B.Sc. Part 1 Zoology (Subsidiary & General Course)

# ULTRASTRUCTURE OF ENDOPLASMIC RETICULUM

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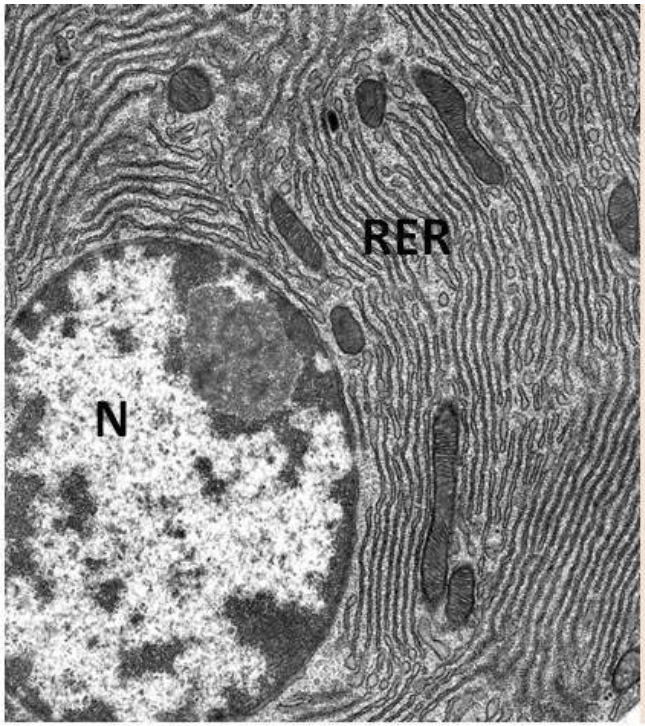
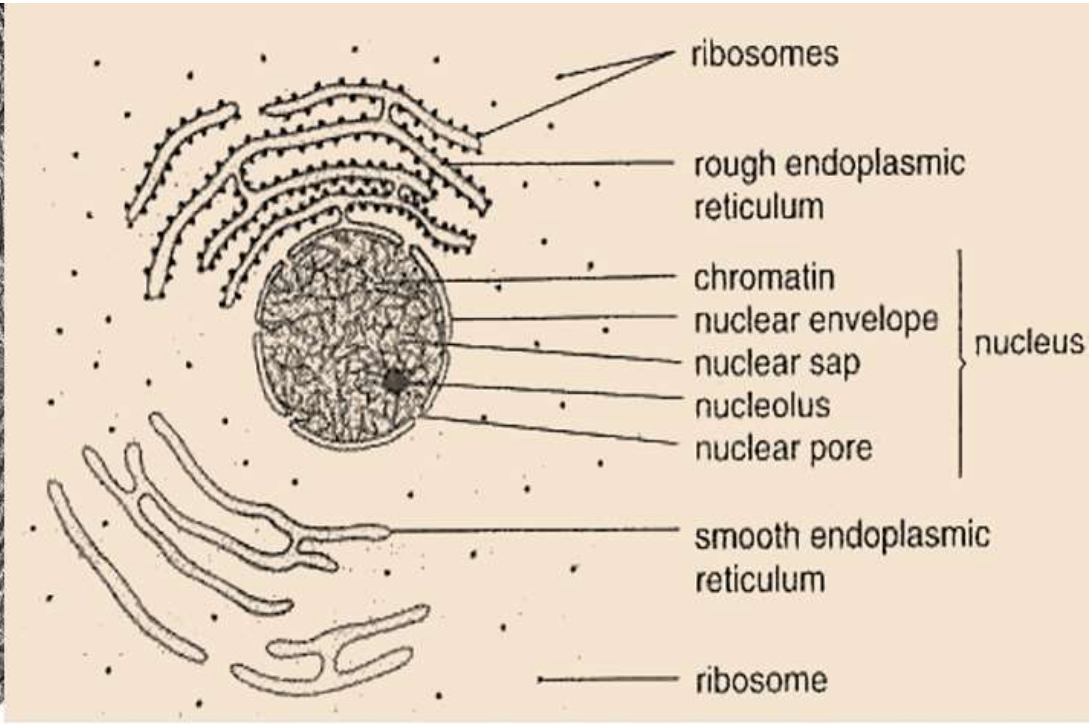
# Introduction

- Endoplasmic reticulum is a sub-cellular organelles composed of single membranous network of membrane bound cavities, vesicles and tubules distributed throughout the cytoplasm.
- It is a largest cell organelle discovered by Porter in 1948 and called it as ‘Endoplasmic Reticulum’ due to its net-like appearance; however it was first observed by Garnier in 1897 and called it as ‘Ergastoplasm’.
- It is more concentrated in the endoplasm than in the ectoplasm.
- It is mainly concerned with the biosynthesis of proteins and lipids (post-translational modification).
- However, it is not present everywhere. It is absent from eggs, embryonic cells, RBC and bacteria.

# Structure



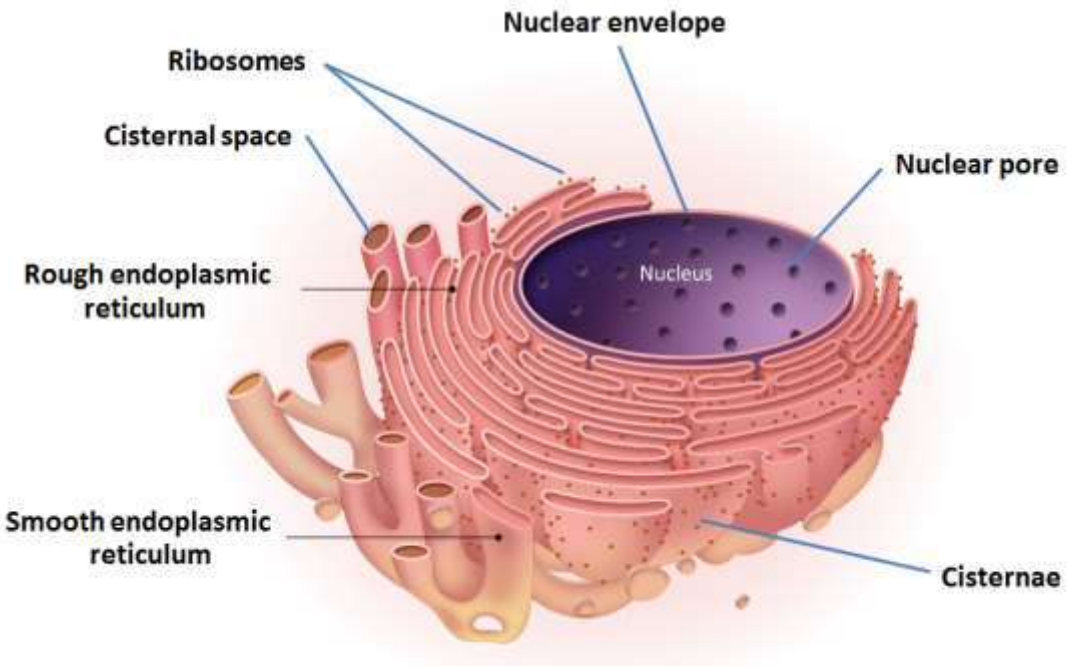

TEM image of RER in an Exocrine Acinar Cell of the pancreas.
*Photo courtesy: Patrick Nahirney, University of Victoria; JEOL JEM1400 TEM.*




