

**MSc I Sem – Life Sciences**

**Course – Cell Biology**

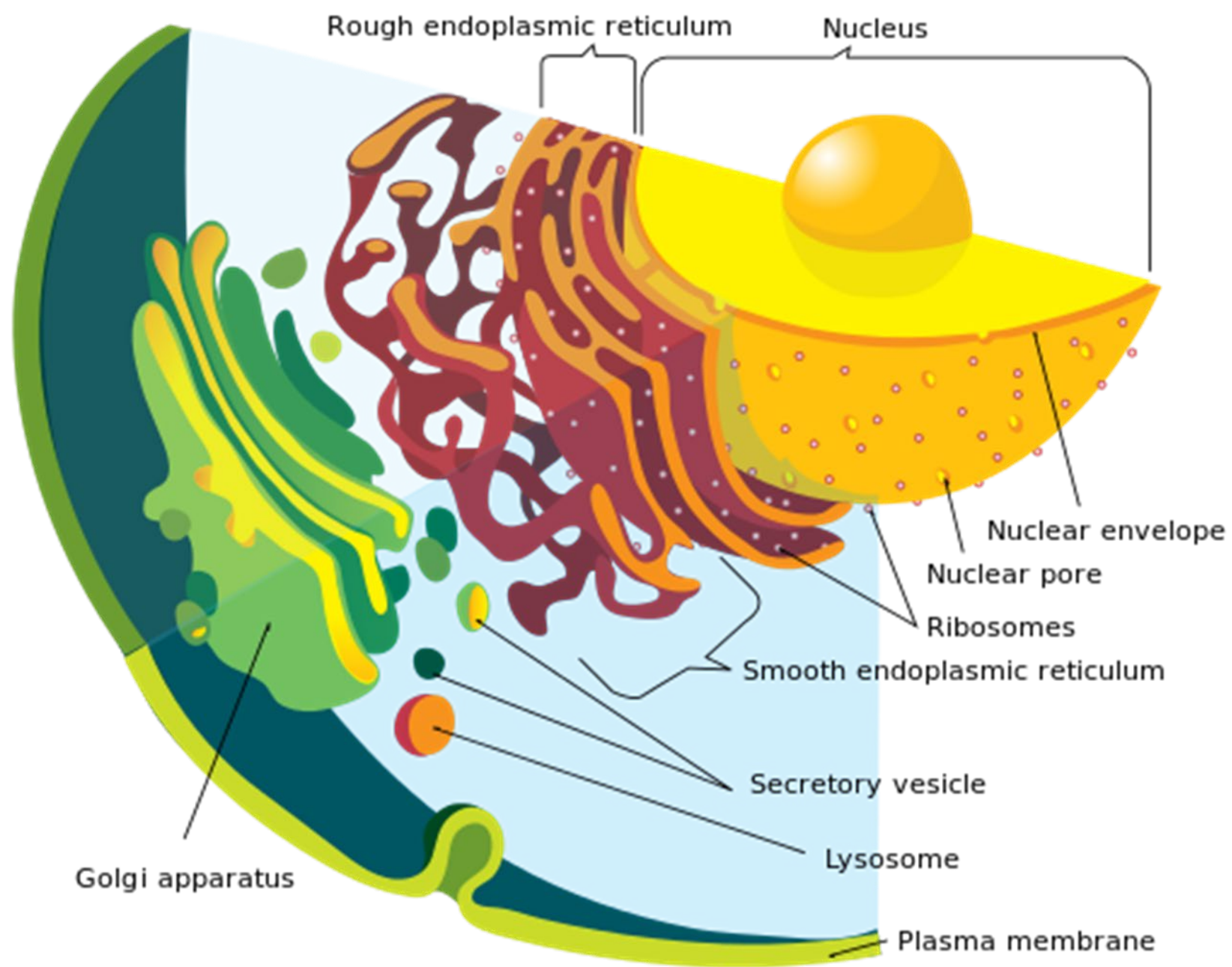
# Endoplasmic Reticulum

---

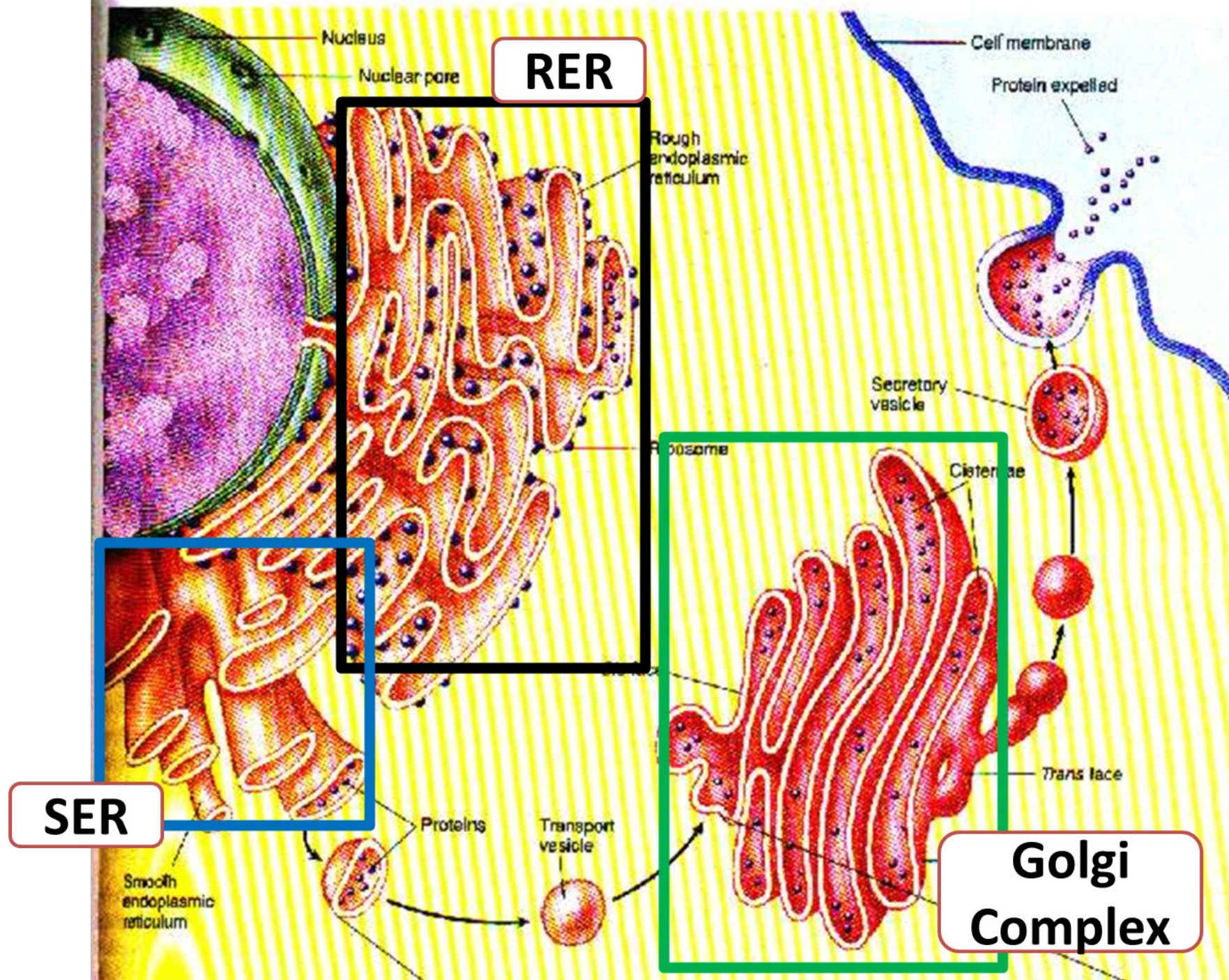


# Endomembrane system

- The endomembrane system is composed of the different membranes that are suspended in the cytoplasm within a eukaryotic cell.
- These membranes divide the cell into functional and structural compartments, or organelles.
- The organelles of the endomembrane system include: the nuclear envelope, the endoplasmic reticulum, the Golgi apparatus, lysosomes, vacuoles, vesicles, endosomes and the cell membrane.
- The endomembrane system does not include mitochondria, chloroplasts, or peroxisomes.







# The endoplasmic reticulum (ER)

- Name derived from microscopic structure showing “net in the cytoplasm”
- Porter 1953 named ER
- A cell organelle that forms an interconnected network of membrane vesicles.

## Occurrence

- Various animal and plant cells types
- NOT IN: erythrocytes (RBC), egg, embryonic cells

## TYPES

- According to the structure, the ER is classified into two types:
  - **Rough endoplasmic reticulum (RER) and**
  - **Smooth endoplasmic reticulum (SER).**
- **Sarcoplasmic reticulum**

# The endoplasmic reticulum (ER)

- ONLY SER: adipose tissues, brown fat cells, adenocortical cells, interstitial cells of testes, corpus luteum of ovum, sebaceous cells, retinal pigment cells
- The SER is abundant in mammalian liver and gonad cells.
- The SER is a smooth network without the ribosomes.
- The SER is concerned with *lipid metabolism*, *carbohydrate metabolism*, and *detoxification*.
- ONLY RER: cells engaged in active protein synthesis such as acinar cells of pancreas, plasma cells, goblet cells, cells of endocrine gland etc.
- The RER is predominantly found in *hepatocytes* where protein synthesis occurs actively.
- The RER is studded with *ribosomes* on the *cytosolic* face. These are the sites of *protein synthesis*.

