

**CELL BIOLOGY &
PHYSIOLOGY**

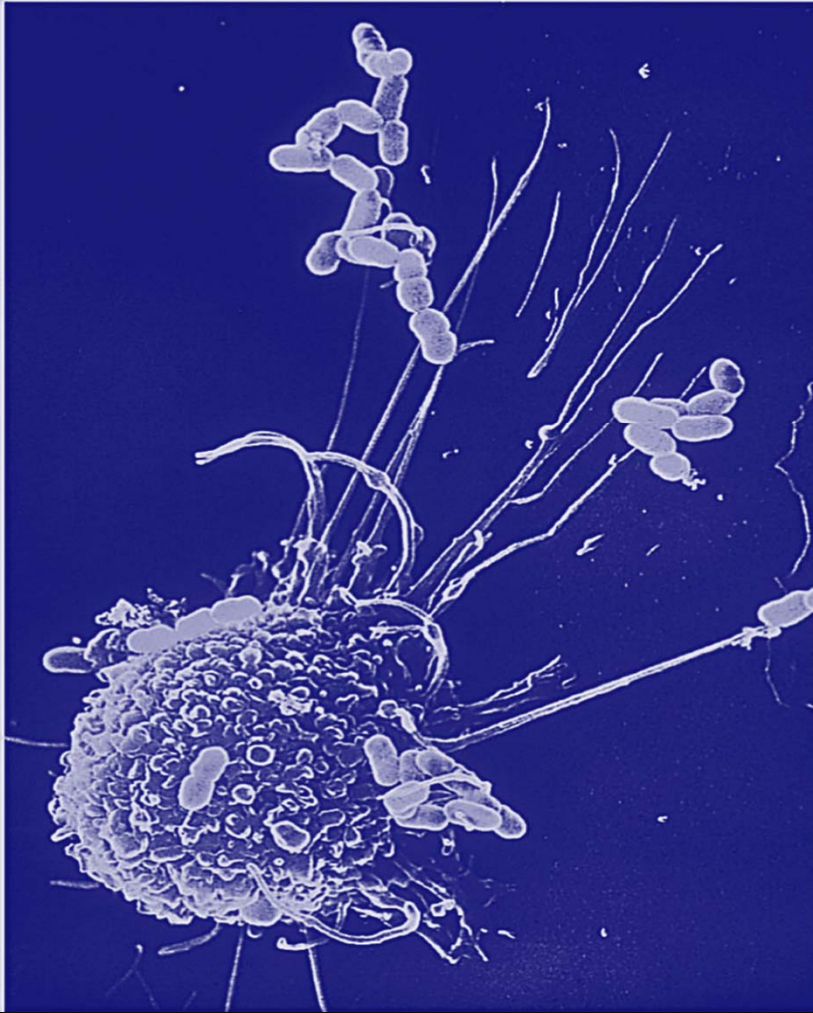
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**Cell Biology and Physiology
ZOO (242)**



Cell organelles in term of structure and function

Endomembrane system •



Introduction

- The **endomembrane system** regulates protein traffic and performs metabolic functions in the cell. The tasks of the endomembrane system include synthesis of proteins and their transport into membranes and organelles or out of the cell, metabolism and movement of lipids, and detoxification of poisons.
- The endomembrane system includes the nuclear envelope, endoplasmic reticulum, Golgi apparatus, lysosomes, vacuoles, and plasma membrane.





Learning objectives

- List the components of the endomembrane system.
- Compare the structure and functions of smooth and rough ER.
- Explain the significance of the *cis* and *trans* sides of the Golgi apparatus.
- Describe the cisternal maturation model of Golgi function.





