Golgi Apparatus

E-Content for UG

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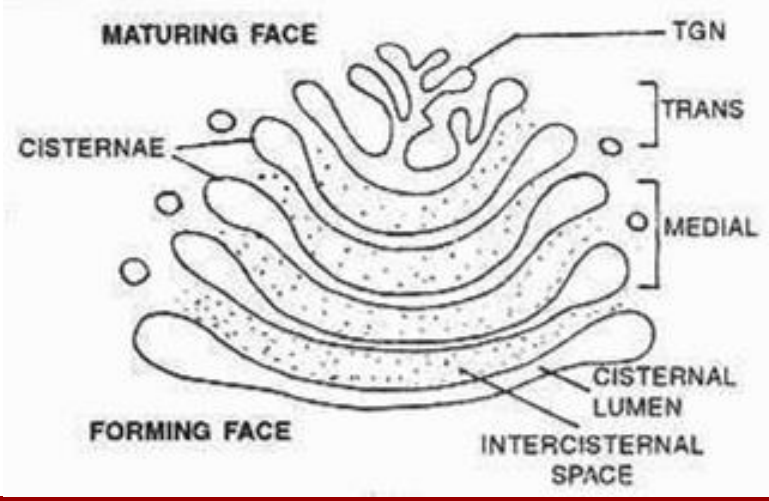


Introduction

- The Golgi Complex is also known as Golgi Body or Golgi Apparatus or simply the Golgi.
- It is an organelle found in most eukaryotic cells of plants and animals.
- It exhibits structural variations and is primarily related with the cell secretion.
- It was first reported by the Italian Neurologist Camillo Golgi (1898) in the nerve cell of barn owl.
- Golgi apparatus forms a part of the endomembrane system and constitutes 2 % of the cytoplasmic volume.

- It is absent in prokaryotic cells, mature mammalian RBCs and sperms.
- The shape and size of Golgi apparatus are variable and depend on the physiological condition of the cells.
- Usually a single Golgi apparatus occurs in a cell however, its **number** may vary from animal to animal and from cell to cell.
- The nerve cells, liver cells and chordate oocytes have multiple Golgi apparatus, there being about 50 of them in the liver cells. It is well developed in secretory cells.
- In animal cells Golgi apparatus is a localized organelle. For example, in the cells of ectodermal or endodermal origin, the Golgi apparatus remains polar and occurs in between the nucleus and the periphery (e.g. thyroid cells, exocrine

