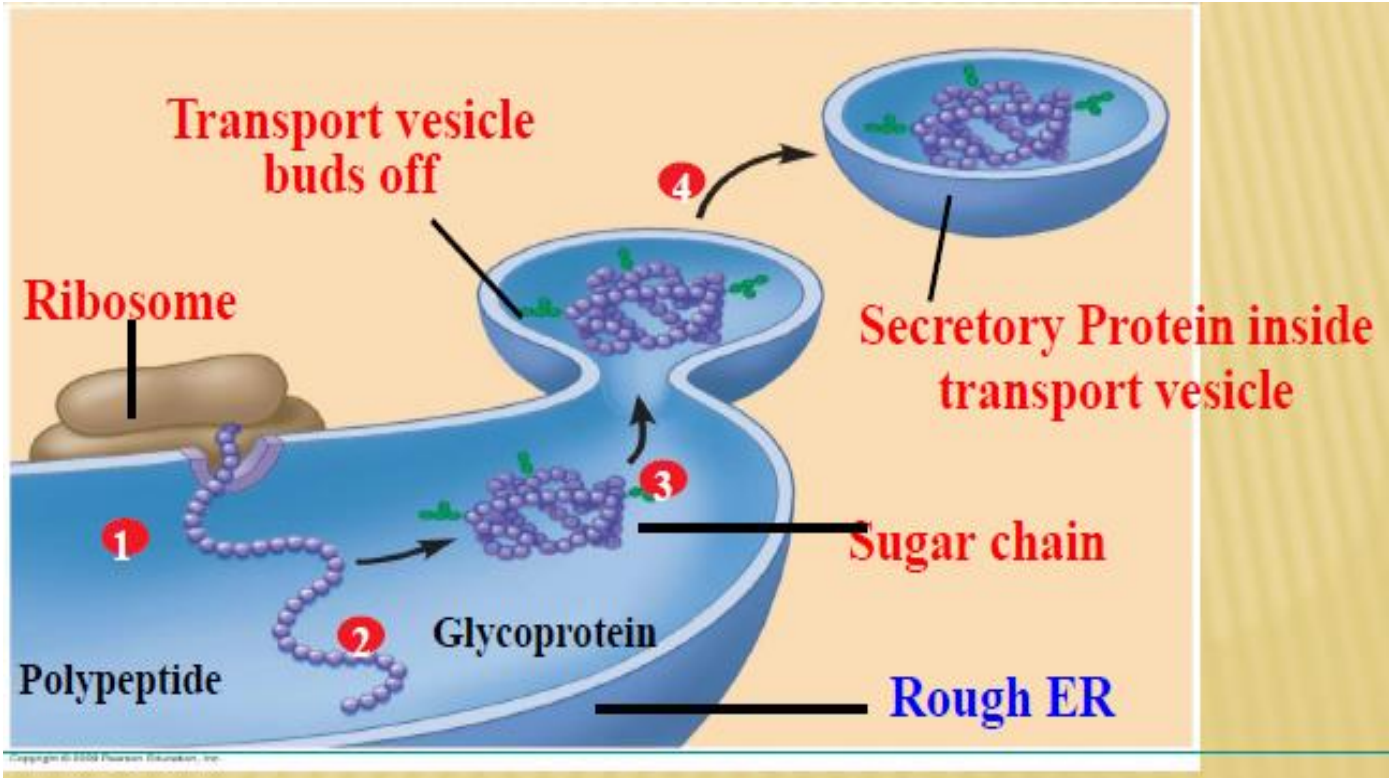
Lecture 5