Components of the endomembrane system:

- Nuclear envelope
- Endoplasmic reticulum
- Golgi apparatus
- Lysosomes
- Vacuoles
- Plasma membrane
- These components are either continuous or connected via transfer by vesicles

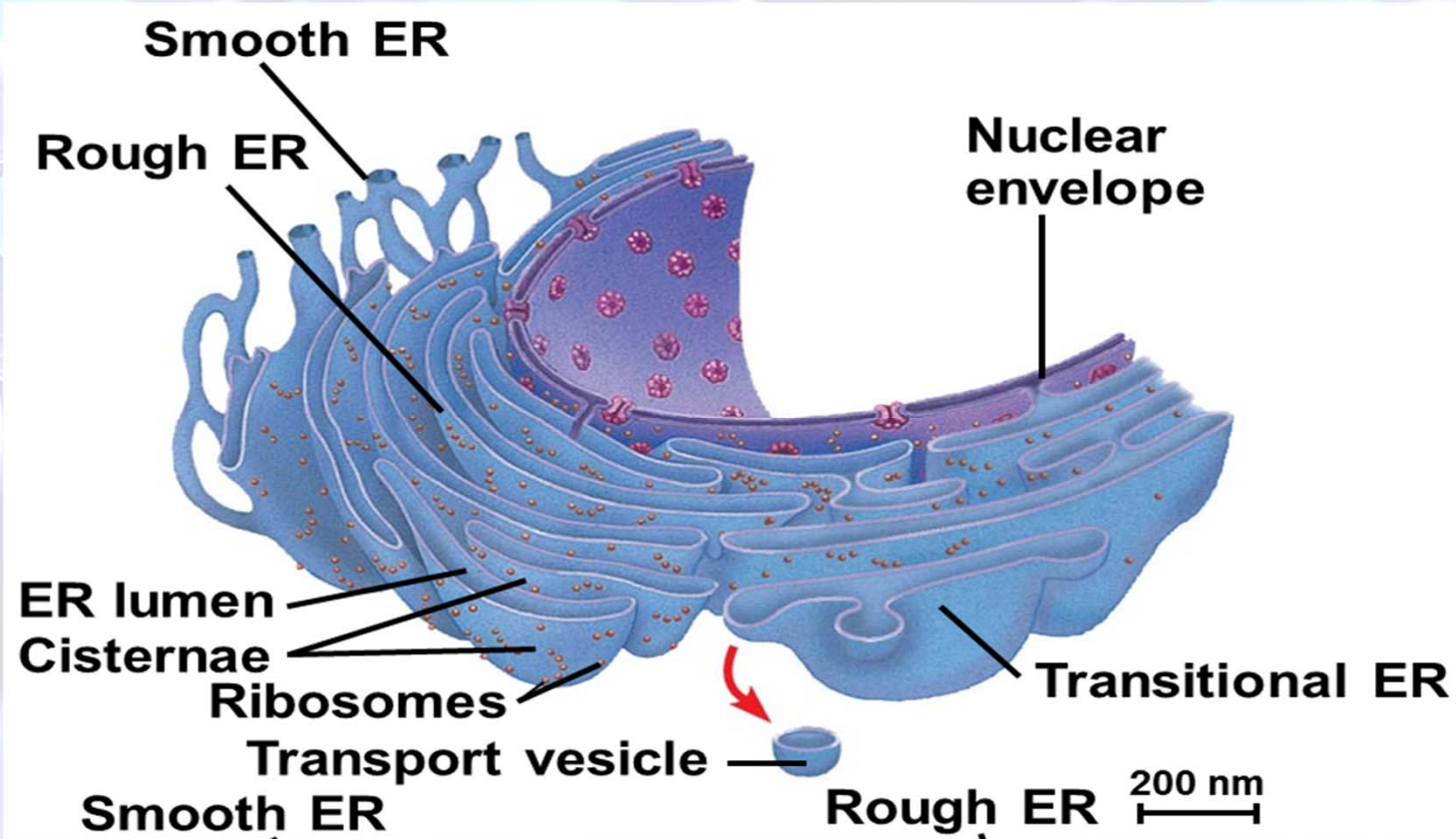




The Endoplasmic Reticulum: Biosynthetic Factory

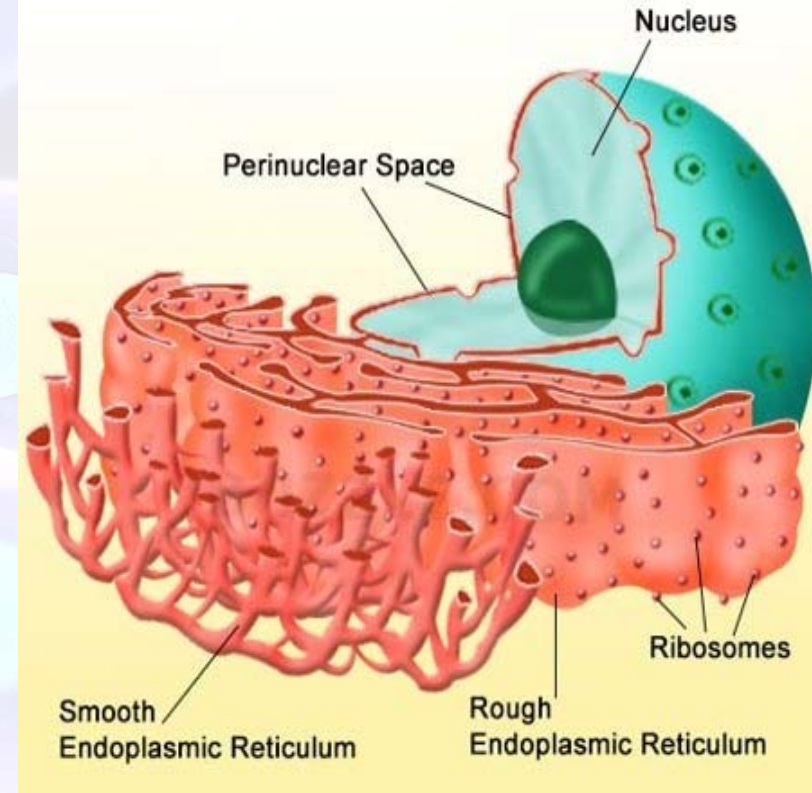
- The word endoplasmic means “within the cytoplasm,” and reticulum is Latin for “little net.”)
- The endoplasmic reticulum (ER) is such an extensive network of membranes that it accounts for more than half the total membrane in many eukaryotic cells.
- The ER consists of a network of membranous tubules and sacs called **cisternae**.
- The ER membrane separates the internal compartment of the ER, called the ER lumen (cavity) or cisternal space, from the cytosol. And because the ER membrane is continuous with the nuclear envelope, the space between the two membranes of the envelope is continuous with the lumen of the ER.







- There are two distinct, though connected, regions of the ER that differ in structure and function: Smooth ER and rough ER.
- **Smooth ER** is so named because its outer surface lacks ribosomes.
- **Rough ER** is dotted with ribosomes on the outer surface of the membrane and thus appears rough through the electron microscope





Functions of smooth ER

- Smooth ER is rich in enzymes and plays a role in a variety of metabolic processes, including
- **Synthesis of lipids:** Enzymes of smooth ER synthesize lipids, including oils, phospholipids, and steroids. Among the steroids produced by the smooth ER in animal cells are the sex hormones of vertebrates and the various steroid hormones secreted by the adrenal glands. Smooth ER is also site for the **metabolism of carbohydrates**
- **Detoxification of drugs and poisons:** In the smooth ER of the liver, enzymes help detoxify poisons and drugs such as alcohol. Frequent use of these drugs leads to the proliferation of smooth ER in liver cells, increasing the rate of detoxification. Detoxification usually involves adding **hydroxyl** groups to drug molecules, making them more soluble and easier to flush from the body.
- **Smooth ER stores calcium ions:** Muscle cells have a specialized smooth ER that pumps calcium ions from the cytosol into the ER lumen. When a nerve impulse stimulates a muscle cell, calcium ions rush from the ER into the cytosol, triggering contraction of the muscle cell.