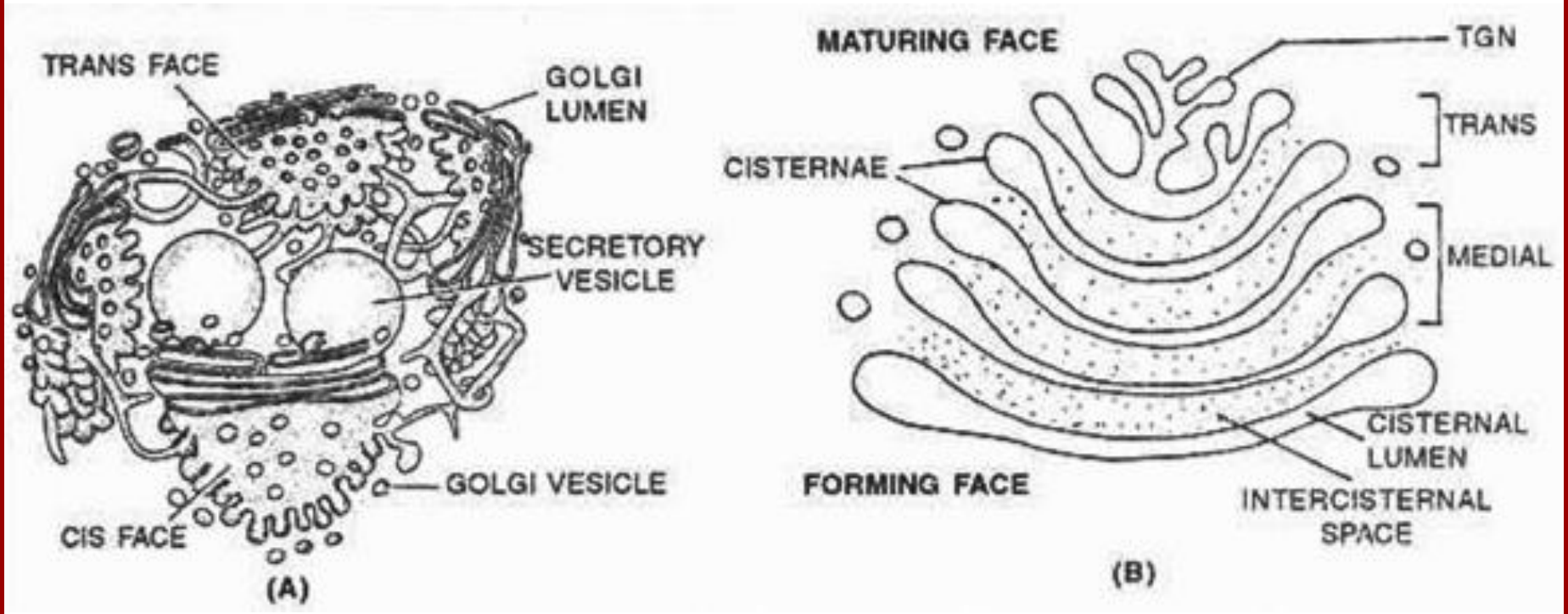
- Pancreatic cells and mucous producing goblet cells of intestinal epithelium) and in the nerve cells it occupies a circum-nuclear position.
- The specific density of Golgi apparatus is less than that of mitochondria and endoplasmic reticulum.
- The **ultrastructure** of Golgi apparatus was studied by Dalton and Felix (1954) in the epididymis of rat.
- Golgi apparatus is made up of three components:
  1. Cisternae
  2. Vacuoles/ Tubules/ Associated vesicles and
  3. Vesicles

1. Cisternae: Flattened Sac

- These are flattened tubular sac-like, plate-like or saucer-like closed compartments which are held in parallel bundles or stacks one above the other.
- The cisternae (singular cisterna) are about 01μm in diameter (It is also called dictyosomes)
- In each stack, cisternae are separated by a space of 20 to 30 mm which may contain rod-like elements or fibres.
- Cisternae are the most constant element of the Golgi apparatus. They lack ribosomes.
- Between 4 and 8 cisternae are usually present in a stack. In some mammalian cells 40 to 100 cisternae may be present in a stack.

- Each cisterna is bounded by a smooth unit membrane (7.5 nm thick), having a lumen varying in width from about 500 to 1000 nm.
- The margins of each cisterna are gently curved so that the entire Golgi apparatus takes a bow-like appearance.
- The cisternae has two faces.
- The cisternae at the convex end comprise of proximal, forming face (F face) or cis-face and the cisternae at the concave end comprise of distal, maturing (M face) or trans-face.
- The forming or cis face of Golgi is located next to either the nucleus or a specialized portion of rough endoplasmic reticulum (ER) that lacks bound ribosomes and is called ‘transitional’ ER.

- Trans face of Golgi is located near the plasma membrane.
- This polarization is called cis-trans axis of the Golgi apparatus.
- These two faces differ in staining property.
- The membranes of the maturing face are thicker (7-8μm) while those of forming face are thinner (about 4μm).



(A): 3D structure of Golgi Apparatus **(B): Ultra structure of Golgi Apparatus in C.S.**

2. Vacuoles or Tubules

- A complex array of associated vesicles and anastomosing tubules (30 to 50 nm diameter) surround the cisternae and radiate from it.