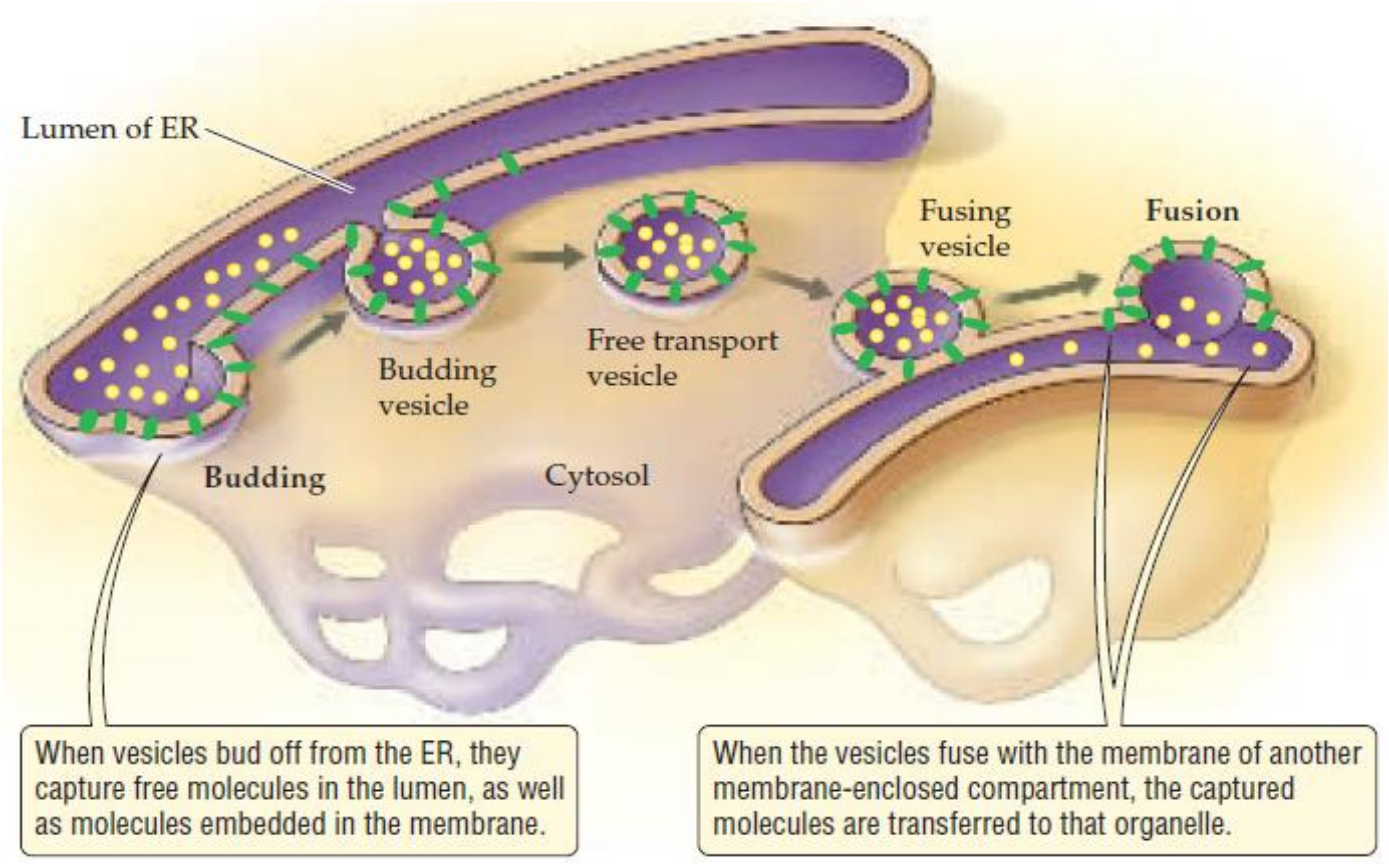
Functions of Rough Endoplasmic Reticulum