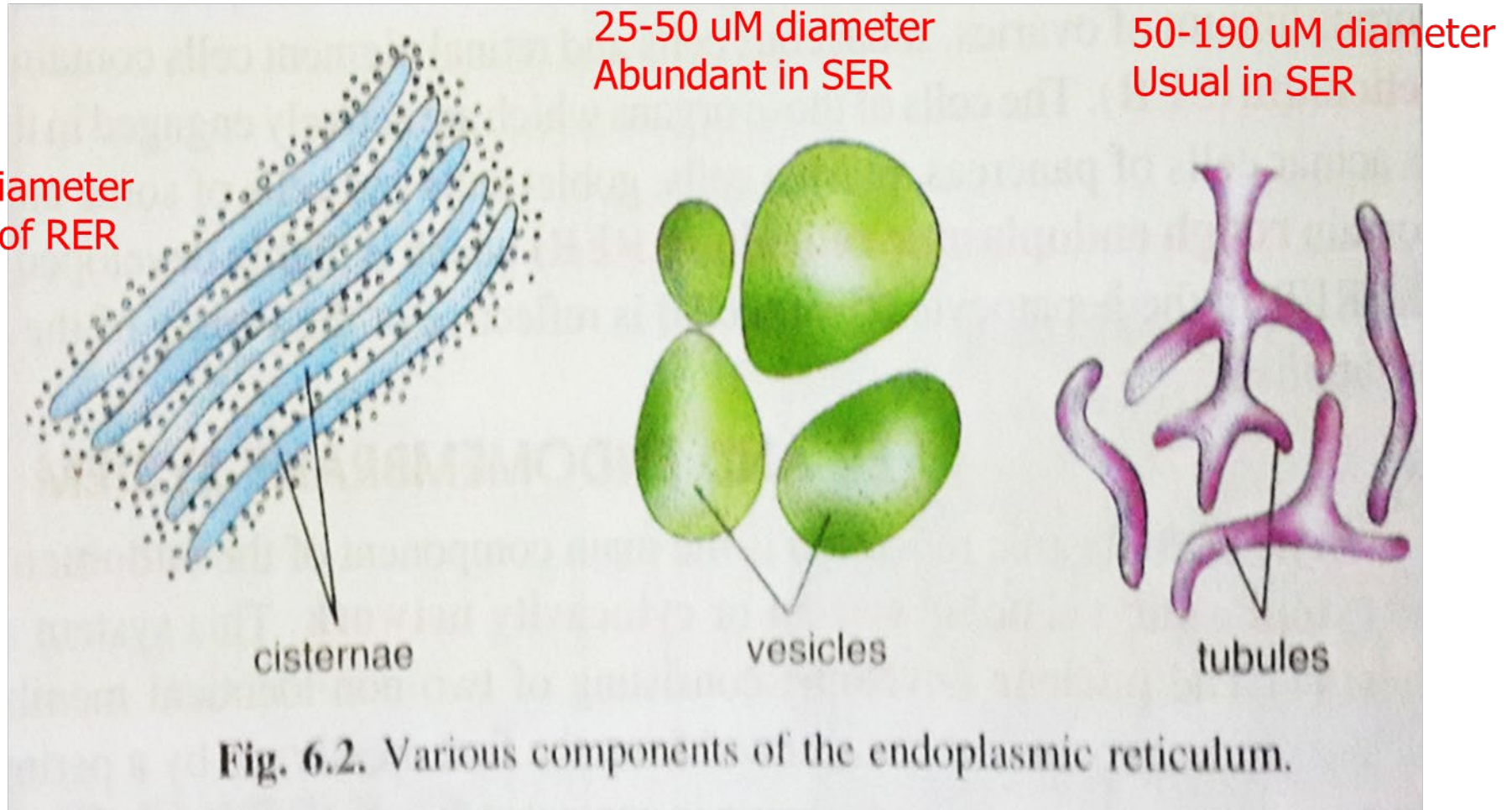


# ER Morphology

Components of ER:

1. Lamellar form or cisternae (a closed fluid sac, vesicle or cavity)
2. Vesicular form or vesicle
3. Tubular form or tubules