Representative labeled diagram of the endoplasmic reticulum in the cell.
*Photo courtesy: Cell Structure 2.1, PPT. Nirmala Josephine.*

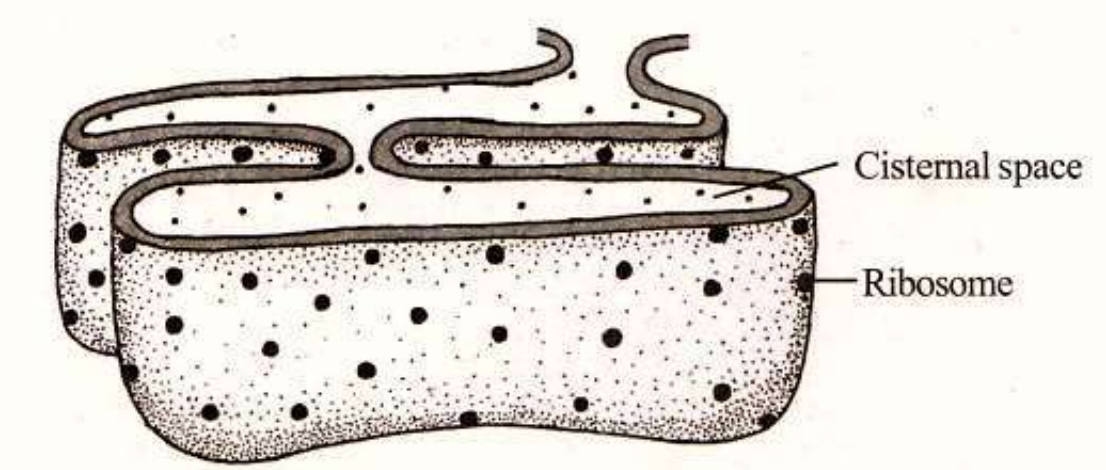
# Structure

- Emanating from nuclear membrane, endoplasmic reticulum spread all over endoplasm.
- It consists of three distinct components; cisternae, vesicles and tubules.



# Cisternae

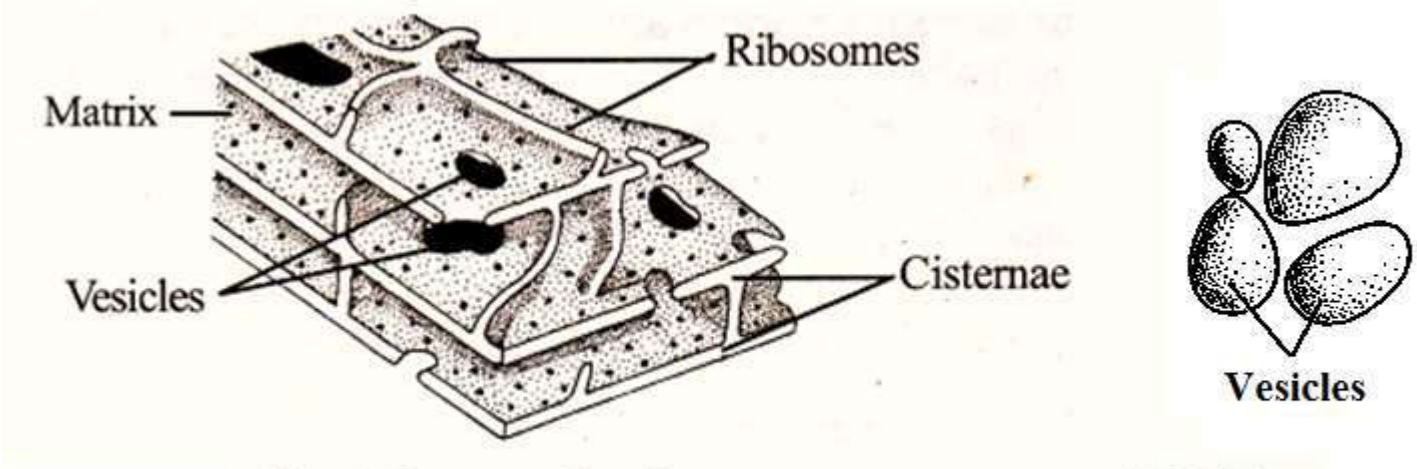
- Cisternae are long flattened, unbranched sac-like structures with 40 – 50 µm diameter.
- They are arranged in parallel bundles where ribosomes are found associated with the outer membrane.
- They are normally present in secretory cells.




Cisternae of rough endoplasmic reticulum (RER)

# Vesicles

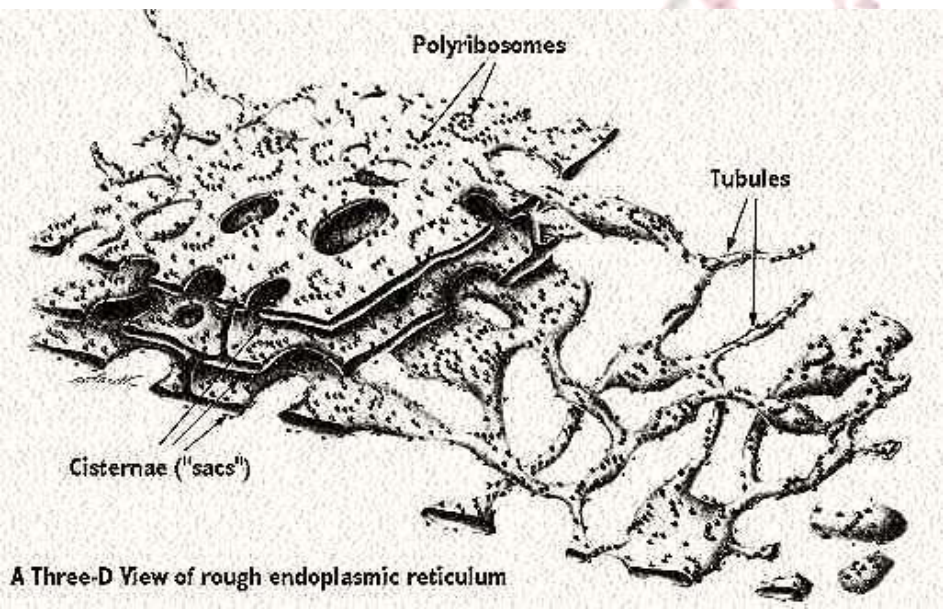
- These are either transport or secretory vesicles, which are rounded or ovoidal structures having the diameter of 25 – 500 µm.
- They are single membrane-bound organelle found generally at the end of cisternae and tubules. Some are found left free in the cytoplasm.
- The are abundantly found in secretory cells such as pancreatic cells.

