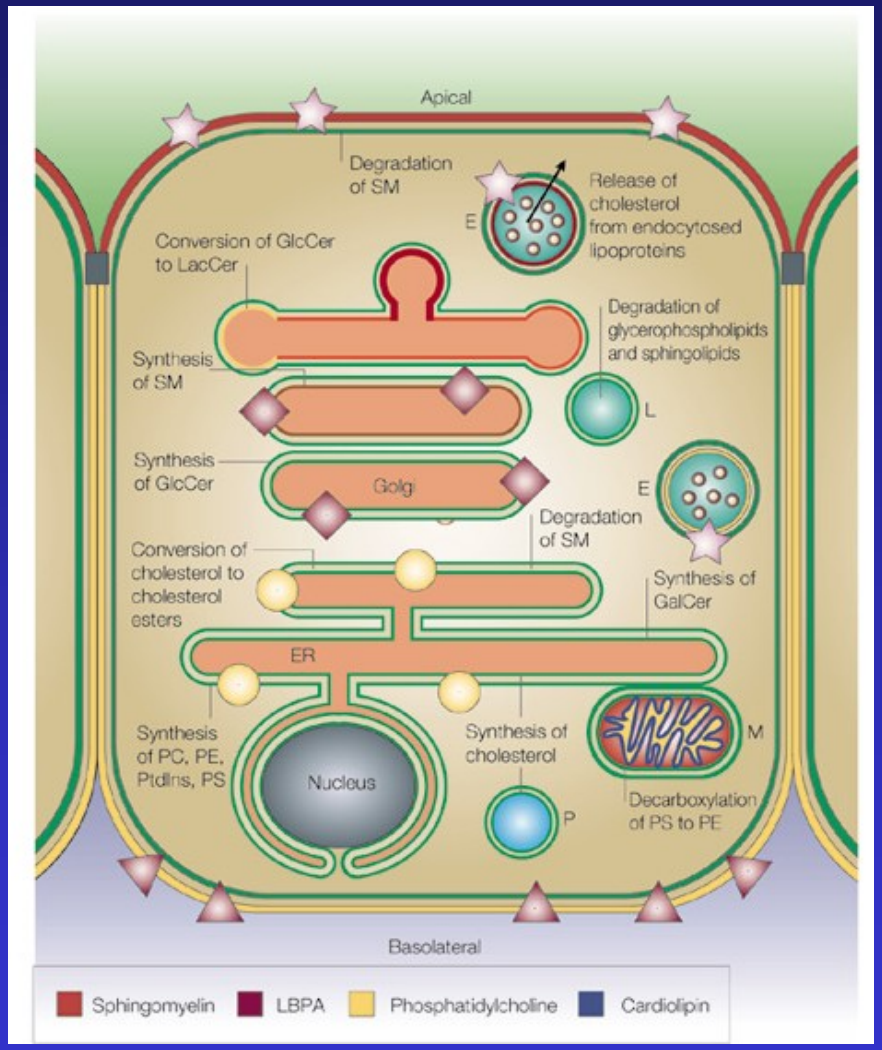
- the **M-6-P signal** is not formen on the enzymes
- lysosomal enzymes "**escape**" from the cell
- deficient intracellular digestion
- the **non-digested** substances form INCLUSIONS


mRNA
1
1
Nascent protein
ER signal sequence
2
Endoplasmic reticulum
3
Golgi complex
4a
4b
4c
Cell surface (secreted)
Lysosome
Plasma membrane
SECRETORY PATHWAY
Mature cytosolic protein
2
Organelle-specific uptake-targeting sequence
3a
3b
3c
3d
Intermembrane space
Outer membrane
Matrix
Cristae
Inner membrane
4a
Mitochondrion
Thylakoids
Outer membrane
Inner membrane
Stroma
Chloroplast
Inner nuclear membrane
Outer nuclear membrane
4c
Nuclear envelope
Chromatin, nucleolus, other proteins
Nuclear pore
Rough endoplasmic reticulum
Nucleus
4b
Core
Membrane
Matrix
Peroxisome

