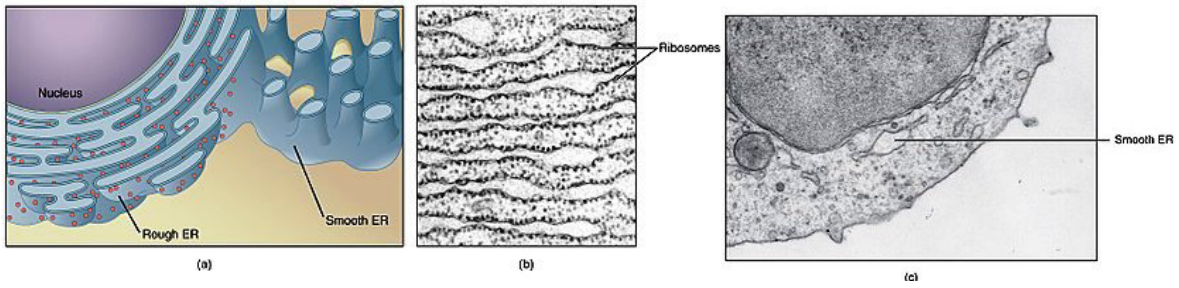
Endoplasmic reticulum

Endoplasmic reticulum (ER) is the largest, membrane-bound intracellular organelle found in eukaryotic cells (prokaryotes lack membrane-bound organelles). Electron microscope study reveals it as extensive membrane system and highly dynamic organelle in cytoplasm that radiates from the nuclear envelope towards the plasma membrane. It was first reported by Porter (1945). It is generally absent in egg and embryonic cells. Depending on the cell, endoplasmic reticulum may account for as much as 50 percent of the cell volume.

Endoplasmic reticulum is made up of a single, continuous membrane system andit is generally divided into three main parts; viz. Nuclear membrane, Tubular network and Cisternae.



Nuclear Envelope

The nuclear membrane is composed of two lipid bilayers that make the inner and outer nuclear membrane. Due to the continuity of the endoplasmic reticulum from the nuclear envelope, researchers agree that in eukaryotic organisms, the endoplasmic reticulum was present since development (from prokaryotic/ more primitive cells).

The morphology of nuclear membrane is maintained by protein linkers which are located in the perinuclear space (NS) maintain a distance of about 50nm between the outer and inner nuclear membrane. Protein linkers play an important role in maintaining the morphology of the nuclear membrane/envelope.

Apart from protein linkers, the structure of the nuclear envelope is also enhanced by a number of other molecules. Interactions between the proteins of the inner nuclear membrane and chromatin as well as lamin of the outer nuclear membrane and the nuclear pores have found to be necessary for the maintenance of the nuclear membrane.

Although nuclear envelope plays an important role in creating a barrier between the inner part of the nucleus and cytoplasm (in eukaryotic cells), it consists of hundreds of pores through which various molecules (e.g. proteins) are transported. This allows molecules to diffuse out of nucleus to cytoplasm where they may be involved in the development of different parts of the cell.

The rate of diffusion is largely dependent on the molecule size. For instance, whereas molecules up to 9nm in diameter can simple diffuse passively through the nuclear pore complexes, those with a diameter of about 39nm have to be actively transported (in or out of the nucleus).

Cisternae (ER Sheets)

Also known as an endoplasmic sheet, the cisternae is the section of the endoplasmic reticulum that makes up part of the peripheral ER. It appears as a series of stacked flat sheets. They are prominent around the nucleus as they radiate from the nuclear membrane/envelope.

Like the nuclear membrane, the endoplasmic sheets are also composed of two lipid bilayers as well as a lumen. The structure of this portion of the endoplasmic reticulum, including the curved regions at the membrane edges, is maintained by several proteins. A good example of this is the CLIMP63, a type II integral membrane protein.

