CELL BIOLOGY - 2

Cell Membrane

- Cell membranes are crucial to the life of the cell.

- The plasma membrane encloses the cell, defines its boundaries and maintains the essential differences between the cytosol and the extracellular environment.

- The membranes of the Endoplasmic reticulum, Golgi apparatus, Mitochondria and other membrane-enclosed organelles maintain the characteristics differences between the contents of each organelle and the cytosol.

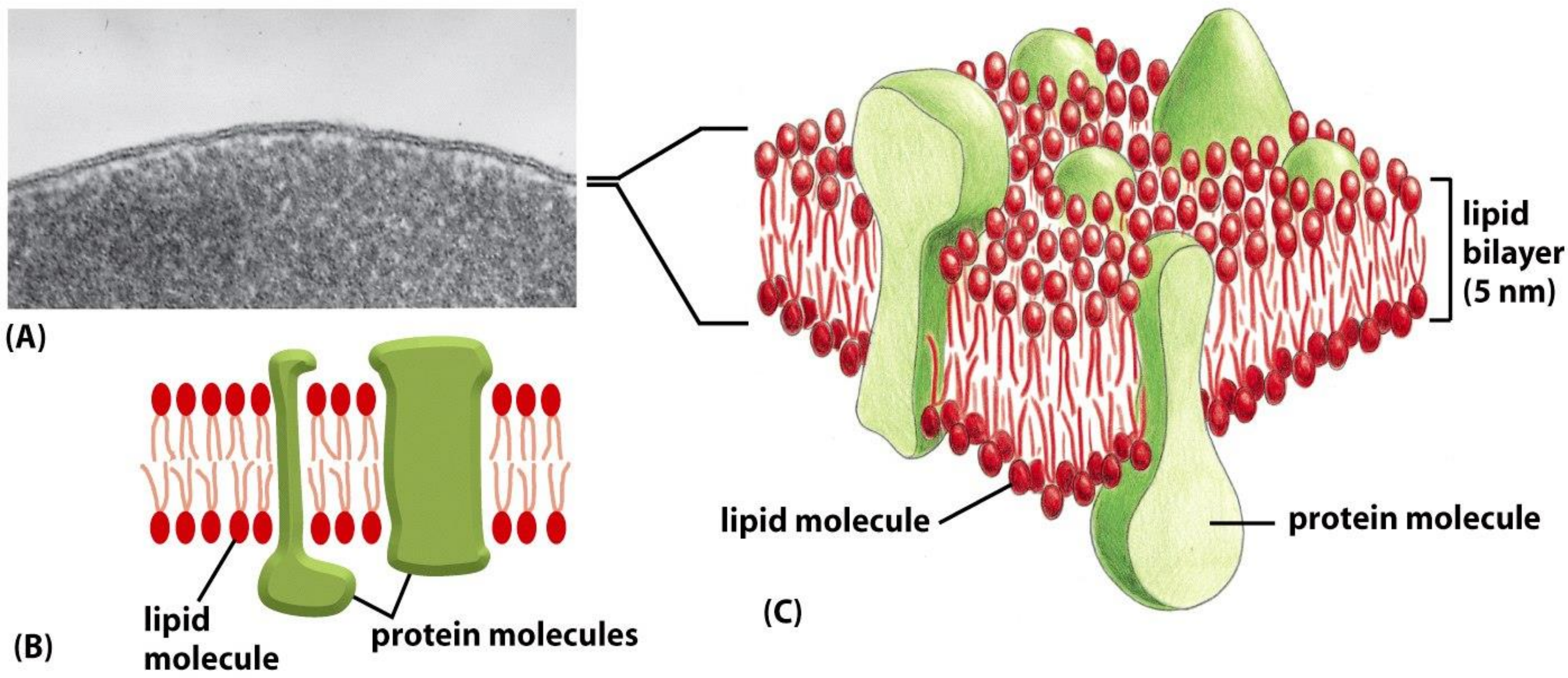
Cell Membrane

- Membranes act in transmembrane movement of selected molecules – membrane transport. Membrane serves as a selectively permeable barrier - which allows the free passage of some molecules, but restricts the entry of other molecules.

- Membrane takes part in ATP synthesis and in production and transmission of electrical signals in nerve/muscle cells.

- The plasma membrane also contains proteins that act as sensors/receptors of external signals, allowing the cell to change its behavior in response to environmental factors, including signals from other cells. These protein sensors/receptors transfer information across the membrane.

Membrane Structure



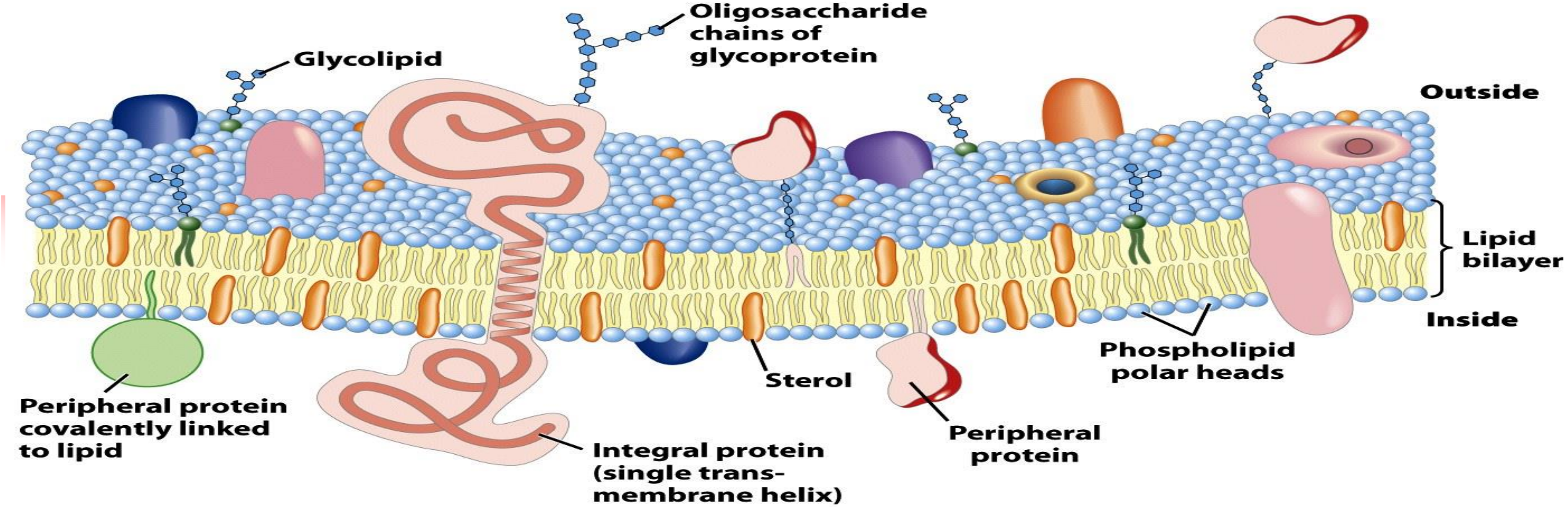


Figure 11-3
Lehninger Principles of Biochemistry, Fifth Edition

All biological membranes have a common general structure:

- **Membranes are very thin film - about 5 to 8 nm thick - made up of lipid and protein molecules - held together mainly by noncovalent interactions.**

- **Cell membranes are dynamic, fluid structures. Most of their molecules can move about in the plane of the membrane.**