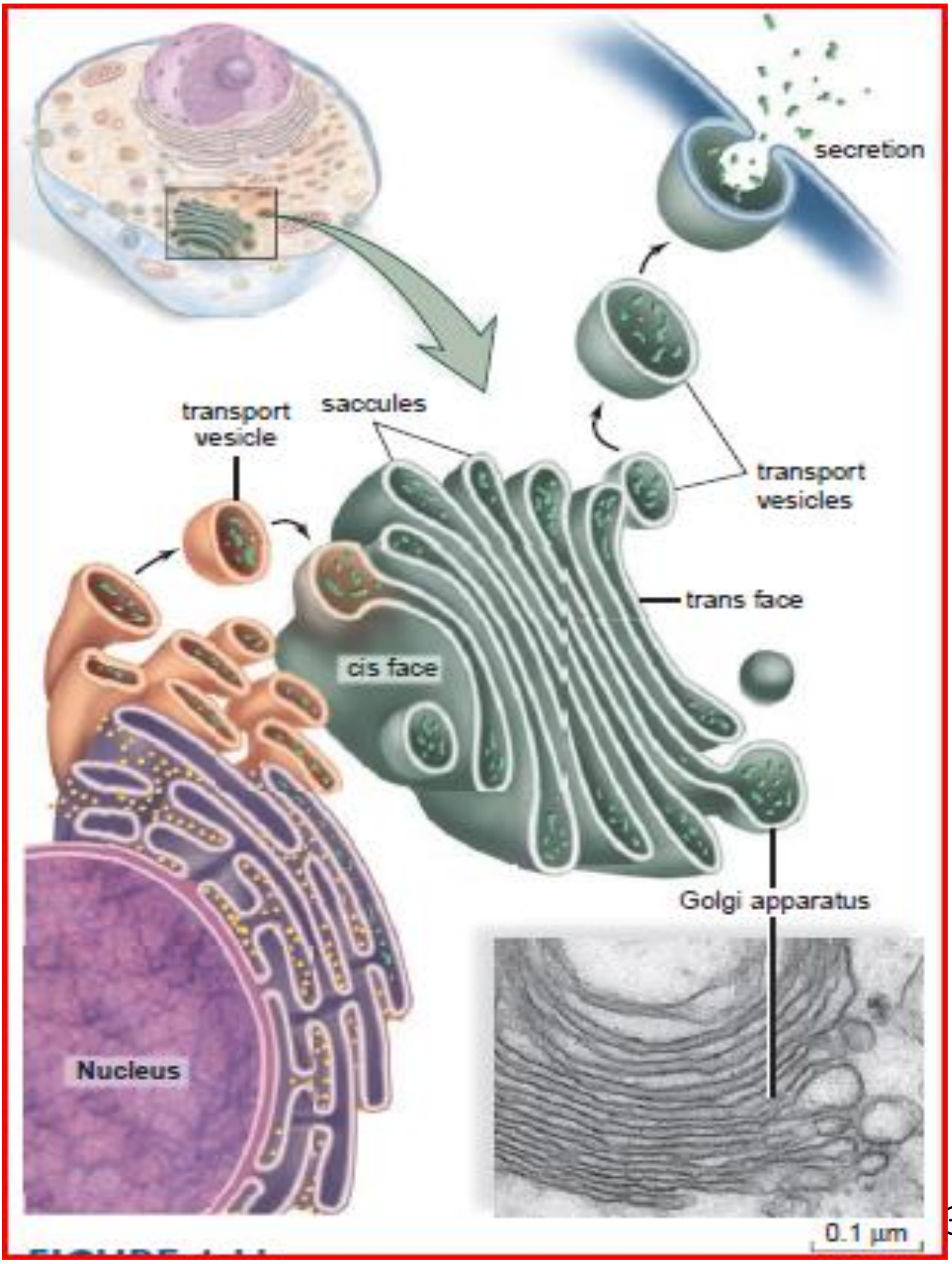
- **Secretory proteins produced by ribosomes attached to rough ER, Example:**
- **Ribosomes of some pancreatic cells synthesise the protein (=hormone) insulin which is stored inside cisternal space of Rough ER.**
- **Most secretory proteins are stored inside cisternal space.**
- **Rough ER contains enzymes that can add carbohydrate (sugar) chains to proteins, and then these proteins are called glycoproteins (proteins that have carbohydrates covalently bonded to them).**
- **Rough ER is a membrane factory for the cell; it grows in place by adding membrane proteins and phospholipids to its own membrane.**

