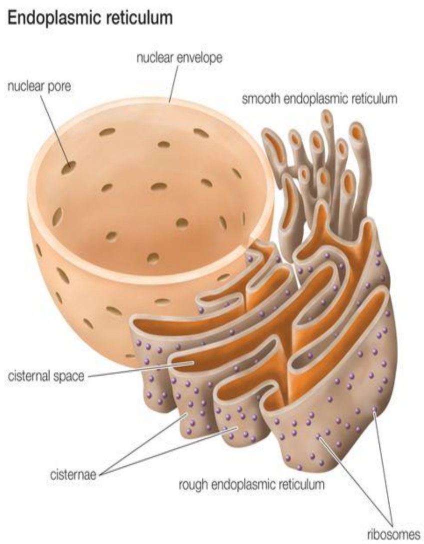
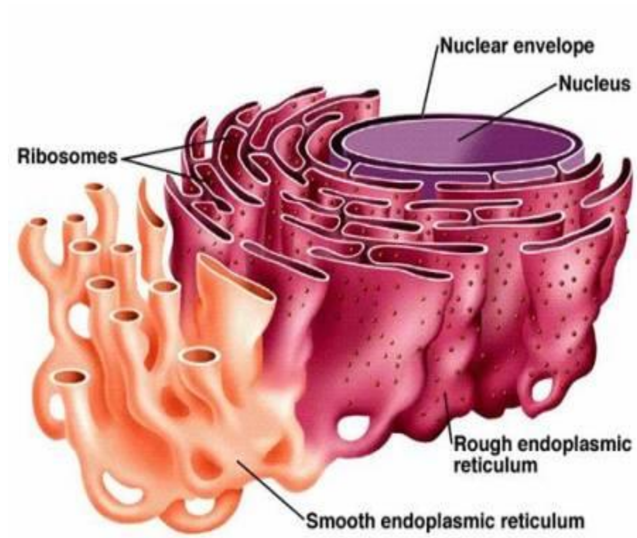
# **Endoplasmic reticulum**



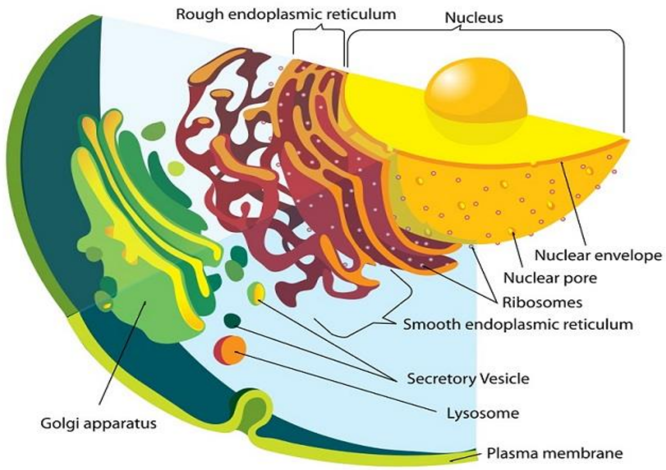

The endoplasmic reticulum (ER) is an important organelle in eukaryotic cells. It plays a major role in the production, processing, and transport of proteins and lipids. The ER produces transmembrane proteins and lipids for its membrane and many other cell components including lysosomes, secretory vesicles, the Golgi appatatus, the cell membrane, and plant cell vacuoles.

## Endoplasmic Reticulum Definition

The endoplasmic reticulum (ER) is a large organelle made of membranous sheets and tubules that begin near the nucleus and extend across the cell. The endoplasmic reticulum creates, packages, and secretes many of the products created by a cell. Ribosomes, which create proteins, line a portion of the endoplasmic reticulum. **Cisternae:** They are long, flattened, unbranched membrane-bound tubule with a diameter of 40-50 µm. They arranged parallel to each other to form lamellae. They are coated with ribosome.

## Endoplasmic Reticulum Overview

The entire structure can account for a large proportion of the endomembrane system of the cell. For instance, in cells such as liver hepatocytes that are specialized for protein secretion and detoxification, the ER can account for more than 50% of the total lipid bilayer of the cell. Similarly, the ER membrane system is particularly prominent in pancreatic beta cells that secrete insulin, or within activated B-lymphocytes that produce antibodies.