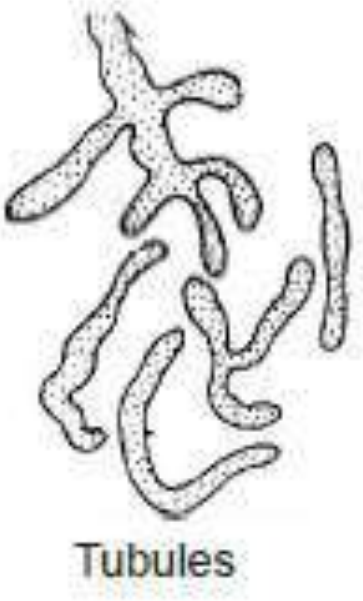



Vesicles and other components of RER

# Tubules

- These are smooth walled and highly branched tubular spaces having diverse forms with 50 – 100 µm.
- They normally occur in non-secretory cells like striated muscle cells.
- They are originated from the cisternae of the ER.




*http://cytochemistry.net/cell-biology/rer.htm*

# Types of ER

- There are two types of endoplasmic reticulum; granular or rough endoplasmic reticulum (RER) and agranular or smooth endoplasmic reticulum (SER).

- 1. Rough endoplasmic reticulum (RER)
  - Granular appearance is due to spherical granular structures called ribosomes which are attached on the surface. Ribosomes is responsible for protein synthesis.
  - The binding site of ribosomes on the RER is called as translocon.
  - It occurs in almost all cells which are actively engaged in protein synthesis, such as liver cells, goblet cells, pancreatic cells, and plasma cells.
  - It is generally found in the form of flattened sacs.

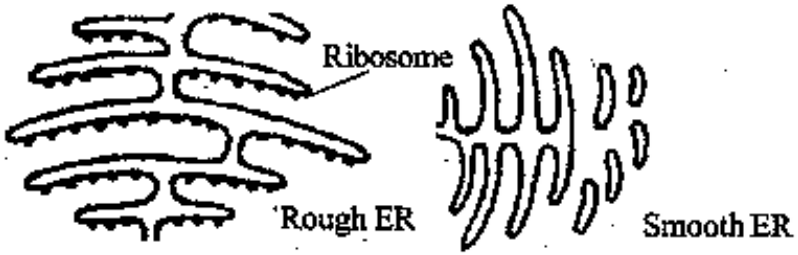
- 2. Smooth endoplasmic reticulum
  - Ribosomes are not attached with the membranes so the appearance is smooth.
  - It is well developed in cells that synthesize steroid hormones.
  - It is a system of tubules which occurs especially in those cells which are almost inactive in protein synthesis.

# Sarcoplasmic reticulum

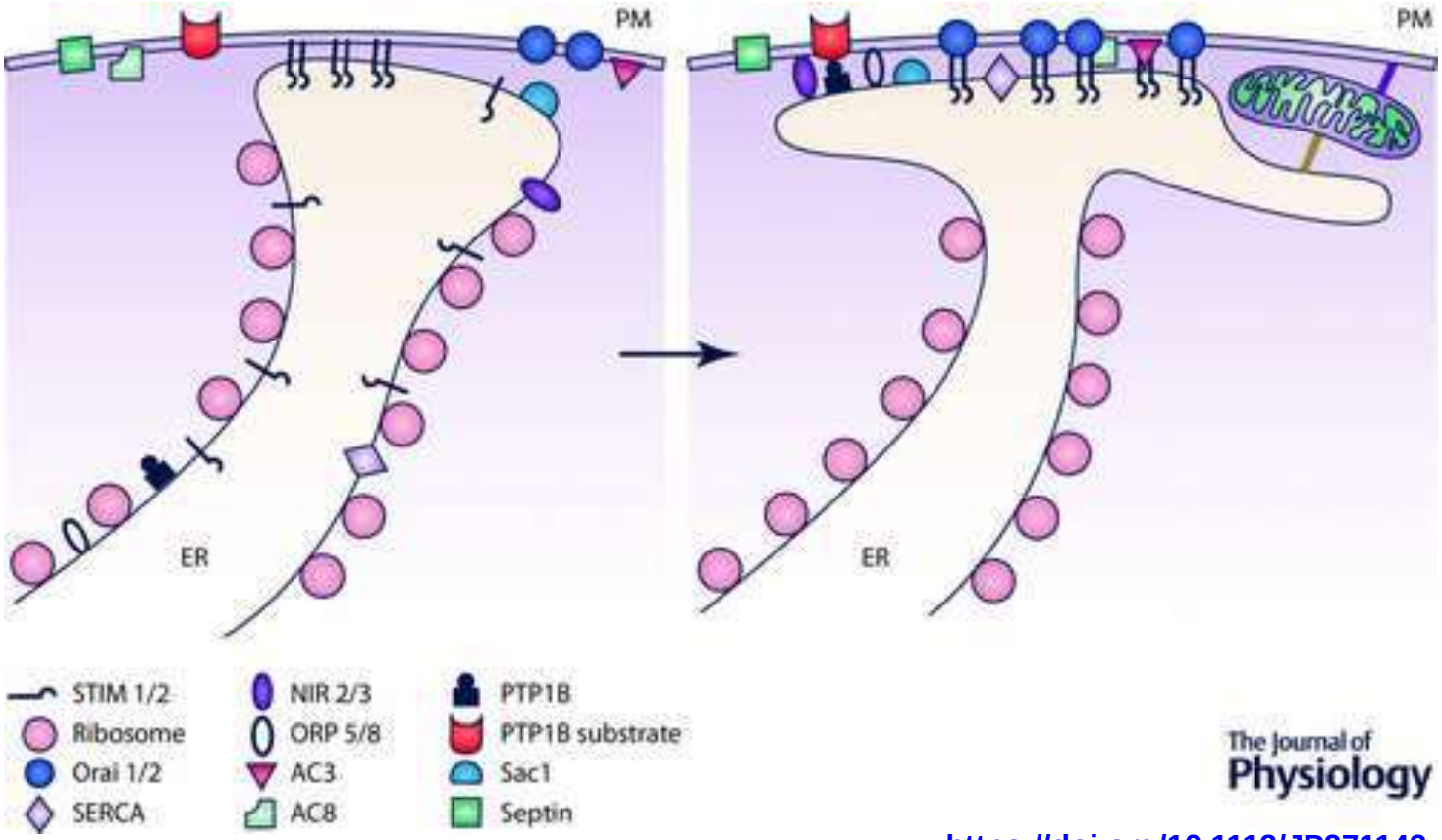
- It is smooth endoplasmic reticulum present in the muscles and serves as the specialized function.
- It plays a major role in the sequestration of calcium, which modulates the tonic force of contraction (and relaxation).
- Ultrastructure details vary in different types of muscles.
- In striated muscles, they are arranged around the perpendicular T tubules.
- Malignant hyperthermia (MH) is an acute condition that is resulted from mutation of the ryanodine receptor of the sarcoplasmic reticulum – exaggerated release of calcium – hypermetabolic crisis – leads to massive consumption of oxygen.