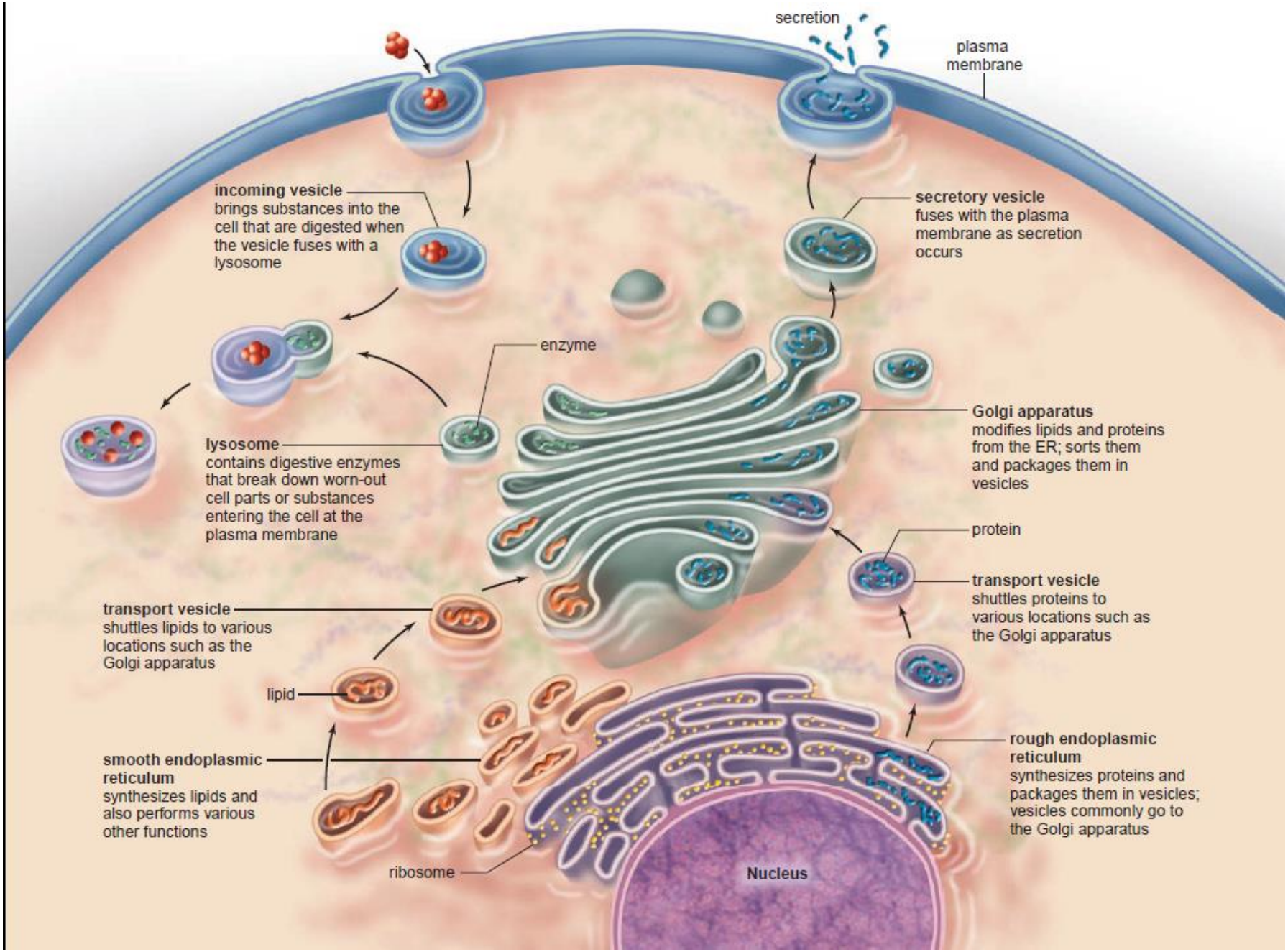


Ribosome and rough endoplasmic reticulum

- **Secretory proteins depart** from **both** ER **wrapped** in the membranes of **vesicles** that **bud** like **bubbles** from a specialised region called **transitional ER**. Vesicles in **transit** from one part of the cell to another are called **transport vesicles**.




secretion
transport vesicle
saccules
transport vesicles
trans face
cis face
Golgi apparatus
Nucleus
0.1 µm


secretion
plasma membrane
incoming vesicle
brings substances into the cell that are digested when the vesicle fuses with a lysosome
secretory vesicle
fuses with the plasma membrane as secretion occurs
enzyme
lysosome
contains digestive enzymes that break down worn-out cell parts or substances entering the cell at the plasma membrane
Golgi apparatus
modifies lipids and proteins from the ER; sorts them and packages them in vesicles
protein
transport vesicle
shuttles proteins to various locations such as the Golgi apparatus
transport vesicle
shuttles lipids to various locations such as the Golgi apparatus
lipid
smooth endoplasmic reticulum
synthesizes lipids and also performs various other functions
rough endoplasmic reticulum
synthesizes proteins and packages them in vesicles; vesicles commonly go to the Golgi apparatus
ribosome
Nucleus