Function of rough ER

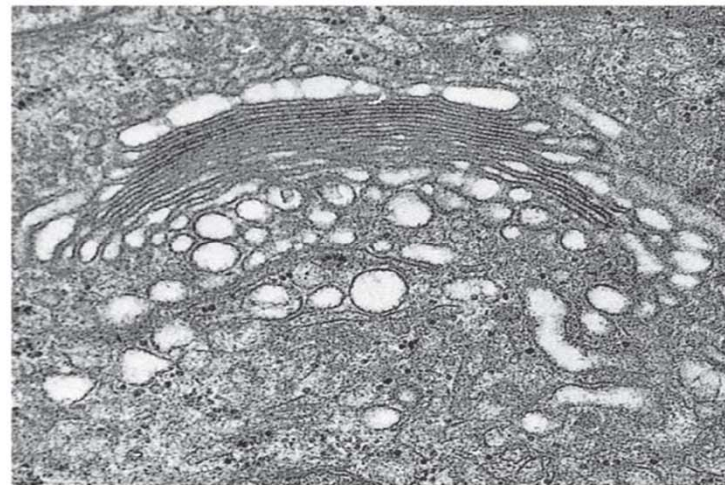
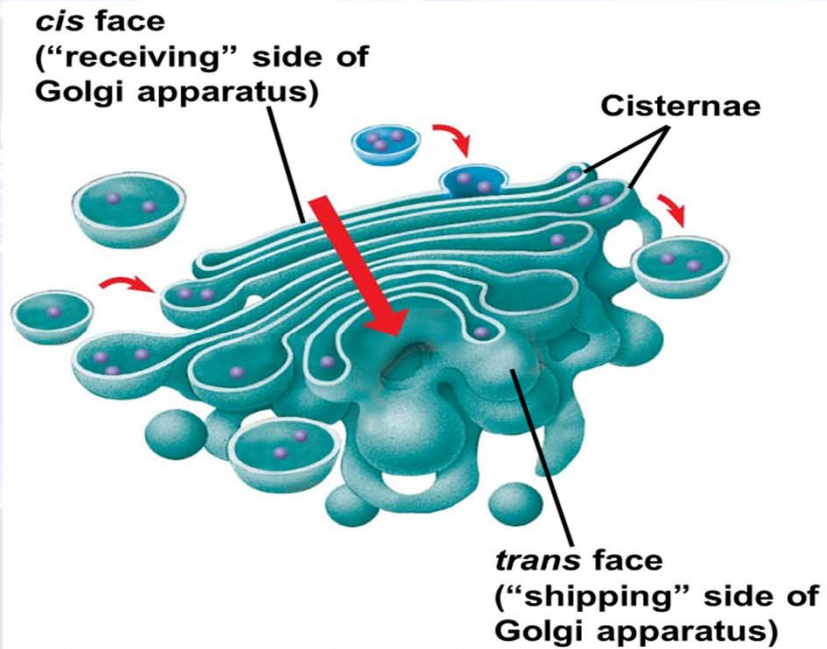
- **Secretion of proteins:** Rough ER is especially abundant in cells that secrete proteins. Certain cells in the pancreas secrete the hormone insulin into the bloodstream.
- As a polypeptide chain grows from a bound ribosome, it makes its way into the ER lumen through a pore formed by a protein complex in the ER membrane.
- Most secretory polypeptides are glycoproteins (proteins to which a carbohydrate is attached), the carbohydrate is attached to the protein in the ER by specialized molecules built into the ER membrane.
- After secretory proteins are formed, the ER membrane keeps them separate from proteins that are produced by free ribosomes and that will remain in the cytosol.
- Secretory proteins are packaged in transport vesicles that bud from a specialized region called **transitional ER**. Transport vesicles carry proteins from one part of the cell to another.





Golgi Apparatus

The Golgi apparatus is the shipping and receiving center for cell products.



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- The **Golgi apparatus** consists of flattened membranous sacs called cisternae.
- **Functions of the Golgi apparatus:**
 - Modifies products of the ER
 - Manufactures certain macromolecules
 - Sorts and packages materials into transport vesicles
- Many transport vesicles from the ER travel to the Golgi apparatus for modification of their contents.
- The Golgi apparatus is a center of manufacturing, warehousing, sorting, and shipping.
- Some products of the ER are modified and stored and then sent on.
- The Golgi apparatus is especially extensive in cells specialized for secretion.