# Difference between RER & SER

| Rough Endoplasmic Reticulum (RER) | Smooth Endoplasmic Reticulum (SER) |
|---|---|
| Ribosomes are present and attached to the surface. | Ribosomes are not found on its surface. |
| They help in the synthesis of proteins and enzymes. | They help in the synthesis of glycogen, lipids. |
| They are mainly formed of cisternae and few tubules. | They are formed mainly of vesicles and tubules. |
| They are internal. | They are peripheral.. |
| They are connected with nuclear envelope | They are connected with plasmalemma. |
| Enzymes for detoxification are absent here. | Enzymes for detoxification are present here. |
| They are developed from nuclear envelope. | They are developed from RER. |



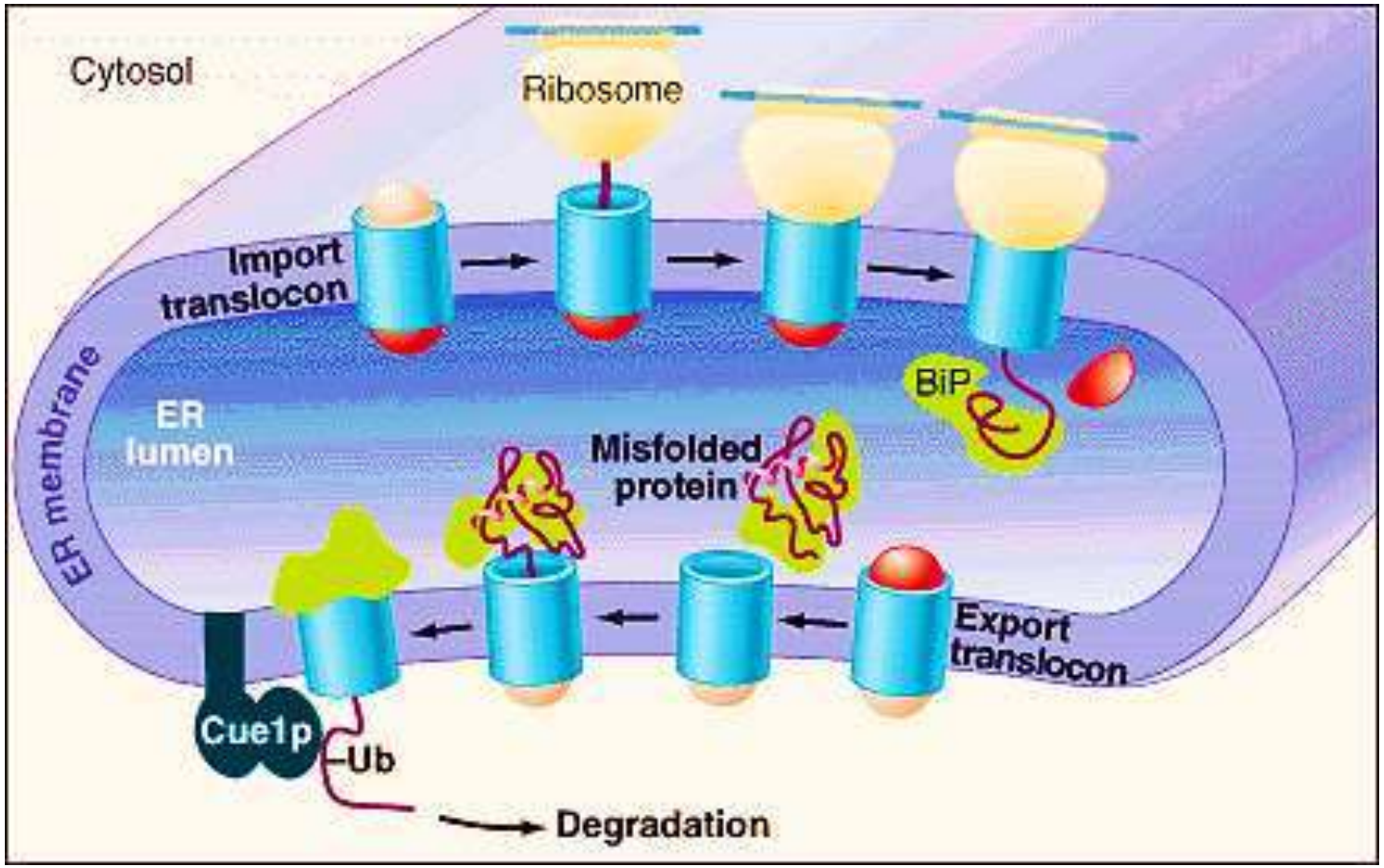
# ER-PM Junctions




https://doi.org/10.1113/JP271142

**STIM1,** stromal interaction molecule 1; **AC**, Adenyl cyclase; **ORP,** oxysterol-binding protein-related protein; **PTP1B**, protein-tyrosine phosphatase 1B; **SERCA**, Sarco/endoplasmic reticulum $Ca^{2+}$-ATPase