Golgi apparatus

- **The Golgi apparatus consists of flattened membranous sacs-cisternae-looking like a stack of pita bread called saccules.**
- **A cell may have many, even hundreds, of these stacks.**
- **The membrane of each saccule in a stack separates its internal space from the cytosol.**
- **The Golgi is a centre of manufacturing, warehousing of receiving, sorting, and shipping.**
- **After leaving the ER, many transport vesicles travel to the Golgi apparatus.**
- **Products of the ER, such as proteins, are modified and stored and then sent to other destinations.**
- **Golgi apparatus is especially abundant in cells specialised for secretion.**
- **Vesicles concentrated close to Golgi apparatus are engaged in the transfer of material between parts of the Golgi and other structures.**
- **A Golgi stack has a distinct structural end, with the membranes of cisternae on opposite sides of the stack differing in thickness and molecular composition.**
- **The two poles of a Golgi stack are referred to as the *cis* face acts as the receiving and the *trans* face; acts as the shipping departments of the Golgi apparatus.**
- **The *cis* face is usually located near the ER (opposite side to transitional ER).**
- **Transport vesicles move material from the ER to the Golgi apparatus.**

How Golgi apparatus works?

- A vesicle that buds from the ER can add its membrane and the contents of its lumen to the *cis* face by fusing with a Golgi membrane.
- The *trans* face gives rise to vesicles, which pinch off and travel to other sites.
- Products of the ER, such as proteins, are modified and stored during their transit from *cis* face region to *tans* face region of Golgi apparatus and then sent to other parts of the cell by Transport vesicles.

Function of Golgi apparatus

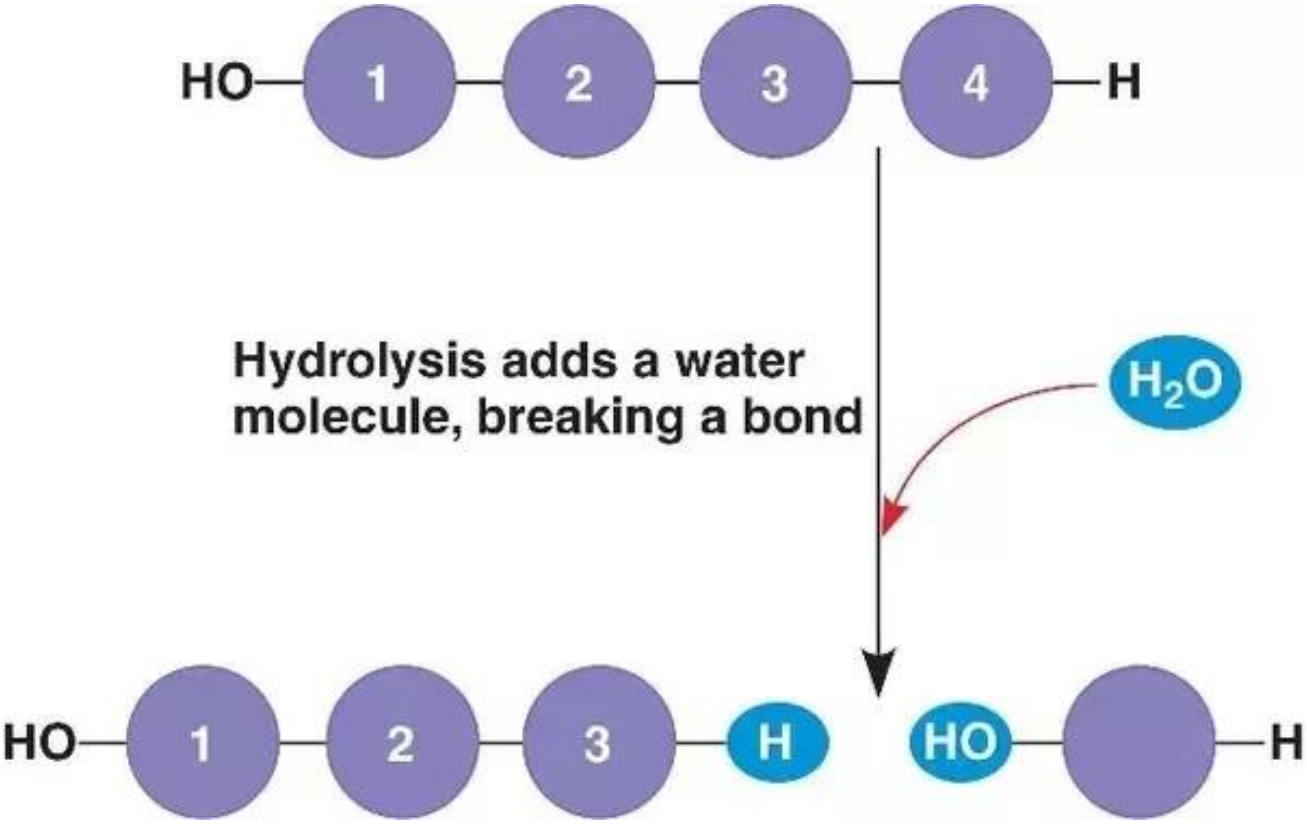
- Various Golgi enzymes modify the carbohydrate portions of glycoproteins.
- All products (secretory proteins & non-proteins) inside Golgi will be departed from the *trans* face inside transport vesicles that fused with the plasma membrane.

