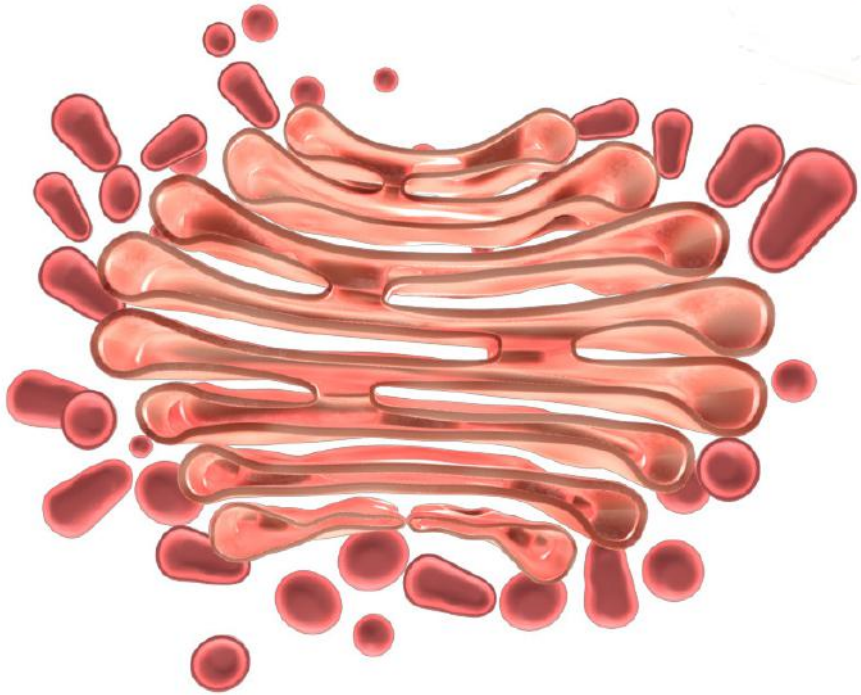
BIOLOGI SEL

Chapter VI

ORGANEL SEL

APARATUS GOLGI (BADAN GOLGI)

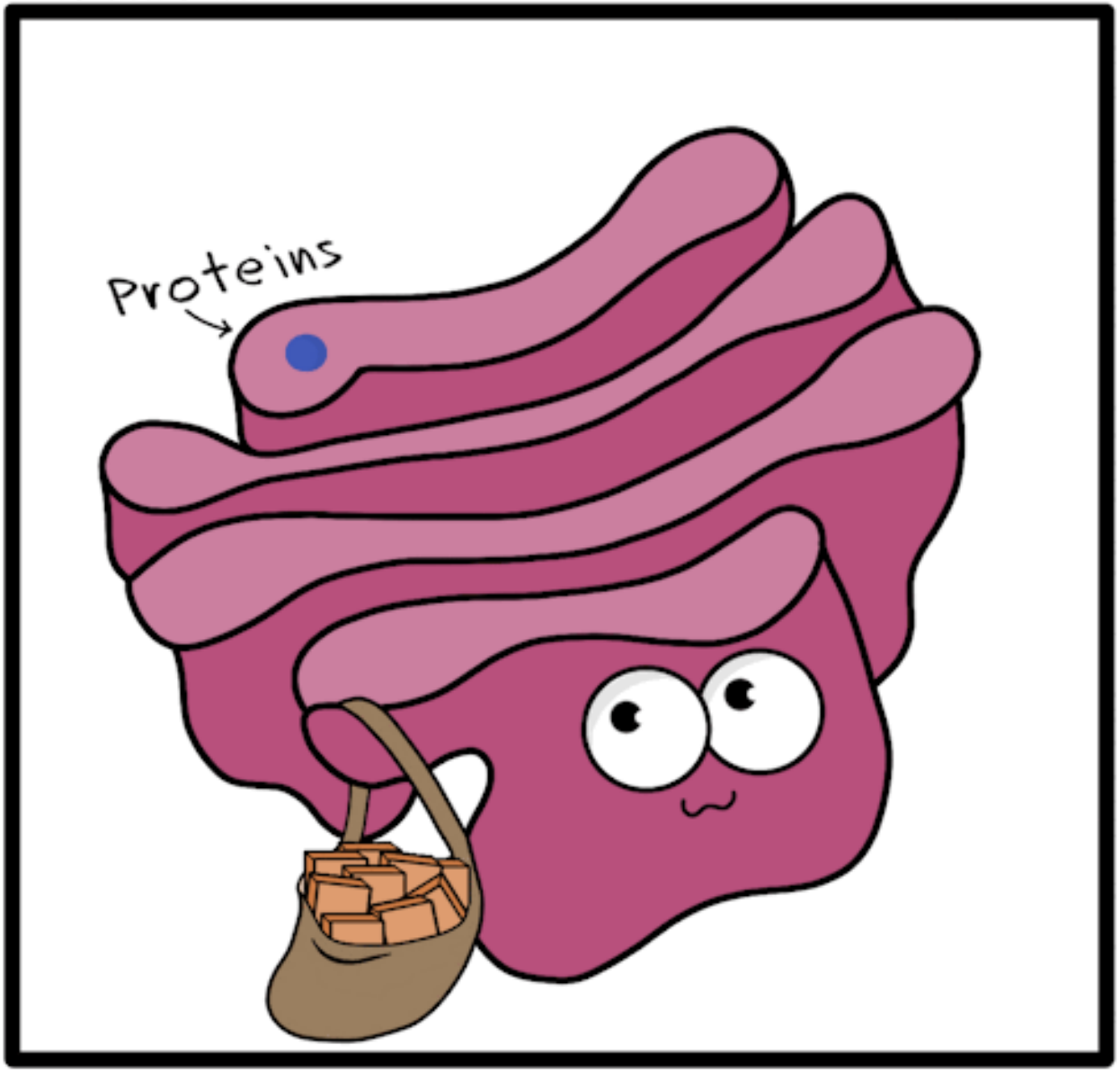
Husni Mubarok, S.Pd., M.Si.



GOLGI
LOOKS LIKE
PANCAKE

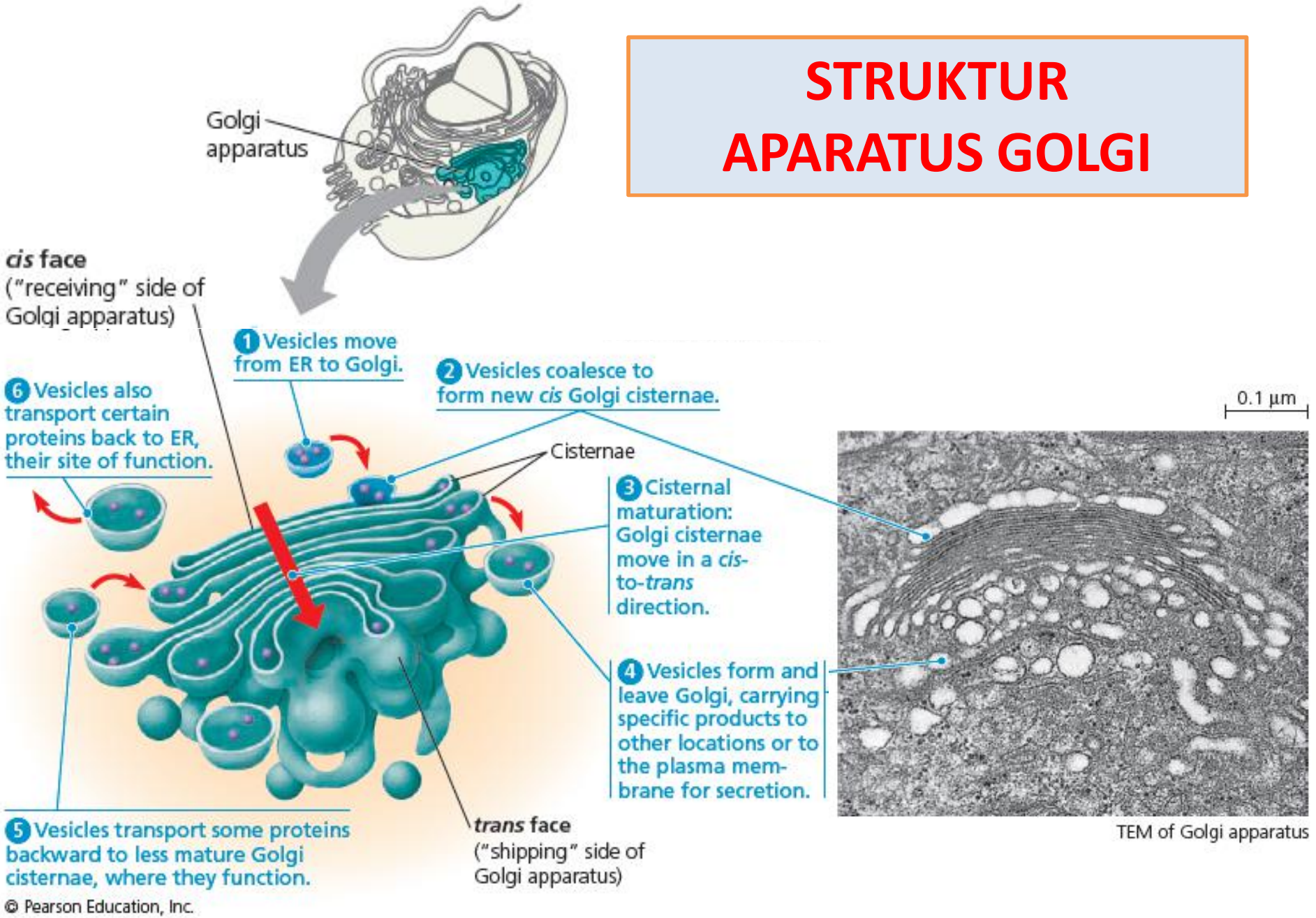
Golgi Apparatus

Amoeba Sisters #AmoebaGIFs



Post office of the cell

STRUKTUR APARATUS GOLGI



- Ditemukan oleh Camillo Golgi Th 1898
- Tersusun atas **3 sampai 8 Cisternae**
- Satu tumpukan cisternae = **Diktiosom**
- *Unicellular flagellates* → 60 Cisternae
- Satu sel paling sedikit 1 Set Golgi
- Sel hewan, 10 -20 golgi
- **Mamalia** = 40 – 100 tumpukan dengan 4 sampai 8 cisternae
- **Protista** = 60 cisternae
- Beberapa sel tumbuhan jml golgi sampai Ribuan
- Sel tudung akar Jagung, 2 Golgi
- Ketebalan membran ***Cis*** dan ***Trans*** berbeda
- Tiap tumpukan dihubungkan oleh **Mikrotubulus, protein aktin**

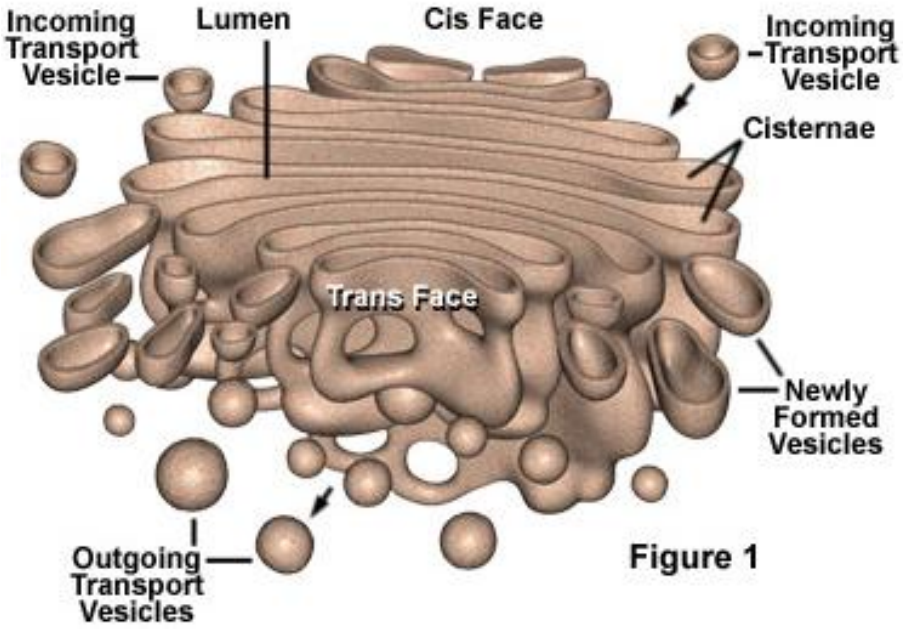


Figure 1

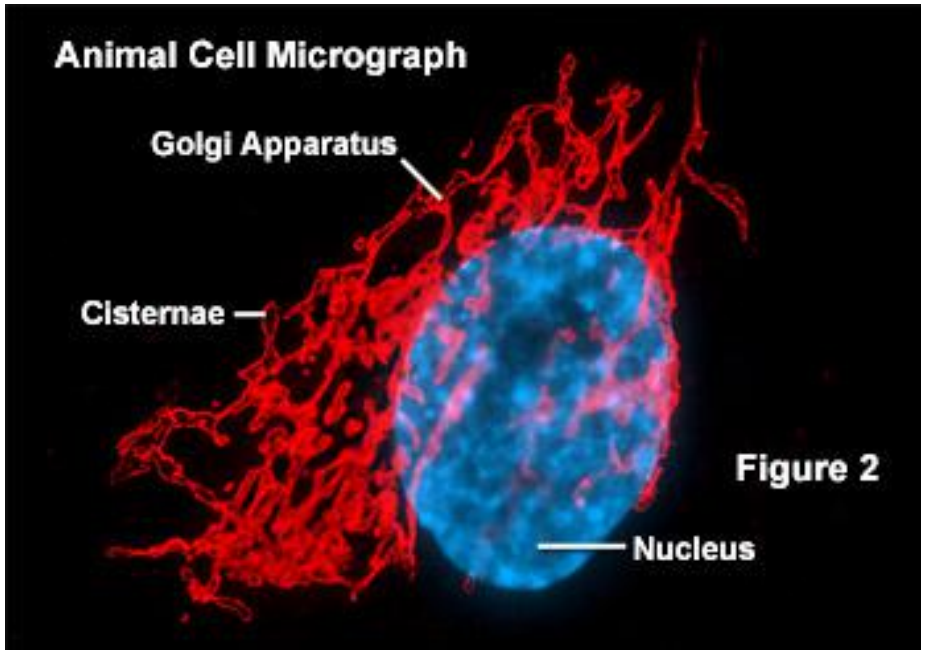
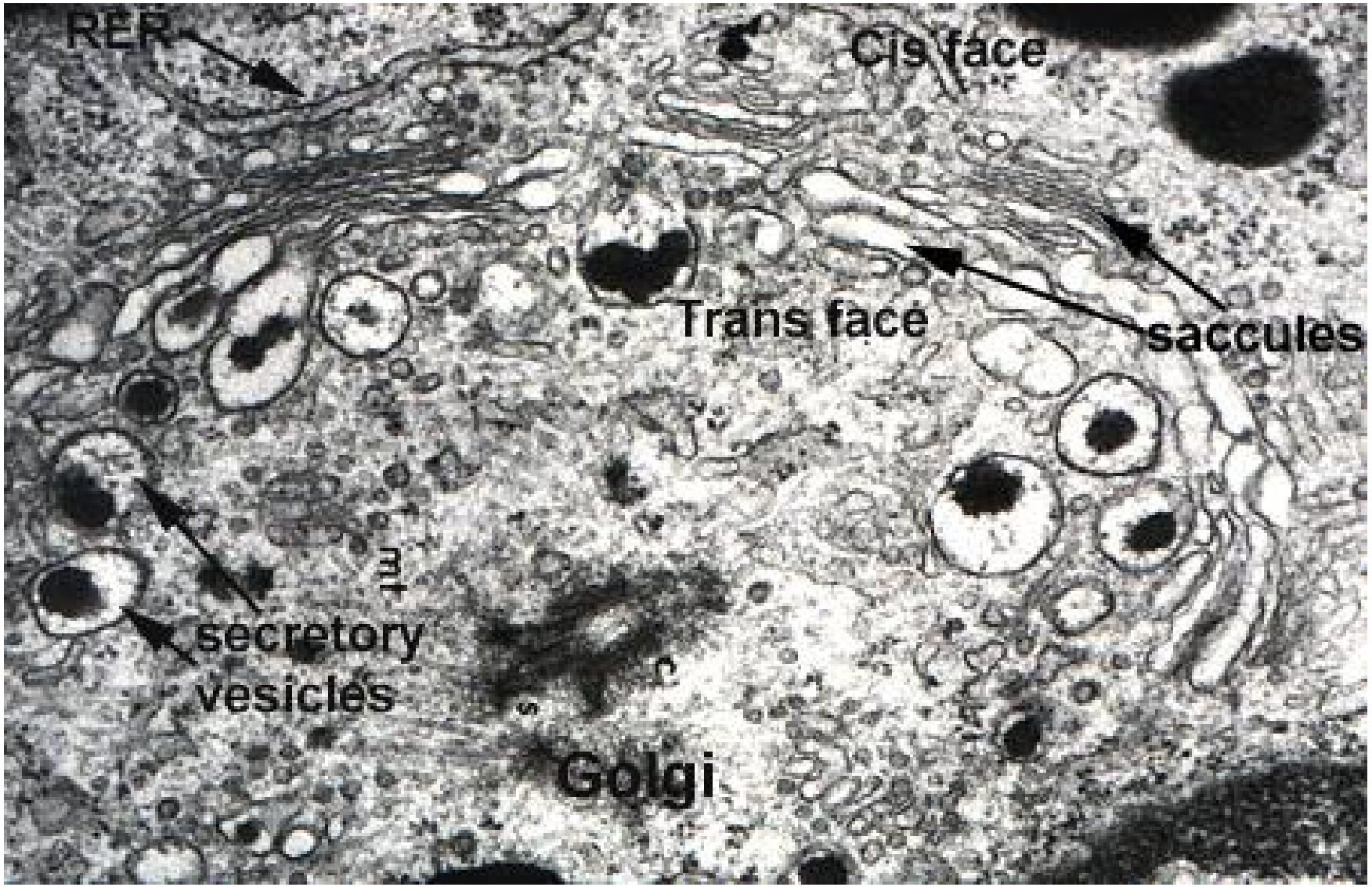
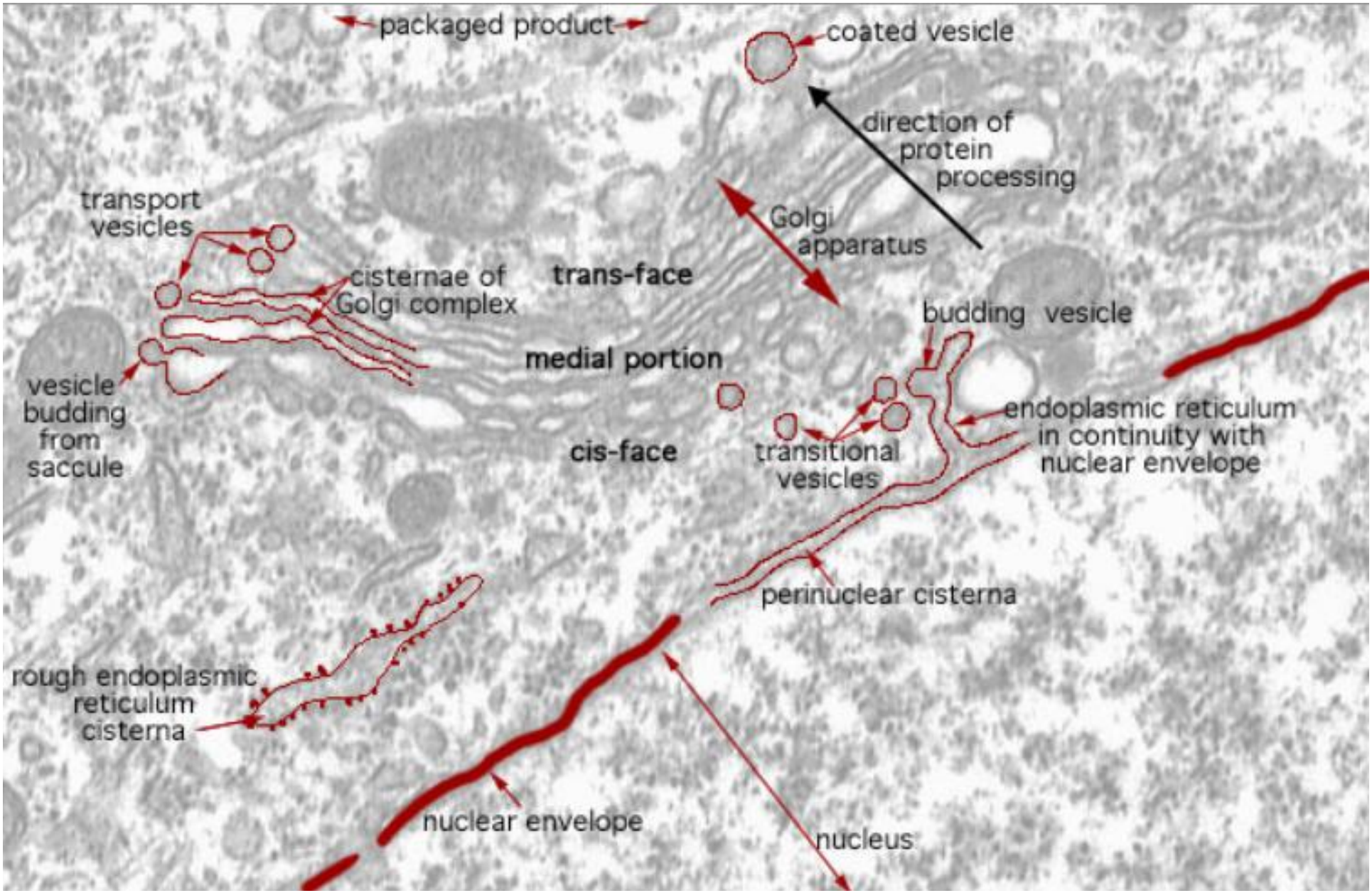