As seen in the image, the membranes of the endoplasmic reticulum are contiguous with the outer nuclear membrane, even though their compositions can be different. The ER contains special membrane-embedded proteins that stabilize its structure and curvature. This organelle acts as an important regulator of cell function because it interacts closely with a number of other organelles. Products of the endoplasmic reticulum often travel to the Golgi body for packaging and additional processing before being secreted.

## Endoplasmic Reticulum Function

The ER plays a number of roles within the cell, from protein synthesis and lipid metabolism to detoxification of the cell. Cisternae, each of the small folds of the endoplasmic reticulum, are commonly associated with lipid metabolism. This creates the plasma membrane of the cell, as well as additional endoplasmic reticulum and organelles. They also appear to be important in maintaining the $Ca^{2+}$ balance within the cell and in the interaction of the ER with mitochondria. This interaction also influences the aerobic status of the cell.

ER sheets appear to be crucial in the response of the organelle to stress, especially since cells alter their tubules-to-sheets ratio when the number of unfolded proteins increases. Occasionally, apoptosis is induced by the ER in response to an excess of unfolded protein within the cell. When ribosomes detach from ER sheets, these structures can disperse and form tubular cisternae.

## Protein Synthesis and Folding

Protein synthesis occurs in the rough endoplasmic reticulum. Although translation for all proteins begins in the cytoplasm, some are moved into the ER in order to be folded and sorted for different destinations. Proteins that are translocated into the ER during translation are often destined for secretion. Initially, these proteins are folded within the ER and then moved into the Golgi apparatus where they can be dispatched towards other organelles.

For instance, the hydrolytic enzymes in the lysosome are generated in this manner. Alternately, these proteins could be secreted from the cell. This is the origin of the enzymes of the digestive tract. The third potential role for proteins translated in the ER is to remain within the endomembrane system itself. This is particularly true for chaperone proteins that assist in the folding of other proteins. The genes encoding these proteins are upregulated when the cell is under stress from unfolded proteins.

## Lipid Synthesis

The smooth endoplasmic reticulum plays an important role in cholesterol and phospholipid biosynthesis. Therefore, this section of the ER is important not only for the generation and maintenance of the plasma membrane but of the extensive endomembrane system of the ER itself.

The SER is enriched in enzymes involved in sterol and steroid biosynthetic pathways and is also necessary for the synthesis of steroid hormones. Therefore the SER is extremely prominent in the cells of the adrenal gland that secrete five different groups of steroid hormones that influence the metabolism of the entire body. The synthesis of these hormones also involves enzymes within the mitochondria, further underscoring the relationship between these two organelles.

### Calcium Store

The SER is an important site for the storage and release of calcium in the cell. A modified form of the SER called sarcoplasmic reticulum forms an extensive network in contractile cells such as muscle fibers. Calcium ions are also involved in the regulation of metabolism in the cell and can change cytoskeletal dynamics.

The extensive nature of the ER network allows it to interact with the plasma membrane and use $Ca^{2+}$ for signal transduction and modulation of nuclear activity. In association with mitochondria, the ER can also use its calcium stores to induce apoptosis in response to stress.

## Functions of ER

- It forms the skeletal frame work of the cell.
- It gives support to the cytoplasmic matrix.

- Rough endoplasmic reticulum synthesizes protein while the smooth endoplasmic reticulum synthesizes lipid, glycogen, cholesterol etc.
- Smoot endoplasmic reticulum also protects the cell from the effects of various substances by its detoxification properties.
- Membrane of endoplasmic reticulum takes part to conduct intracellular impulse as seen in the muscles.
- The endoplasmic reticulcum of certain cell such as testis or corpus luteum are concerned with the synthesis of respective steroid hormones.
- Endoplasmic reticulum of parietal cells of stomach helps to secrete hydrochloride acid.
- It acts as a circulatory system of the cell for transporting materials very quickly.
- It helps to form various vacuoles.
- It provides larger surface area which is useful for rapid synthesis of biochemicals.
- Endoplasmic reticulum of one cell makes communicate wit endoplasmic reticulum of adjacent cells.

  It provides the mechanical support to the cells.
- It provides sites to cytochromes to carry out the specific reactions.
- It transmits information from outside to inside of the cells.
- It also transmits information between different organelles of the same cells.
- They help to form the new nuclear membrane after each nuclear division.
- They produce some hormones such as progesterone, testosterone, etc
- They help to transport of carbohydrates and proteins to another cell organelles such as plasma membrane, lysosomes, Golgi apparatus, etc.