Lysosomes: Digestive Compartments

- (*lyso* = to loosen and *soma* = body)
- Lysosome is a membranous sac of hydrolytic digestive enzymes that an animal cell uses to digest macromolecules, and these enzymes work in an acidic environment.
- If a lysosome breaks open or leaks its contents, the released enzymes are not very active because the cytosol has a neutral pH, but cell might be destroyed by autodigestion if there is an excessive leakage from a large number of lysosomes.
- Lysosomal membrane & hydrolytic enzymes are made by rough ER and then transferred to the Golgi apparatus for further processing.

- Some lysosomes probably arise by budding from the *trans* face of the Golgi apparatus.
- Proteins of the inner surface of lysosomal membrane and the digestive enzymes themselves can be protected from destruction by having three-dimensional (3D) shapes that protect vulnerable bonds from enzymatic attack.

Lysosomes: Hydrolysis

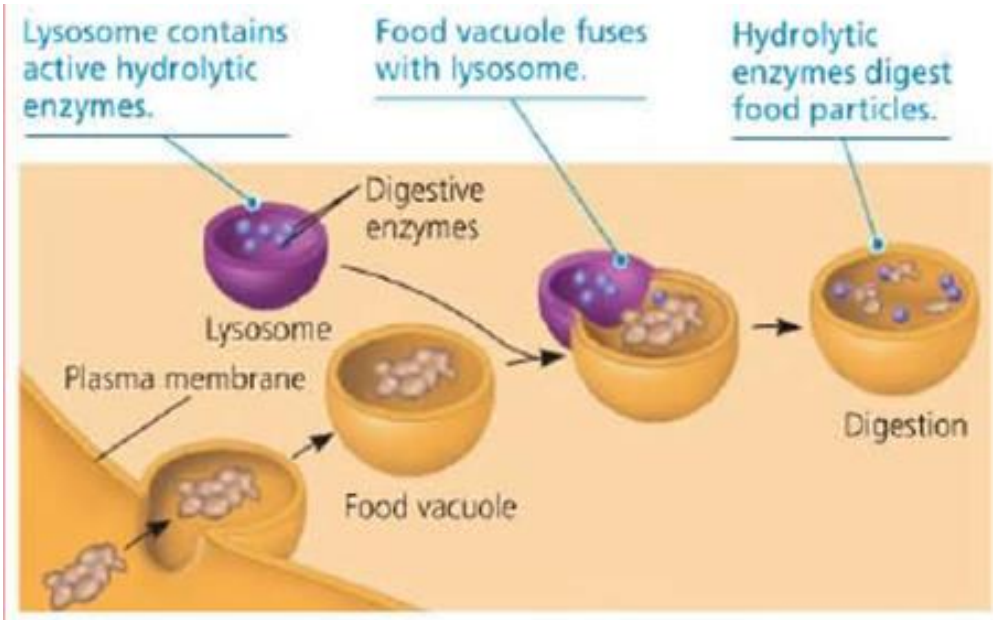


Phagocytosis

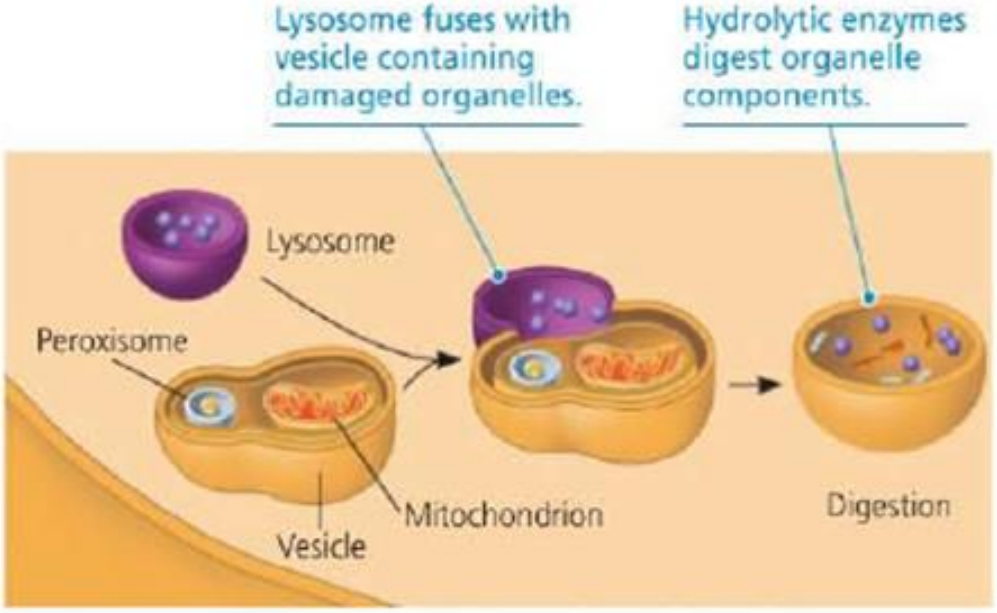
- Lysosomes carry out intracellular digestion:

➢ Phagocytosis (*phago* means to eat): done by engulfing smaller organisms or other food particles and producing a food vacuole (in *Amoeba* and other Protozoa).

- **The digested food (simple sugar & amino acids) passes into the cytosol and becomes nutrients for the cell.**
- **In human, phagocytosis is done by macrophage (type of white blood cell) which helps in defense.**



(a) Phagocytosis: lysosome digesting food



(b) Autophagy: lysosome breaking down damaged organelles

Autophagy

- **Process is done by lysosomes, which use their hydrolytic enzymes to recycle the damaged organelle and cell's own organic material.**
- **With the help of lysosomes, the cell continually renews itself (human liver cell, recycles half of its macromolecules each week).**

Tay-Sachs disease

- **Rare inherited lysosomal storage diseases.**