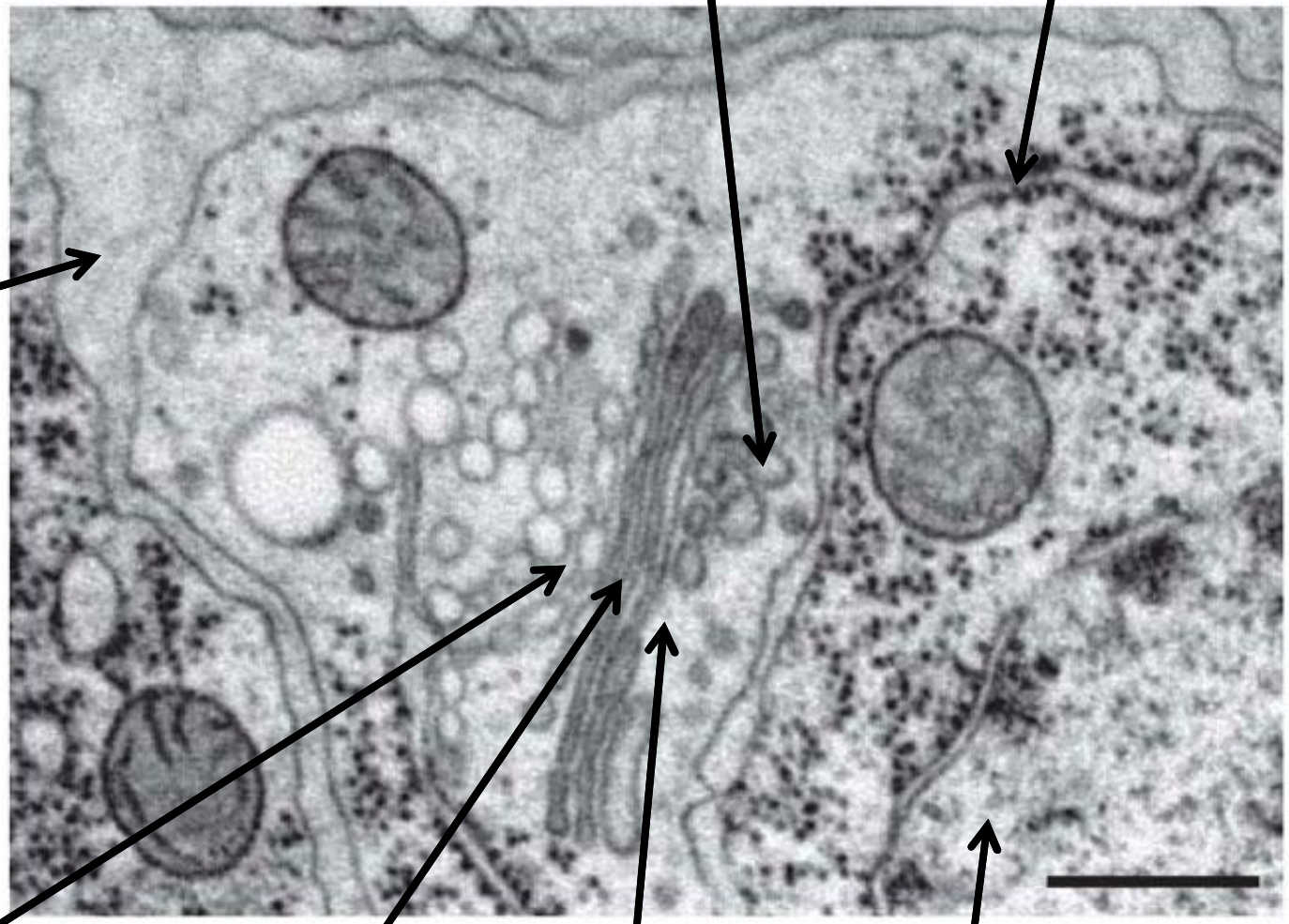
Figure 2


cis face
trans face


RER
Cis face
Trans face
saccules
secretory
vesicles
Golgi


packaged product
coated vesicle
direction of protein processing
transport vesicles
Golgi apparatus
cisternae of Golgi complex
trans-face
budding vesicle
medial portion
vesicle budding from saccule
endoplasmic reticulum in continuity with nuclear envelope
cis-face
transitional vesicles
perinuclear cisterna
rough endoplasmic reticulum cisterna
nuclear envelope
nucleus

IDENTIFIKASILAH



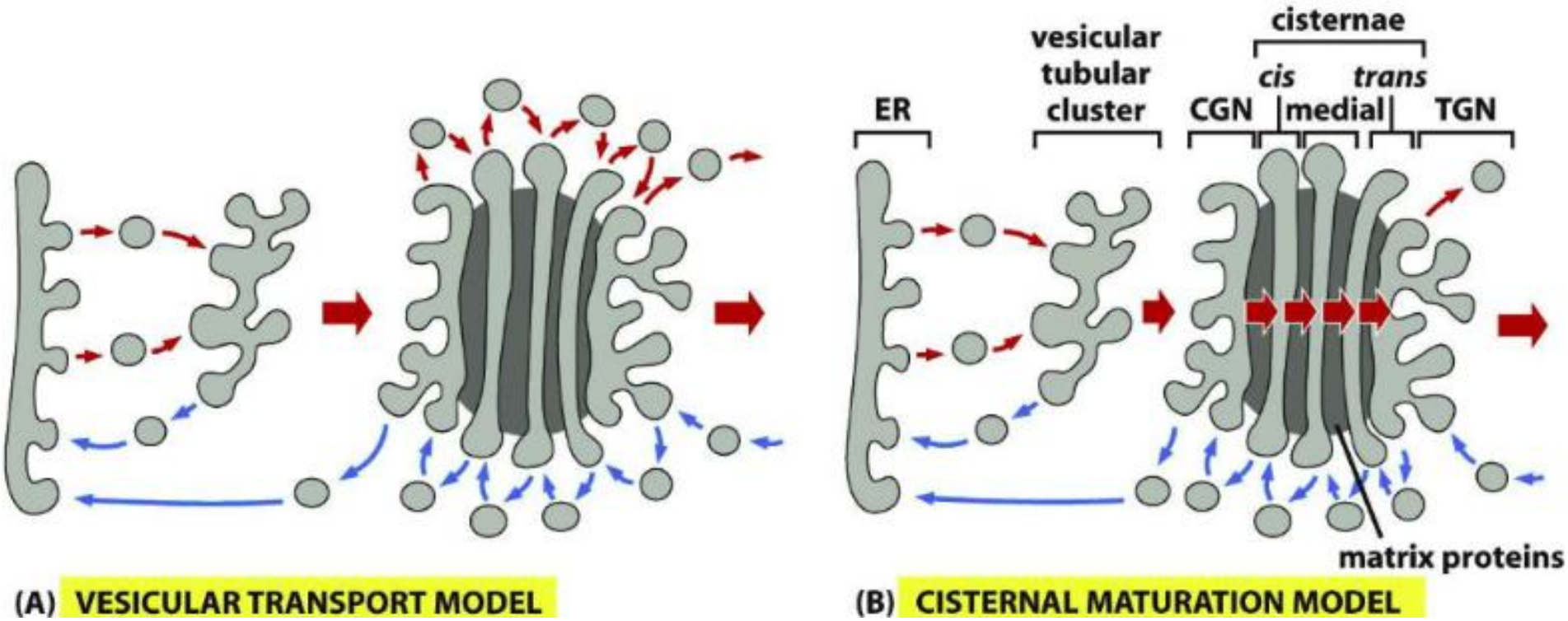
FUNGSI GOLGI

- Memodifikasi, mensortir dan mengemas makromolekul
- Memodifikasi protein dari RER (menambah **Karbohidrat – Glikosilasi** dan **Fosfat – Fosforilasi**)
- Glikosilasi di Golgi berbeda dengan Glikosilasi di RE
- Transport lipid
- Mensintesis Lisosom
- Produksi ***Proteoglycans*** → matriks ekstraseluler sel hewan
- Pada sel tumbuhan → 80% reaksi biokimia pada Cisternae → produksi **pektin** dan **polisakarida** → membuat dinding sel

MODEL GOLGI TRAFFIC

Model	
Model 1	**Vesicular Transport (Anterograde Vesicular Transport Between Stable Compartments)**
Model 2	**Cisternal Progression/Maturation**
Model 3	Cisternal Progression/Maturation with Heterotypic Tubular Transport
Model 4	Rapid Partitioning in a Mixed Golgi
Model 5	Stable Compartments as Cisternal Model Progenitors

GOLGI TRAFFIC



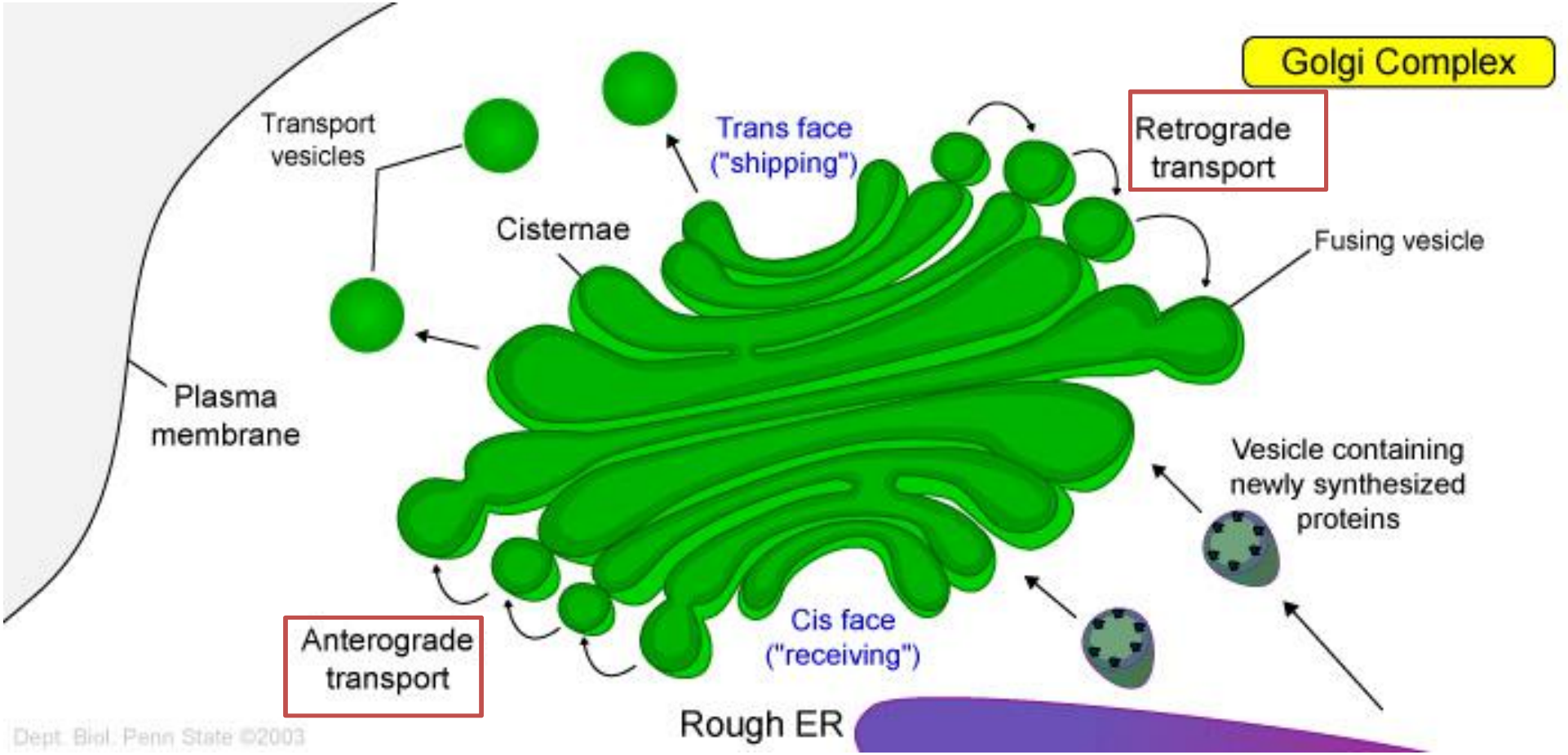
Kompartemen Stabil

Kompartemen Dinamik

Enzyme

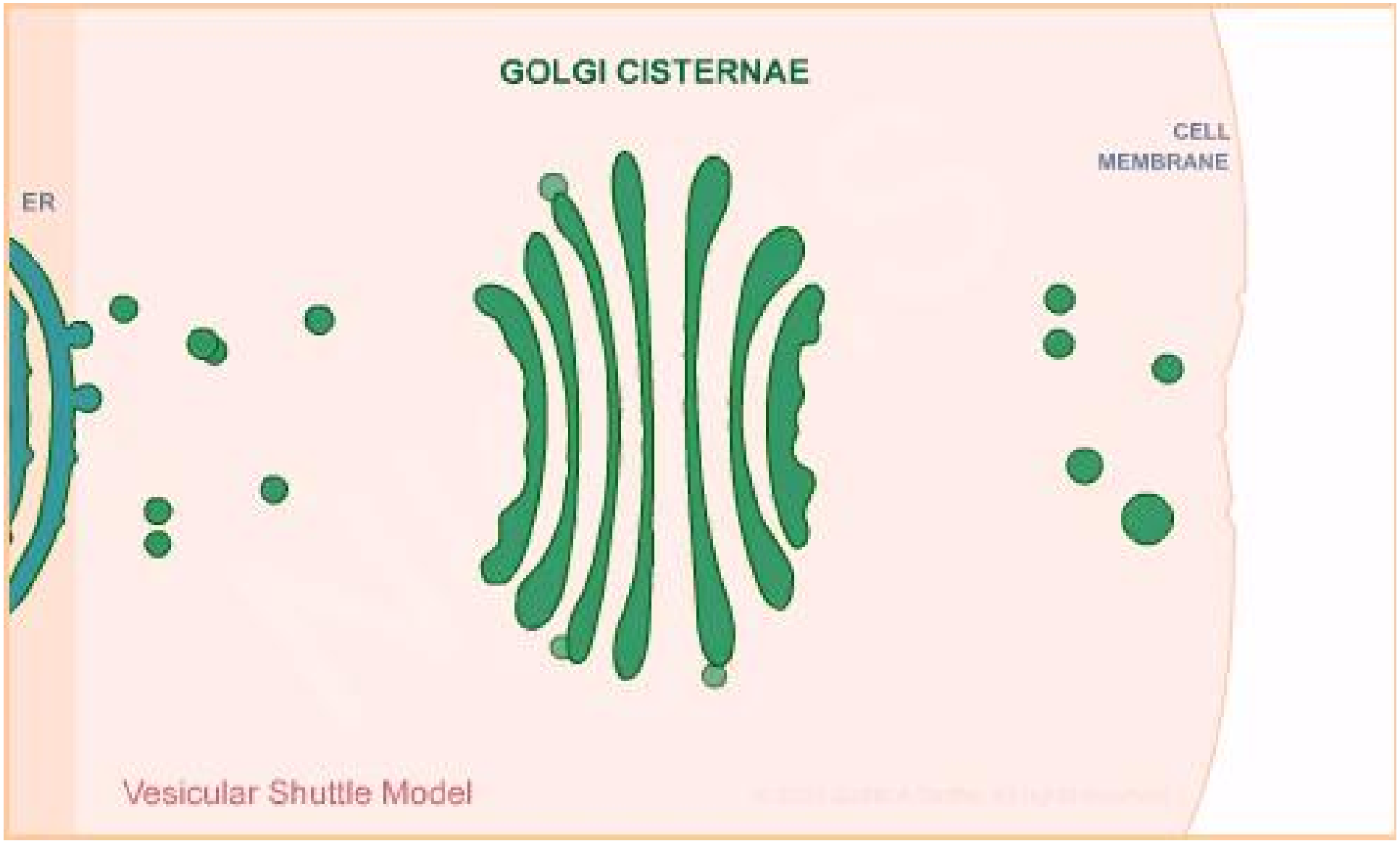
Paling disetujui Scientist

GOLGI TRAFFIC

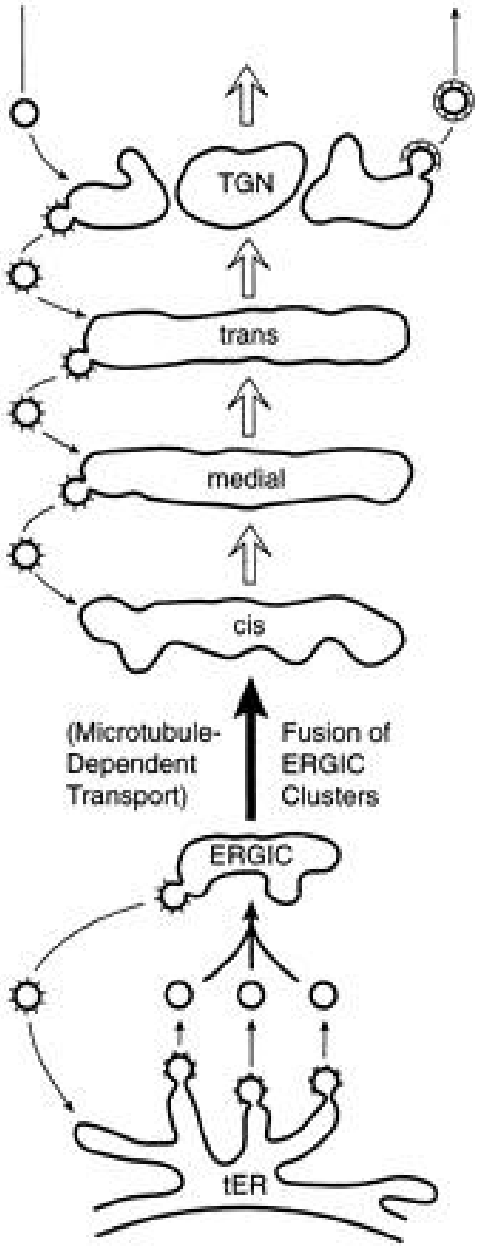


Termasuk model yg mana??