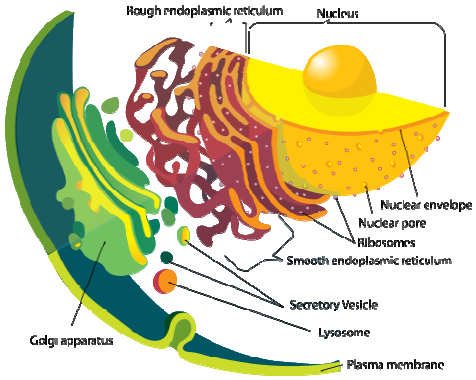
When ribosomes (and polyribosomes) localize to the sheets of the endoplasmic reticulum, these sheets are referred to as rough sheets, or more commonly, rough endoplasmic reticulum. Here, ribosomes are localized on the cytosolic surface which is the surface between outer membrane of endoplasmic reticulum and cytoplasm. There are about 1000 ribosomes per square micrometer of the cytosolic face of the endoplasmic reticulum. It is estimated that about 13 million ribosomes are attached to the cytosolic face of the rough ER. Part of the endoplasmic reticulum devoid of ribosomes is known as smooth endoplasmic reticulum. Ribosomes on the endoplasmic reticulum are known as membrane-bound ribosomes. On the rough endoplasmic reticulum, ribosomes play an important role in the assembly of proteins. Amount of proteins assembled is dependent on the organ/tissue. For instance, some cells of the digestive system produce high amounts of proteins (enzymes) involved in the digestive process. Proteins may enter the ribosome co-translationally or posttranslationally and ultimately transverse the membrane through the translocon complex.

Endoplasmic Reticulum Tubules

As compared to the other portions of the endoplasmic reticulum, ER tubules are highly dynamic structures that are continually re-arranging and interconnecting. They are cylindrical in shape with a diameter that ranges between 30 and 100nm. Because of the interconnection that takes place at the three-way junctions, ER tubules are loosely packed in what resembles polygonal arrays in the cytoplasm. With regards to location, tubules radiate from both nuclear membrane and cisternae. From here, they spread throughout the cytoplasm. As compared to the sheets of the endoplasmic reticulum, tubules have a higher surface area. Unlike rough endoplasmic reticulum, they have fewer ribosomes. They are largely composed of the smooth endoplasmic reticulum. Shape of tubules is maintained by membrane-associated proteins (e.g. RTNs, DP1) that are also involved in their formation. They are restricted in close proximity to the cell membrane where they are referred to as cortical ER.

Lumen is the area of the endoplasmic reticulum that is enclosed by the ER membrane. It is an extensive/elongated area located within the membranes of the ER.

In eukaryotic cells, lumen is found throughout the cell wherever ER spreads. As the ER radiates from the nuclear membrane, studies have shown the internal compartment of the nucleus to be in continuity with the lumen of the endoplasmic reticulum.



Function

Protein Synthesis and Processing:

Protein synthesis is one of the major functions of the endoplasmic reticulum. Translation starts in the cytoplasm. However, some of these proteins are taken to the endoplasmic reticulum (through the translocon) where they undergo folding before being transported to appropriate destination. Apart from simply processing proteins, the endoplasmic reticulum is also known as the site for quality control. It ensures that only proteins that are properly processed are transported to the appropriate destination. Here proteins are retained until they attain the right conformation.

Lipid Synthesis:

Apart from being the major site for protein synthesis, endoplasmic reticulum is also the site of lipid biogenesis (synthesis of cholesterol and phospholipids). Lipid components are first moved to ER-Golgi intermediate compartment where they are biochemically modified. Unlike protein synthesis, lipid synthesis takes place in smooth ER which contains enzymes involved in it. As the smooth ER is involved in biosynthetic pathways of sterol and steroid, it is commonly found in cells of adrenal gland where a group of steroid hormones are secreted.

Calcium Storage:

Endoplasmic reticulum is one of the storage sites for calcium. Various channels and receptors on ER membrane are involved in the release of Ca^{++} into cytosol where they regulate metabolism.

Transportation:

Aside from various synthetic functions, the endoplasmic reticulum also acts as the transport system for various molecules. Endoplasmic reticulum is responsible for the transport of proteins from cytosol to Golgi apparatus. As endoplasmic reticulum spreads from nuclear membrane to other parts of the cell (towards the plasma membrane), allows it to transport various molecules from one point to the desired destination.

Sources:

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