Network of membran flow in eukaryotic cells



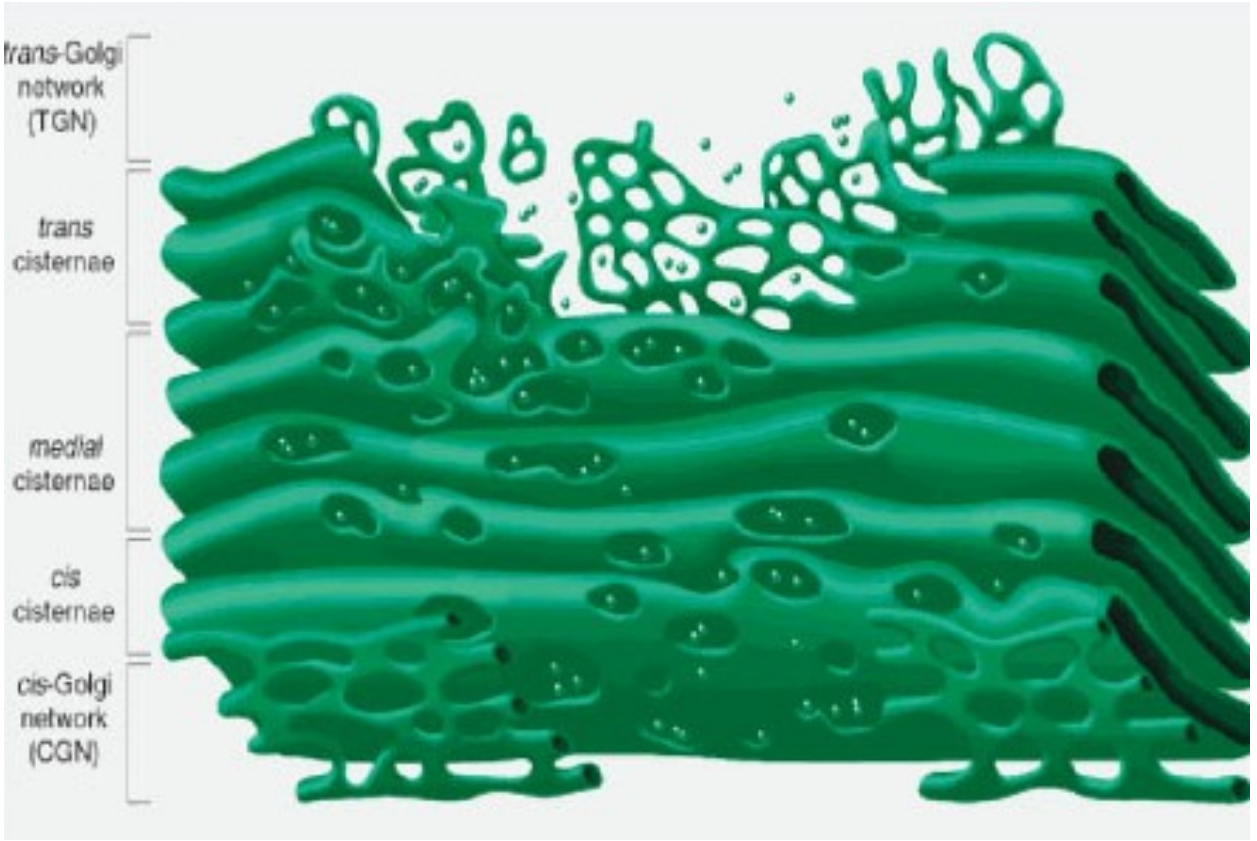
Organell-dependent metabolism of lipids



http://www.youtube.com/watch?v=u38LjCOvDZU

Appendix

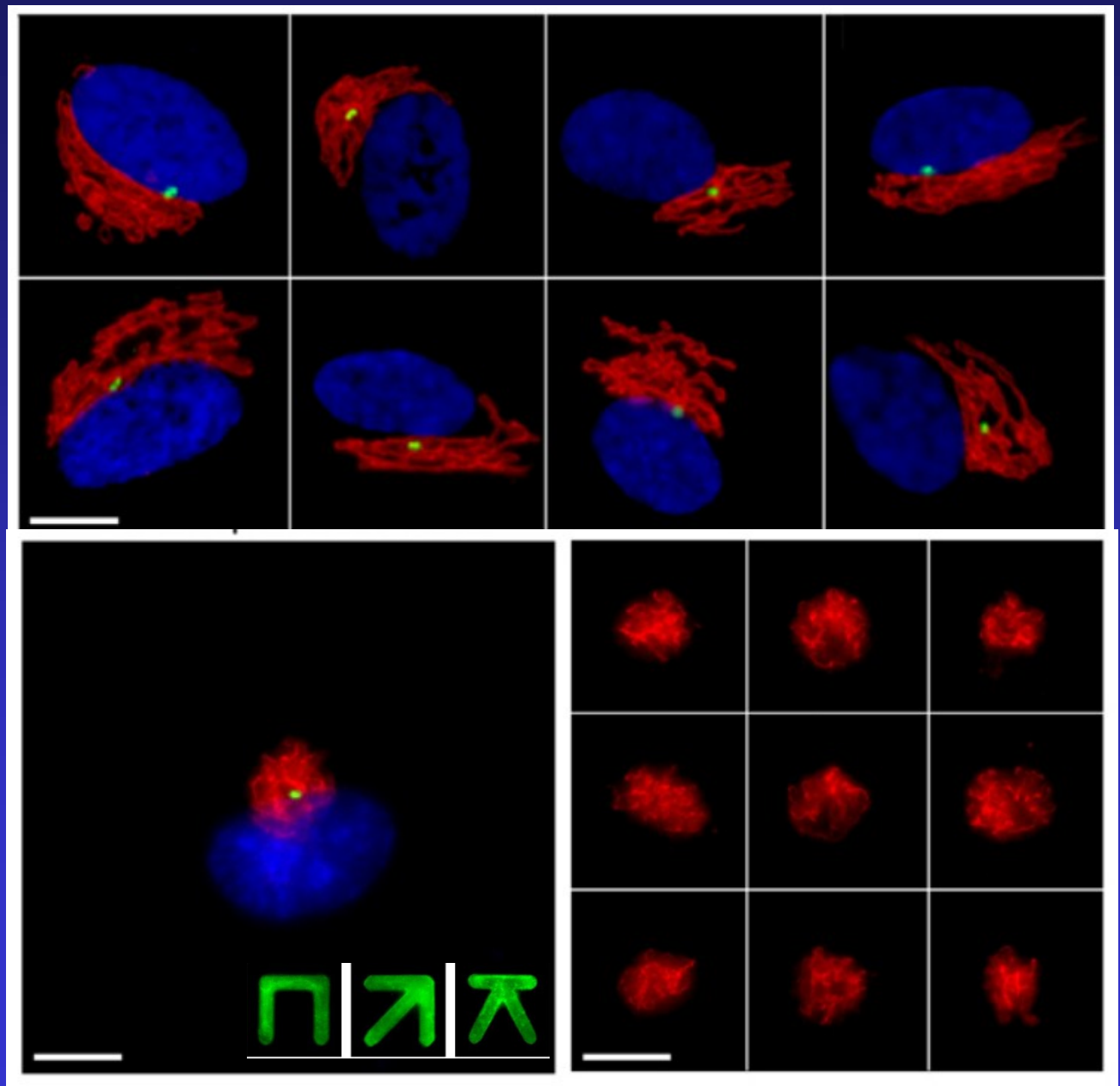
Information on the next slides are only to inform students about the subjetc, they do not belong to the core subjects of Cell Science.


trans-Golgi network (TGN)
trans cisternae
medial cisternae
cis cisternae
cis-Golgi network (CGN)