- The membrane of each cisterna separates its internal space from the cytosol.
- One side of the Golgi apparatus, the *cis* face, is located near the ER. The *cis* face receives material by fusing with transport vesicles from the ER.
- The other side, the *trans* face, buds off vesicles that travel to other sites.
- Products from the ER are usually modified during their transit from the *cis* to the *trans* region of the Golgi apparatus.





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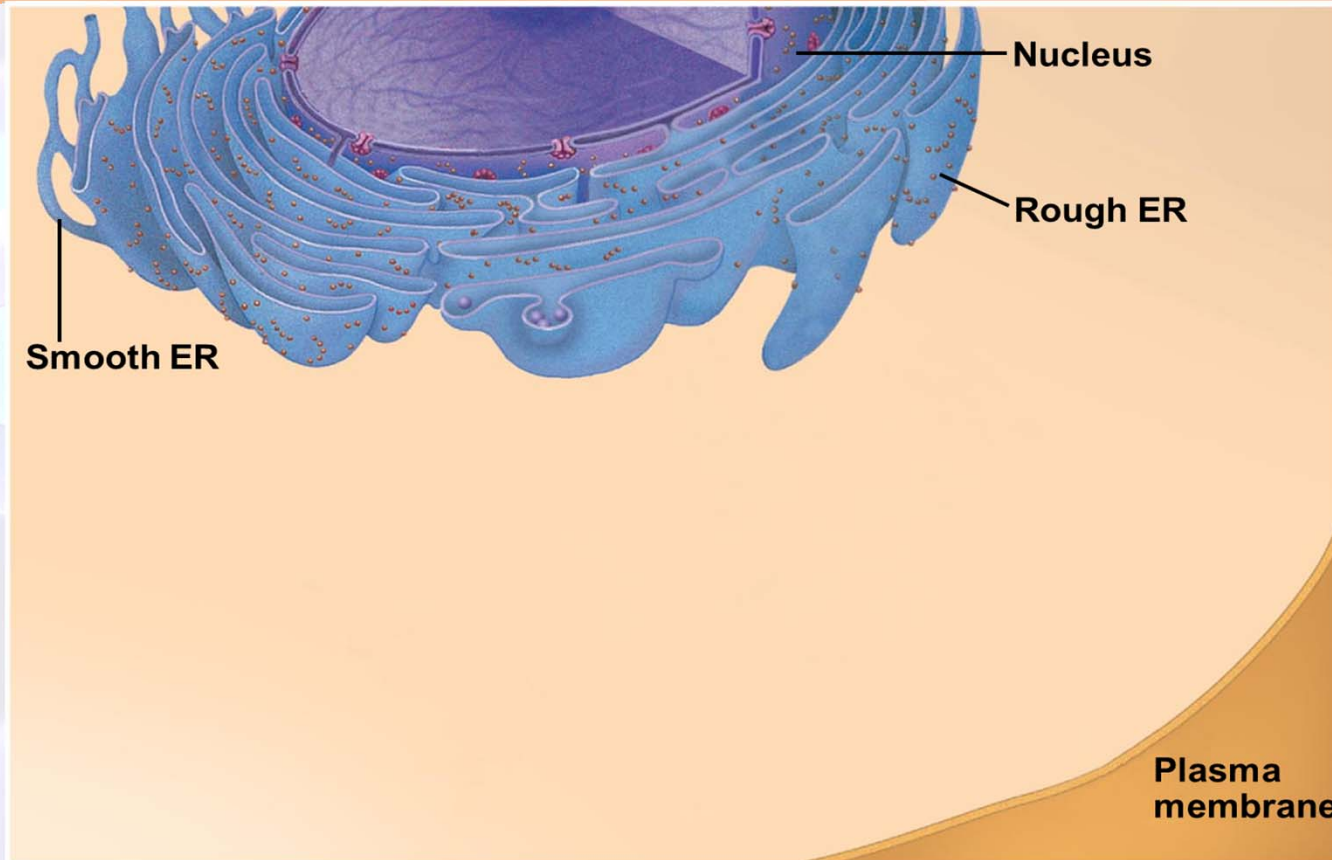