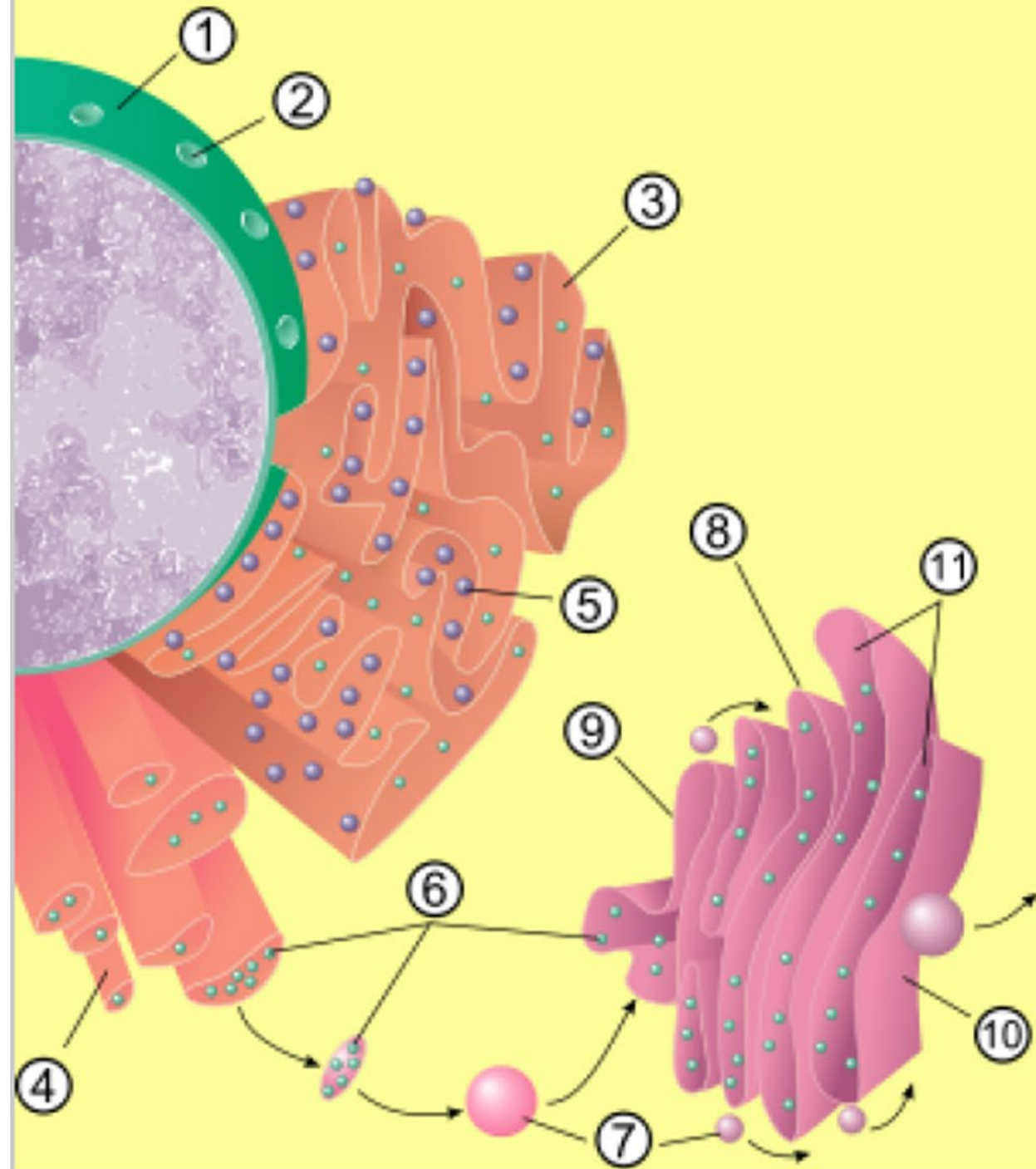
40-50  $\mu\text{m}$  diameter  
Usual form of RER