Position

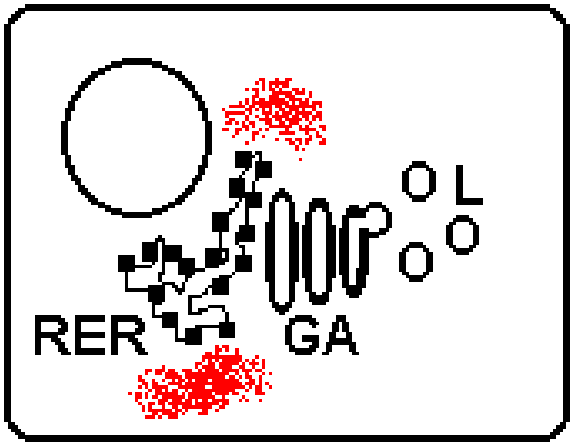
free adhesion

pattern induced adhesion

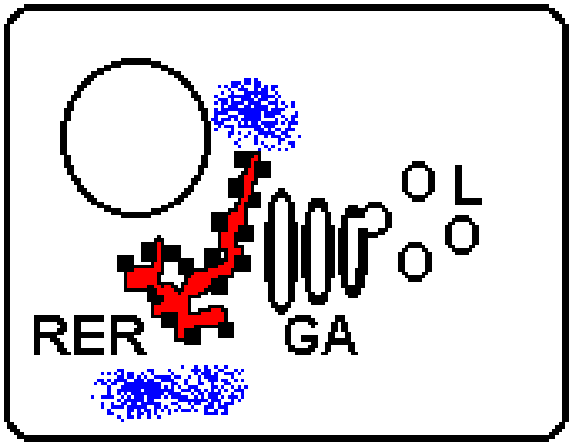


www.pnas.org cgi doi 10.1073 pnas.060926710

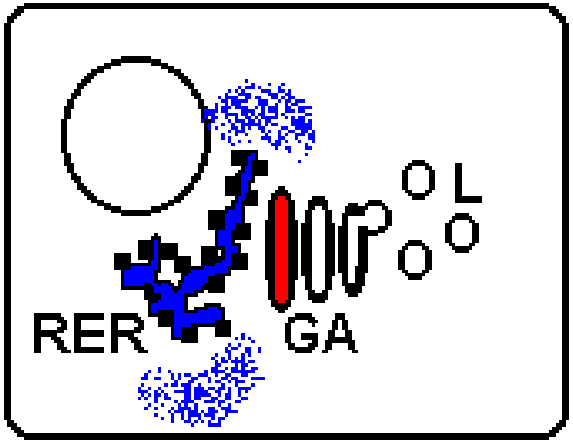