## Structure of the Endoplasmic Reticulum

The endoplasmic reticulum membrane system can be morphologically divided into two structures– cisternae and sheets. Cisternae are tubular in structure and form a three-dimensional polygonal network. They are about 50 nm in diameter in mammals and 30 nm in diameter in yeast. ER sheets, on the other hand, are membrane-enclosed, two-dimensional flattened sacs that extend across the cytoplasm. They are frequently associated with ribosomes and special proteins called translocons that are necessary for protein translation within the RER.

## Types of Endoplasmic Reticulum

### Rough and Smooth

There are two basic types of ER. Both rough ER and smooth ER have the same types of membranes but they have different shapes. Rough ER looks like sheets or disks of bumpy membranes while smooth ER looks more like tubes. Rough ER is called rough because it has ribosomes attached to its surface.

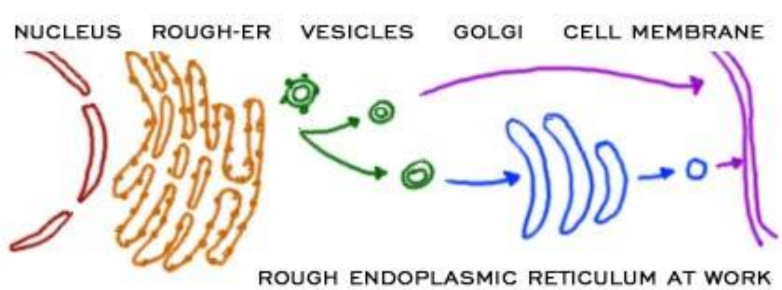
The double membranes of smooth and rough ER form sacs called cisternae. Protein molecules are synthesized and collected in the cisternal space/lumen. When enough proteins have been synthesized, they collect and are pinched off in vesicles. The vesicles often move to the Golgi apparatus for additional protein packaging and distribution.

**Smooth ER (SER**) acts as a storage organelle. It is important in the creation and storage of lipids and steroids. Steroids are a type of ringed organic molecule used for many purposes in an organism. They are not always about building the muscle mass of a weight lifter. Cells in your body that release oils also have more SER than most cells.

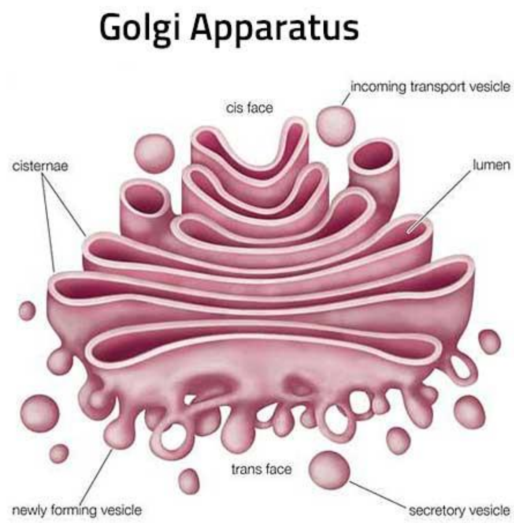
**The sarcoplasmic reticulum (SR)** is a variation of the SER. It is able to store many ions in solution that the cell will need at a later time. When a cell needs to do something immediately, it doesn't make sense to search the environment for extra ions that may or may not be floating around. It is easier to have them stored in a pack for easy use. For example, when you are running around and your muscle cells are active, they need calcium (Ca) ions. The SR can release those ions immediately. When you are resting, they are able to store them for later use.

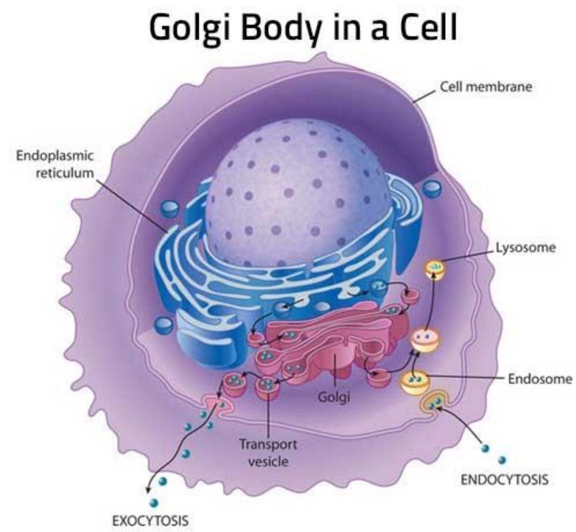
**Rough ER (RER)** was also mentioned in the section on ribosomes and is very important in the synthesis and packaging of proteins. Ribosomes are attached to the membrane of the ER, making it "rough." The RER is also attached to the nuclear envelope that surrounds the nucleus. This direct connection between the perinuclear space and the lumen of the ER allows for the movement of molecules through both membranes.