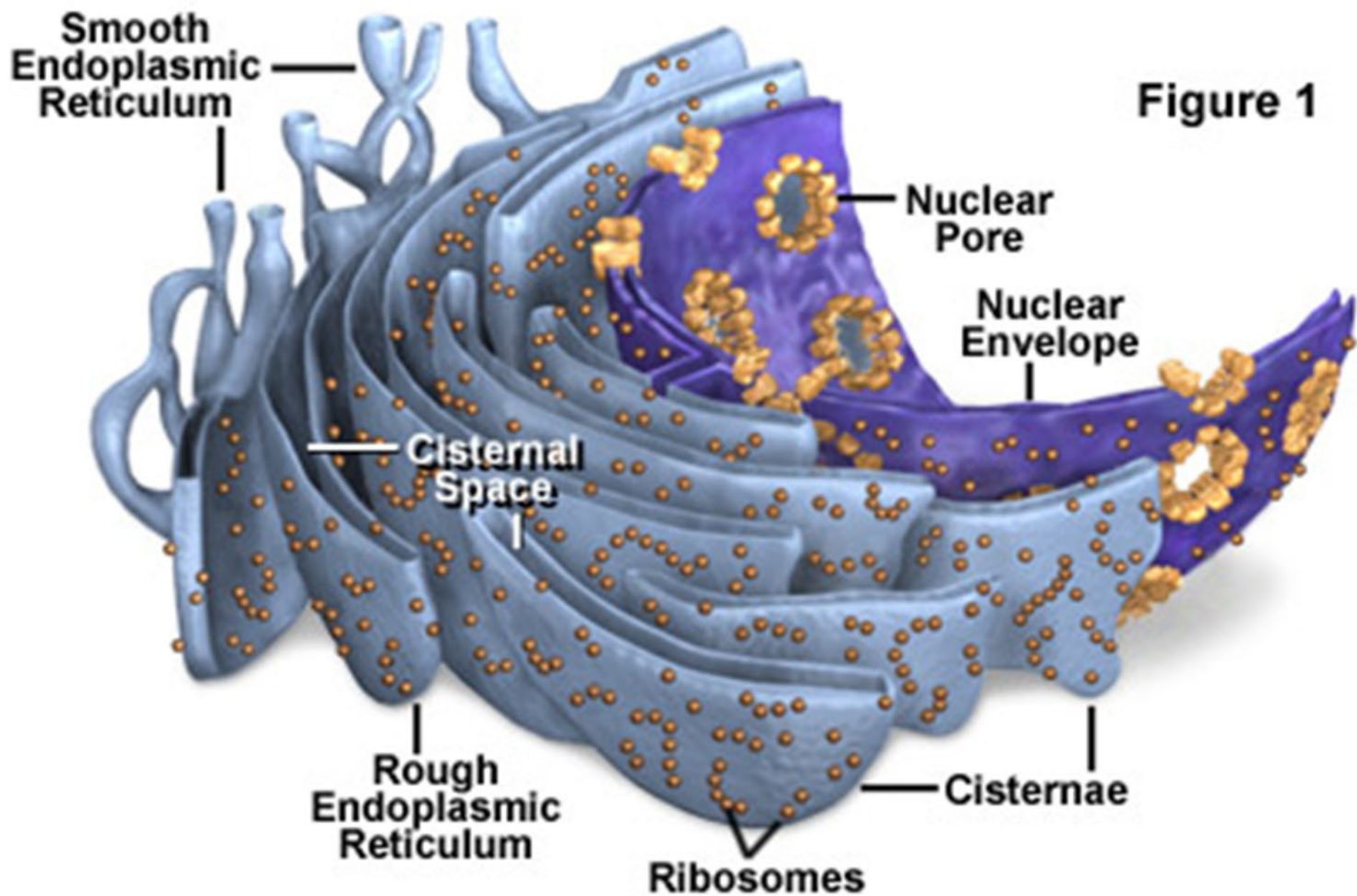


## Localization of ER in the Cell

1 Nucleus, 2 Nuclear pore, 3 RER, 4 SER, 5 Ribosome on the RER, 6 Proteins that are transported, 7 Transport vesicle, 8 Golgi apparatus, 9 Cis face of the Golgi apparatus, 10 Trans face of the Golgi apparatus, 11 Cisternae of the Golgi apparatus



# Endoplasmic Reticulum



## Rough Endoplasmic Reticulum (RER)

- The surface of the RER is studded with protein-manufacturing ribosomes giving it a "rough" appearance. The region of the cytoplasm containing RER take *basiophilic stain* and is named as ergatoplasm, basiphilic bodies, chromophilic substances or **Nissl Bodies**.
- The binding site of the ribosome on the RER is the **translocon**.
- Ribosomes binding is not a stable part of the RER as they are constantly being bound and released from the membrane.
- A ribosome binds to the ER only when it begins to synthesize a protein.
- A ribosome in the cytosol begins synthesizing a protein until a signal recognition particle (SRP) recognizes the signal peptide (of 5–30 hydrophobic amino acids).
- This signal sequence allows the recognition particle to bind to the ribosome, causing the ribosome to bind to RER and pass the new protein through the RER membrane.
- The signal peptide is then cleaved off within lumen of the ER by a signal peptidase.
- Ribosomes at this point may be released back into the cytosol; however, non-translating ribosomes are also known to stay associated with translocons.

## **Smooth Endoplasmic Reticulum (SER)**

- SER has functions in several metabolic processes: synthesizes lipids, phospholipids, and steroids.
- Cells which secrete these products, such as those in the testes, ovaries, and skin oil glands have abundance of SER.
- Also the metabolism of: carbohydrates, drug detoxification, attachment of receptors on cell membrane proteins, and steroid metabolism.
- In muscle cells, it regulates calcium ion concentration. It is connected to the nuclear envelope.
- SER also contains the enzyme glucose-6-phosphatase, which converts glucose-6-phosphate to glucose, a step in gluconeogenesis.
- It consists of tubules that are located near the cell periphery.
- These tubes sometimes branch forming a network that is reticular in appearance.



## **Sarcoplasmic Reticulum (SR)**

- SR is SER found especially in smooth and striated muscle.
- The only structural difference between SR and SER is the protein combinations.
- The SR functions to store and pump calcium ions.
- The SR contains large stores of calcium, which it sequesters and then releases when the muscle cell is stimulated.
- It plays a major role in excitation-contraction coupling.

## Common Functions of the ER (RER/SER)

- ER makes ultrastructural cytoskeletal framework to cell and provides mechanical support to cytoplasmic matrix.
- Performs exchange of molecules via osmosis, diffusion, active transport across ER membrane.
- Enzymes storage for various catalytic, synthetic, and metabolic activities.
- Intracellular circulatory or transport system.
- **Secretory products transport:**  
**RER → SER → Golgi membrane → lysosomes**
- RNA and nuclear proteins export from N→C in nucleo-cytoplasmic interaction.
- ER membranes form nuclear membrane after each nuclear division.
- SR releases Ca ion when muscles are stimulated and active transport of Ca back in to SR after muscle relaxation.