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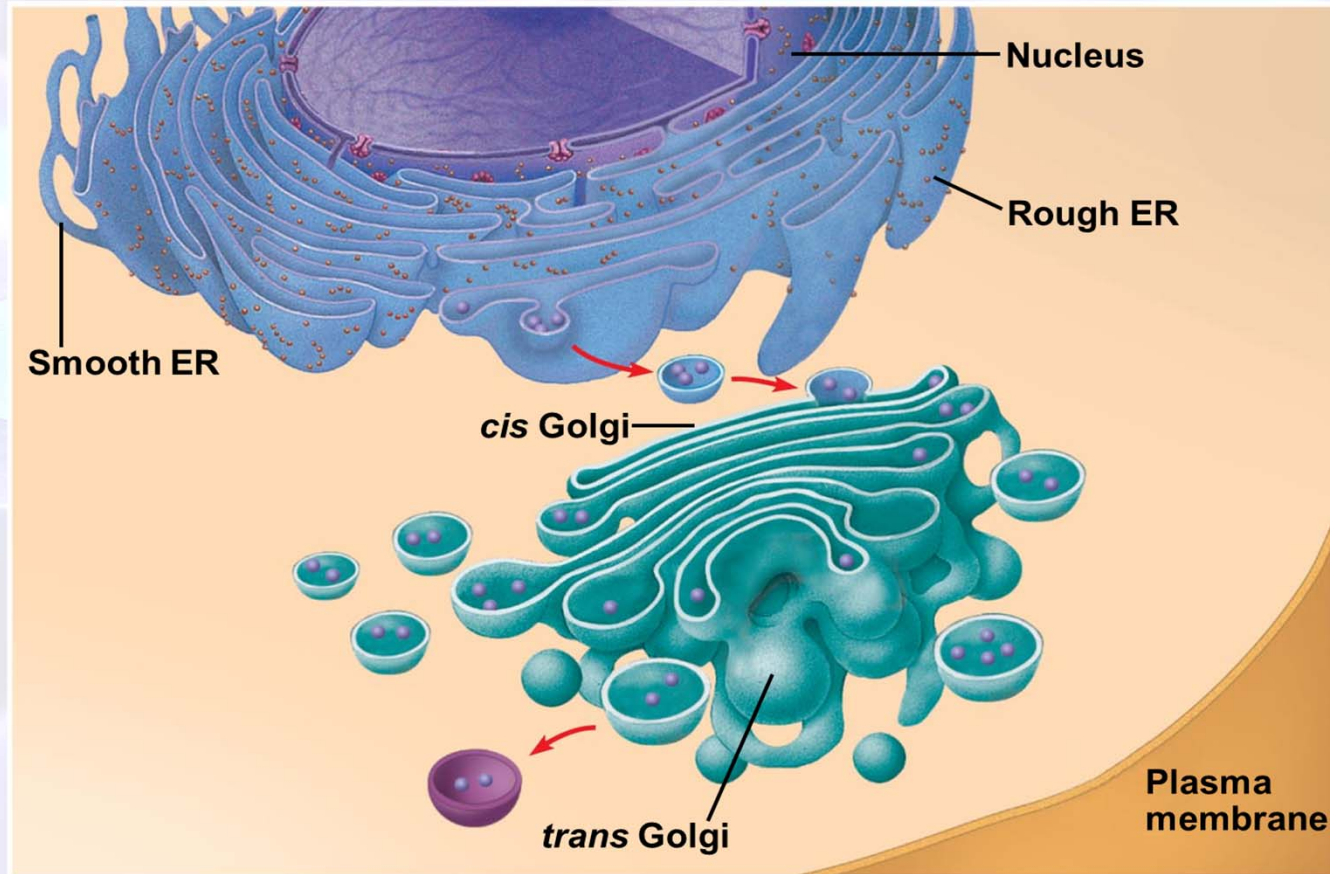
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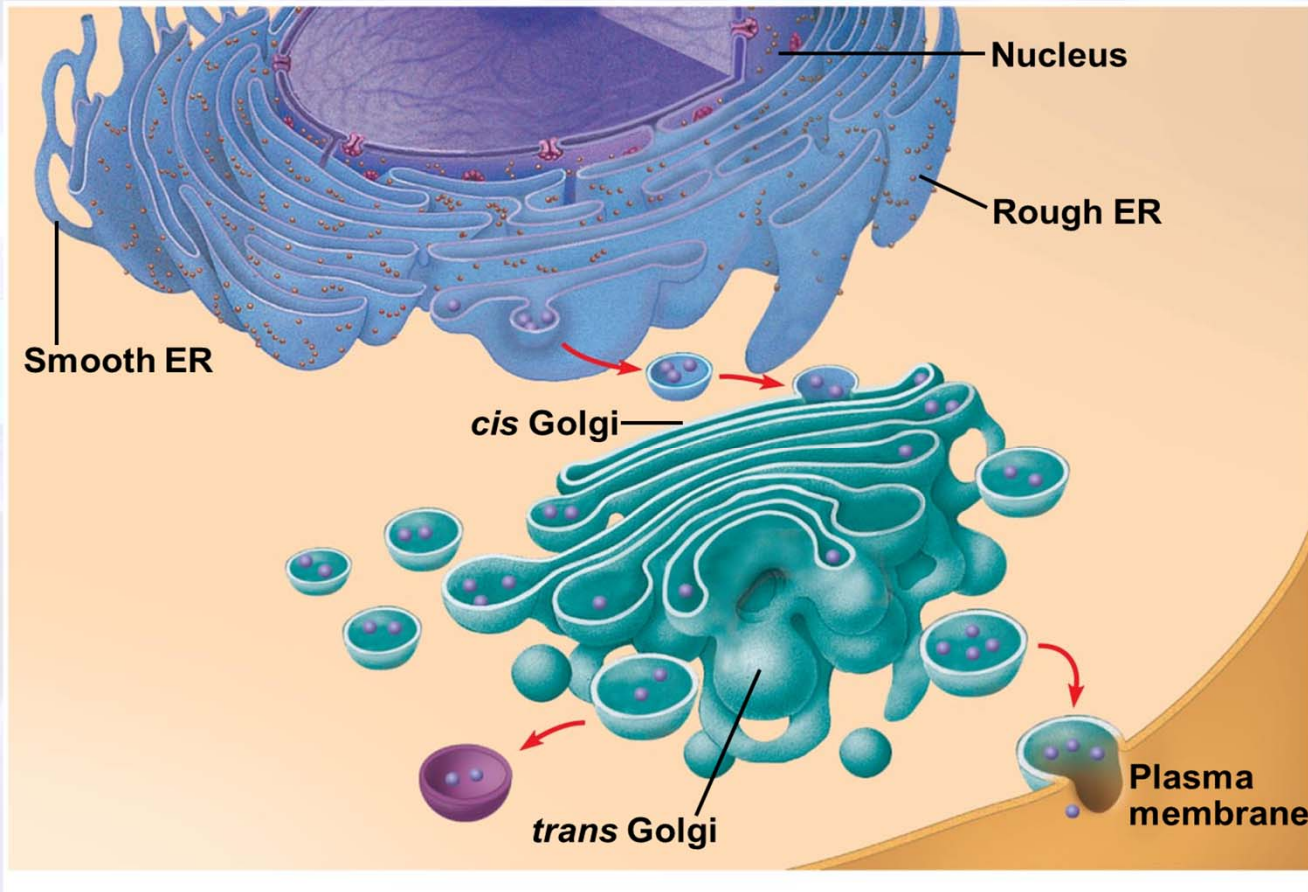
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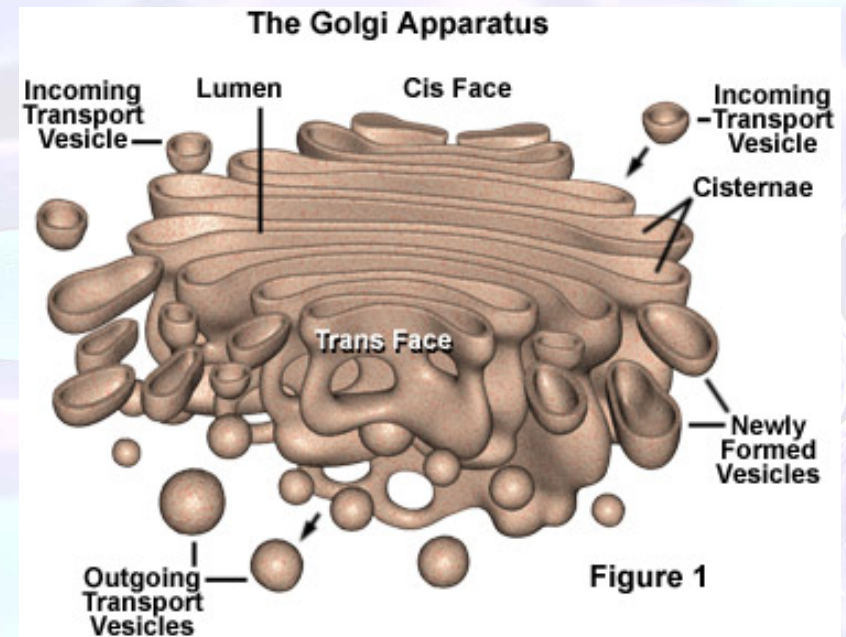