# Translocon-ribosome assembly




*Reizman H. 1997. Science 278(5344): 1728-1729.*
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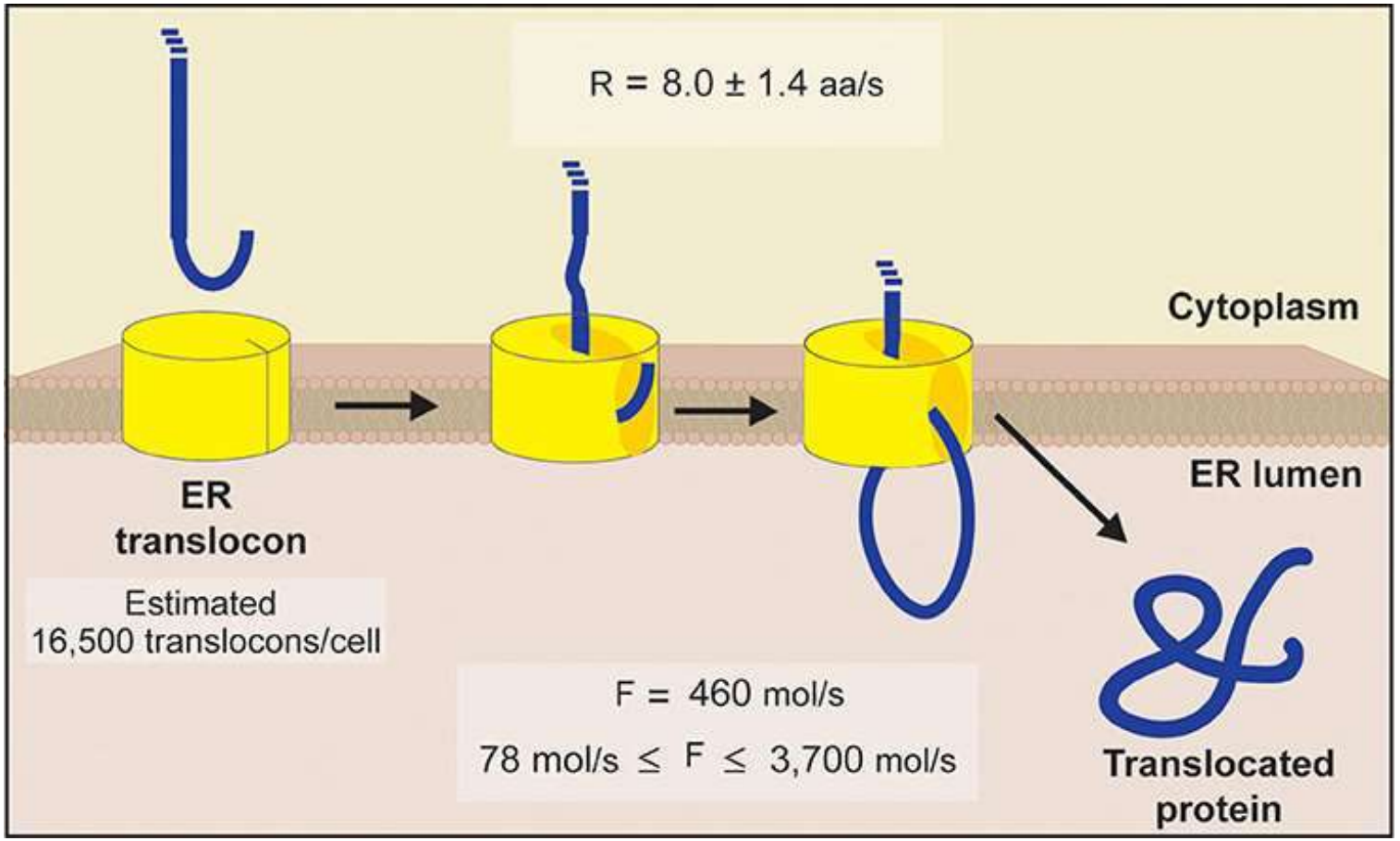
# Protein-influx through translocon




*Reizman H. 1997. Science 278(5344): 1728-1729.*
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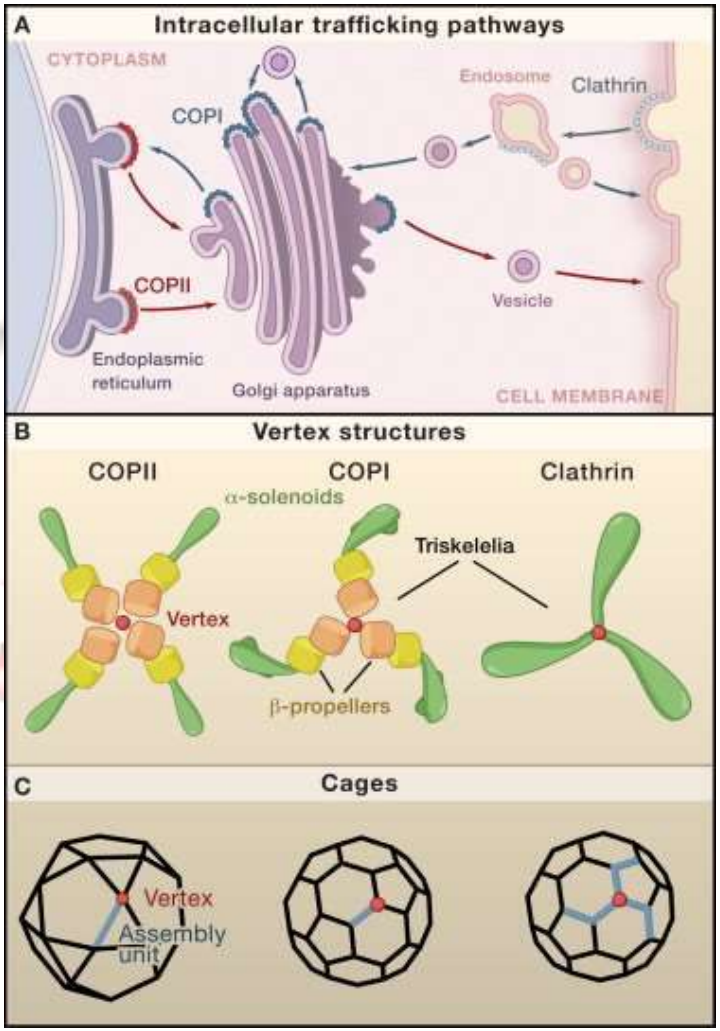
# ..... Formation of vesicles

- They are formed when part of the ER or Golgi complex pinches or budded off.
- The fate of the vesicles depend on the vesicle “coat” having distinct coat proteins, which binds to various transmembrane receptor called cargo receptors.
- The vesicles may be coated with clathrin, COPI and COPII, which help with sorting of vesicles to their final destination.
- Clathrin coats are required for trafficking between the Golgi and plasma membrane; COPI are responsible for retrograde transport from the Golgi to the ER, while COPII are responsible for anterogarde transport form the ER to the Golgi.
- Clathrin coats are assembled in response to regulatory G protein due to association and dissociation of ADP ribosylation factor (ARF) protein *cis*-Golgi complex.