GOLGI TRAFFIC - Vesicular Transport Modelc



GOLGI TRAFFIC – Cisternal Maturation Model

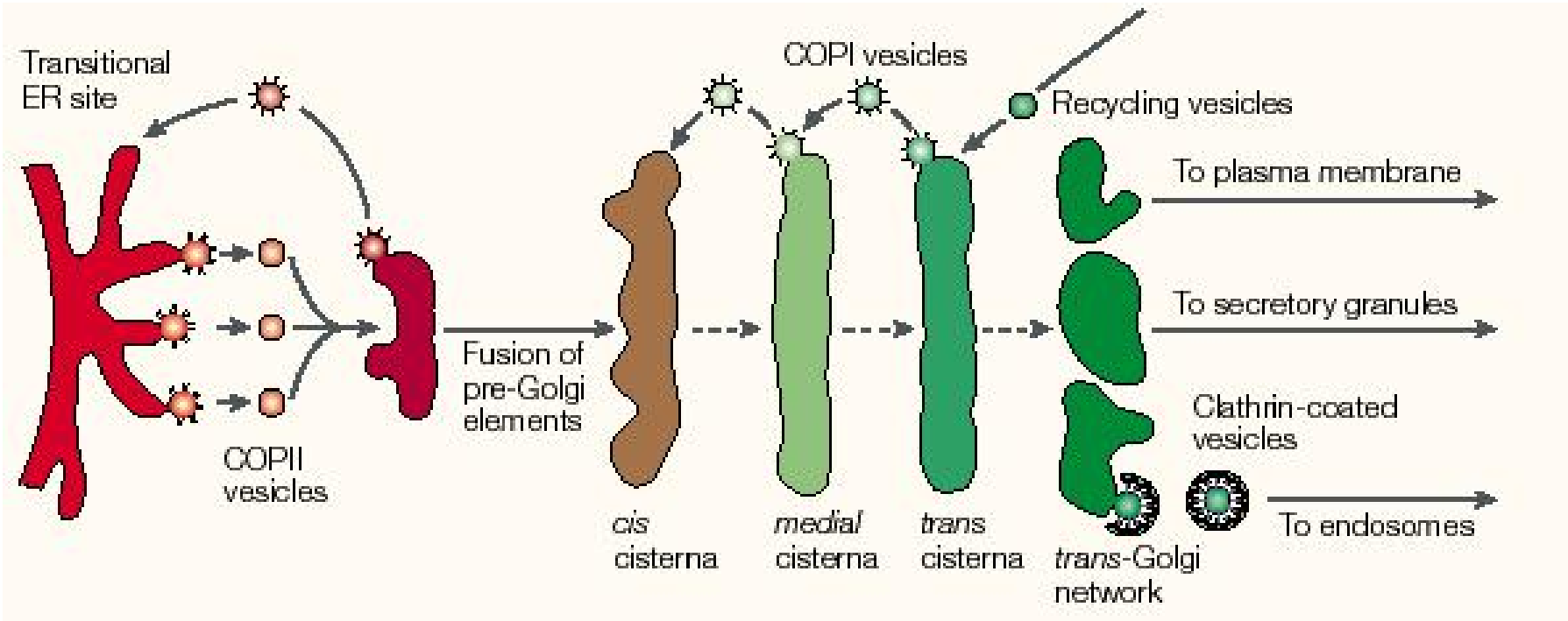


Tunas Vesikel (kantung) **Coatomer Protein Complex II (COPII)** dari transisional RE (tER) → Fusi (melebur) scara homogen → membentuk **ER-Golgi intermediate compartment (ERGIC)** → Beberapa komponen dikirim ke RE melalui Vesikel **COPI**

Sel Vertebrata

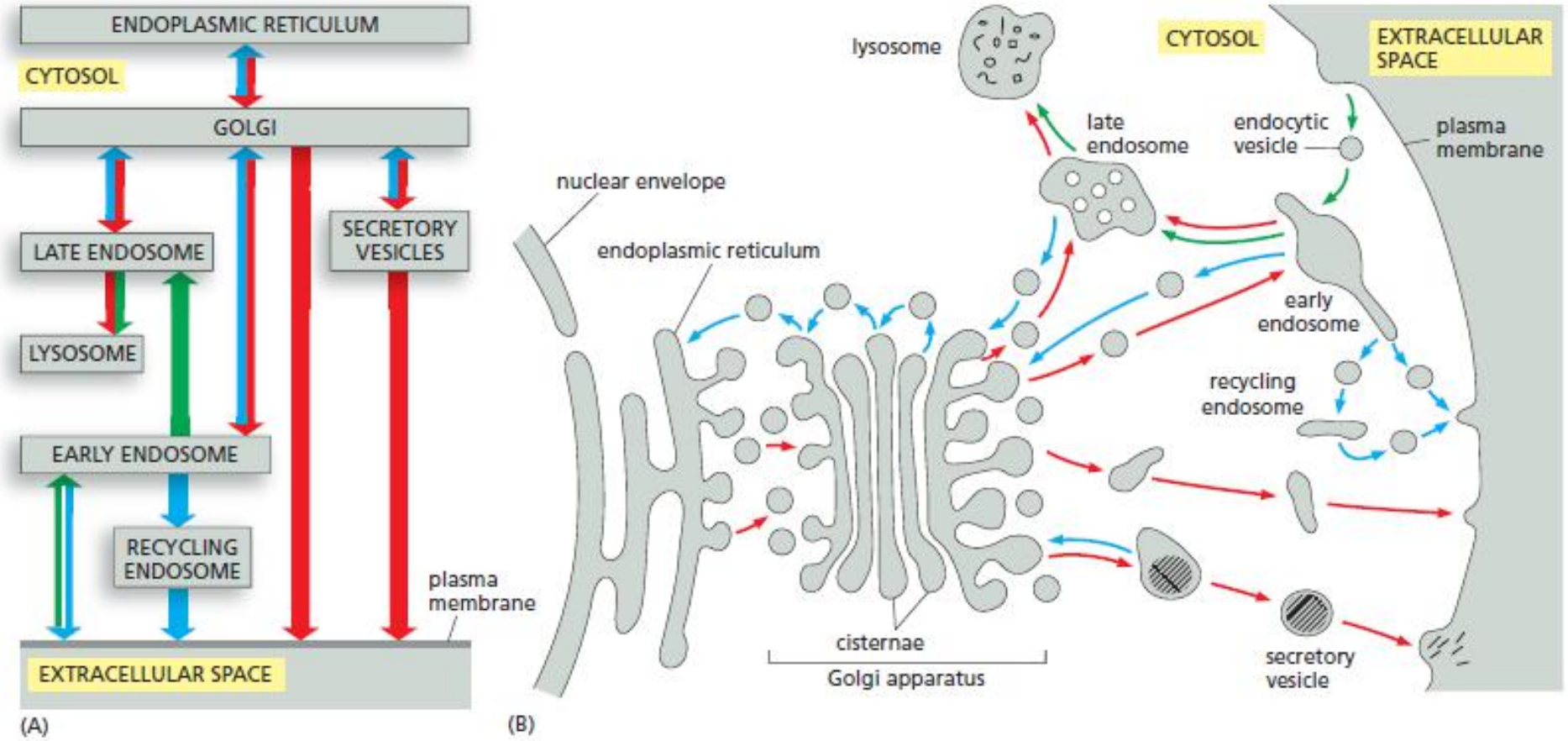
Culster ERGIC berjalan spanjang mikrotubul ke **Juxtanuclear Region** → melebur dgn Culster ERGIC lain + COPI → Cisterna Cis Golgi baru → matang → menjadi Cisterna Medial → matang → menjadi Cisterna Trans

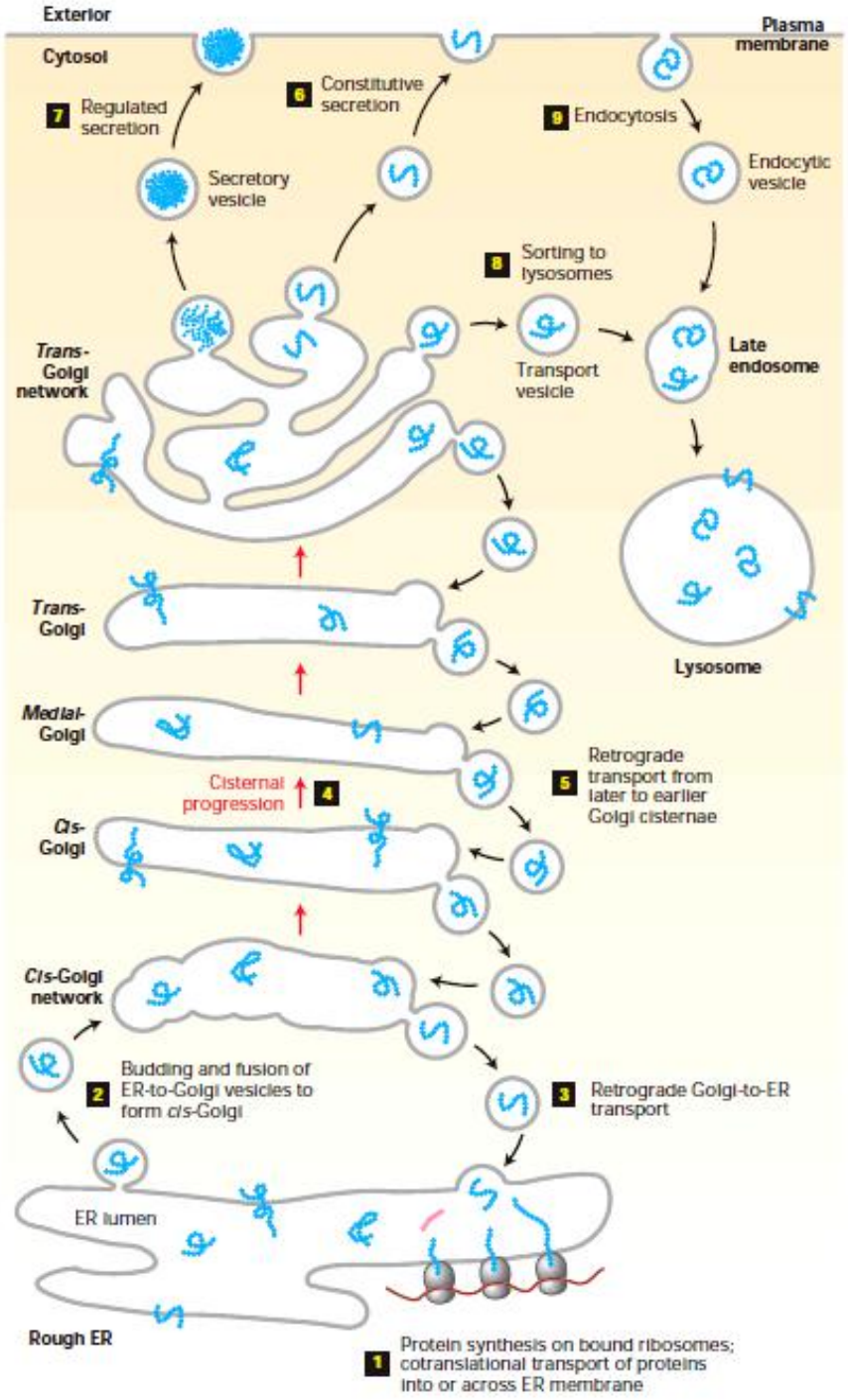
GOLGI TRAFFIC – Cisternal Maturation Model



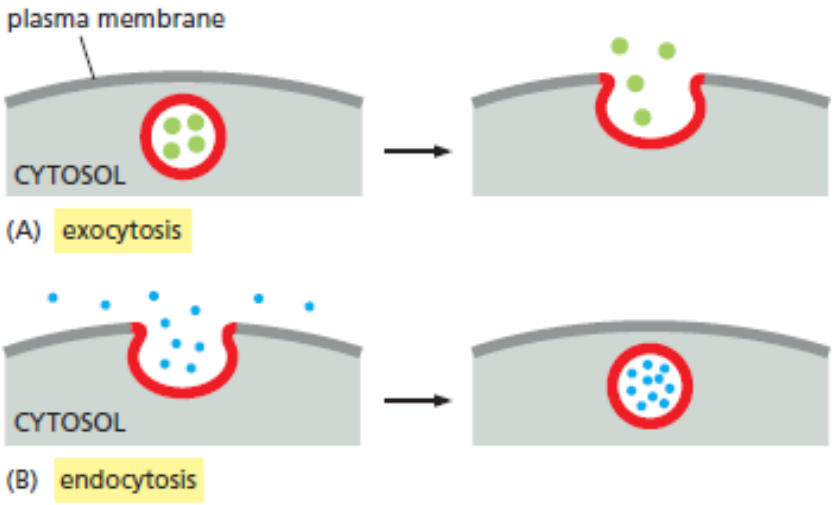
GOLGI TRAFFIC – Cisternal Maturation Model

GOLGI TRAFFIC




Exterior
Cytosol
Plasma membrane
7 Regulated secretion
6 Constitutive secretion
9 Endocytosis
Secretory vesicle
Endocytic vesicle
8 Sorting to lysosomes
Trans-Golgi network
Transport vesicle
Late endosome
Lysosome
Trans-Golgi
Medial-Golgi
Cisternal progression 4
5 Retrograde transport from later to earlier Golgi cisternae
Cis-Golgi
Cis-Golgi network
2 Budding and fusion of ER-to-Golgi vesicles to form cis-Golgi
3 Retrograde Golgi-to-ER transport
ER lumen
Rough ER
1 Protein synthesis on bound ribosomes; cotranslational transport of proteins into or across ER membrane

Vesikel



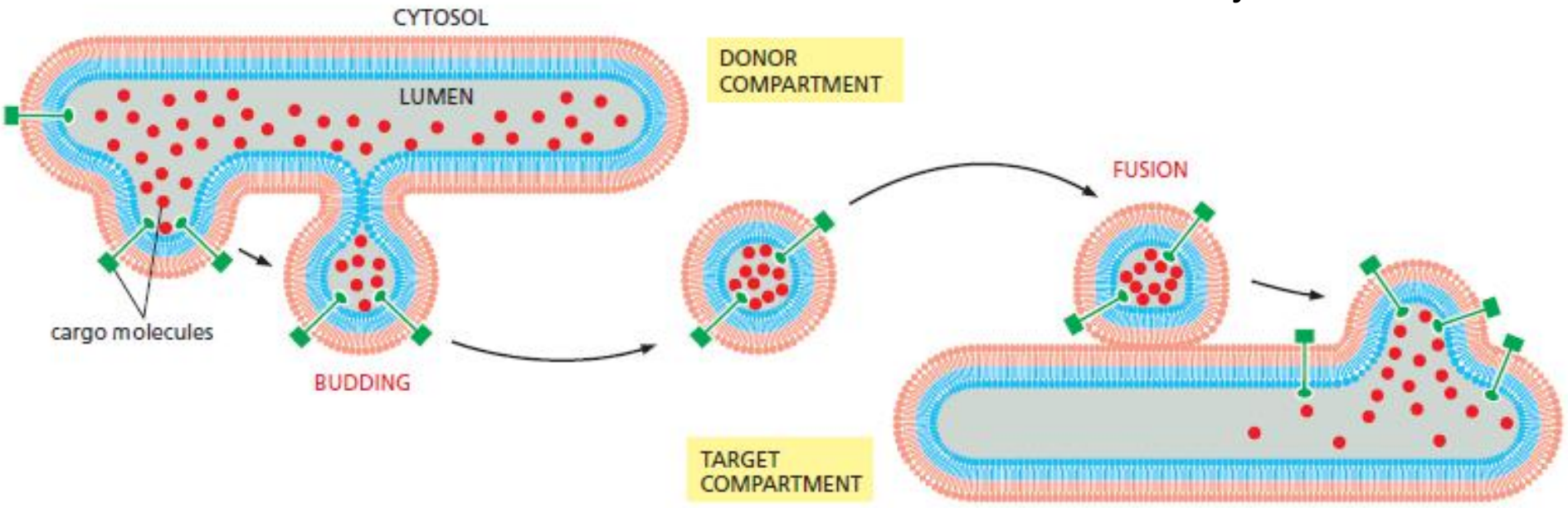
Coated Vesicle = Kantung Bermantel

Mantel → Protein; Struktur dua lapisan

Sebelum berfusi → mantel dilepas

Fungsi mantel:

- **Lapisan mantel dalam** → membran protein spesik, memilih molekul yg akan di transport , mengangkat membran
- **Lapisan Mantel Luar** →merakit menjadi lengkungan, struktur spt keranjang , membentuk membran mjd vesikel