The process of protein synthesis starts when mRNA moves from the nucleus to a ribosome on the surface of the RER. As the ribosome builds the amino acid chain, the chain is pushed into the cisternal space of the RER. When the proteins are complete, they collect and the RER pinches off a vesicle. That vesicle, a small membrane bubble, can move to the cell membrane or the Golgi apparatus. Some of the proteins will be used in the cell and some will be sent out into intercellular space.



# Golgi apparatus




The Golgi apparatus, also known as the Golgi complex, Golgi body, or simply the Golgi, is an organelle found in most eukaryotic cells. Part of the endomembrane system in the cytoplasm, it packages proteins into membrane-bound vesicles inside the cell before the vesicles are sent to their destination

## Discovery

Owing to its large size and distinctive structure, the Golgi apparatus was one of the first organelles to be discovered and observed in detail. It was discovered in 1898 by Italian physician **Camillo Golgi** during an investigation of the nervous system. After first observing it under his microscope, he termed the structure as *apparato reticolare interno* ("internal reticular apparatus".

### Golgi Apparatus Location

The Golgi apparatus is situated in between the endoplasmic reticulum and the cell membrane. Most often, the Golgi appears to be an extension of the endoplasmic reticulum which is slightly smaller and smoother in appearance. However, the Golgi apparatus can be easily mistaken for smooth endoplasmic reticulum. Although they look similar, the Golgi is an independent organelle which has different functions.

## Structure

In most eukaryotes, the Golgi apparatus is made up of a series of compartments and is a collection of fused, flattened membrane-enclosed disks known as cisternae (singular: *cisterna*, also called "dictyosomes"), originating from vesicular clusters that bud off the endoplasmic reticulum. A mammalian cell typically contains 40 to 100 stacks of cisternae.[8] Between four and eight cisternae are usually present in a stack; however, in some protists as many as sixty cisternae have been observed. This collection of cisternae is broken down into *cis*, medial, and *trans* compartments, making up two main networks: the **cis Golgi network** (CGN) and the **trans Golgi network** (TGN). The CGN is the first cisternal structure, and the TGN is the final, from which proteins are packaged into vesicles destined to lysosomes, secretory vesicles, or the cell surface. The TGN is usually positioned adjacent to the stack, but can also be separate from it. The TGN may act as an early endosome in yeast and plants.

There are structural and organizational differences in the Golgi apparatus among eukaryotes. In some yeasts, Golgi stacking is not observed.

The Golgi apparatus tends to be larger and more numerous in cells that synthesize and secrete large amounts of substances; for example, the antibody-secreting plasma B cells of the immune system have prominent Golgi complexes.

In all eukaryotes, each cisternal stack has a ***cis*** **entry face** and a ***trans*** **exit face**. These faces are characterized by unique morphology and biochemistry. Within individual stacks are assortments of enzymes responsible for selectively modifying protein cargo. These modifications influence the fate of the protein. The compartmentalization of the Golgi apparatus is advantageous for separating enzymes, thereby maintaining consecutive and selective processing steps: enzymes catalyzing early modifications are gathered in the *cis* face cisternae, and enzymes catalyzing later modifications are found in *trans* face cisternae of the Golgi stacks.