Pulse-chase technique



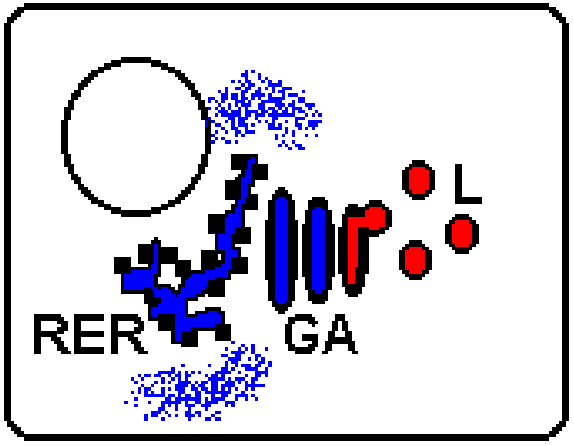
Pulse



Chase 3 h

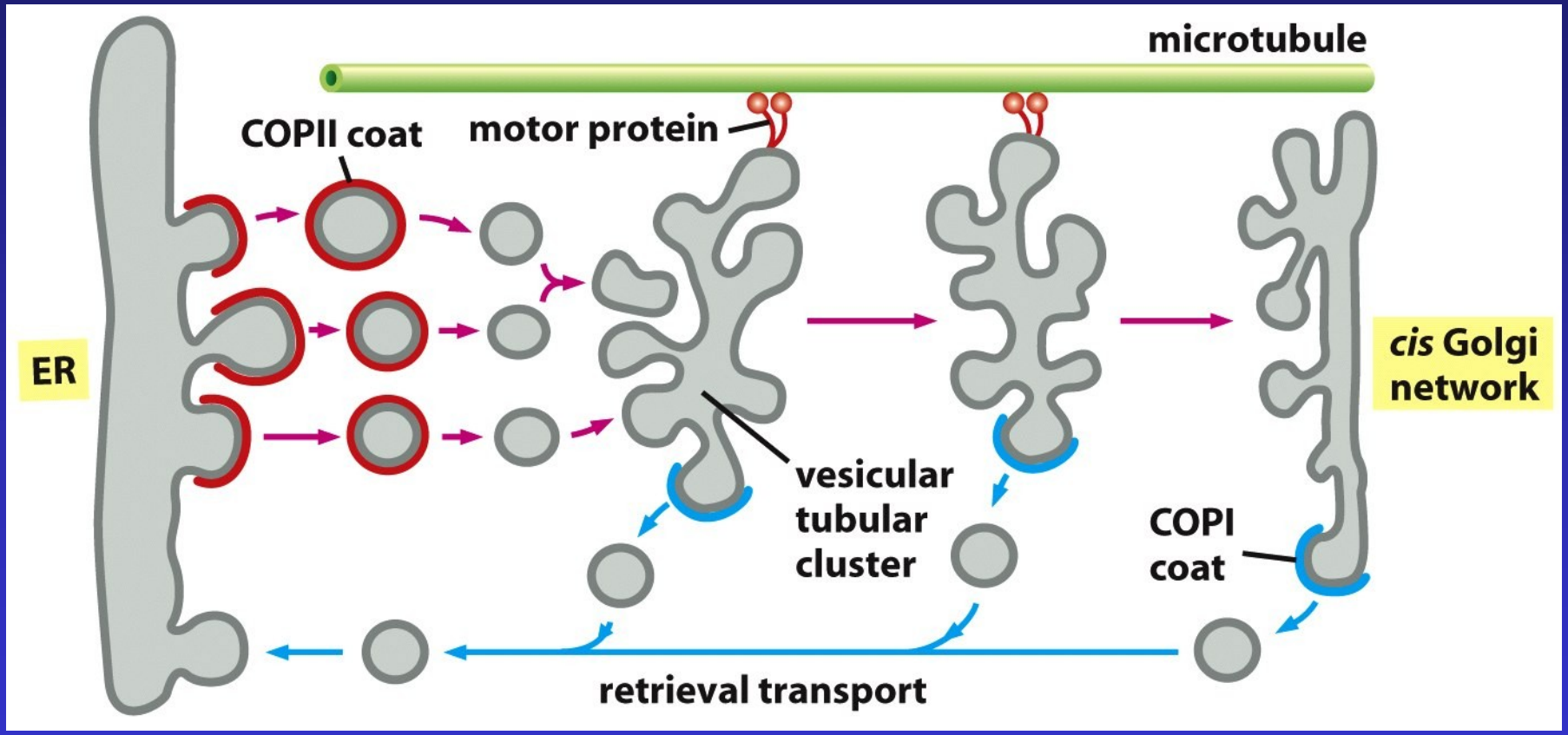


Chase 6h

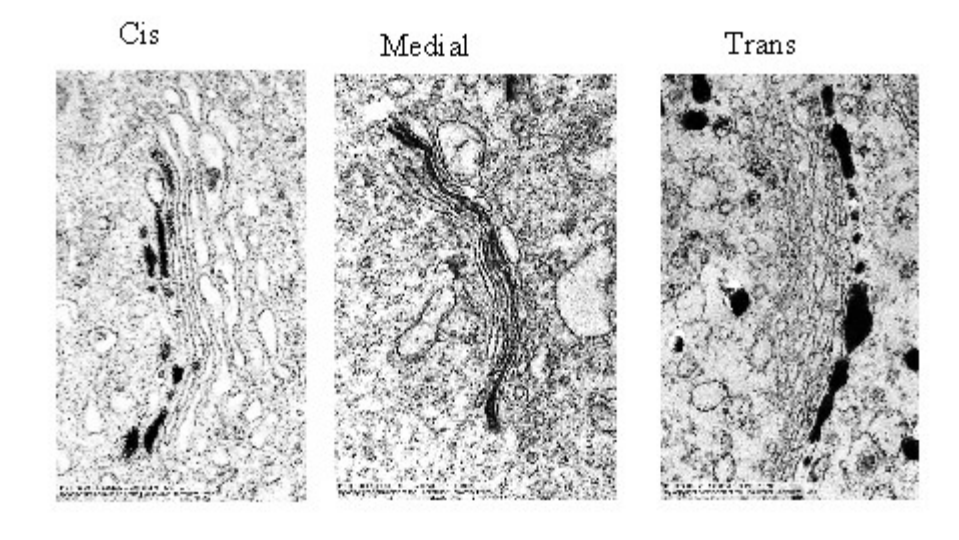


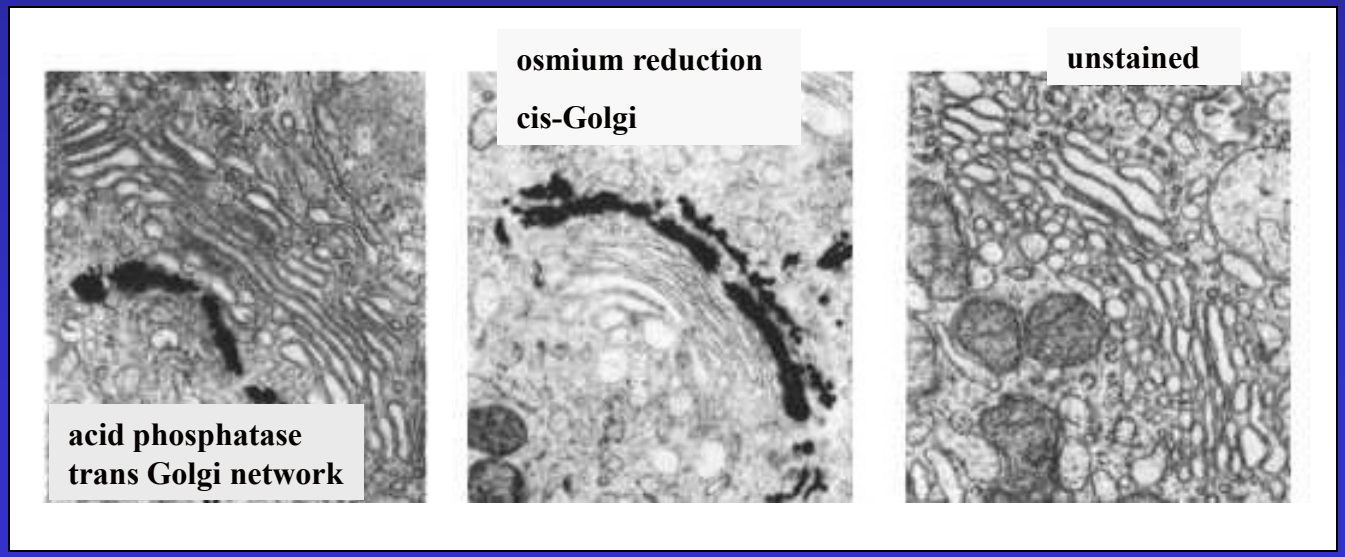