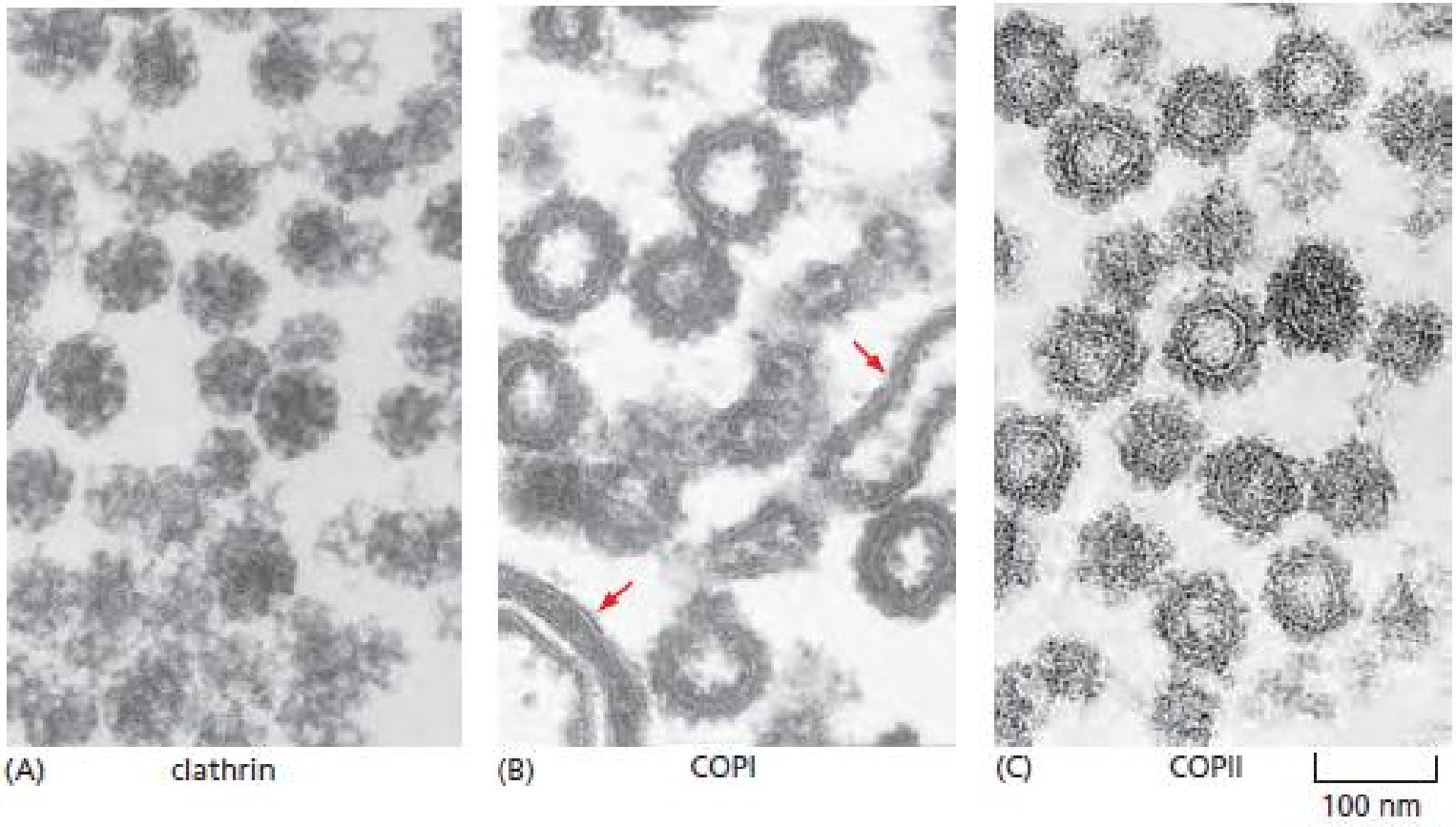


Tipe-Tipe Vesikel

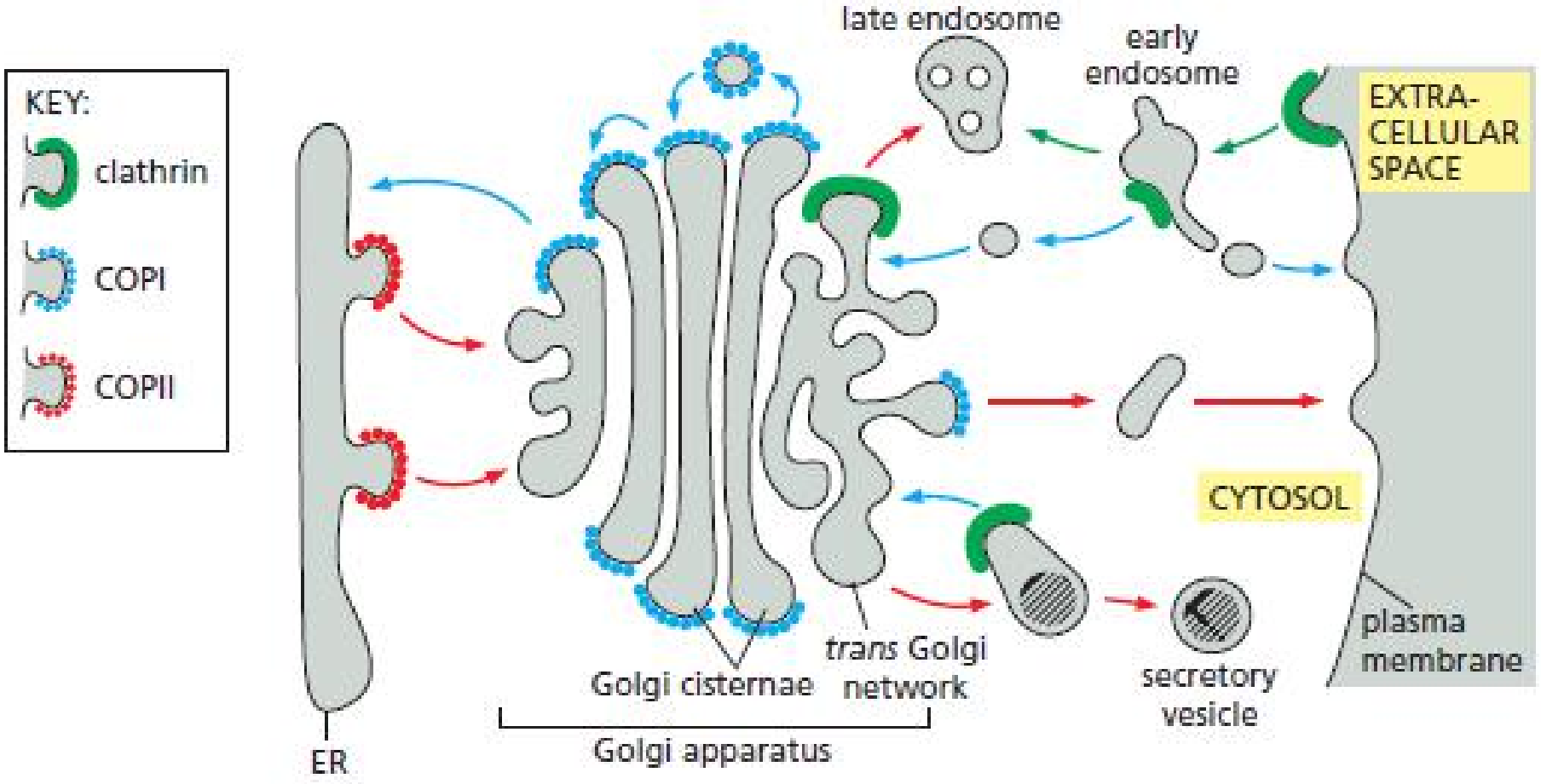
3 Jenis Vesikel Transport

1. ***Clathrin-Coated***
2. **Coatomer Protein Complex I (*COPI)-Coated***
3. **Coatomer Protein Complex II**

- **COPII** vesicles transport proteins from the rough ER to the Golgi.
- **COPI** vesicles mainly transport proteins in the retrograde direction between Golgi cisternae and from the *cis*-Golgi back to the rough ER.
- **Clathrin** vesicles transport proteins from the plasma membrane (cell surface) and the *trans*-Golgi network to late endosomes.



Tipe2 Vesikel Dalam Jalur Transport

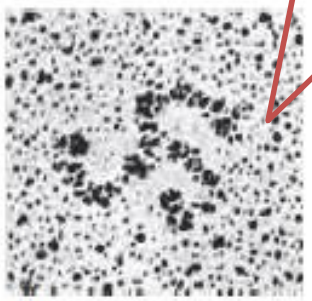


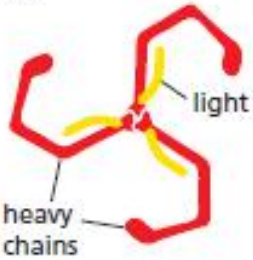
Clathrin-Coated

Rantai Polipeptida
Kaki Tiga = **Triskelion**

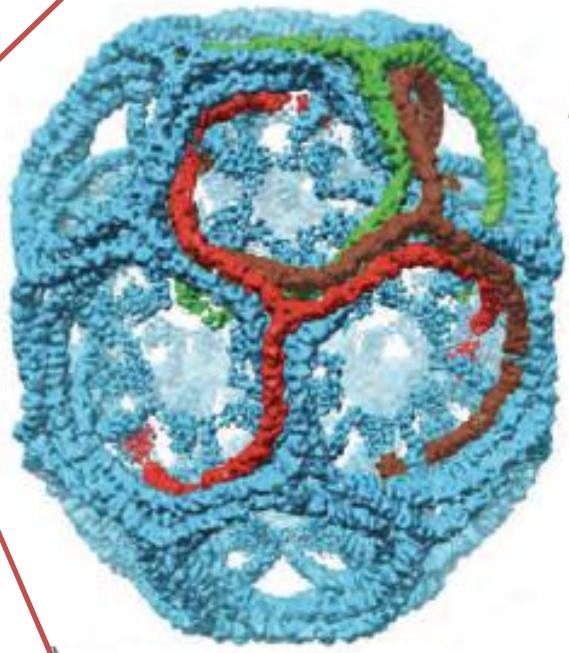
Famework
Heksagon & Pentagon
→ Tunas

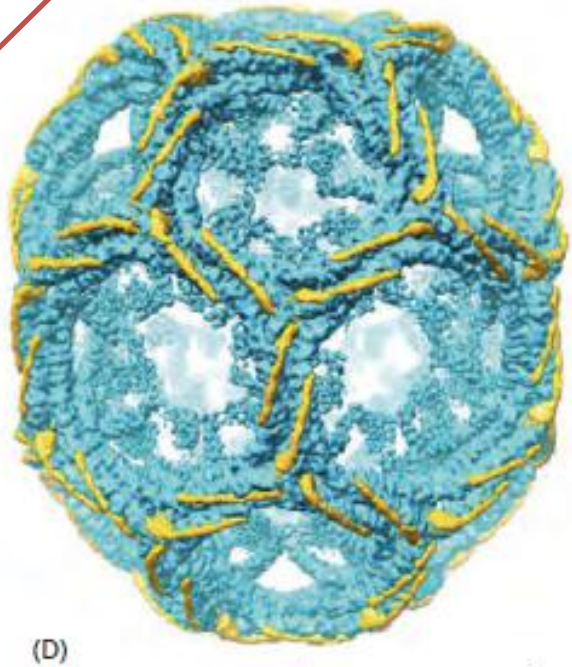
36 Triskelion
12 Pentagon
6 Heksagon


(A)

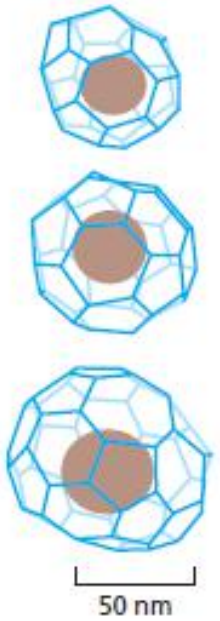


(B)



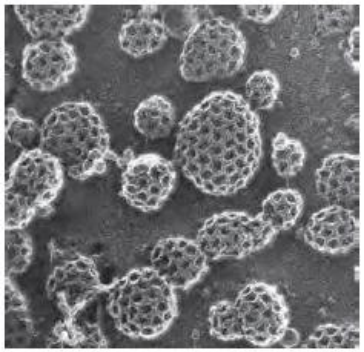

(D)

25 nm



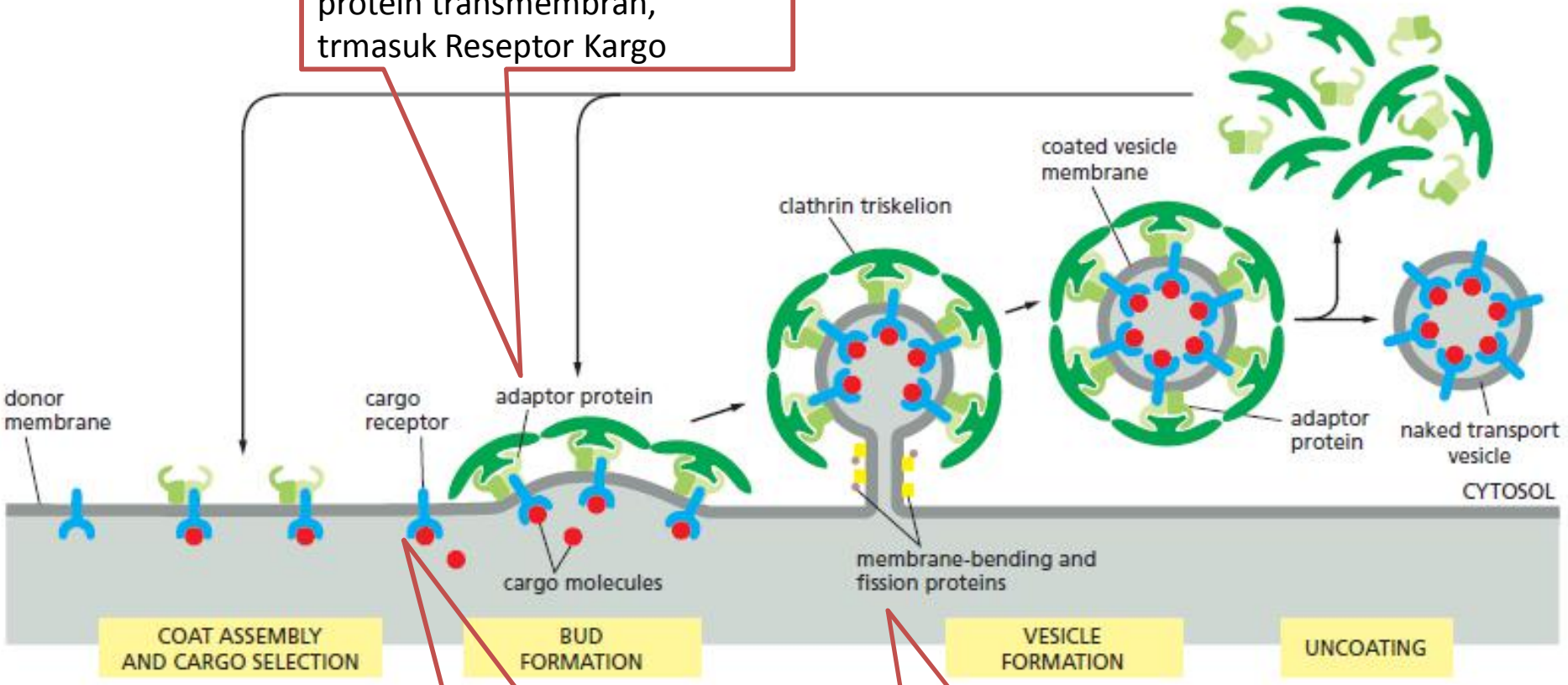
(E)

Terhubung dgn
Aktin Sitoskeleton



Clathrin-Coated – Pembentukan dan Perombakan

Komponen CC; Mengikat CC ke membran dan menjebak protein transmembran, trmasuk Reseptor Kargo

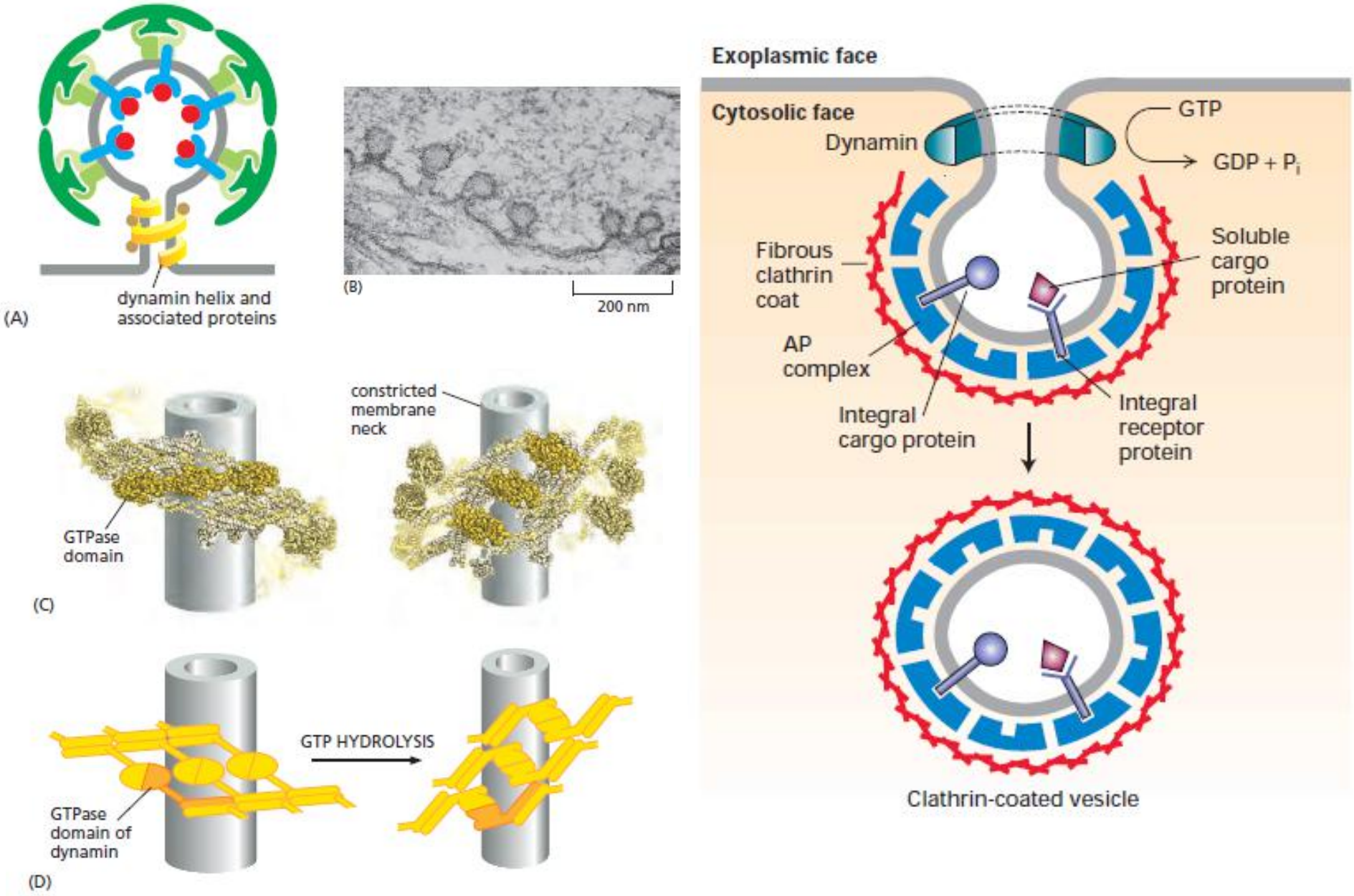


Ex: **AP2** mengikat Phosphoinositides (**Phospatidylinositol Phosphates ; PIPs**)