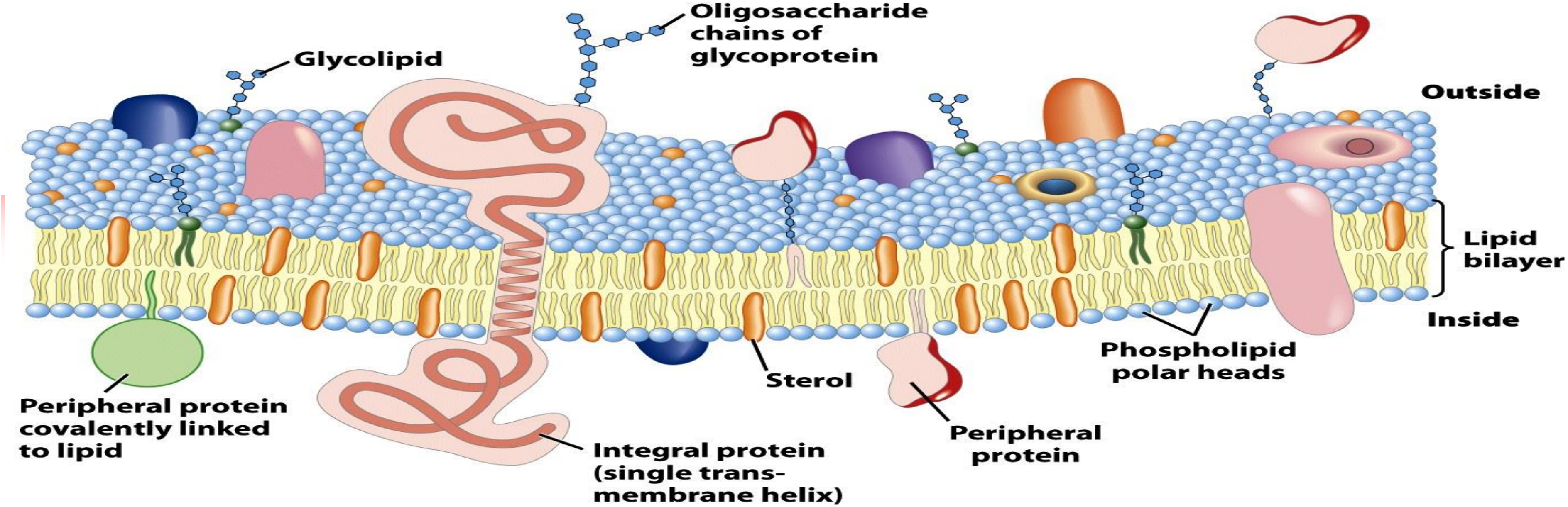


Figure 11-3
Lehninger Principles of Biochemistry, Fifth Edition

- **The lipid molecules are arranged as a continuous double layer forming lipid bilayer, which provides the basic fluid structure of the membrane.**

- **Membranes are impermeable to most polar (water soluble) or charged solutes, but permeable to nonpolar compounds. The lipid bilayer serves as the relatively impermeable barrier to the passage of most water soluble molecules.**

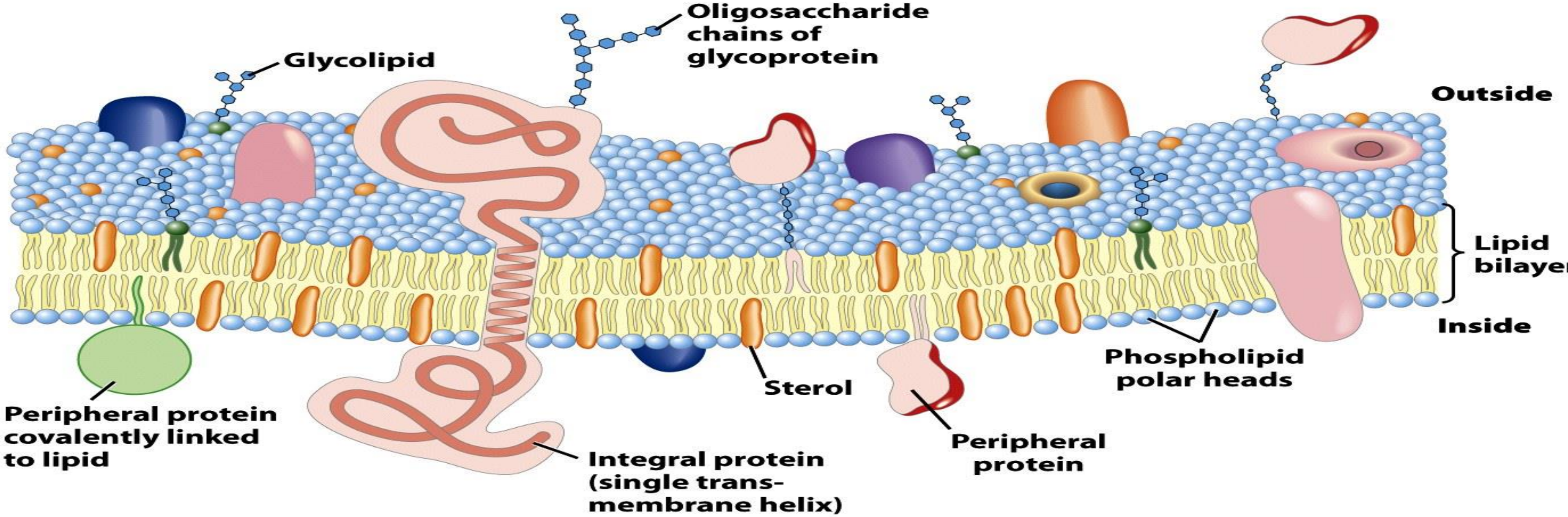


Figure 11-3
Lehninger Principles of Biochemistry, Fifth Edition

- **Phospholipids and sterols are the major lipids in cell membrane – the most abundant lipids are the phospholipids.**

- **All the lipid molecules in cell membrane are amphiphilic – that is they have a hydrophilic (water-loving) or polar end and a hydrophobic (water-fearing) or nonpolar end.**

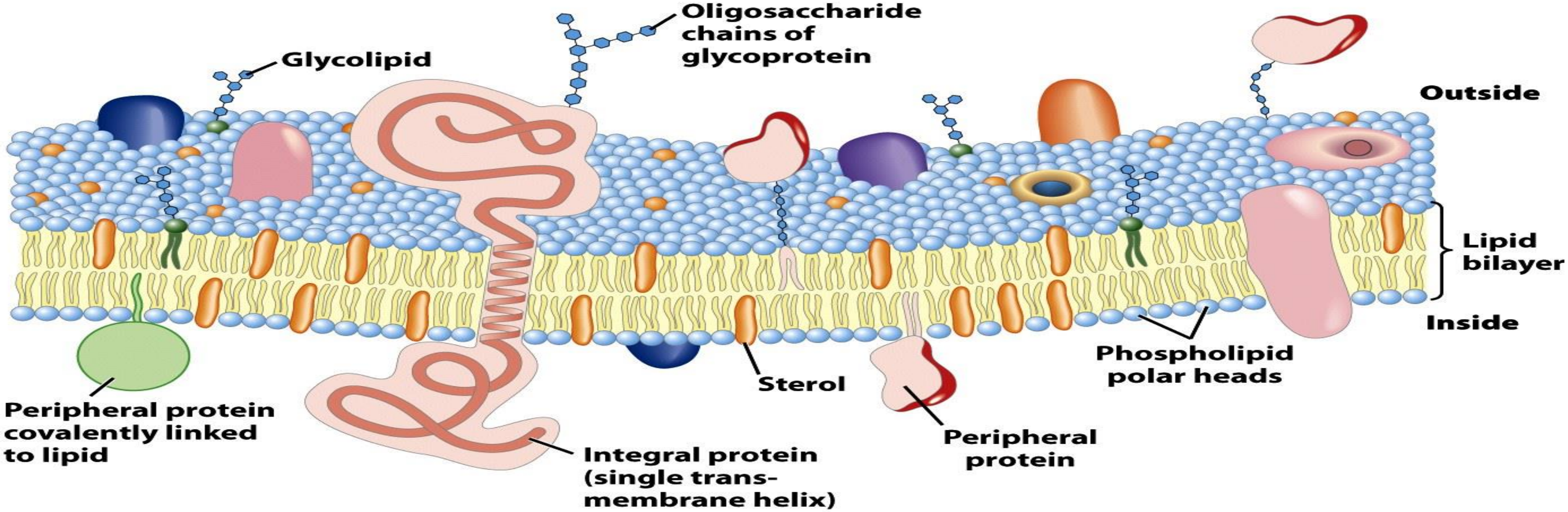


Figure 11-3
Lehninger Principles of Biochemistry, Fifth Edition

- **Phospholipids form the bilayer in which the nonpolar, hydrophobic fatty acid tails of the phospholipid molecules in each layer face the core of the bilayer.**

- **Their polar, hydrophilic head groups face outward, interacting with the aqueous phase on either side of the cell. Carbohydrate groups may be attached with some lipids – glycolipids.**