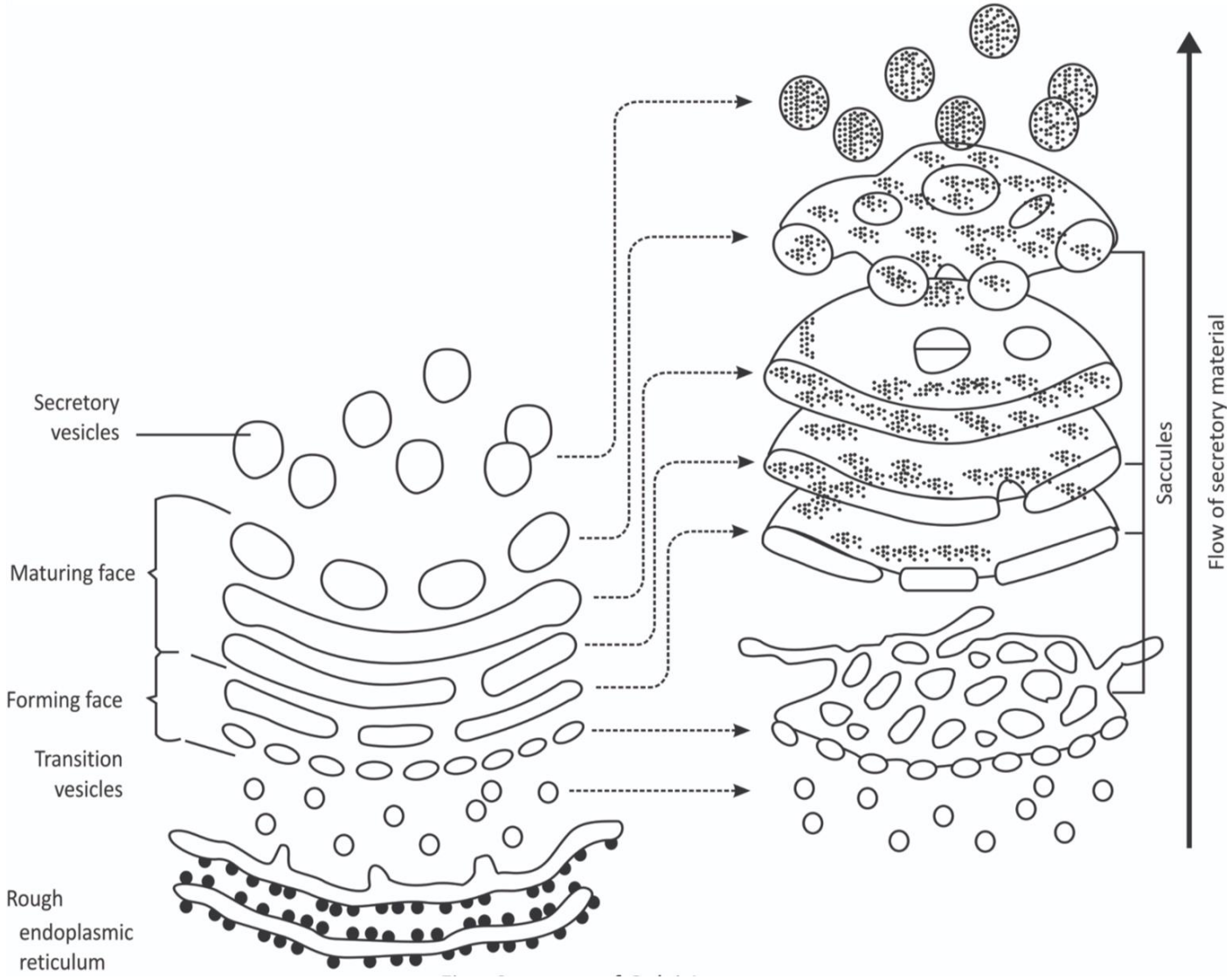
- In fact, the peripheral area of cisternae is fenestrated (lace-like) in structure.