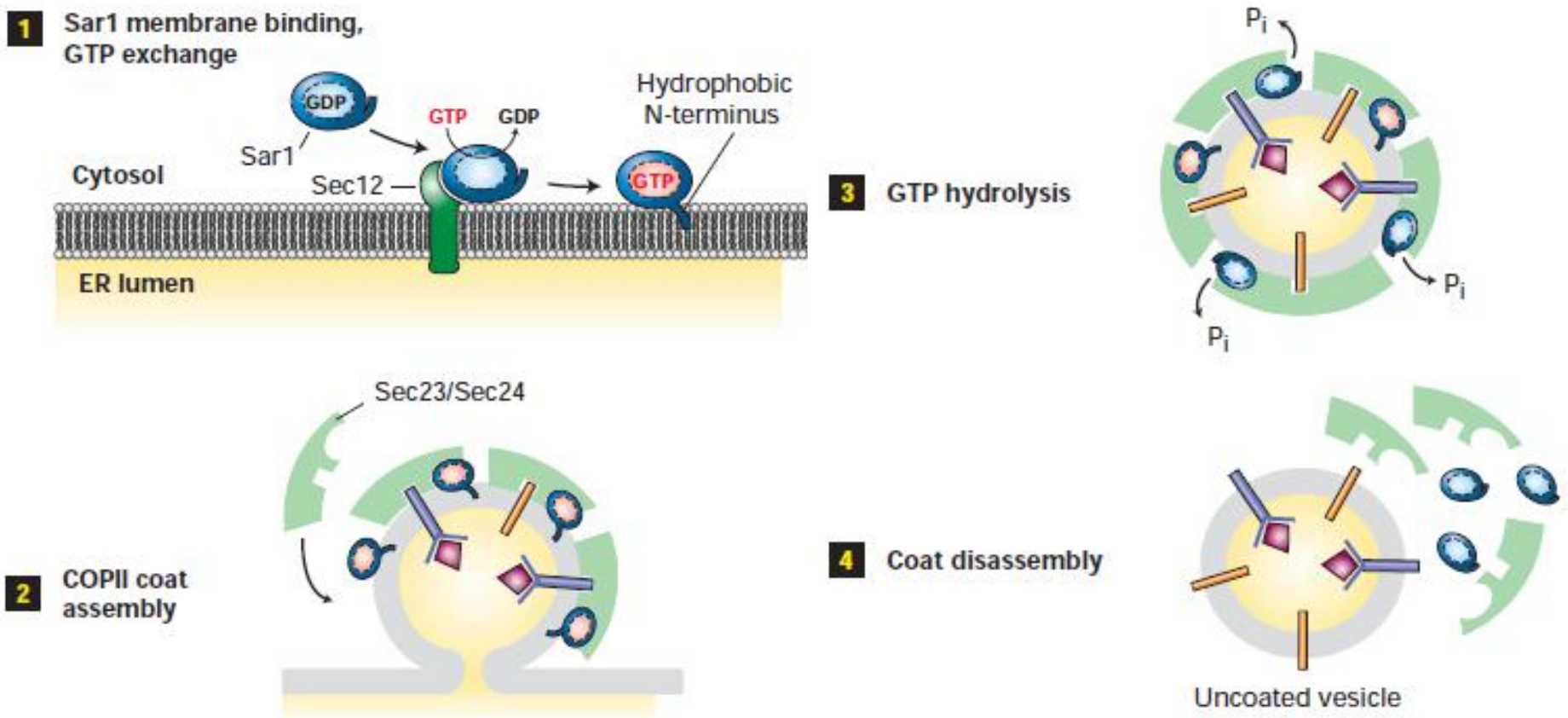
Reseptor transmembran yg menangkap molekul kargo kedalam vesikel

Dynamin helix dan protein asosiasi

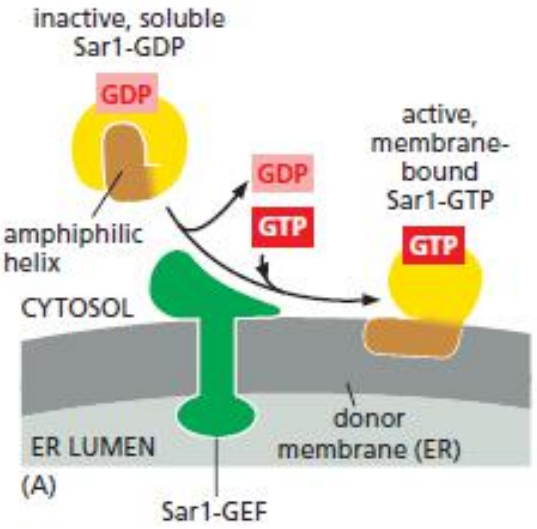
Clathrin-Coated – Pembentukan dan Perombakan

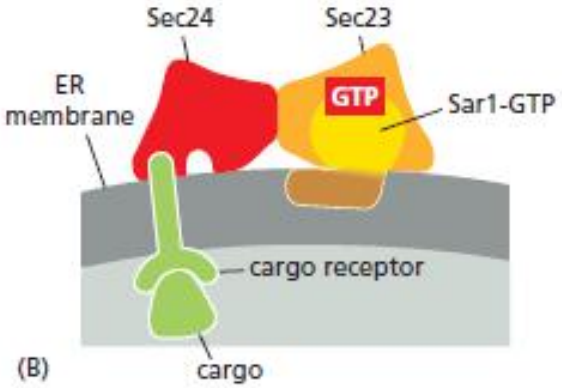


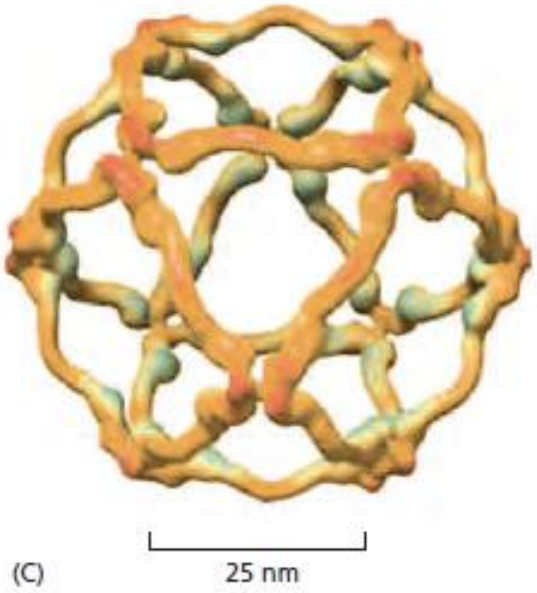
Coatomer Protein Complex II (*COPII)-Coated*

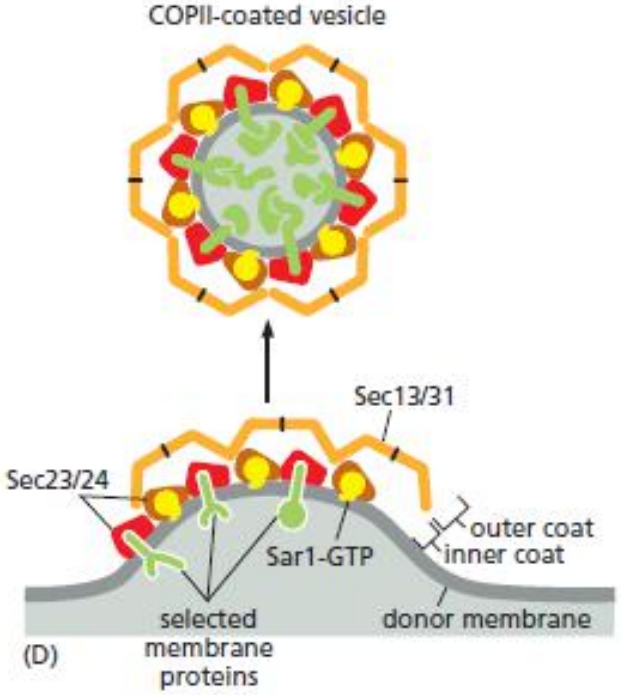


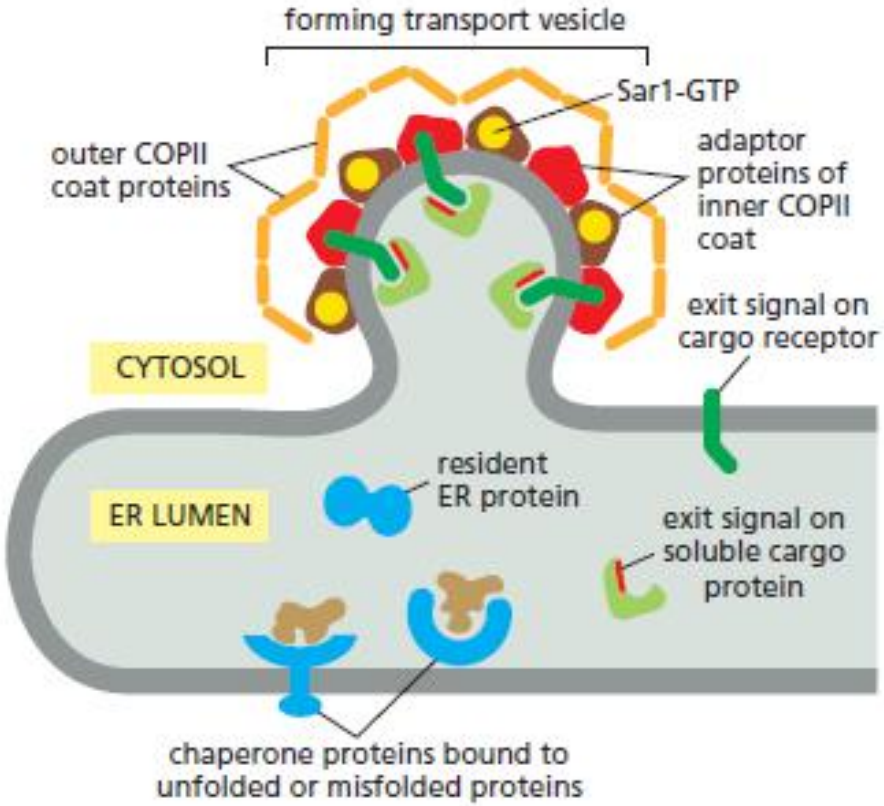
Coatomer Protein Complex II (*COPII)-Coated*

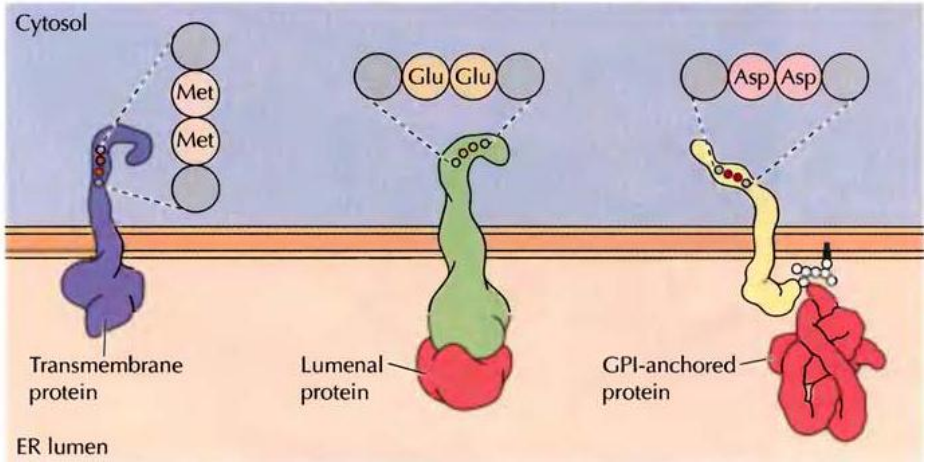


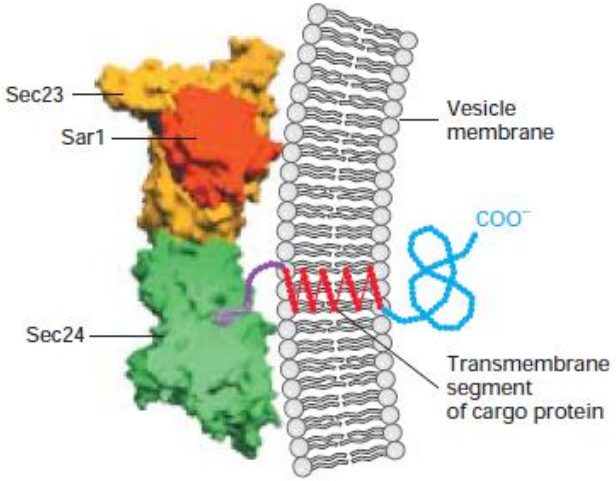


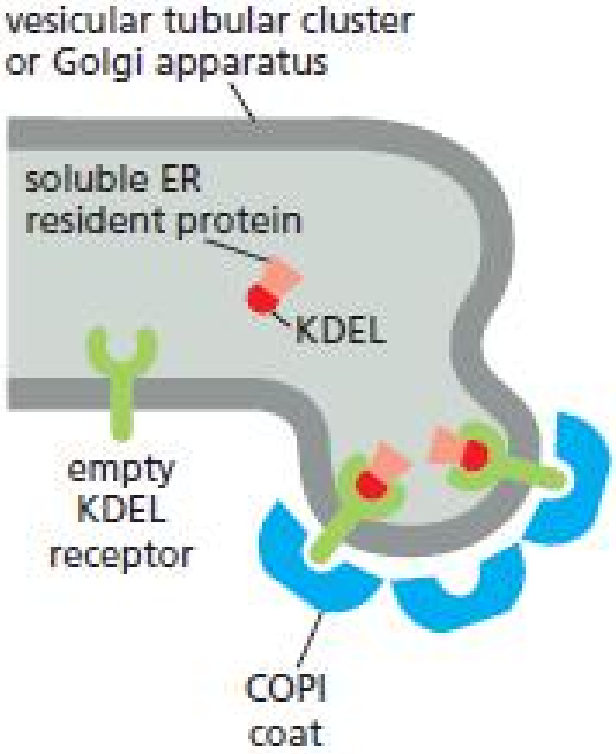


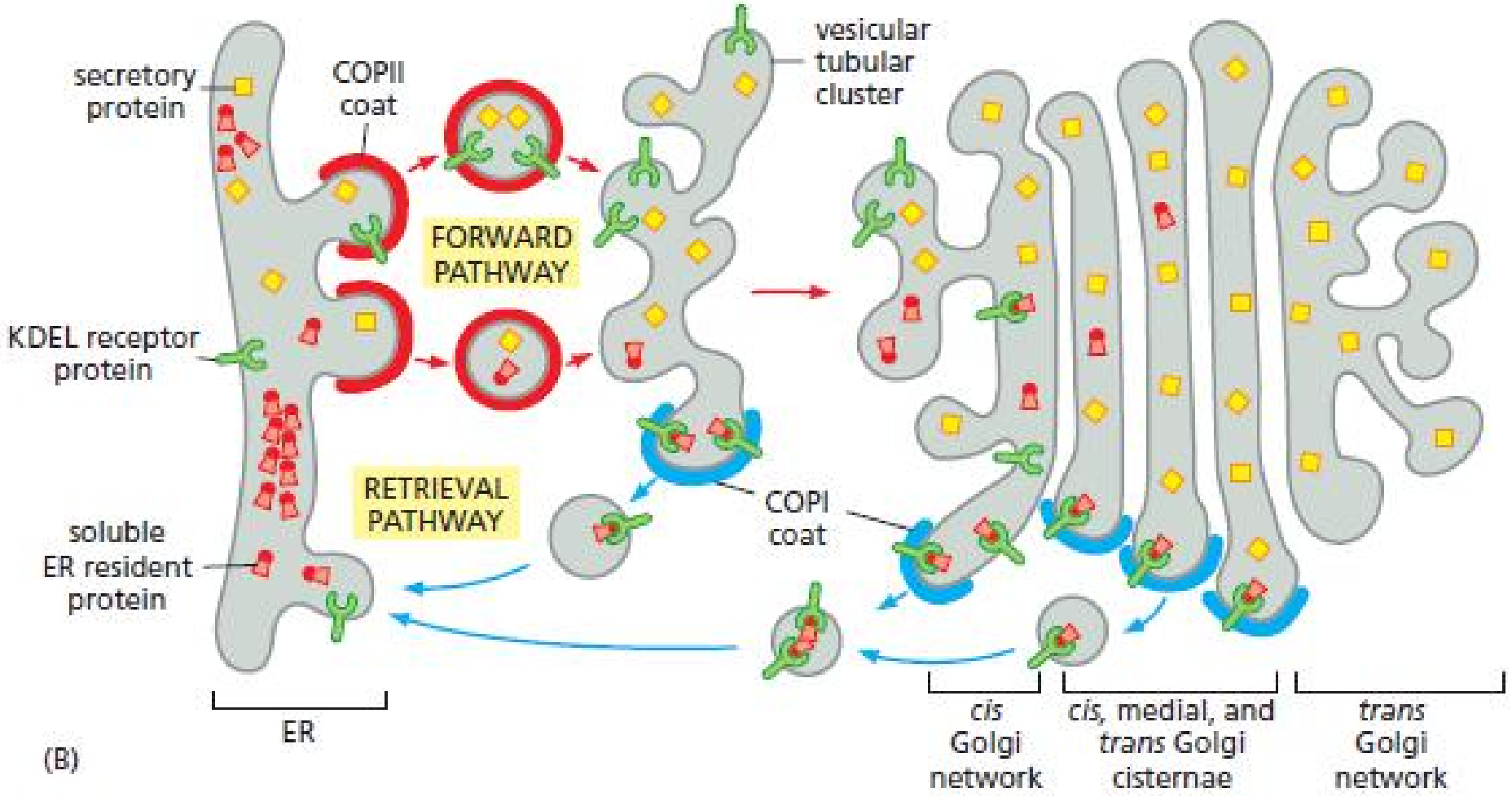


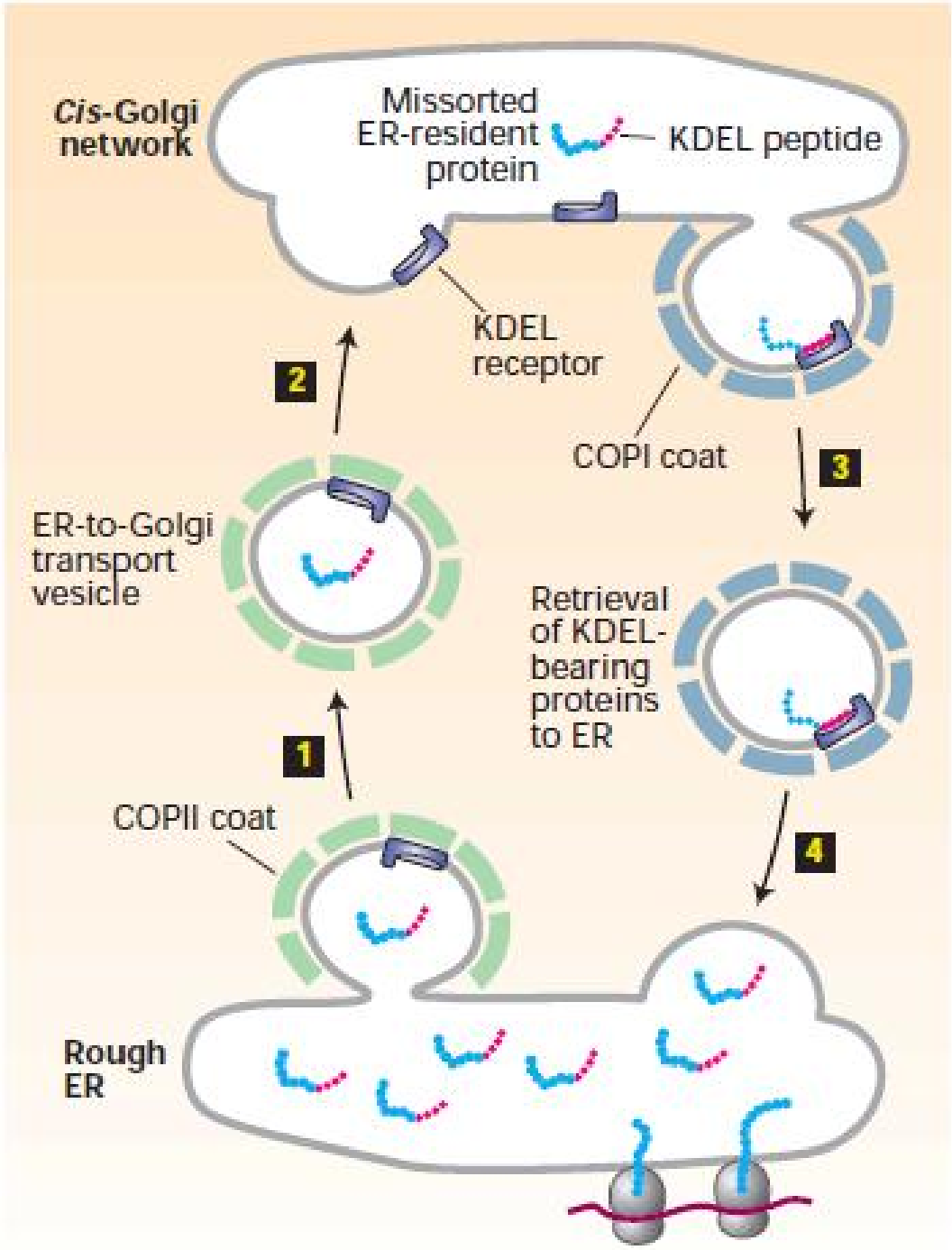

forming transport vesicle
Sar1-GTP
outer COPII coat proteins
adaptor proteins of inner COPII coat
exit signal on cargo receptor
CYTOSOL
ER LUMEN
resident ER protein
exit signal on soluble cargo protein
chaperone proteins bound to unfolded or misfolded proteins