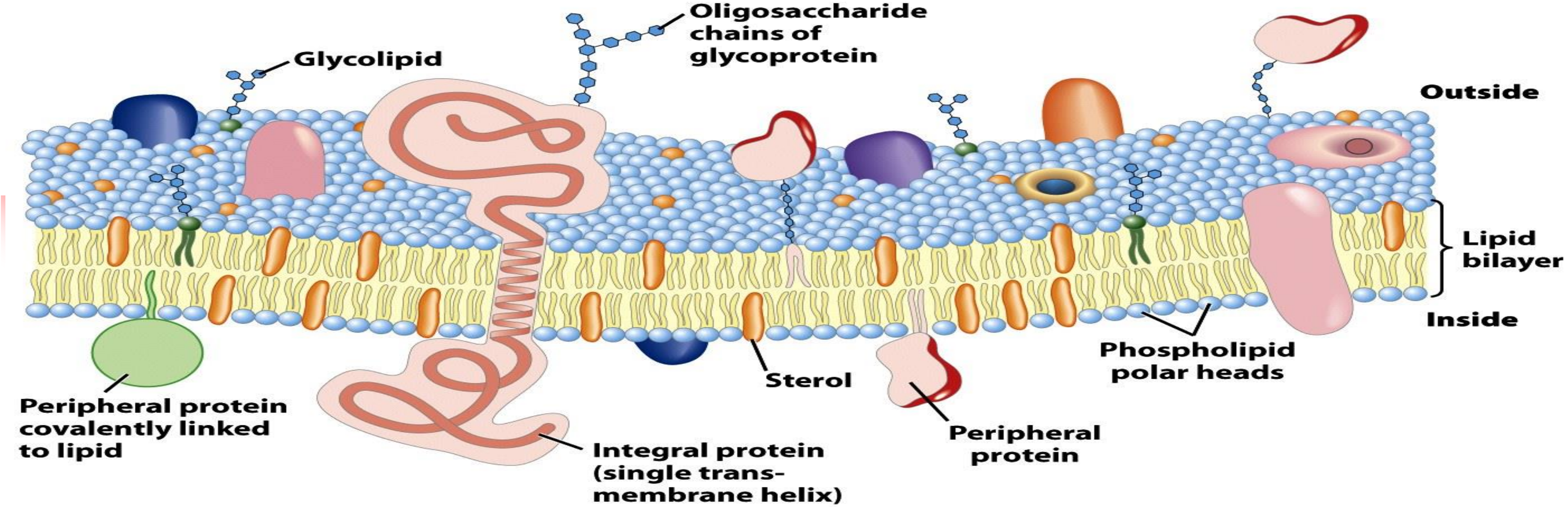


Figure 11-3
Lehninger Principles of Biochemistry, Fifth Edition

- **Two types of membrane proteins are associated with the membrane: Integral membrane proteins, Peripheral membrane proteins. Peripheral proteins are loosely attached to the lipid layer.**

- **Integral proteins are amphitropic – having both hydrophilic and hydrophobic domains. These proteins are held by hydrophobic interactions between the membrane lipids and the hydrophobic domains of the proteins. Carbohydrate groups may be attached with some proteins – glycoproteins.**

3 most important functions of cell membrane

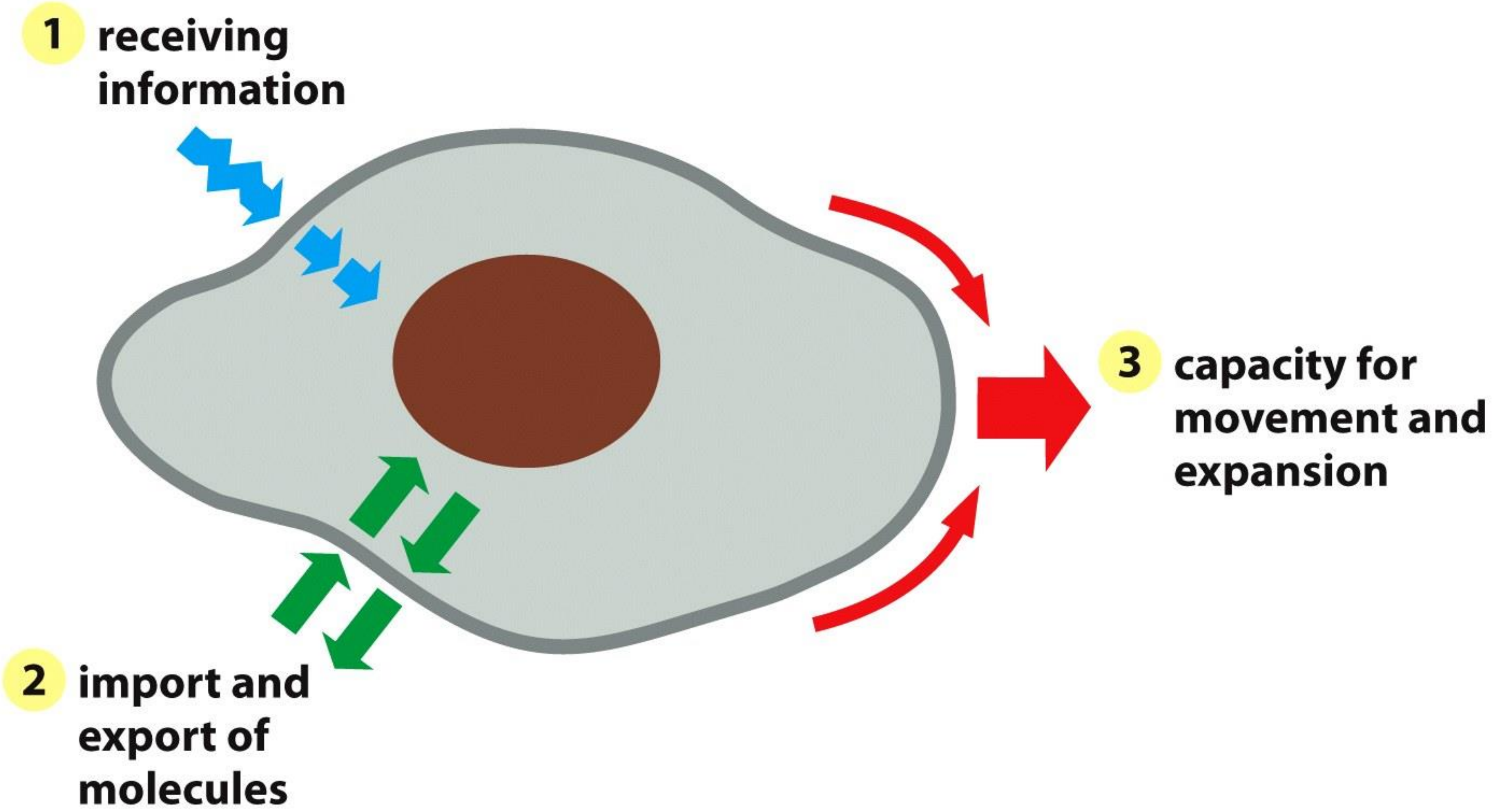
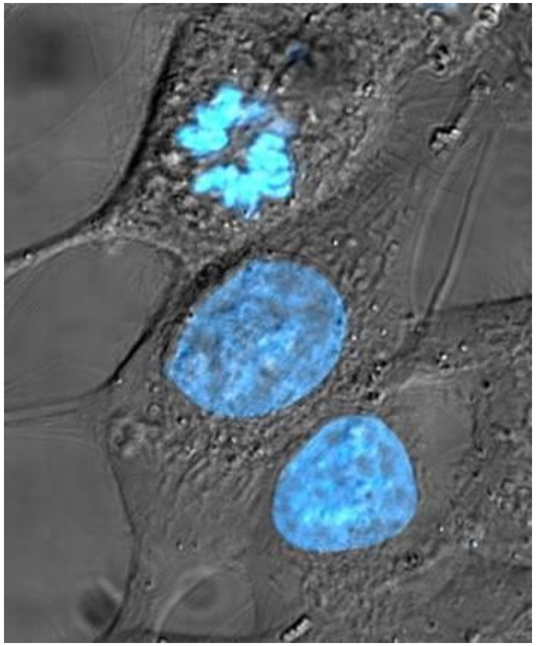
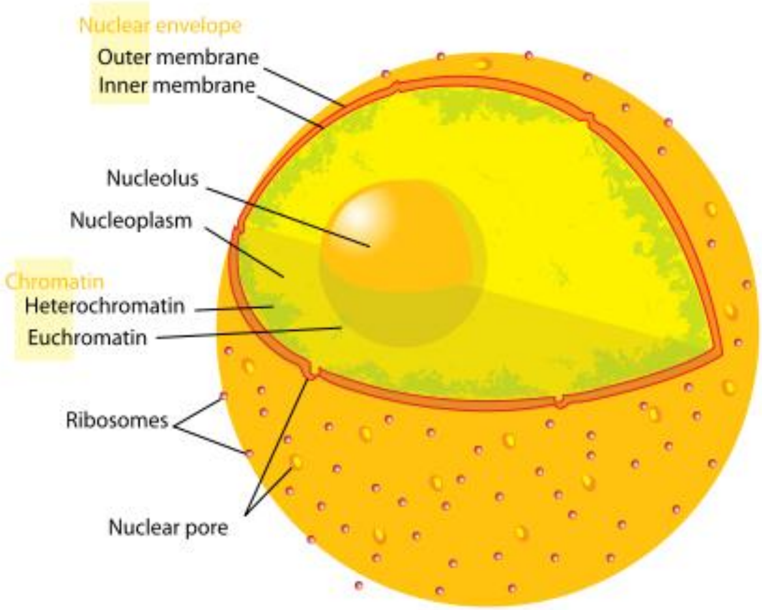