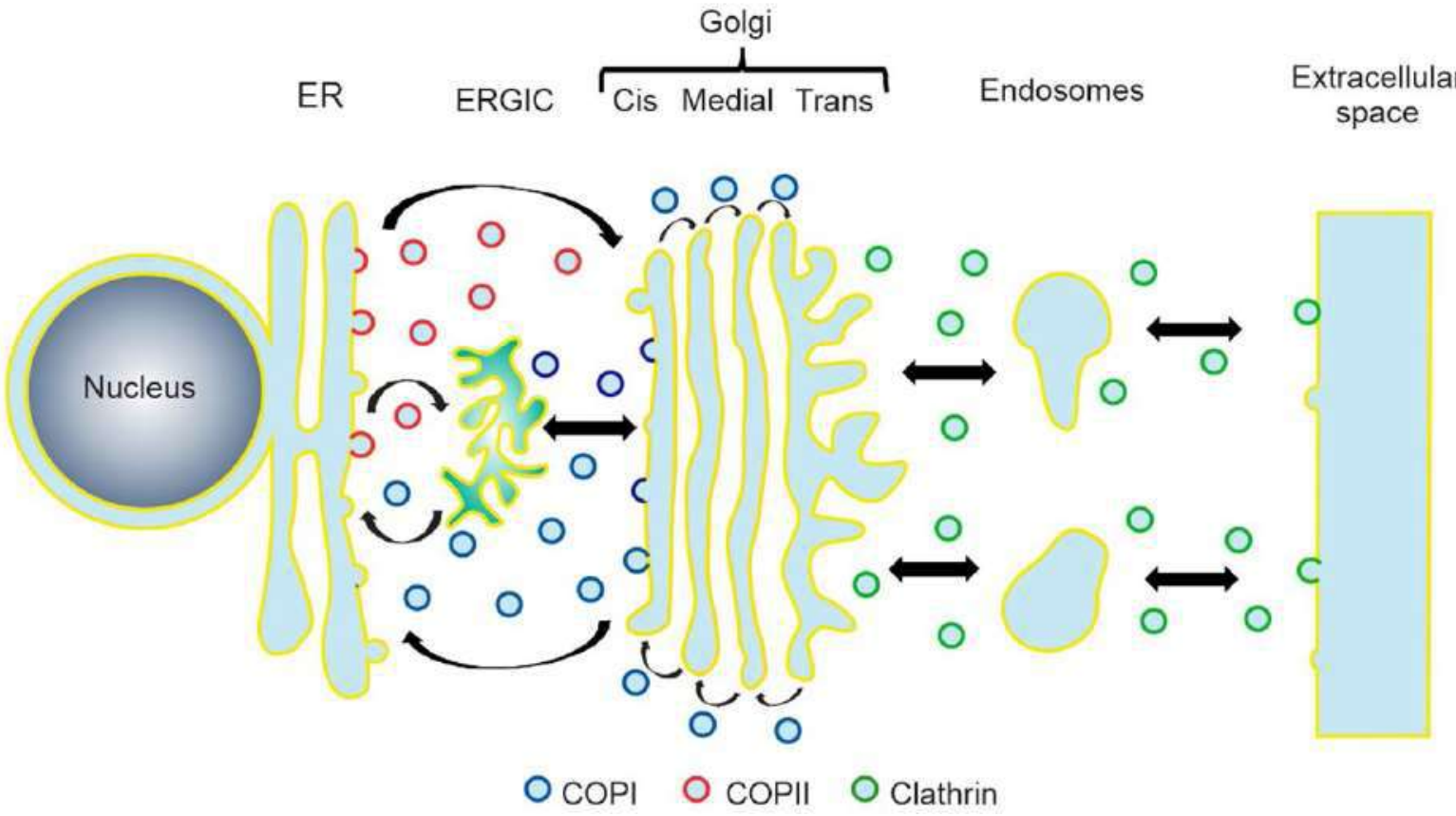
# ..... Formation of vesicles




**The Three Archetypal Vesicle Coats**

*Hughson F.M. 2010. Cell. Volume 142, ISSUE 1, P19-21*

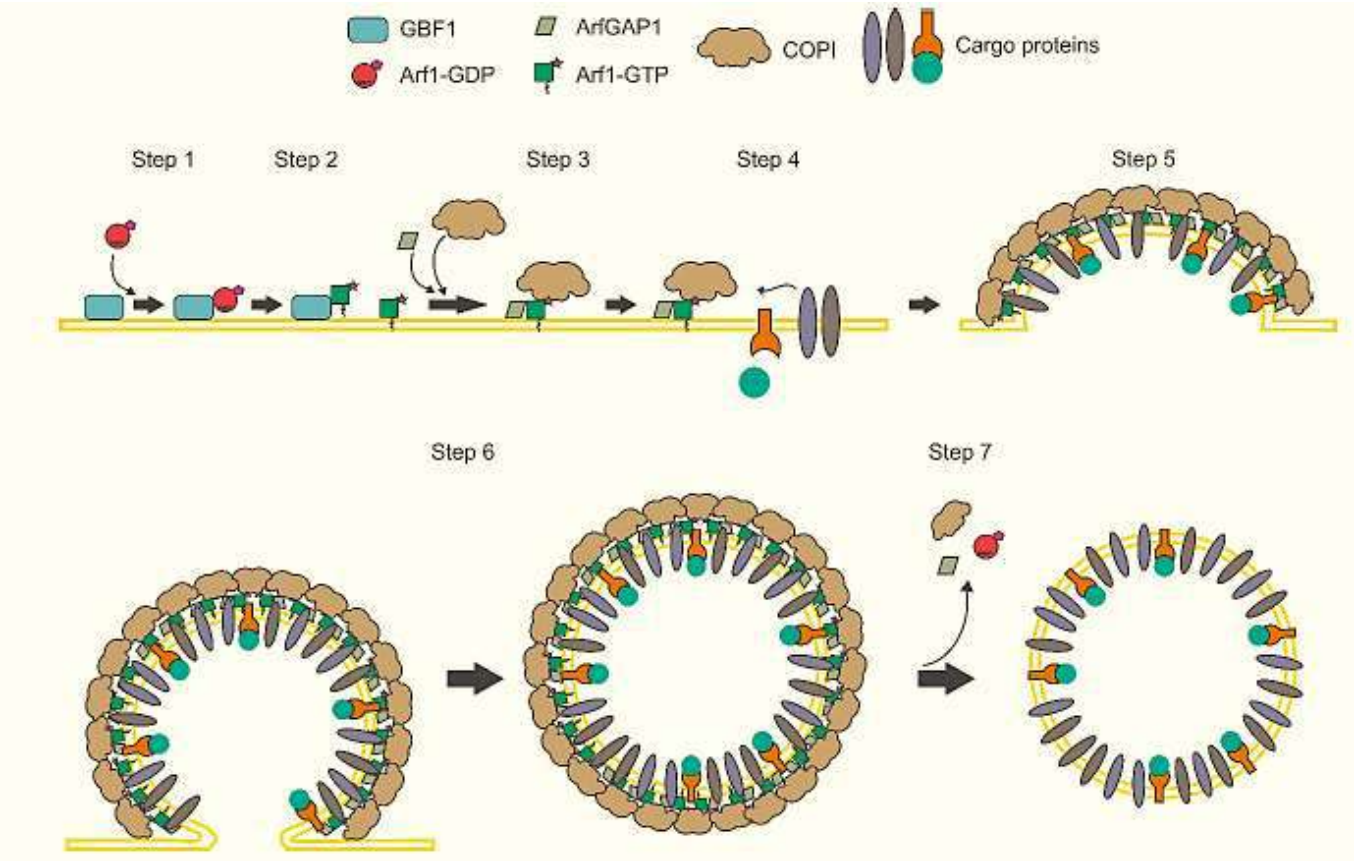