Chase 12h

Significance of cytoskeletal network !

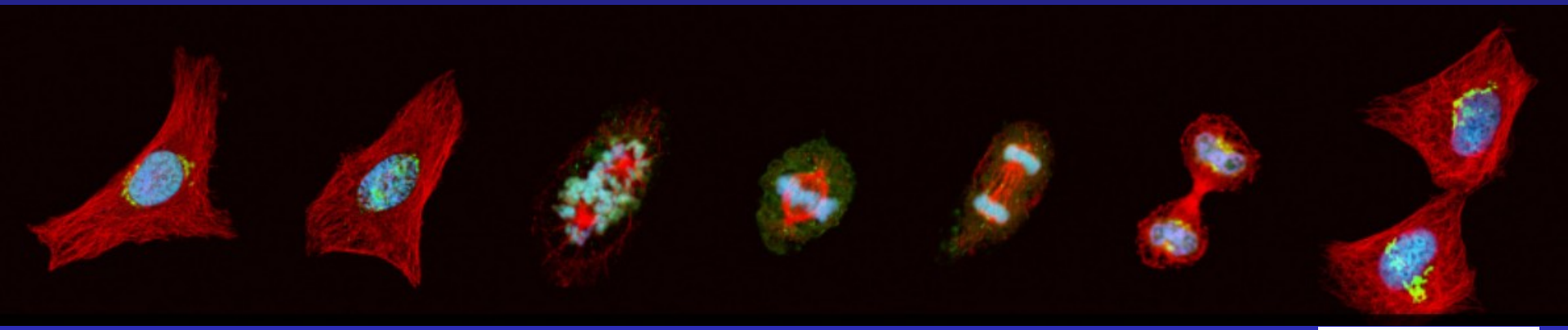


Enzyme content of different compartments in Golgi





Golgi and the cell division



The basic targeting pathways