Figure 11-2 *Essential Cell Biology* (© Garland Science 2010)

The Nucleus – contains the genome and is the principal site of DNA and RNA synthesis

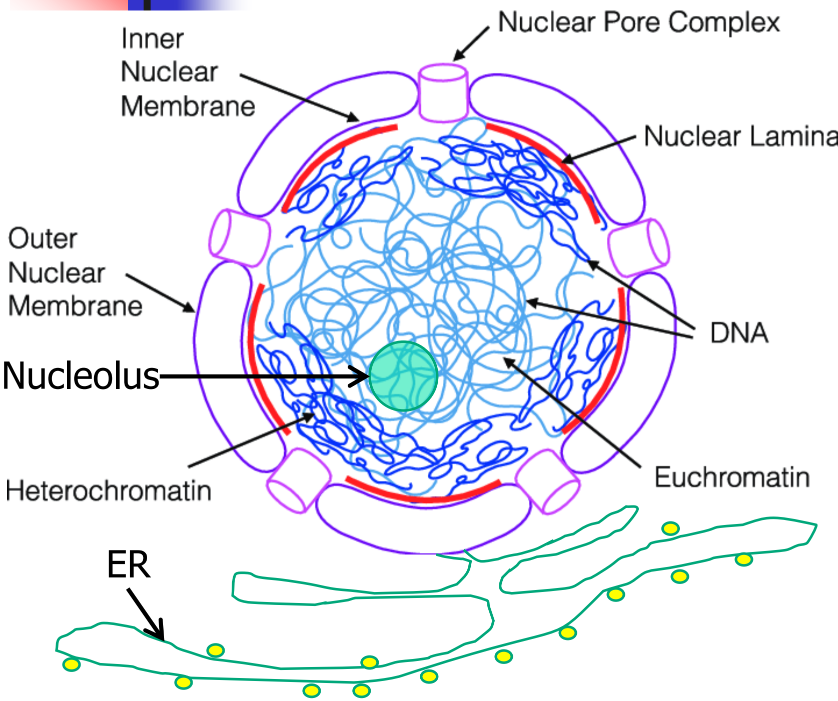


Cells stained with DNA staining Blue Hoechst Dye



The eukaryotic cell nucleus

Structure and functions of nucleus



Structure:

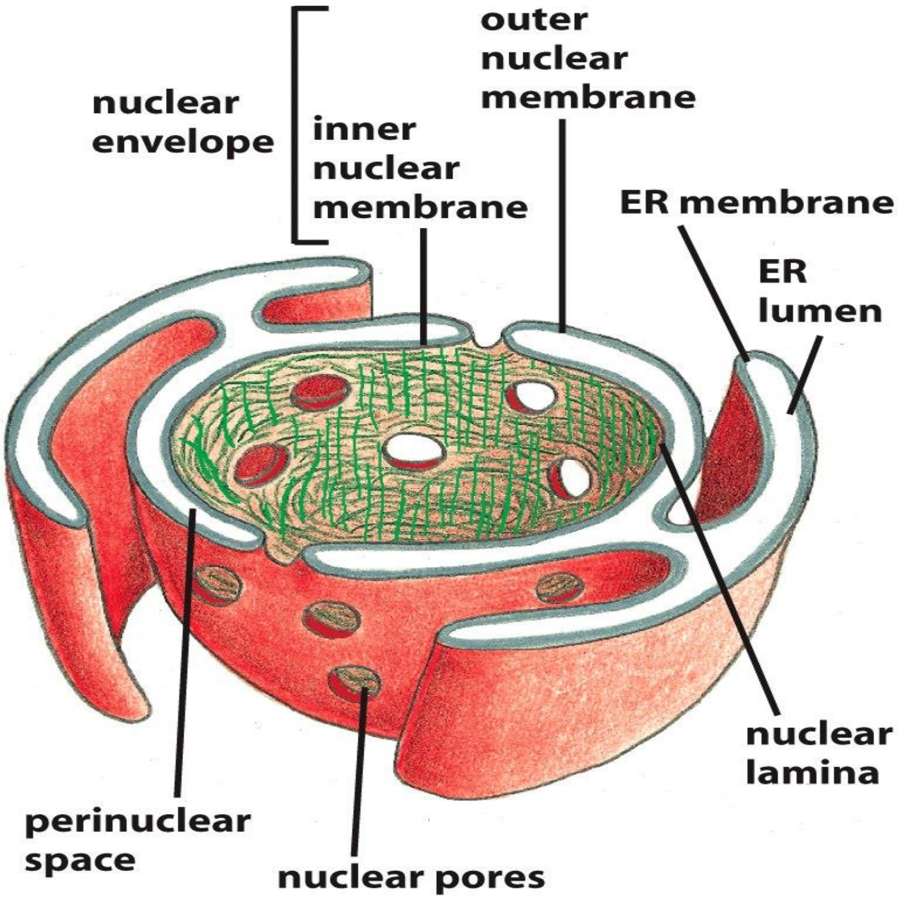
1. The single nucleus is usually the largest organelle in a cell.
2. The nucleus is surrounded by two membranes, which together form the nuclear envelope. The nuclear envelope is continuous with the endoplasmic reticulum.
3. Nuclear envelop is perforated by nuclear pores which connect the interior of the nucleus with the cytoplasm. RNA and proteins pass through these pores to enter or leave the nucleus.
4. Inside the nucleus, DNA combines with proteins to form a fibrous complex called **chromatin**. Chromatin consists of exceedingly long, thin, entangled threads. Prior to cell division, the chromatin aggregates to form discrete, readily visible condensed structures called **chromosomes**.
5. Surrounding the chromatin are water and dissolved substances collectively referred to as the **nucleoplasm**.

Functions:

1. **The nucleus is the site of DNA duplication (replication)**
2. **The nucleus is the site of RNA synthesis (transcription) and genetic control of the cell's activities.**
3. **A region within the nucleus, the nucleolus, is the ribosome factory.**

The Nuclear Envelope

- Encloses the DNA and defines the nuclear compartment
- Consists of 2 concentric membranes – inner and outer. INM is surrounded by the ONM, which is continuous with the ER membrane
- Double membrane envelope is perforated by nuclear pore complexes. ONM is studded with ribosomes engaged in protein synthesis.
- Perinuclear space – the space between the INM and ONM – continuous with the ER lumen
- Proteins made on the ribosomes are transported into the perinuclear space
- INM contains specific proteins – anchoring sites for chromatin and for nuclear lamina.
- Nuclear lamina - fibrous meshwork, made up of proteins underlying the INM - provides structural support to the nuclear envelope



A small portion of the Nuclear Envelope showing nuclear pore complexes (NPC)