- the Golgi apparatus is often the distributing and shipping cell's products.
- It modifies proteins and lipids that have been built in the endoplasmic reticulum and prepares them for export outside of the cell or for transport to other locations in the cell.
- Proteins and lipids built in the smooth and rough endoplasmic reticulum bud off in tiny bubble-like vesicles that move through the cytoplasm until they reach the Golgi complex.
- The vesicles fuse with the Golgi membranes and release their internally stored molecules into the organelle.
- Once inside, the compounds are further processed by the Golgi apparatus, which adds molecules or chops tiny pieces off the ends. When completed, the product leaves the GA in a vesicle and directed to its final destination inside or outside the cell.
- The exported products are secretions of proteins or glycoproteins that are part of the cell's function in the organism.



Proteins, carbohydrates, phospholipids, and other molecules formed in the endoplasmic reticulum are transported to the Golgi apparatus to be biochemically modified during their transition from the *cis* to the *trans* poles of the complex. Enzymes present in the Golgi lumen modify the carbohydrate (or sugar) portion of glycoproteins by adding or subtracting individual sugar monomers. In addition, the Golgi apparatus manufactures a variety of macromolecules on its own, including a variety of polysaccharides.





Summary

- The endomembrane system regulates protein traffic and performs metabolic functions in the cell.
- **Endoplasmic reticulum**; Extensive network of membrane bounded tubules and sacs; membrane separates lumen from cytosol; continuous with nuclear envelope.
- **Smooth ER**: synthesis of lipids, metabolism of carbohydrates, Ca²⁺ storage, detoxification of drugs and poisons
- **Rough ER**: aids in synthesis of secretory and other proteins from bound ribosomes; adds carbohydrates to proteins to make glycoproteins; produces new membrane.
- **Golgi apparatus**: Stacks of flattened membranous sacs; has polarity (*cis* and *trans* faces). Modification of proteins, carbohydrates on proteins, and phospholipids; synthesis of many polysaccharides; sorting of Golgi products, which are then released in vesicles.





Resources

- **Biology by Jane B Reece; Neil A Campbell; et al** Boston : Benjamin Cummings / Pearson, ©2011. English : 9th ed. chapter 06
- **Video Source** <https://www.youtube.com/watch?v=rvfvRgk0MfA>