Cytosol
Met
Met
Glu
Glu
Asp
Asp
Transmembrane protein
Lumenal protein
GPI-anchored protein
ER lumen

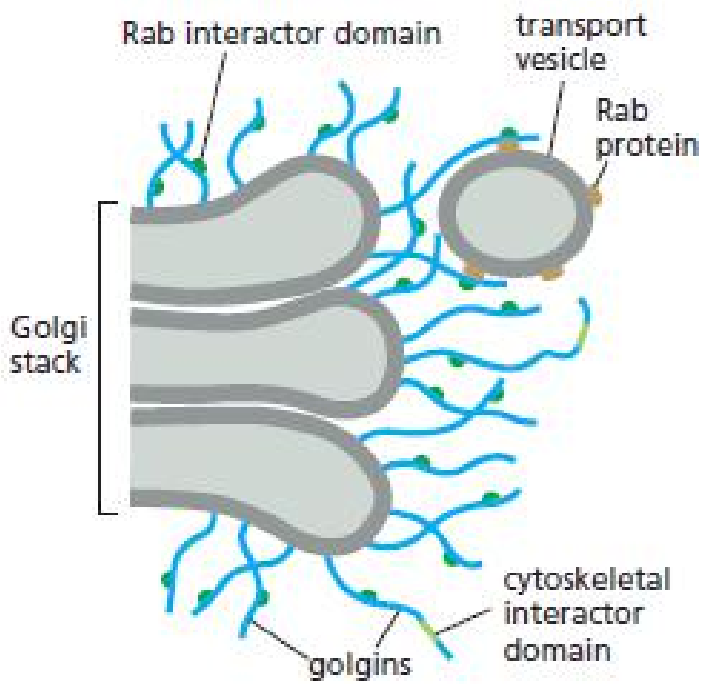

Sec23
Sar1
Vesicle membrane
COO⁻
Sec24
Transmembrane segment of cargo protein

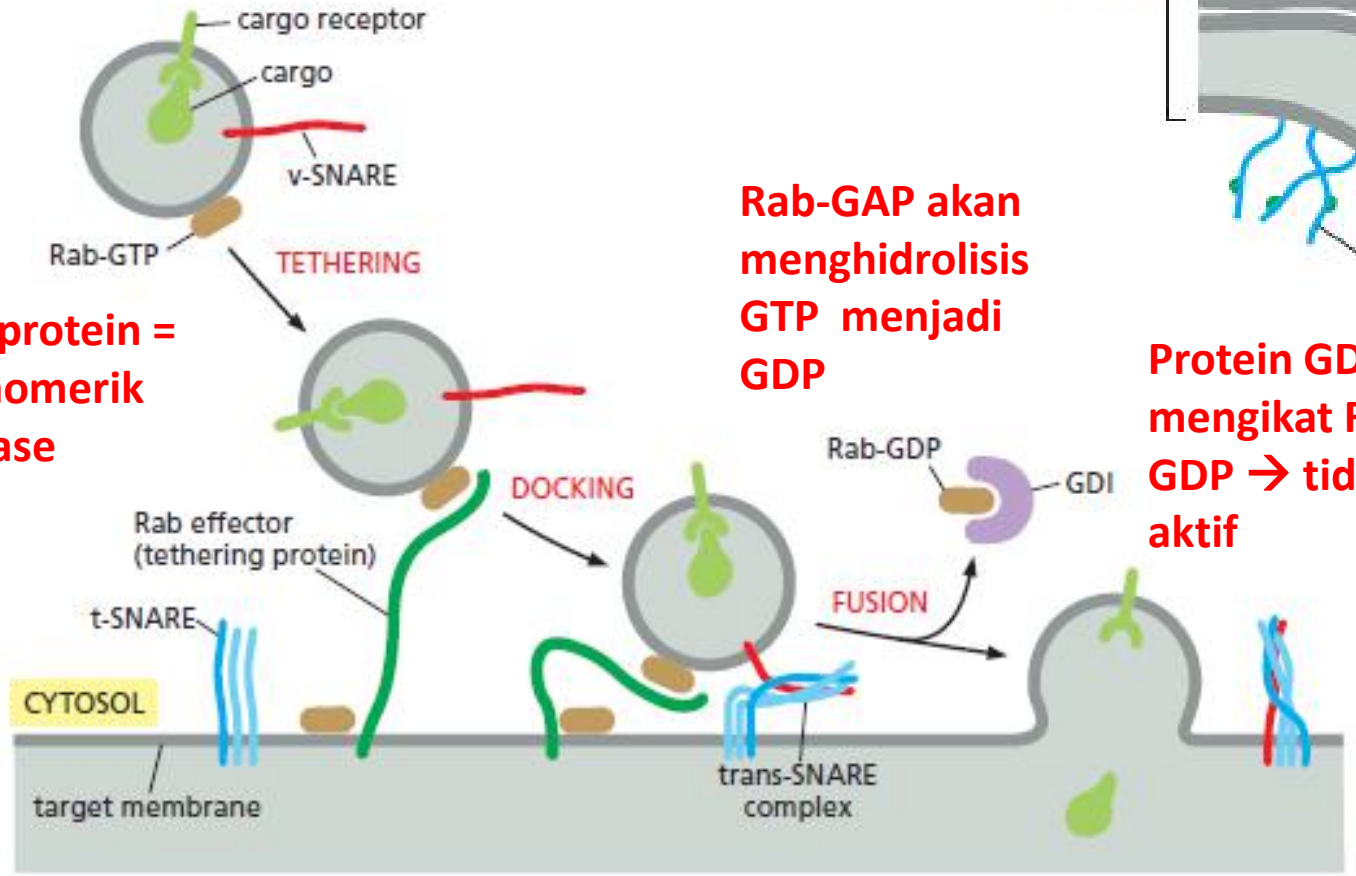

vesicular tubular cluster or Golgi apparatus
soluble ER resident protein
KDEL
empty KDEL receptor
COPI coat


secretory protein
COPII coat
vesicular tubular cluster
FORWARD PATHWAY
KDEL receptor protein
RETRIEVAL PATHWAY
COPI coat
soluble ER resident protein
ER
cis Golgi network
cis, medial, and trans Golgi cisternae
trans Golgi network
(B)


Cis-Golgi network
Missorted ER-resident protein
KDEL peptide
KDEL receptor
COPI coat
2
3
ER-to-Golgi transport vesicle
Retrieval of KDEL-bearing proteins to ER
1
4
COPII coat
Rough ER

Vesikel Ke Membran Target





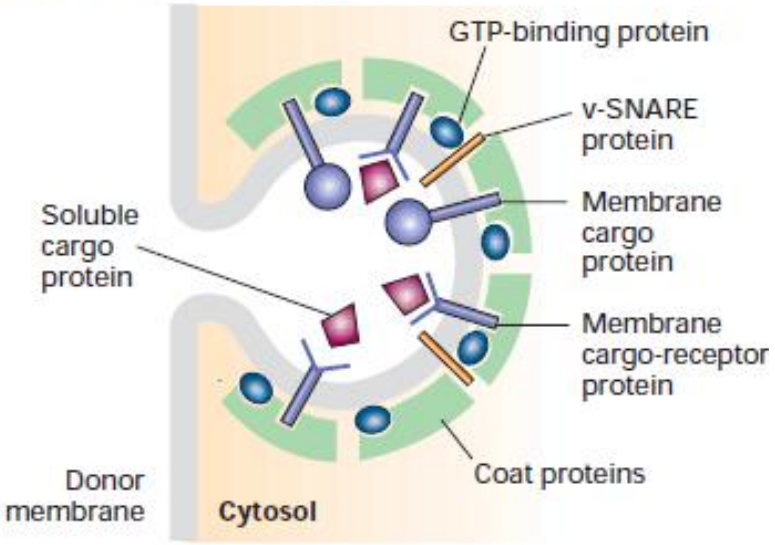
Rab protein = Monomerik GTPase

Rab-GAP akan menghidrolisis GTP menjadi GDP

Protein GDI mengikat Rab-GDP → tidak aktif

Rab Efektor = Protein Motor

(a) Coated vesicle budding



(b) Uncoated vesicle fusion

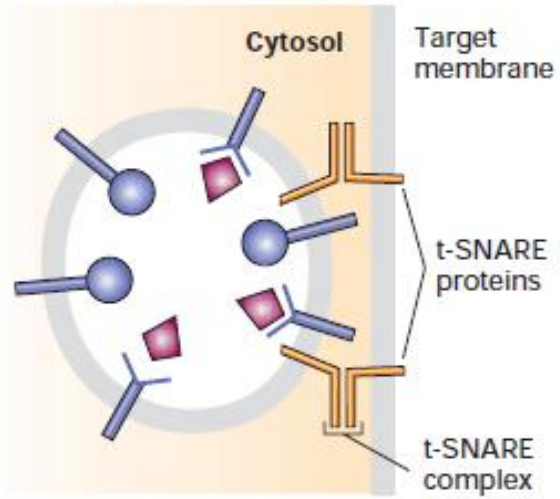
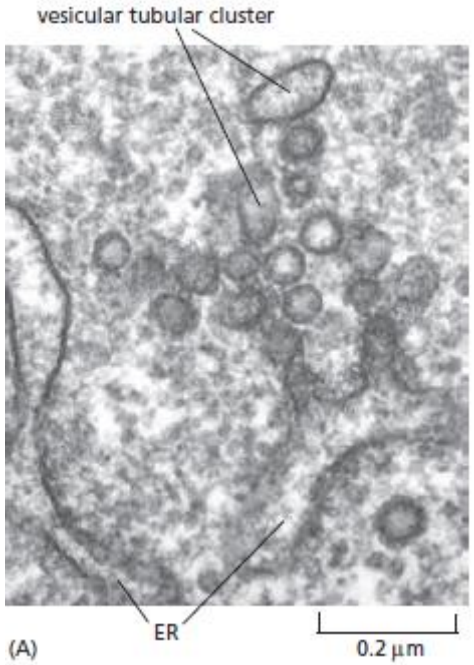
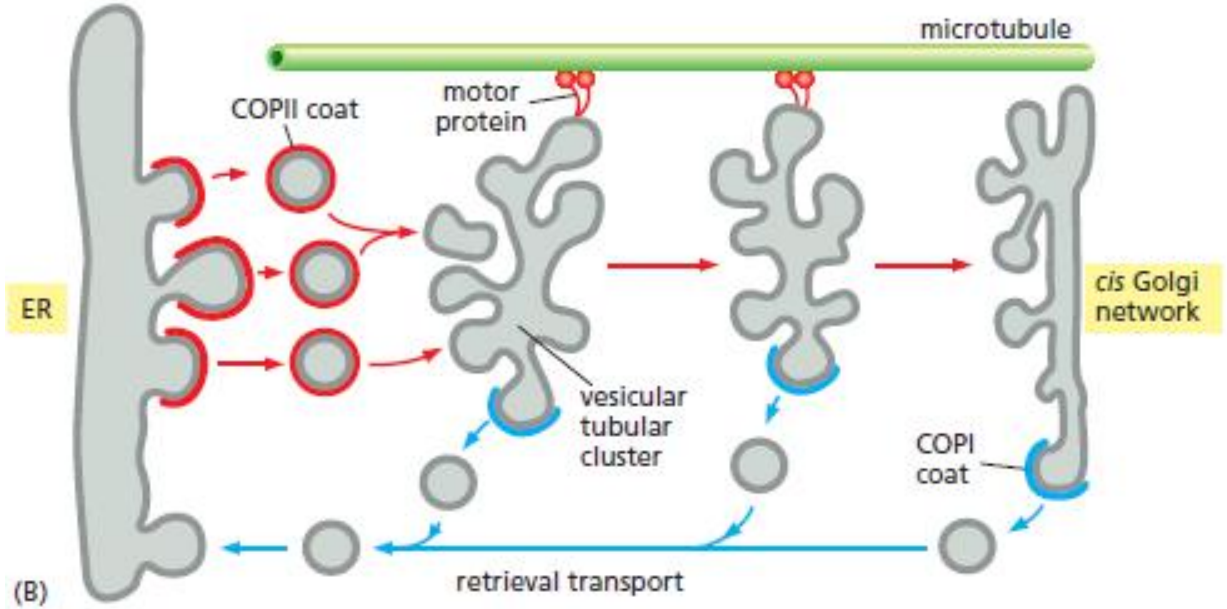
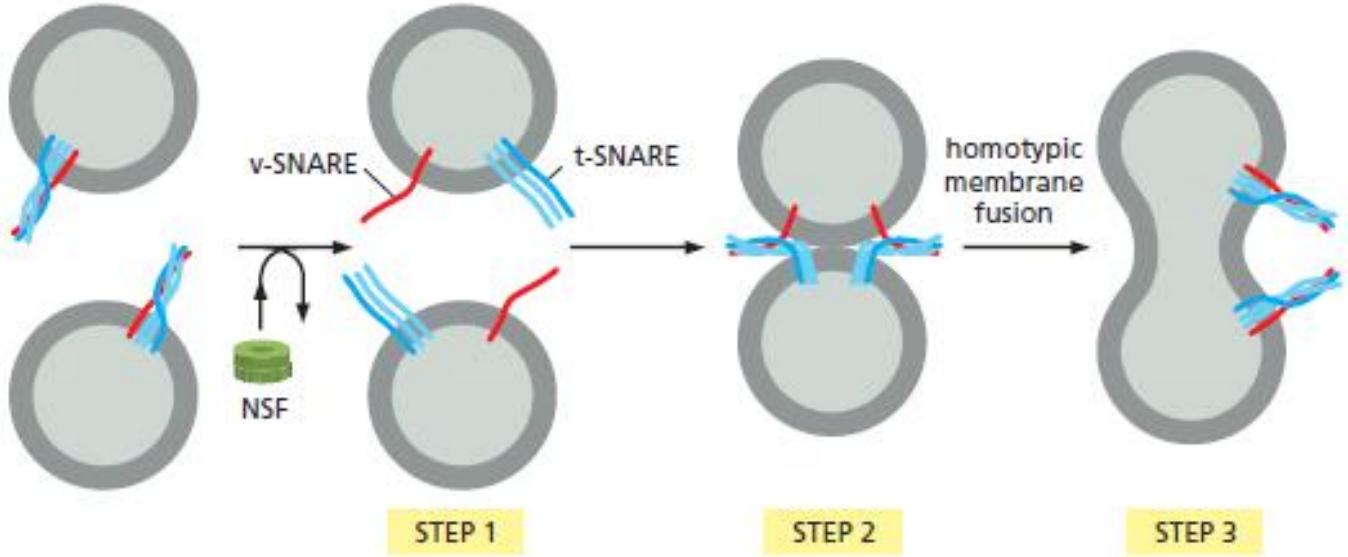


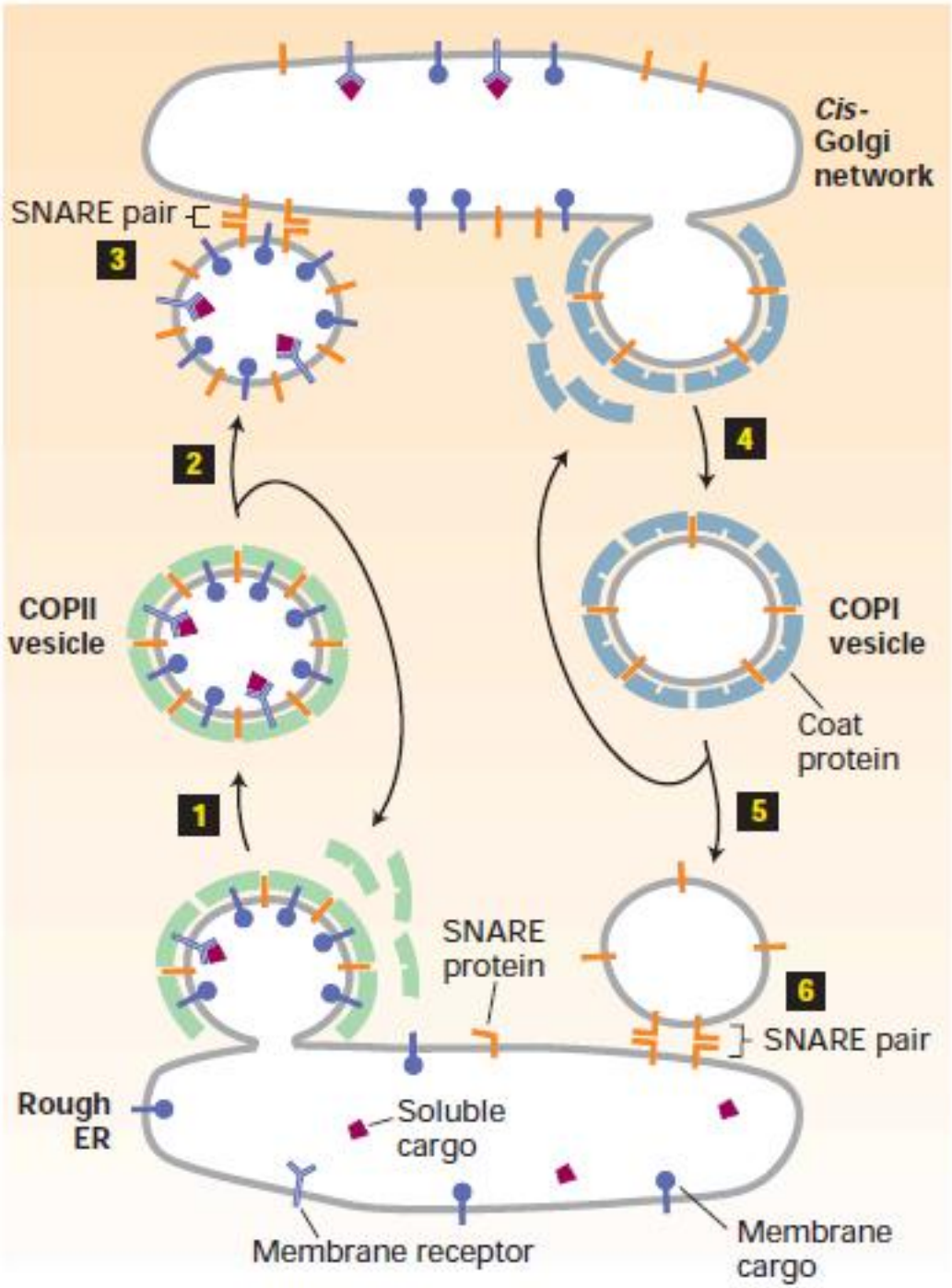
TABLE 13–1 Subcellular Locations of Some Rab Proteins