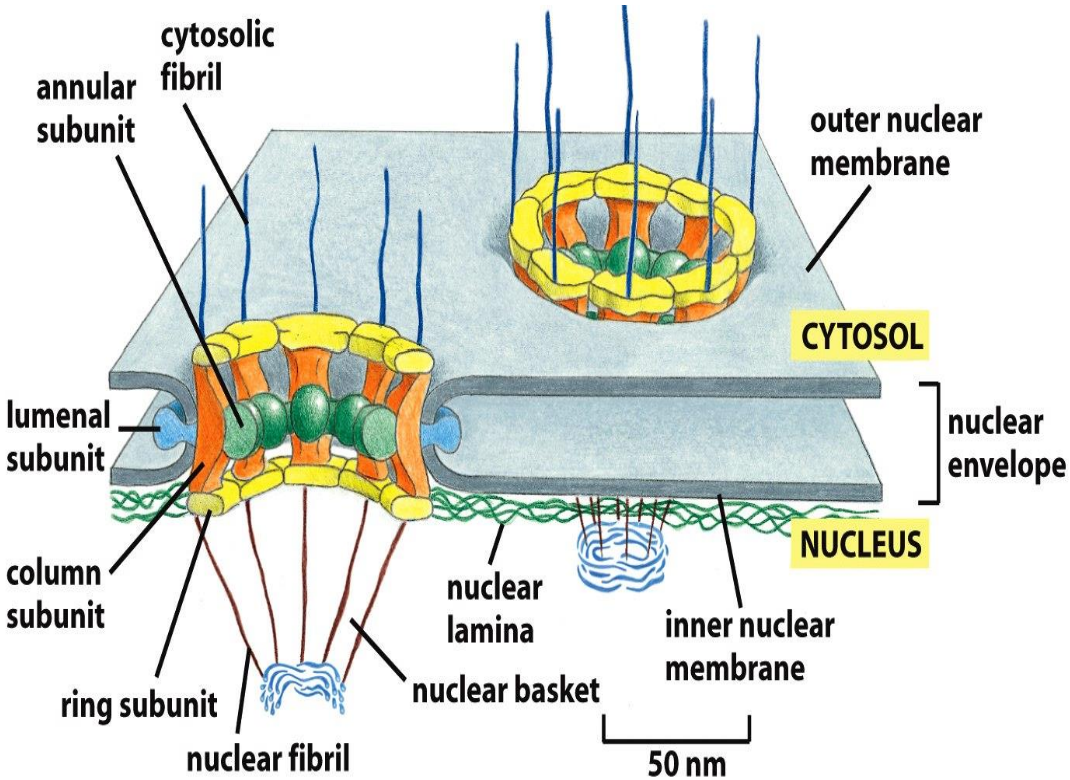


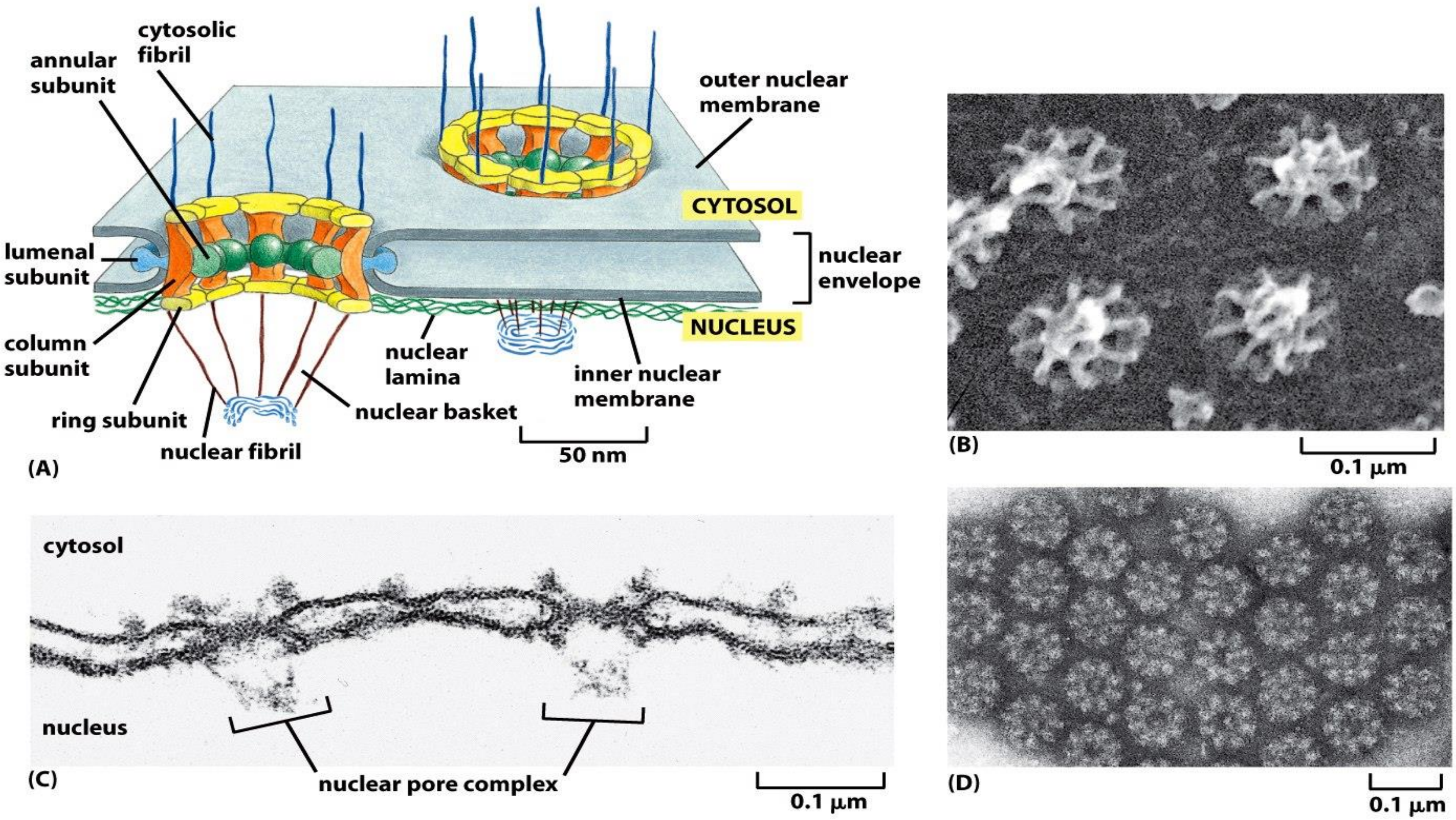
Figure 12-9a Molecular Biology of the Cell 5/e (© Garland Science 2008)

- **NPC perforate the nuclear envelope – composed of about 30 different proteins - the nucleoporins – present in multiple copies – arranged with octagonal symmetry. Estimated molecular mass is about 125 million Dalton**

- **NPC have 4 structural building blocks: column subunits – form the bulk of the pore wall; annular subunits – form the central ring like structure; lumenal subunits – transmembrane protein that anchor the NPC to the nuclear membrane; ring subunit – forms the cytosolic and nuclear faces of the complex.**

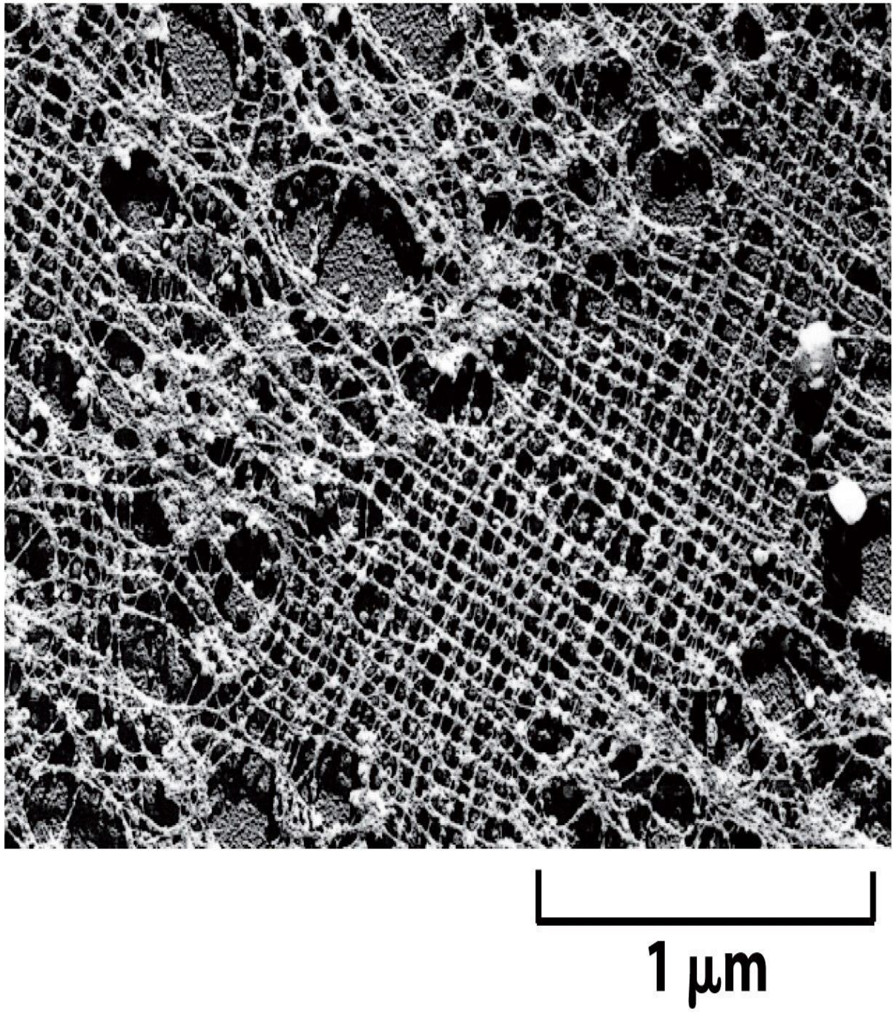
- **Fibrils protrude from both the cytosolic and nuclear side – on the nuclear side the fibrils converge to form basket like structure. Central core is made up of proteins – oriented symmetrically across the envelope.**