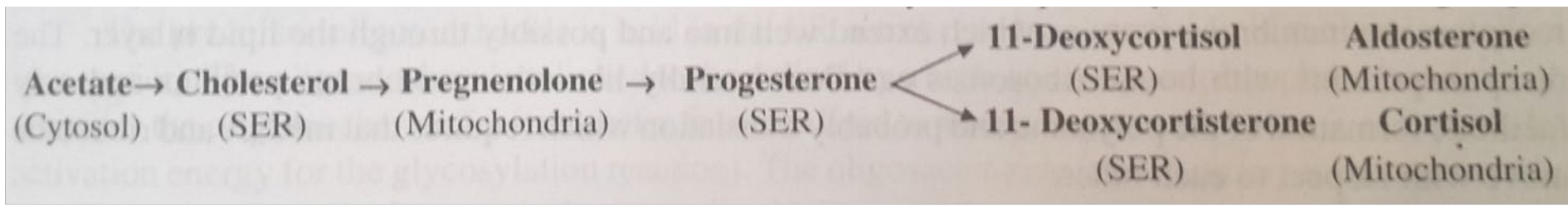
# Functions of the SER

- 1. Synthesis of Lipids:** Lipids (such as phospholipids, cholesterol etc) and lipoproteins. Newly synthesized lipids are rapidly transferred to cellular membrane by cytosolic enzyme **phospholipid exchange proteins**.
- 2. Sterol Metabolism:** SER contains several key enzymes that catalyzed synthesis of cholesterol which acts as precursor for several other metabolites such as steroid hormones and bile acids.
  - i. Cholesterol biosynthesis:** it's a 20-step biosynthetic pathway starting from ACETATE. Out of that 11 enzymes are bound to SER. Other 9 are cytosolic or mitochondrial. SER bound enzyme e.g. **HMG-Co A reductase** and **Squalene synthetase**.
  - ii. Bile acid synthesis:** complex pattern of enzymic process. Such as **Hydroxylase, mono-oxygenase, dehydrogenase, isomerase and reductase**.

Initial steps in bile acid synthesis:

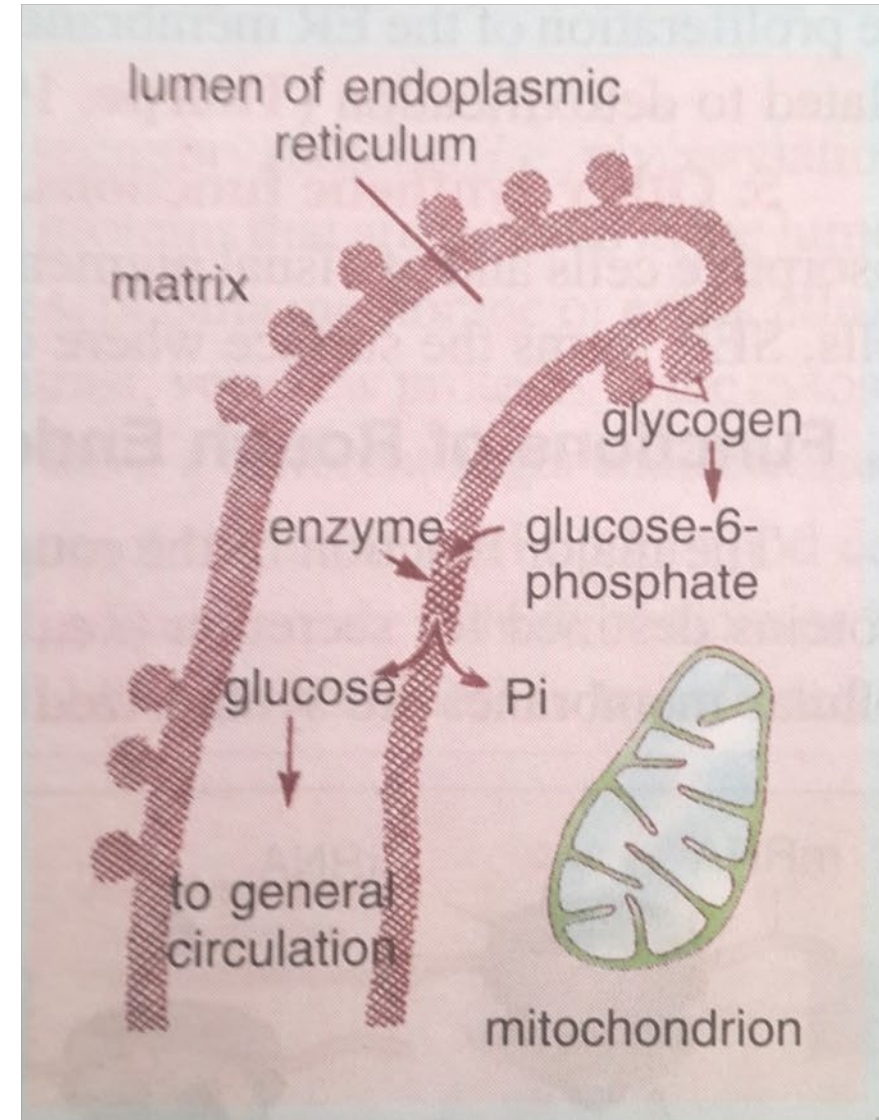
Cholesterol – (cholesterol 7-a-hydroxylase) → 7-a-hydroxyl cholesterol - - - - hydroxylase → bile acids.