- **Lysosome lacks functioning hydrolytic enzyme for lipid can cause Tay-Sachs disease (accumulation of indigestible lipids in brain cells which impair brain activities).**

Definitions

Glycoproteins: carbohydrates that have covalently bonded to proteins.

Transitional ER: a specialised region in endoplasmic reticulum in which the secretory proteins depart from the ER wrapped in the membranes of vesicles that bud like bubbles toward Golgi apparatus.

Transport vesicle: It is a bubble shaped membrane which buds off from transitional ER or trans face (in Golgi apparatus). It transports **secretory protein** (produced by endoplasmic reticulum) or **secretory lipid** (produced by Golgi apparatus) to other parts of the cell.

Saccules: Flattened membranous sacs like a stack of pita bread, which separates the internal space of Golgi apparatus from the cytosol.

***Cis* face:** (Cisterna face) is one of the Golgi apparatus poles, which is located near ER, and it works as **receiving** department of **transport vesicle** produced by ER.

***Trans* face:** (Transport face) is one of the Golgi apparatus poles and works as a **shipping** department. The *trans* face gives rise to transport vesicles, which pinch off and transit material produced by Golgi apparatus towards other parts of the cell or outside of the cell.

Autodigestion: an excessive leakage from a large number of lysosomes that can destroy a cell.

Phagocytosis: Eats by engulfing smaller organisms or other food particles and producing food vacuole by protists and macrophages.

Macrophages: a type of white blood cell that helps defend the body by engulfing and destroying bacteria and other invaders by phagocytosis.

Autophagy: recycle the cell's own organic material or damaged organelle by hydrolytic enzymes of Lysosomes.

Tay-Sachs disease: is a missing or inactive lipid-digesting enzyme in lysosome and causes the brain to become impaired by an accumulation of undigested lipids in the cells.