Electron Micrographs of Nuclear Envelope showing nuclear pore complexes (NPC)



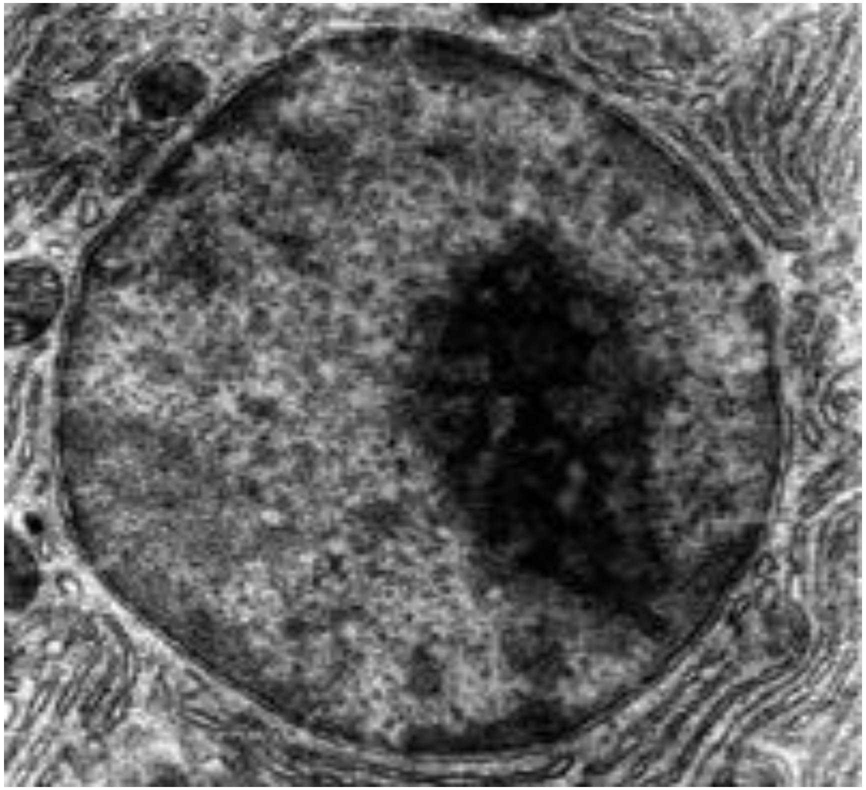
Nuclear Lamina

Nuclear lamina - fibrous meshwork, formed by a regular lattice of specialized intermediate filaments made up of proteins underlying the Inner Nuclear Membrane - provides structural support to the nuclear envelope



Nucleolus

The nucleolus is a discrete densely-stained structure found in the nucleus. It is not surrounded by a membrane, and is sometimes called a *sub-organelle*.

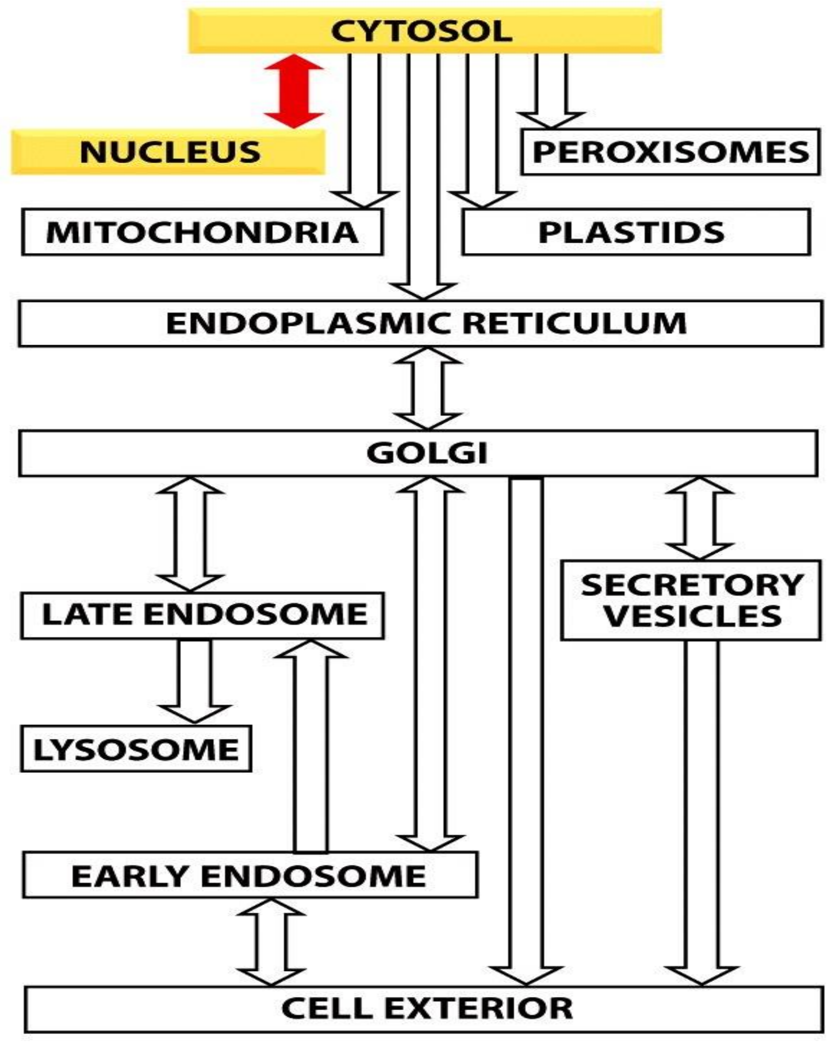


The main roles of the nucleolus are to synthesize rRNA and assemble ribosomes

Bidirectional transport occurs through NPC

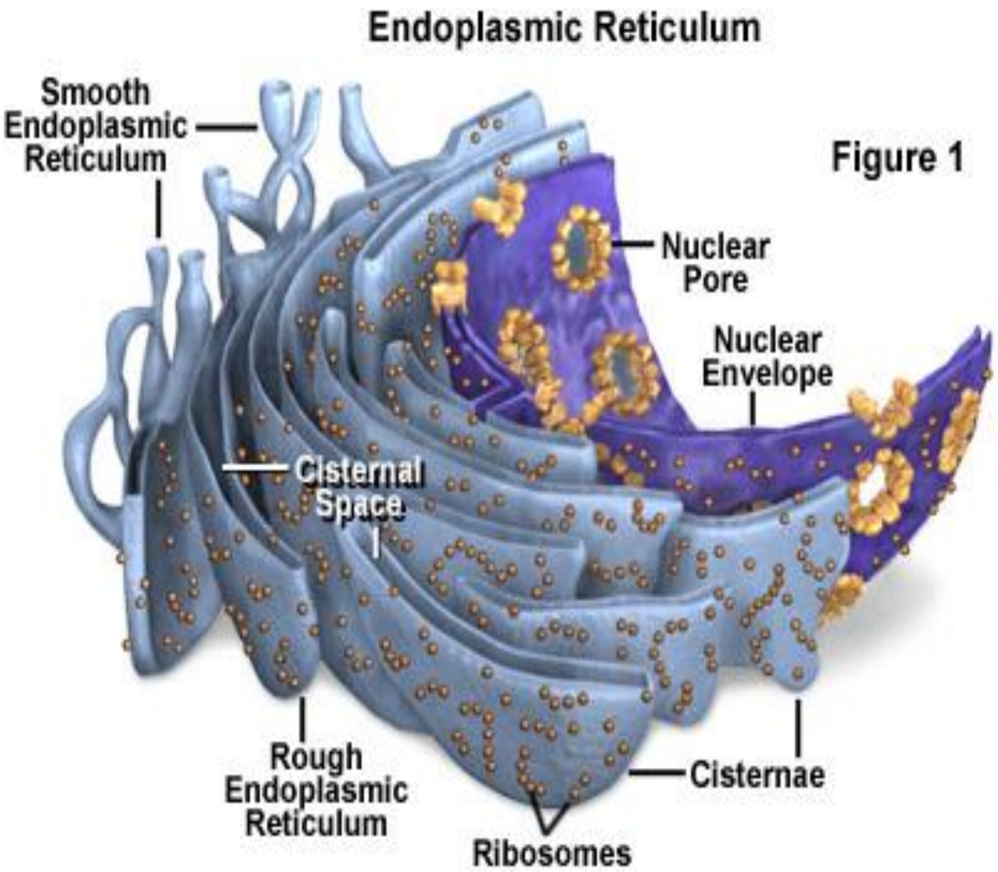
Bidirectional traffic of molecules occurs continuously between the cytosol and the nucleus through the NPCs.