**iii. Steroid hormone biosynthesis:** cholesterol → estrogen and testosterone (in reproductive tissues) and adrenocorticoids (corticosterone, aldosterone and cortisol) (in adrenal glands).



### 3. Glycogenolysis and blood glucose homeostasis:

Glycogen synthesis occurs in glycosomes of cytosol by enzyme **UDPG-glycogen transferase**. SER performs glycogenolysis (breakdown of glycogen). **Glucose-6-phosphatase** enzyme exists as integral protein SER membrane. It releases free glucose in SER lumen and maintains glucose homeostasis.





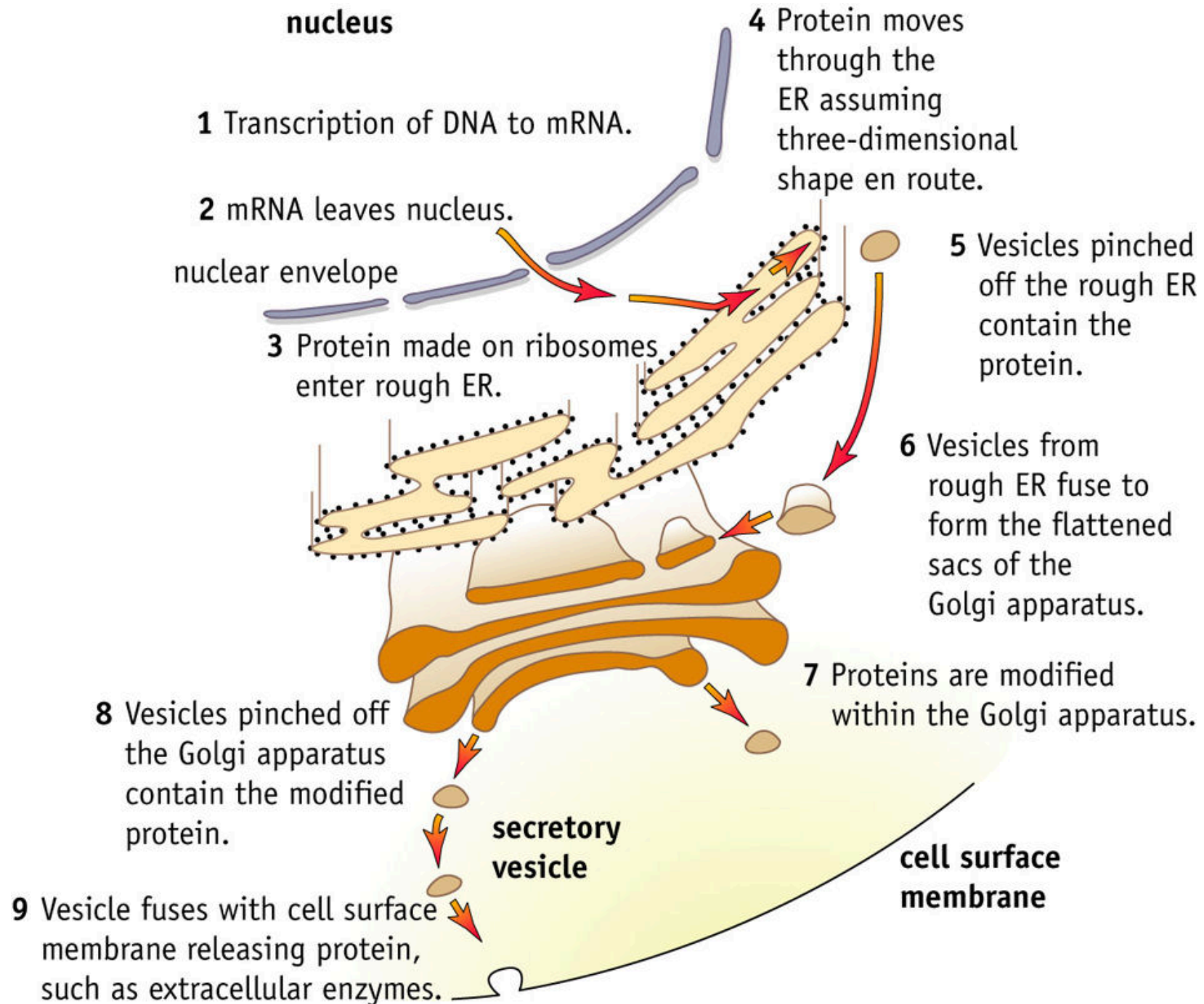
#### **4. Detoxification:**

- Removal of xenobiotics by their chemical modification.
- Making them more hydrophilic, hence more readily excreted.
- Such as drugs, aspirin, insecticides, anaesthetics, petroleum products, and other chemical pollutants,
- Removal of carcinogens like benzopyrene.