# ..... Formation of vesicles




Schematic diagram of the roles of COPI, COPII, and clathrin in the vesicular secretory pathway.

*Martínez & Arias . 2020. Viruses. 12, 682.*

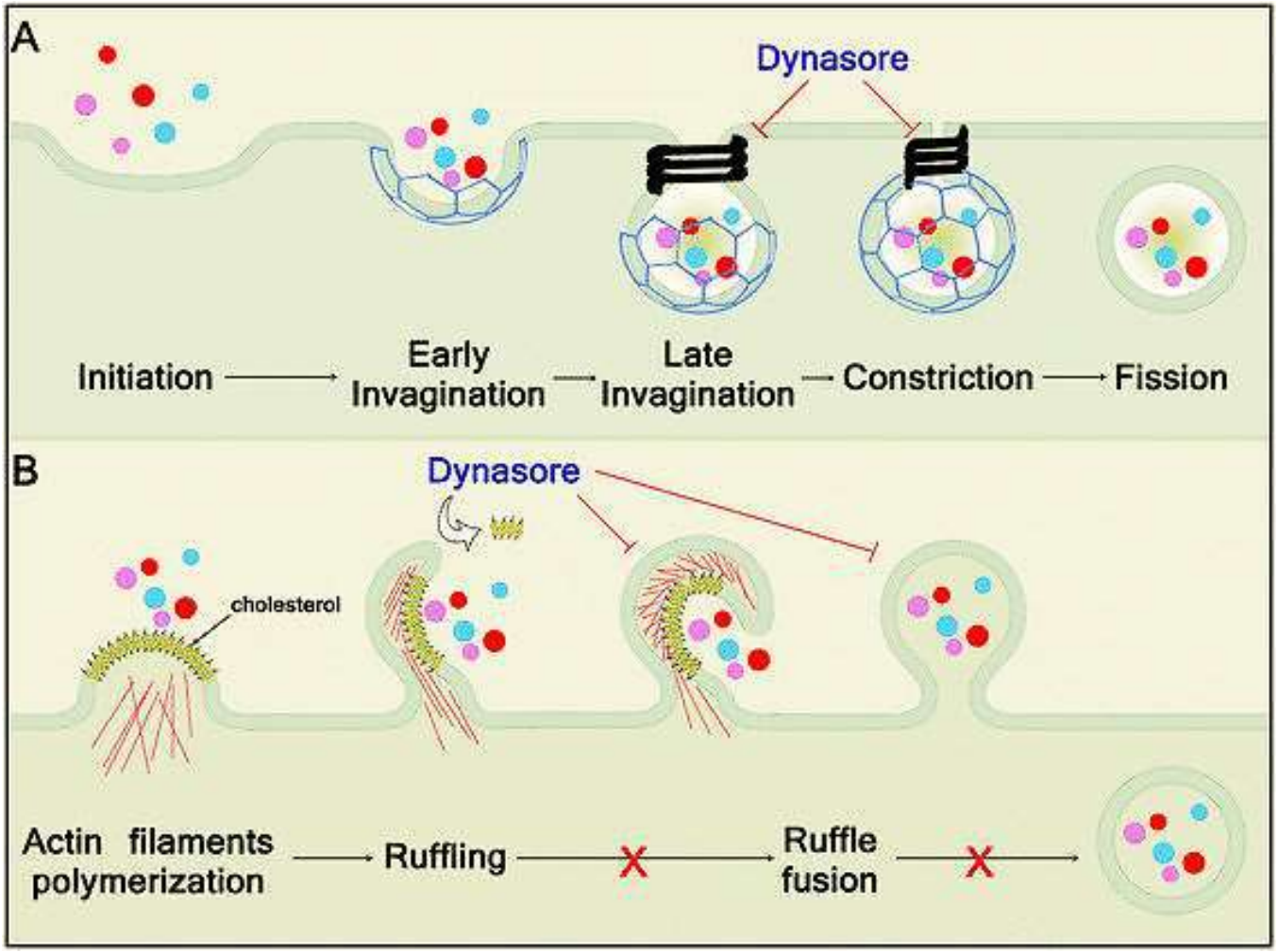
# ..... Formation of vesicles




Mechanism of COPI transport.