Protein	Organelle
Rab1	ER and Golgi complex
Rab2	*cis* Golgi network
Rab3A	Synaptic vesicles, secretory vesicles
Rab4/Rab11	Recycling endosomes
Rab5	Early endosomes, plasma membrane, clathrin-coated vesicles
Rab6	Medial and *trans* Golgi
Rab7	Late endosomes
Rab8	Cilia
Rab9	Late endosomes, *trans* Golgi


vesicular tubular cluster
ER
0.2 μm
(A)


microtubule
COPII coat
motor protein
ER
cis Golgi network
vesicular tubular cluster
COPI coat
retrieval transport
(B)


v-SNARE
t-SNARE
homotypic membrane fusion
NSF
STEP 1
STEP 2
STEP 3


Cis-
Golgi
network
SNARE pair
3
2
4
COPII
vesicle
COPI
vesicle
Coat
protein
1
5
SNARE
protein
6
SNARE pair
Rough
ER
Soluble
cargo
Membrane receptor
Membrane
cargo

Tipe2 Signal Sorting Dalam Jalur Transport Vesikel

TABLE 17-2 Known Sorting Signals That Direct Proteins to Specific Transport Vesicles

Signal Sequence*	Proteins with Signal	Signal Receptor	Vesicles That Incorporate Signal-bearing Protein
Lys-Asp-Glu-Leu (KDEL)	ER-resident luminal proteins	KDEL receptor in *cis*-Golgi membrane	COPI
Lys-Lys-X-X (KKXX)	ER-resident membrane proteins (cytosolic domain)	COPI α and β subunits	COPI
Di-acidic (e.g., Asp-X-Glu)	Cargo membrane proteins in ER (cytosolic domain)	COPII Sec24 subunit	COPII
Mannose 6-phosphate (M6P)	Soluble lysosomal enzymes after processing in *cis*-Golgi	M6P receptor in *trans*-Golgi membrane	Clathrin/AP1
	Secreted lysosomal enzymes	M6P receptor in plasma membrane	Clathrin/AP2
Asn-Pro-X-Tyr (NPXY)	LDL receptor in the plasma membrane (cytosolic domain)	AP2 complex	Clathrin/AP2
Tyr-X-X-Φ (YXXΦ)	Membrane proteins in *trans*-Golgi (cytosolic domain)	AP1 (μ1 subunit)	Clathrin/AP1
	Plasma membrane proteins (cytosolic domain)	AP2 (μ2 subunit)	Clathrin/AP2
Leu-Leu (LL)	Plasma membrane proteins (cytosolic domain)	AP2 complexes	Clathrin/AP2

*X = any amino acid; Φ = hydrophobic amino acid. Single-letter amino acid abbreviations are in parentheses.

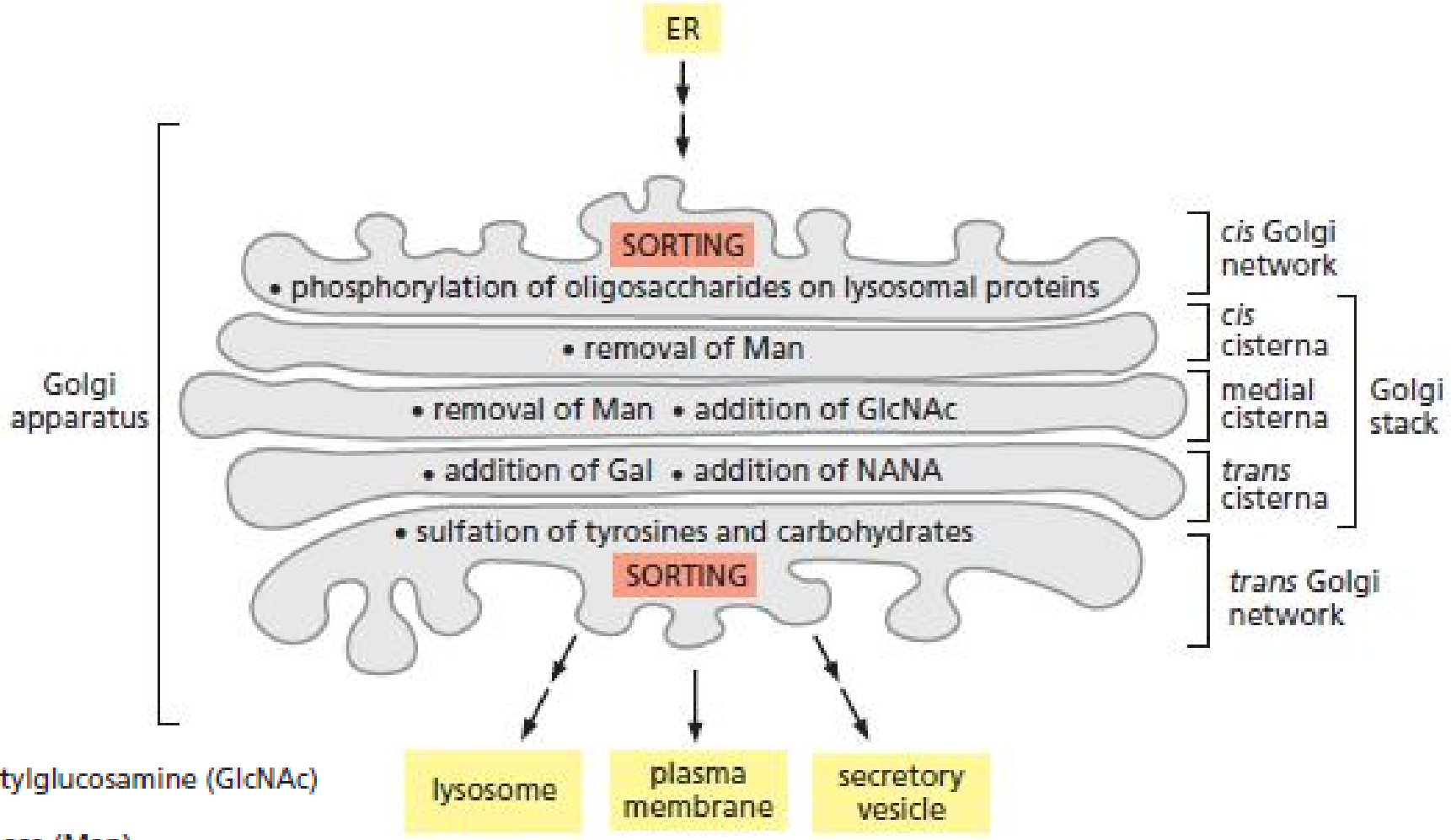
Tipe2 Vesikel Dalam Jalur Transport

TABLE 17-1 Coated Vesicles Involved in Protein Trafficking

Vesicle Type	Coat Proteins	Associated GTPase	Transport Step Mediated
COPII	Sec23/Sec24 and Sec13/Sec31 complexes, Sec16	Sar1	ER to *cis*-Golgi
COPI	Coatomers containing seven different COP subunits	ARF	*cis*-Golgi to ER Later to earlier Golgi cisternae
Clathrin and adapter proteins*	Clathrin + AP1 complexes	ARF	*trans*-Golgi to endosome
	Clathrin + GGA	ARF	*trans*-Golgi to endosome
	Clathrin + AP2 complexes	ARF	Plasma membrane to endosome
	AP3 complexes	ARF	Golgi to lysosome, melanosome, or platelet vesicles

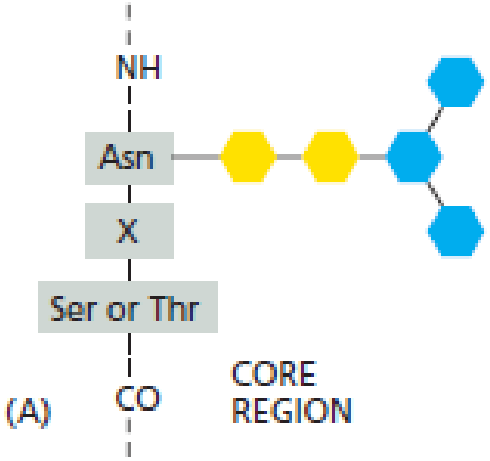
*Each type of AP complex consists of four different subunits. It is not known whether the coat of AP3 vesicles contains clathrin.

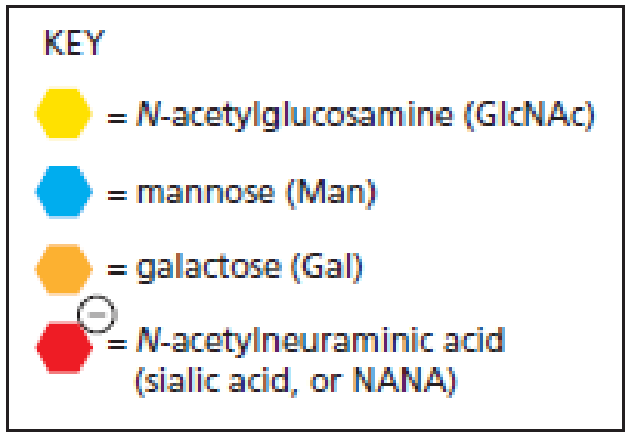
Pemrosesan Oligosakarida di Golgi

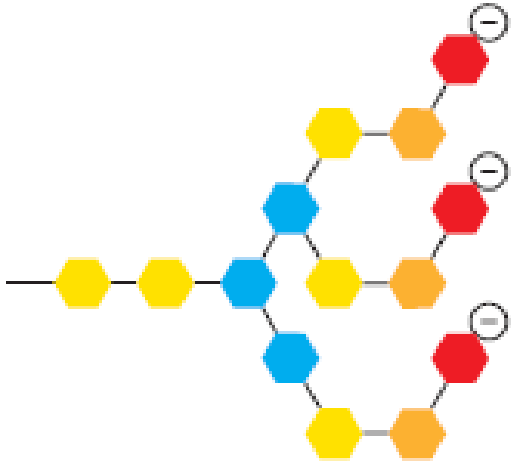


Sulfation plays a role in strengthening protein-protein interactions

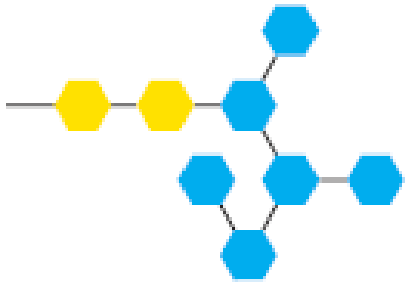
Dua kelas *N-linked oligosaccharides :* (1) *complex oligosaccharides,* (2) *high-mannose oligosaccharides*, menempel pada Glikoprotein Mamalia







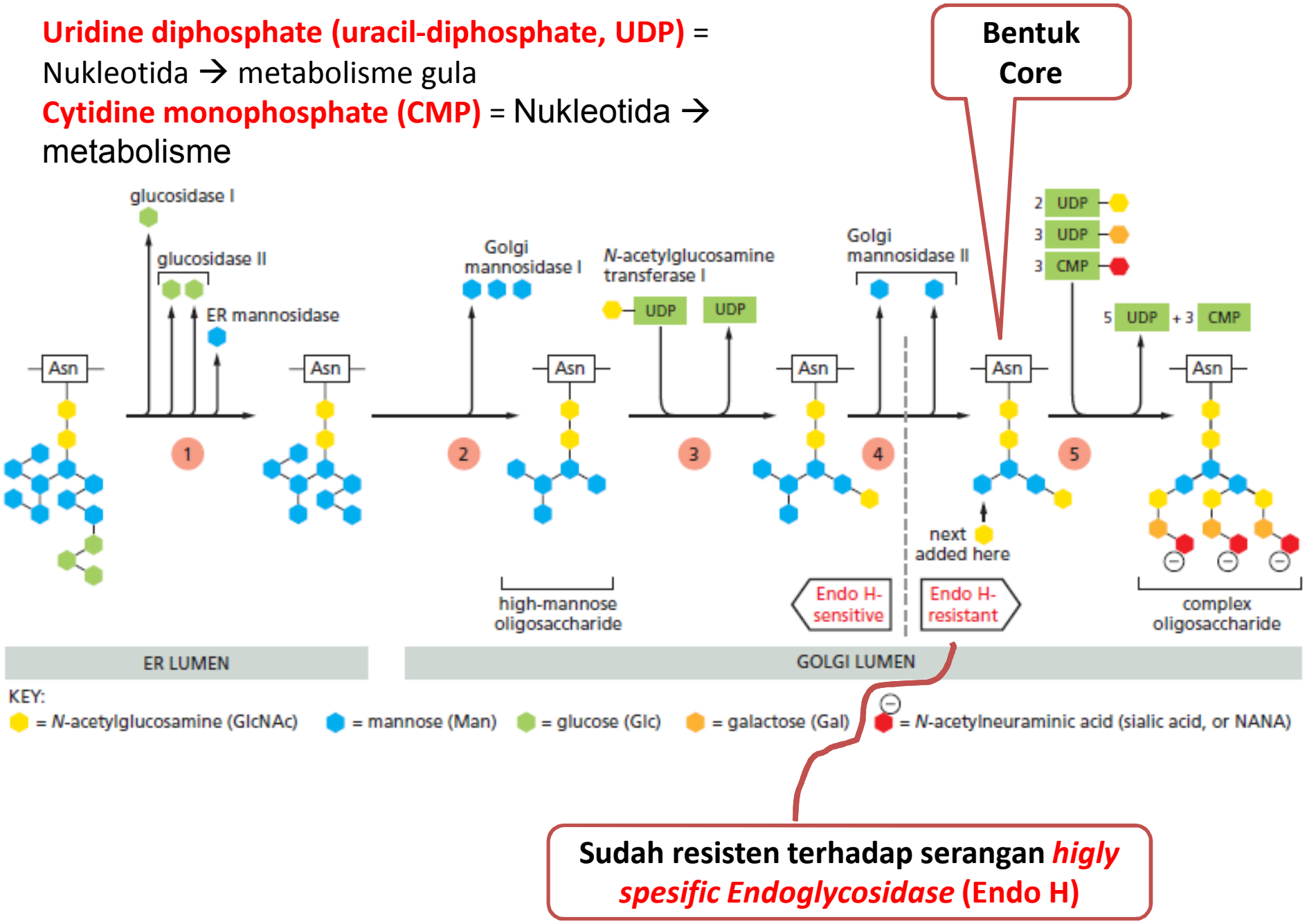
(B) COMPLEX OLIGOSACCHARIDE



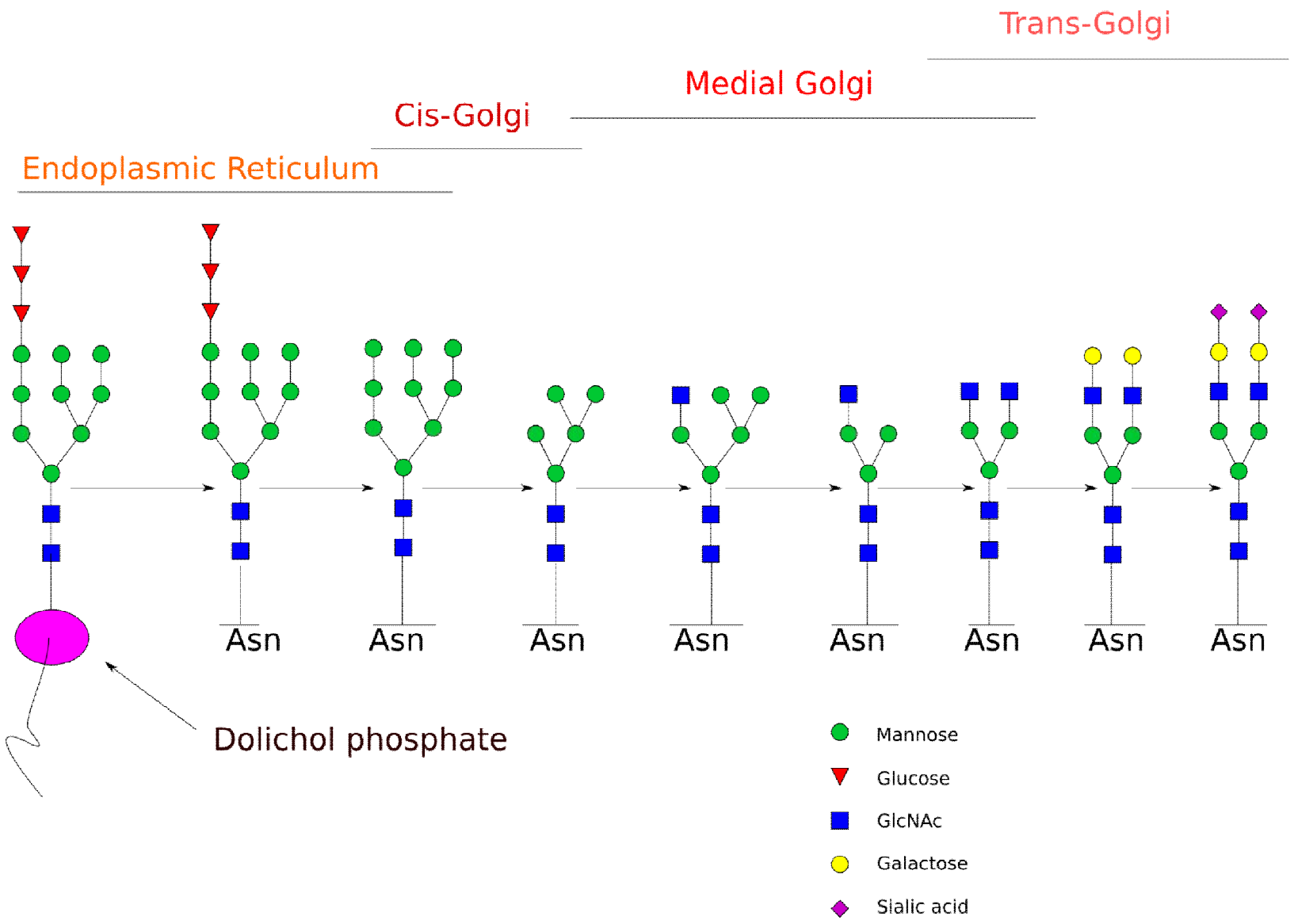
(C) HIGH-MANNOSE OLIGOSACCHARIDE

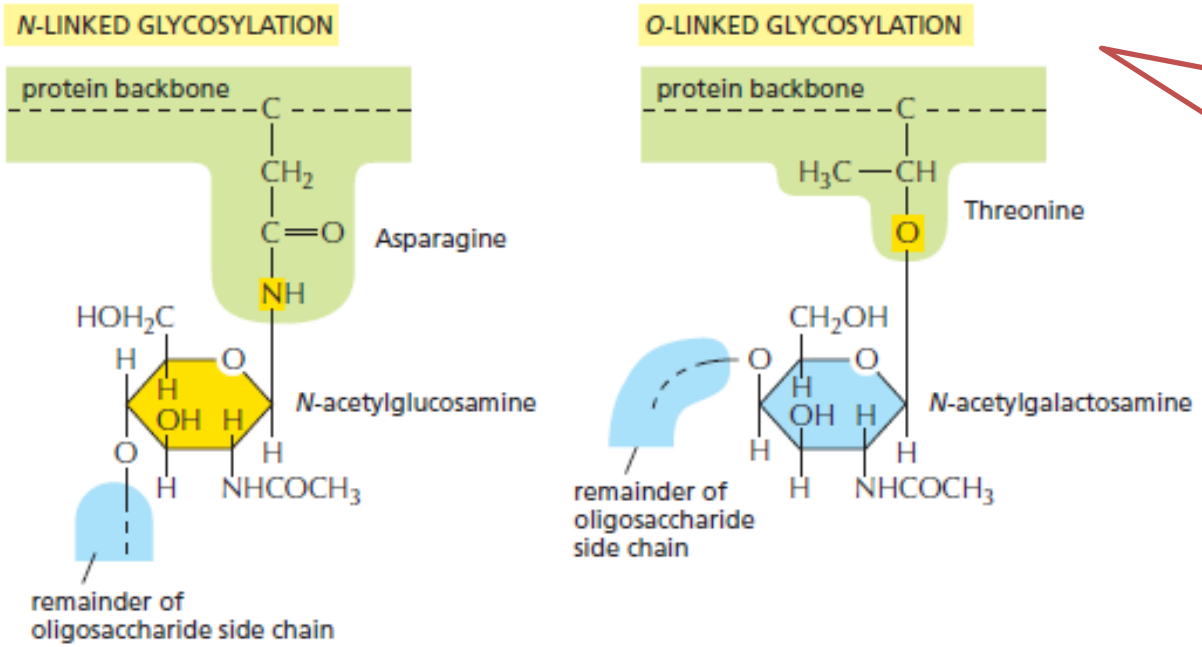
Uridine diphosphate (uracil-diphosphate, UDP) = Nukleotida → metabolisme gula