#### **5. Other synthetic functions:**

- Synthesis of triglycerides in intestinal absorptive cells
- Visual pigments from vitamin A by pigmented epithelium cells of retina
- SER helps in cellulose cell wall formation in plants

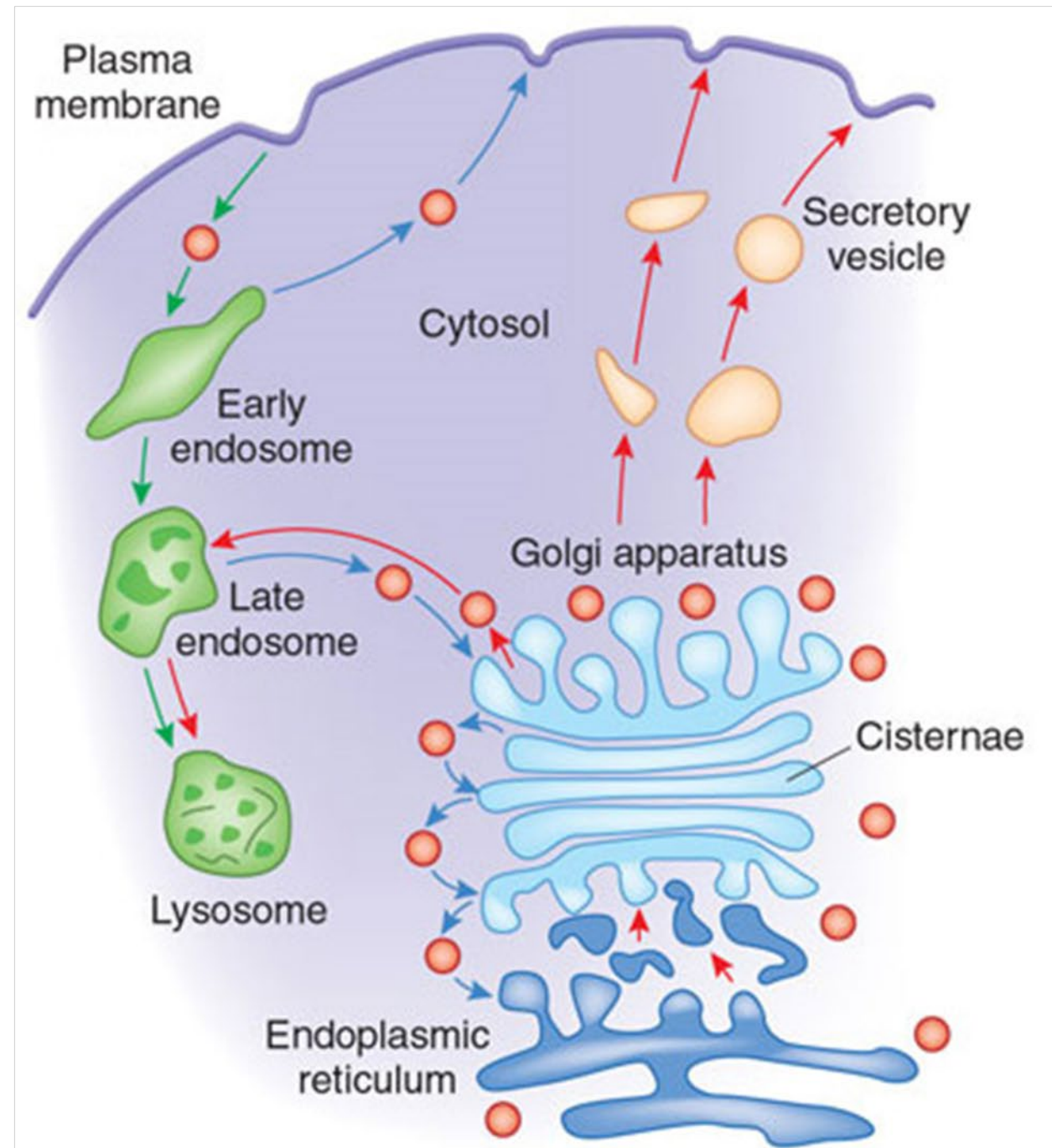
# Overview of Protein Synthesis



# Vesicular Trafficking Golgi

## Pathways:

- **Endocytic**: illustrated in green arrows
- **Biosynthetic-secretory**: illustrated with red arrows
- **Retrieval**: illustrated with blue arrows



Contents from Open Access Online Resources