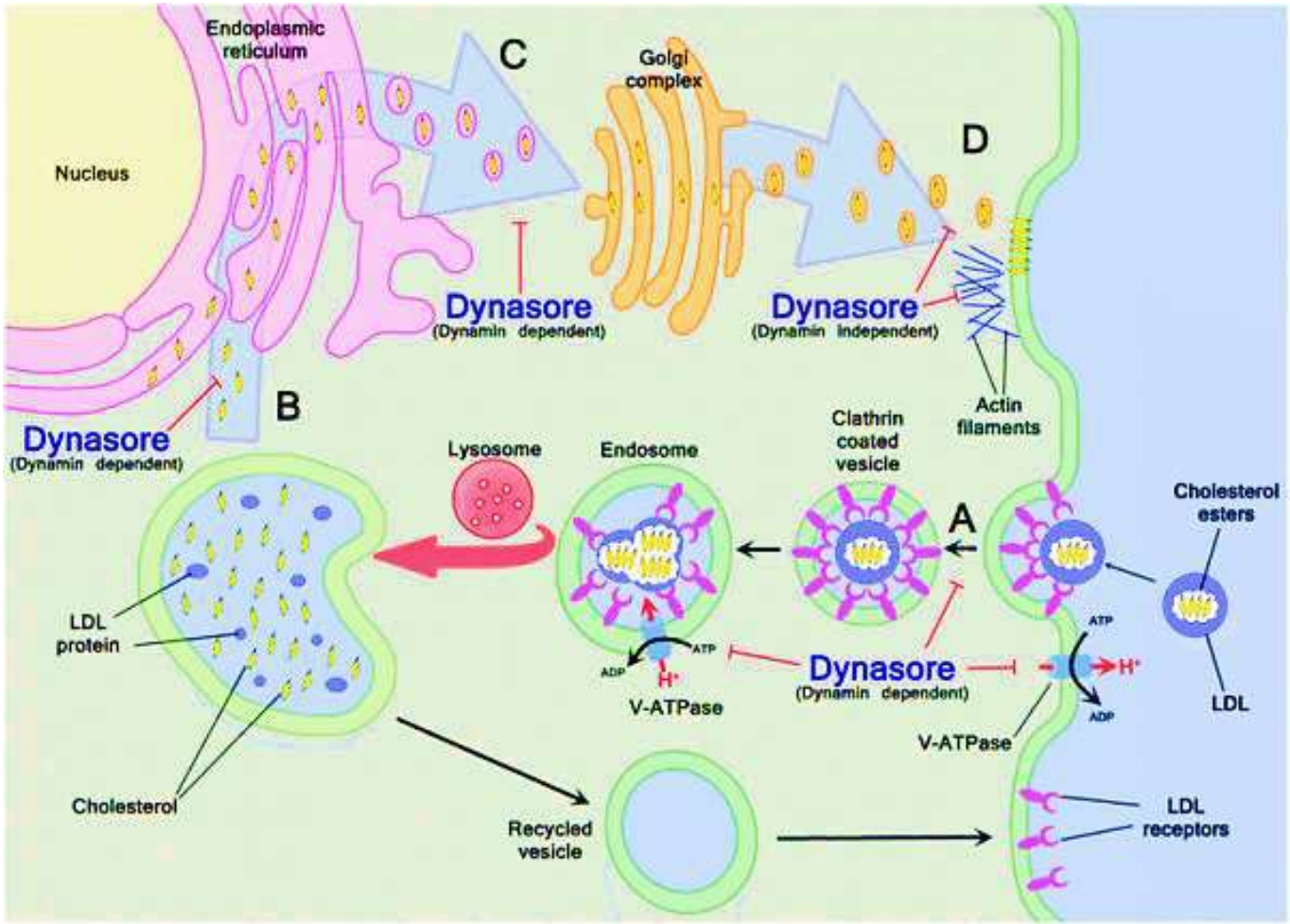
*Martínez & Arias . 2020. Viruses. 12, 682.*

# ..... Formation of vesicles




*Preta G. et al. 2015. Cell Communication and Signaling 13(1)*

# Clathrin mediated endocytosis of LDL receptor

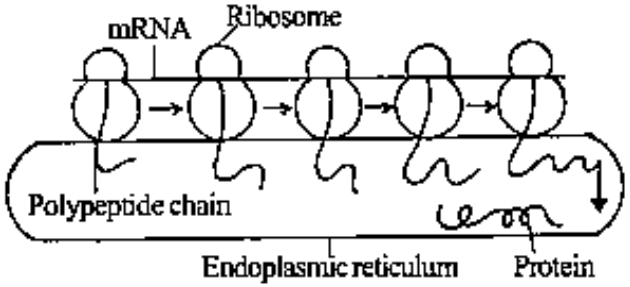



*Preta G. et al. 2015. Cell Communication and Signaling 13(1)*

# Functions of endoplasmic reticulum

Endoplasmic reticulum performs important functions of secretory, storage, circulatory and nervous system for the cell. Its common functions are:

- Mechanical support: It divides the endoplasm into small fluid compartments which gives strength to the cells by acting as cytoskeleton of the cells.
- Transport: It is involved in the import, export and intracellular circulation of various substances of proteins, lipids, enzymes, etc.
- Protein synthesis: Ribosomes attached synthesize proteins which are collected by the ER, processed and transported to other parts of the cell.




- Synthesis of cholesterol: Cholesterol is the precursor of the steroid hormones which is synthesized by the ER.

# Functions of endoplasmic reticulum

- Detoxification: Detoxification of drugs and pollutants are performed by the liver cells in the ER. Enzymatic processing of the toxic materials in the ER lets them to be soluble in water which finally excreted through urine.
- Lipid synthesis: It synthesizes triglycerides and phospholipids and also stores lipids.
- Glycogenolysis: The degradation of glycogen into glucose is called as glycogenolysis which is occurring mainly in liver and muscles. This process takes place inside the ER (It coverts glucose-6-phosphate into glucose which is then transported to the blood).
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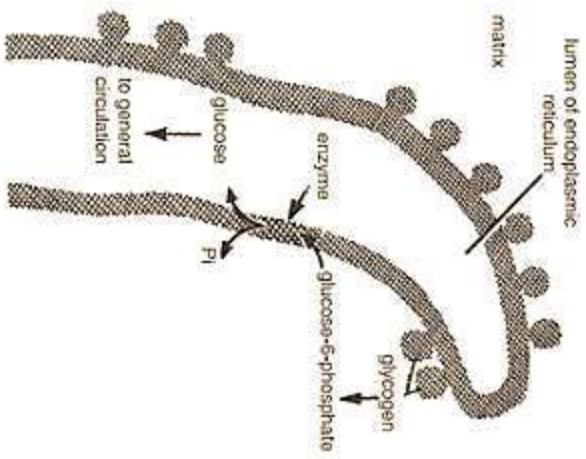

# Further readings


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