- The trans face, facing towards the plasma membrane contains a tubular reticulum called Trans Golgi Network (TGN) or GERL (=Golgi + smooth ER + Lysosomes)

3. Vesicles

- The vesicles (60 nm in diameter) are of three types:
  - **i. Transitional vesicles** are small membrane limited vesicles which are thought to form as blebs from the transitional ER to migrate and converge to cis-face of Golgi, where they coalesce (come together to form one mass) to form new cisternae.
  - **ii. Secretory vesicles** are varied sized membrane limited vesicles which discharge from margins of cisternae of Golgi. They often occur between the maturing face of Golgi and the plasma membrane.
  - **iii. Clathrin-coated vesicles** are spherical protuberances, about 50 in diameter and with rough surface.

- They are found at the periphery of the organelle, usually at the ends of single tubules and are morphologically quite distinct from the secretory vesicles.
- These are known to play a role in intracellular traffic of membranes and of secretory products i.e., between ER and Golgi as well as between trans-reticular-Golgi (TGN) region and the endosomal and lysosomal compartments.
- Golgi Apparatus is surrounded by a **clear zone of exclusion** in which mitochondria, ribosomes, granules etc. are lacking.
- Endoplasmic reticulum within this zone has a smooth surface (lacking ribosomes) and coated vesicles are restricted to this region.



The position and orientation of the Golgi Apparatus in secretory pathway

- Chemically, Golgi complex is made up of protein and phospholipids in the form of phosphatidyl choline. Besides, it also contains many enzymes.
- Golgi apparatus is formed from:
  i. Plasma membrane
  ii. Endoplasmic reticulum
  iii. Nuclear membrane and
  iv. Annulate lamellae

Functions of Golgi Apparatus

- Golgi apparatus is often referred to as the **'Traffic Police'** of the cell (Darnell et al, 1986).
- It plays a key role in sorting many of cells proteins and membrane constituents and in directing them to their proper destination.
- It is primarily a **processing plant of cell**.
- It is a centre of reception, finishing, packaging and dispatch for a variety of material in cells.
- Thus, Golgi apparatus performs the following functions in the eukaryotic cells:

1. Secretion is the major function of Golgi apparatus, which help in collection, storage, condensation, modification, and packaging of various materials into secretory vesicles.
    - These release the contents to the exterior through exocytosis, e.g. secretion of hormones, ground matrix of connective tissue etc.
    - Cellular secretion may be -
        i. Holocrine - e.g. secretion of sebaceous glands.
        ii. Apocrine - e.g. milk fat droplets of the cells of the lactating mammary glands.
        iii. Merocrine - e.g. secretion of sweat glands and secretion of pancreas gland.

2. It helps in formation of cell plate, cell wall and plasma lemma during cell division.
3. It also helps in the formation of primary lysosomes, sperm acrosomes, nematocytes in coelenterates and root hairs.
4. In oocytes of animals yolk is deposited around Golgi apparatus by the process of vitellogenesis.
5. Golgi apparatus brings about transformation of membranes (e.g. ER) into another such as plasma membrane and lysosomal membrane.
6. It also participates in recycling of membranes.

7. It facilitates glycosylation (addition of carbohydrates to protein), liposylation (formation of lipoproteins), sulphation (addition of sulphates), and phosphorylation (addition of phosphates).
8. It helps in lipid transport. When digested lipids are absorbed as fatty acids and glycerol in the small intestine, they are resynthesized to lipids in smooth ER, coated with protein and then transported through the Golgi apparatus to the plasma membrane where they leave the cell by exocytosis, mainly to enter lymph system.

9. It also helps to concentrate and store the secretory products.
    - The proteins, glycoproteins and lipoproteins are concentrated inside the secretory vesicles or in condensing vacuoles which bud off from the Golgi cisternae.
    - Once concentrated, the products may be stored in the cytoplasm (inside the vesicles) or may be secreted to the outside of the cell through exocytosis.

10. Golgi apparatus helps in cytokinesis.