Cytidine monophosphate (CMP) = Nukleotida → metabolisme



Sudah resisten terhadap serangan *higly spesific Endoglycosidase* (Endo H)


Trans-Golgi
Medial Golgi
Cis-Golgi
Endoplasmic Reticulum
Asn
Asn
Asn
Asn
Asn
Asn
Asn
Asn
Dolichol phosphate
Mannose
Glucose
GlcNAc
Galactose
Sialic acid

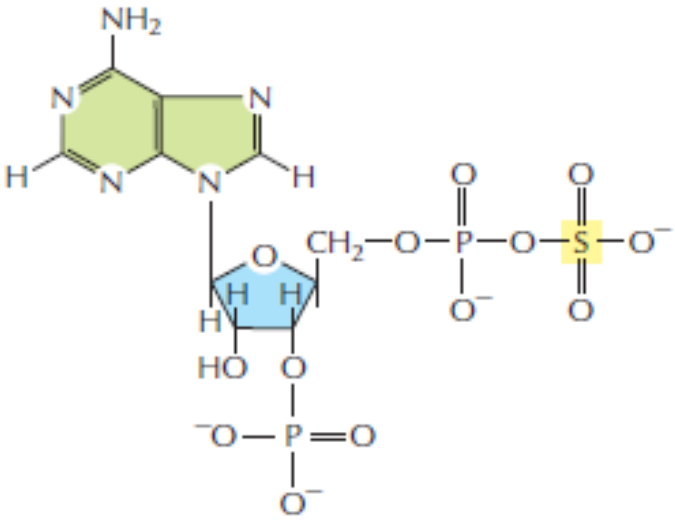


Dikatalis oleh Enzim glikosiltransferase → menggunakan Gula nukleotida di lumen

Sulfation plays a role in strengthening protein-protein interactions

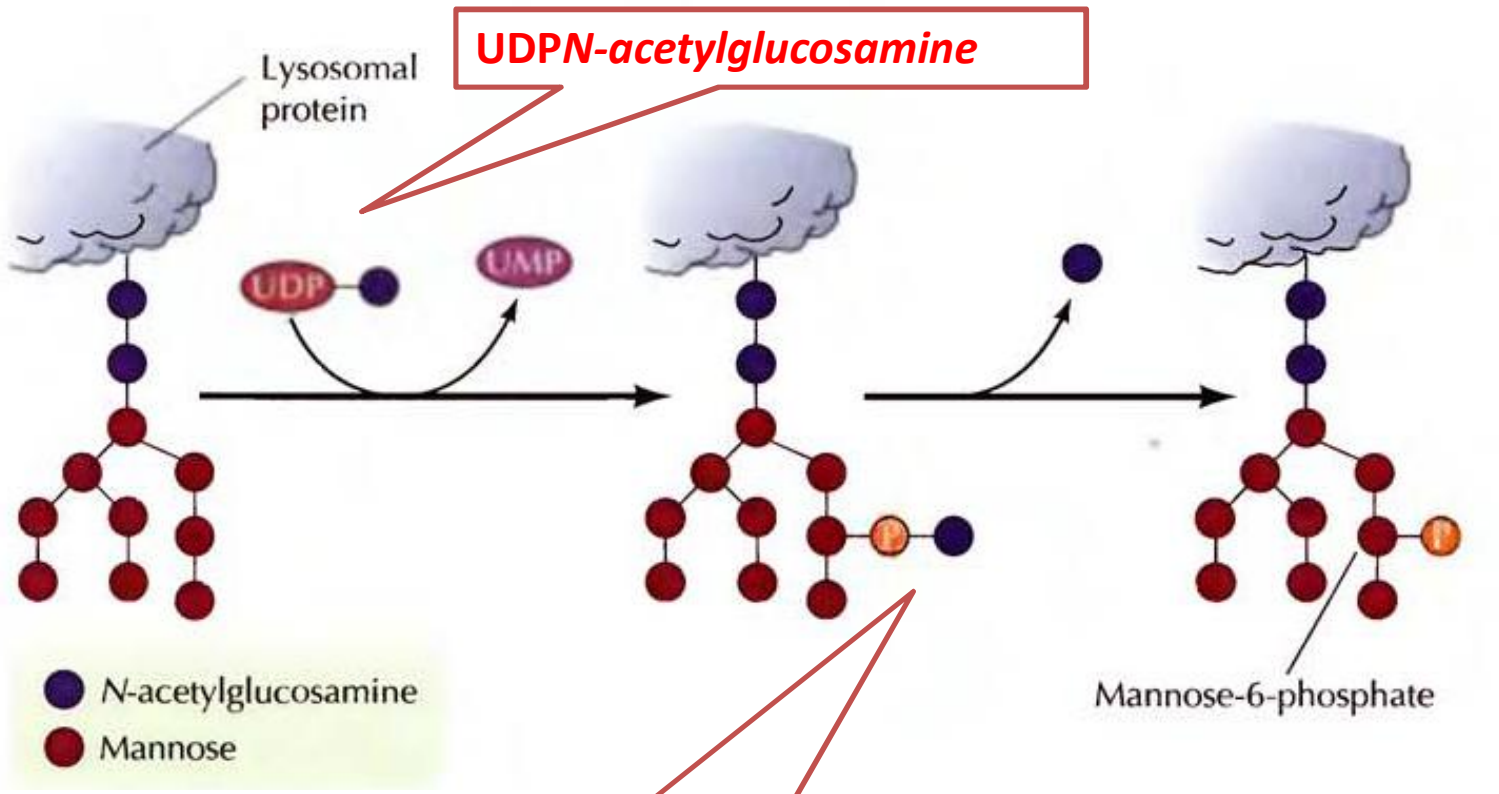
Golgi memberi **Glikosilasi O-Linked** pada **mucin** (glikoprotein pada sekresi mucus/ lendir ex: epitel) dan ***Proteoglycan core proteins*** → dimodifikasi menjadi **Proteoglycans** dari rantai **glycosaminoglycan** (panjang, polimer disakarida yg tidak bercabang) Gula yg ditambahkan ke glycosaminoglycan sangat sulfat

Beberapa tirosin protein → sulfat → karena donor PAPS dikatalis oleh tyrosylprotein sulfotransferase (TPST)

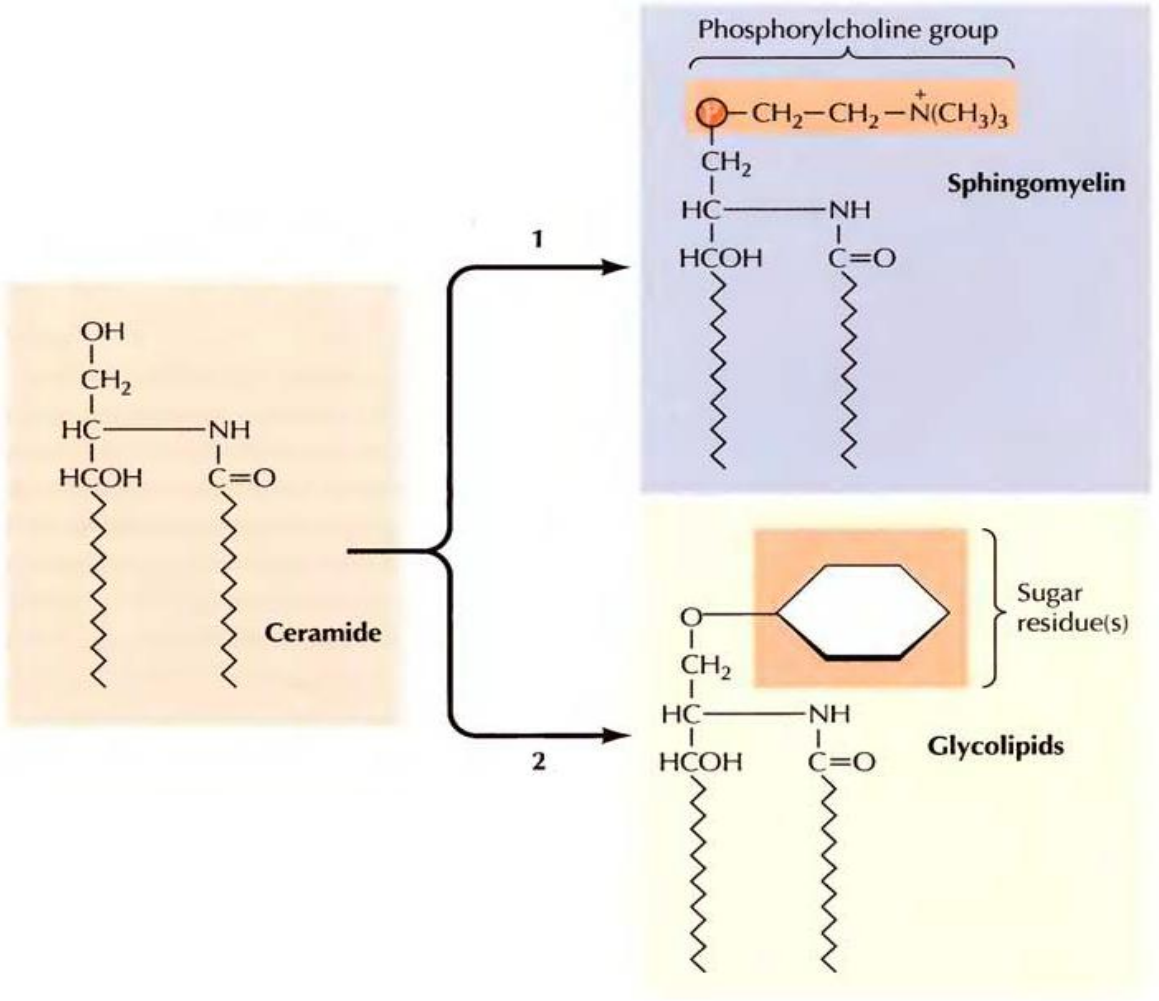


3′-phosphoadenosine-5′-phosphosulfate (PAPS)

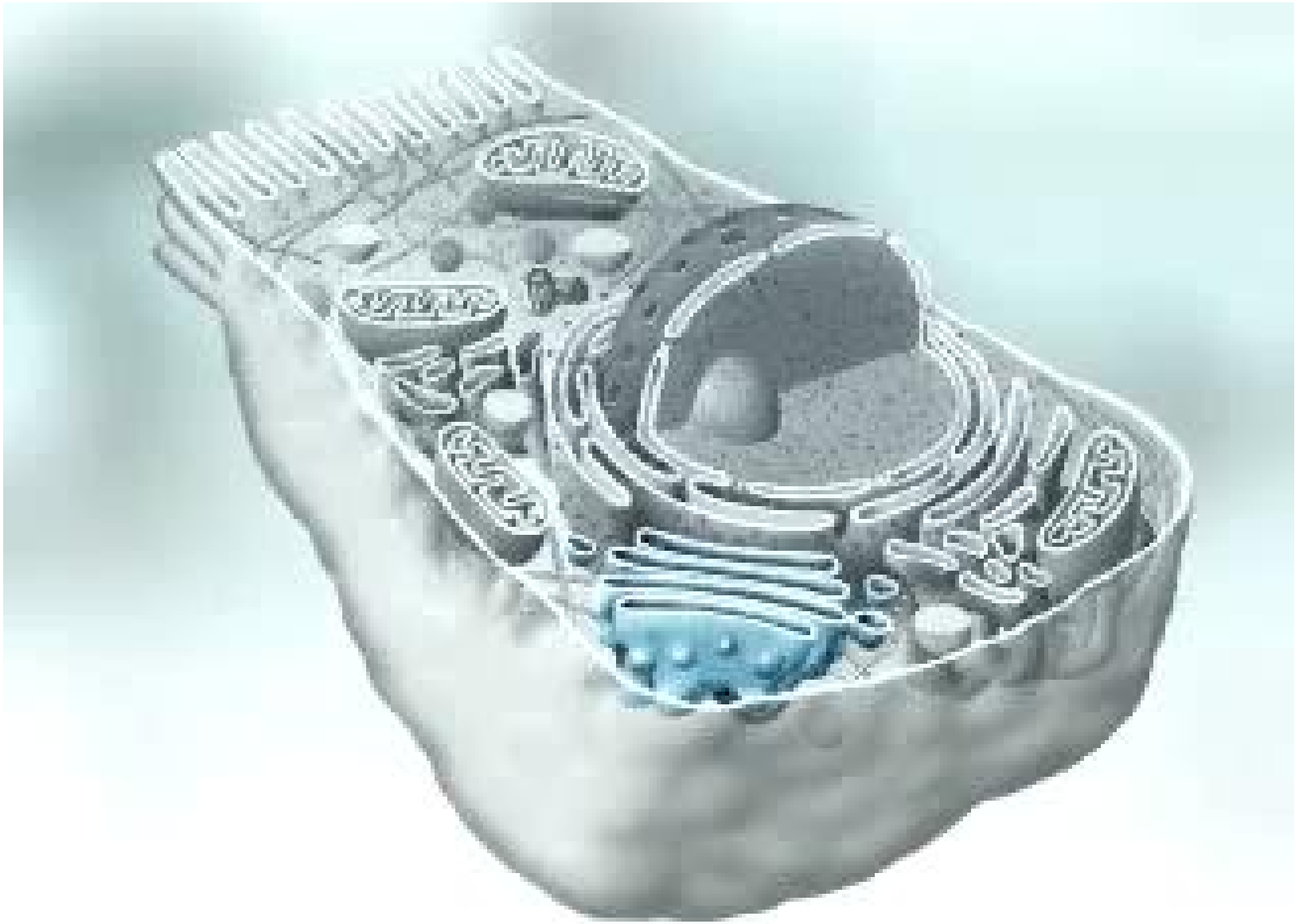
Figure 13–33 The structure of PAPS.



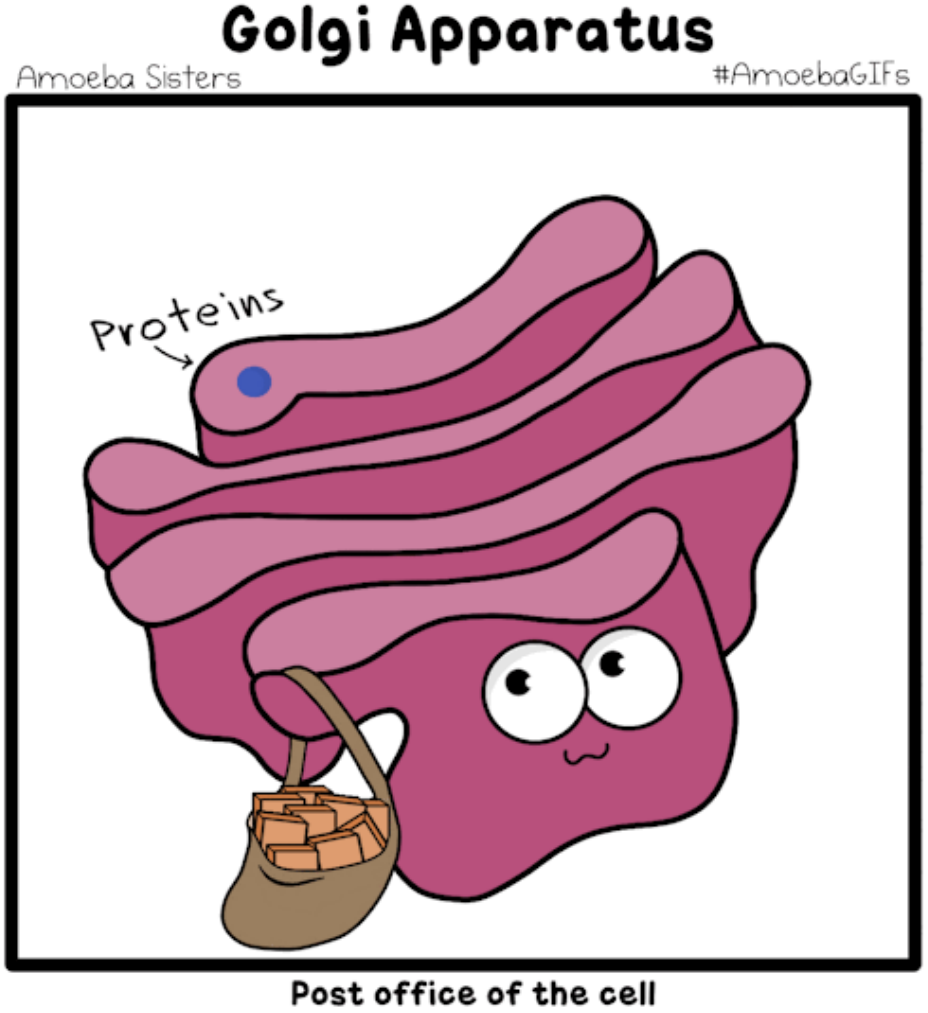
Protein Lisosom berbeda → ada penambahan fosfat (P) pada posisi no.6 residu Manosa



Spingomyelin disintesis oleh transfer kelompok fosforilkolin, dari fosforilkolin ke ceramide
Disintesis di permukaan lumen golgi + karbohidrat




Soft Skill
“Golgi diibaratkan sebagai “Kantor Pos” nya Sel, yang memodifikasi, mensortir, mengemas, dan mengantarkan molekul2 , manusia jg seharusnya bisa menjadi Kantor Pos Kebaikan, yg bukan hanya menerima tp jg mengantarkan molekul2 kebaikan”



THANKS SO MUCH