# Vesicular transport

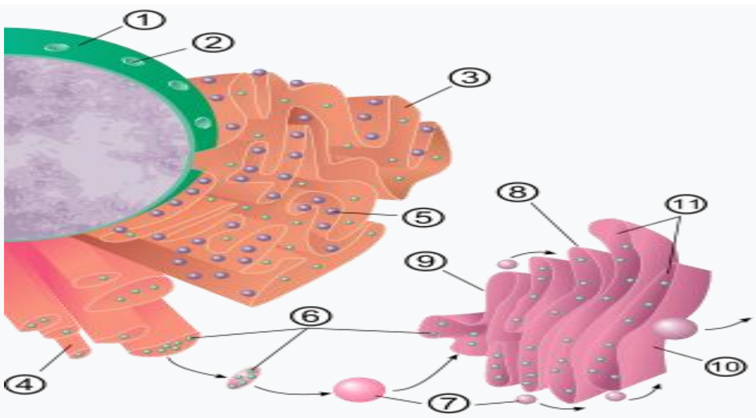
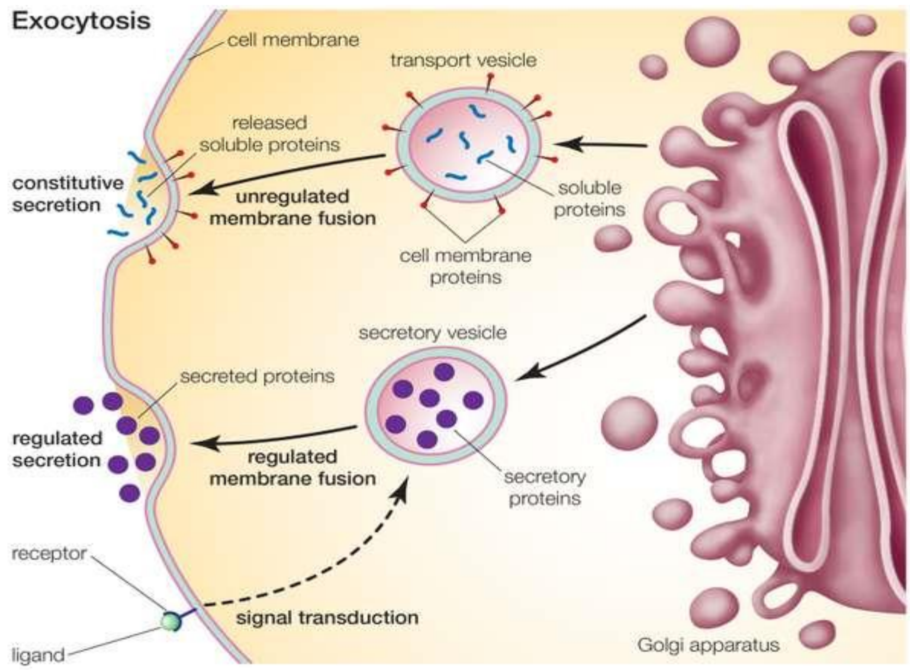



Diagram of secretory process from endoplasmic reticulum (orange) to Golgi apparatus (magenta). 1. Nuclear membrane; 2. Nuclear pore; 3. Rough endoplasmic reticulum (RER); 4. Smooth endoplasmic reticulum (SER); 5. Ribosome attached to RER; 6. Macromolecules; 7. Transport vesicles; 8. Golgi apparatus; 9. *Cis* face of Golgi apparatus; 10. *Trans* face of Golgi apparatus; 11. Cisternae of the Golgi Apparatus

The vesicles that leave the rough endoplasmic reticulum are transported to the *cis* face of the Golgi apparatus, where they fuse with the Golgi membrane and empty their contents into the lumen. Once inside the lumen, the molecules are modified, then sorted for transport to their next destinations.

Those proteins destined for areas of the cell other than either the endoplasmic reticulum or the Golgi apparatus are moved through the Golgi cisternae towards the *trans* face, to a complex network of membranes and associated vesicles known as the *trans-Golgi network* (TGN). This area of the Golgi is the point at which proteins are sorted and shipped to their intended destinations by their placement into one of at least three different types of vesicles, depending upon the signal sequence they carry.





## Golgi Apparatus Function:

1. Golgi apparatus is the major site of synthesis of carbohydrates
2. These are organelles to where the newly synthesized proteins are transferred and temporarily stored.
3. Small vesicles generate peripherally by a pinching – off process.
4. Golgi Apparatus small vacuoles in which secretory products are concentrated help in the synthesis of carbohydrates.
5. The Golgi bodies also play a significant role in the production of proteoglycans.
6. The proteoglycans are those molecules that are present in the extracellular matrix of the animal cells and play a vital role for the mechanical support to the cell.
7. The Golgi bodies help in the process of the sulfation process of many important molecules.

8. Golgi apparatus provide ATP for the process of phosphorylation of molecules.
9. Glycosylation occurs in the Golgi apparatus.
10. Golgi bodies help is lipids transportation.
11. The enzymes of the cisternae have the high ability to adjust or modify proteins by the addition of carbohydrates and phosphate by the process of glycosylation and phosphorylation respectively.