Histones, DNA/RNA polymerase enzymes, gene regulatory proteins, RNA processing proteins – selectively imported into the nucleus from the cytosol, whereas, tRNAs and mRNAs are synthesized in the nucleus and exported to the cytosol.



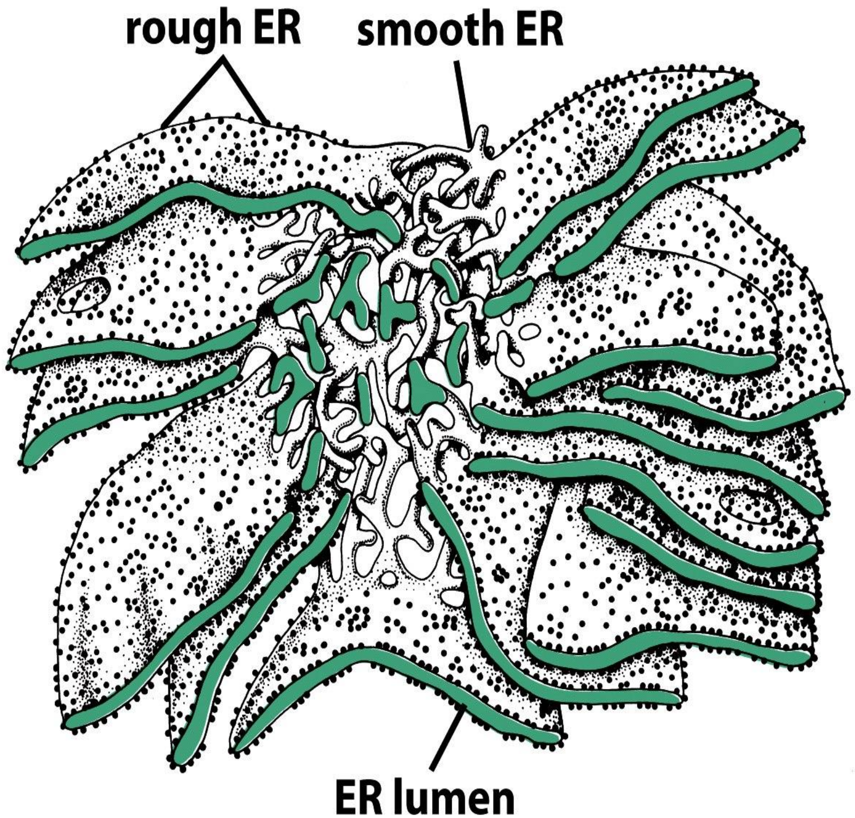
The Endoplasmic Reticulum

- The endoplasmic reticulum (ER) - a network of flattened sacs and branching tubules that extends throughout the cytoplasm in plant and animal cells.
- These sacs and tubules are all interconnected by a single continuous membrane so that the organelle has only one large, highly convoluted and complexly arranged lumen (internal space). Usually referred to as the endoplasmic reticulum cisternal space.
- The lumen of the organelle often takes up more than 10 percent of the total volume of a cell.
- Rough ER – ribosomes attached on the membrane. Smooth ER – no ribosome attached
- The endoplasmic reticulum manufactures, processes, and transports a wide variety of biochemical compounds (lipids, proteins) for use inside and outside of the cell.
- ER also serves as the intracellular store of the Ca ions that is used in cell signaling responses.

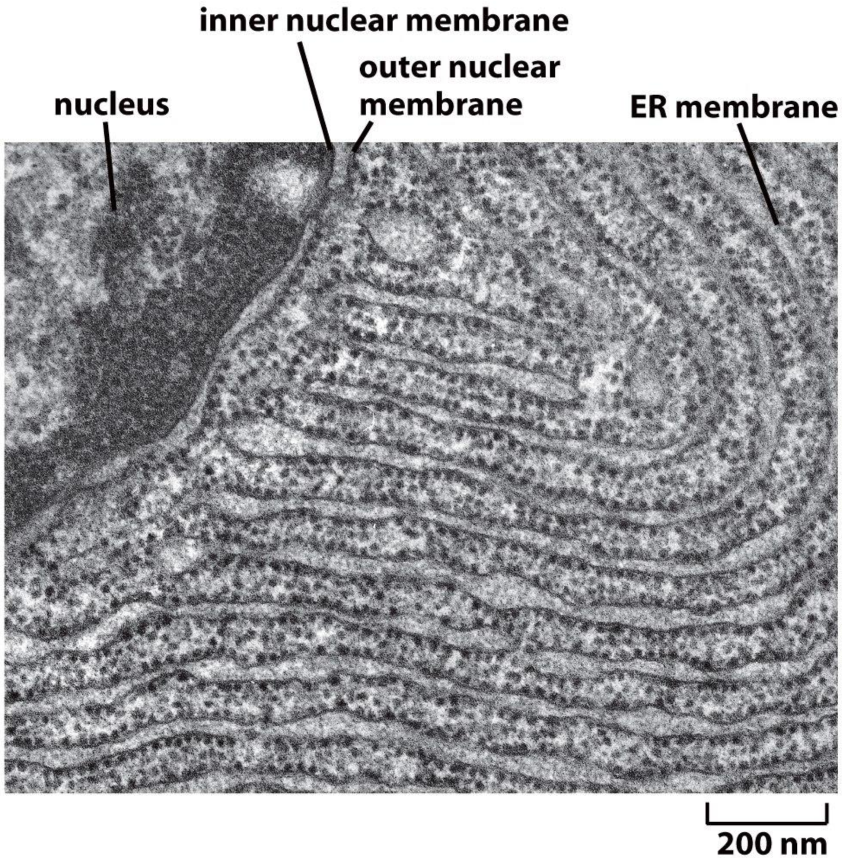


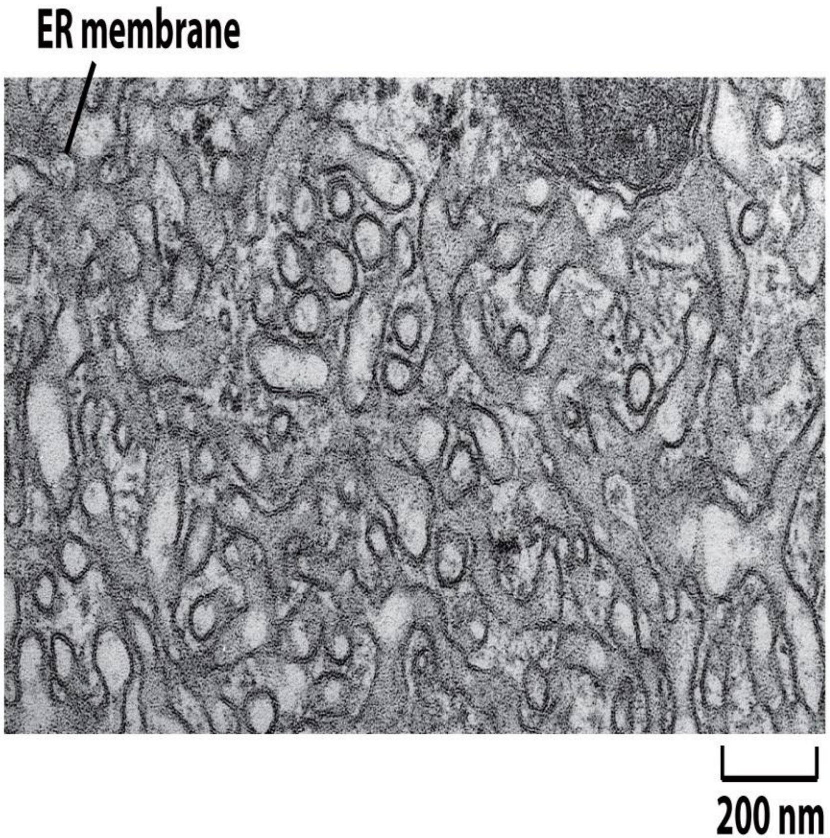
The Endoplasmic Reticulum

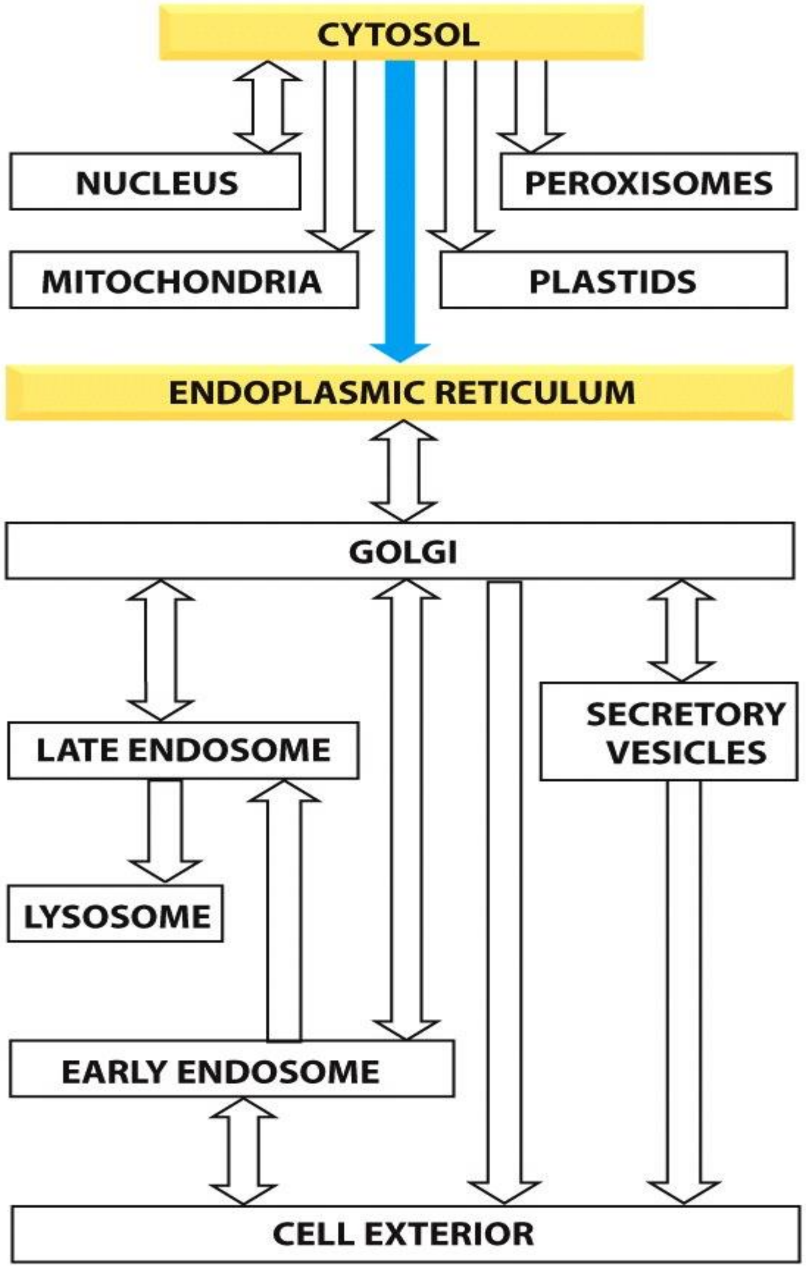
- Typically, the smooth ER is a tubule network and the rough ER is a series of flattened sacs.
- Proteins made on the rough ER's ribosomes end up in other organelles or are sent out of the cell to function elsewhere in the body. A few examples of proteins that leave the cell (called secreted proteins) are antibodies, insulin, digestive enzymes, and many hormones.
- *Smooth ER* has no ribosomes associated with it and has a very different function: synthesizes lipids and also contains enzymes that break down harmful substances.
- Most cell types have very little smooth ER, but some cells, such as those in the liver, which are responsible for neutralizing toxins – contain lots of it.



Electron micrograph of Endoplasmic Reticulum







The ER captures selected proteins from the cytosol as they are being synthesized. These proteins are of two types – transmembrane proteins, which are embedded in ER membrane and water soluble proteins, which are fully translocated across the ER membrane and are released into the ER lumen.

Some of the transmembrane proteins function in the ER , many are destined to reside in the plasma membrane or the membrane of other organelle.

The water soluble proteins are destined either for secretion or for residence in the lumen of an organelle

All of these proteins, regardless of their subsequent fate, are directed to the ER

Translocated polypeptide chains fold and assemble in the lumen of the rough ER.

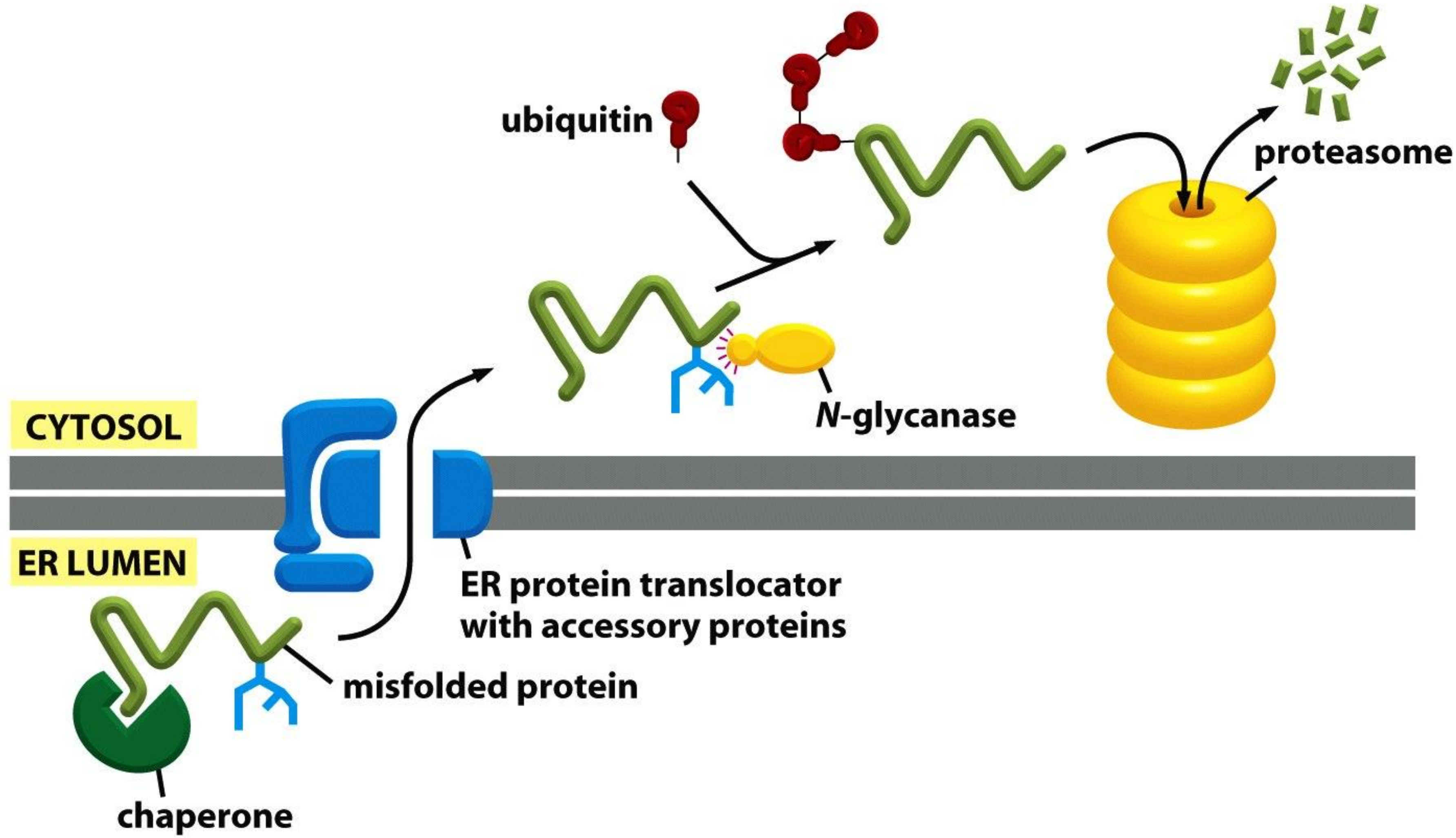
Many of the proteins in the lumen of the ER are in transit, en-route to other destinations. Some proteins normally reside in the lumen and are present at high concentrations.

Some of these resident proteins function as catalysts that help many proteins to fold and assemble correctly.

One important ER resident protein is protein disulfide isomerase (PDI), which helps in disulfide (S-S) bond formation between amino acids.

Another ER resident protein is the chaperone proteins, which can recognize incorrectly folded proteins, as well as subunits that have not yet assembled into their final oligomeric complexes. Improperly folded proteins are exported from the ER and degraded in the cytoplasm.

The ER assembles most lipid bilayers.



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