Faculty Science

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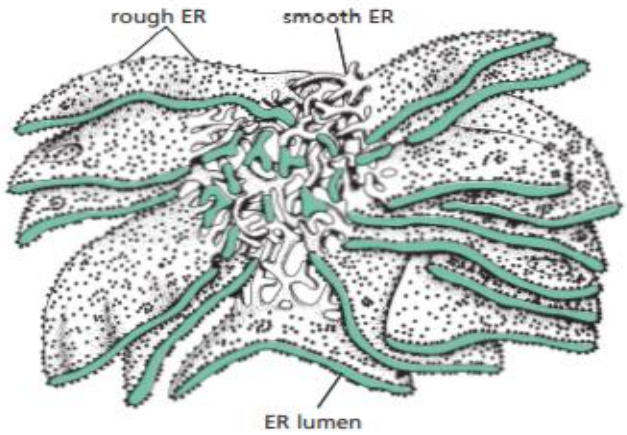
B.Sc II Paper-II(Cytology, Genetics, Evolution& Ecology)

Unit-I Topic- Endoplasmic Reticulum

Endoplasmic reticulum is a vast network of closed and open cavities in the form of membrane bound tubules, vesicles and flattened sacs(cisternae) in the cytoplasmic matrix of all eukaryotic cells. It was observed in electron micrographs of liver cells by Porter in 1945.The name endoplasmic reticulum was coined in 1953 by Porter.



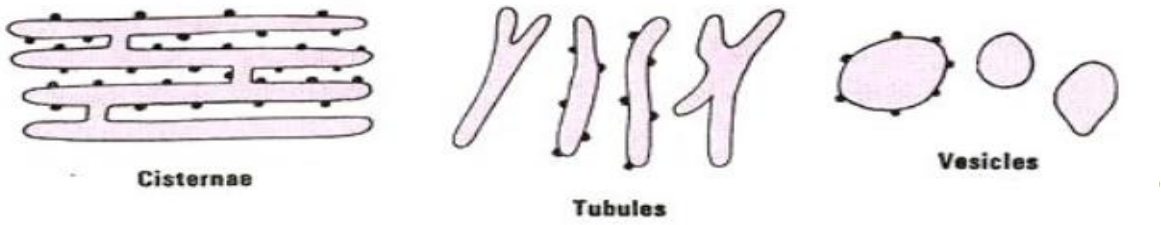
3D Structure of Endoplasmic Reticulum

Structure- The strands of ER appear as a network of branching tubules and flattened sacs with variable spaces, forming a hollow system. The tubules and sacs are interconnected and their membrane is continuous with the outer nuclear membrane forming continuous lumen with perinuclear space, called as ER Lumen or ER Cisternal space. ER may occur in three forms cisternae, vesicles and tubules.

1. Cisternae- They are long, flattened, sac-like, unbranched tubules. They remain arranged parallel in bundles. The RER usually occurs in this form.

2. Vesicles- They are oval, membrane bound vacuolar structure. They occur isolated in the cytoplasm. They are also known as microsomes. The SER often occurs in this form.

3. Tubules- They are branched tube- like structures forming reticular system along cisternae and vesicles.



Three components of Endoplasmic Reticulum

Types of Endoplasmic Reticulum- It is of two types, smooth and rough.

i) **Smooth Endoplasmic Reticulum (SER)-** The regions of ER that lack bound ribosomes are called smooth or agranular endoplasmic reticulum. This type of ER is found in cells involved in the metabolism of lipids and carbohydrates.

ii) **Rough Endoplasmic Reticulum (RER)-** The regions of ER remain studded with ribosomes are called rough or granular endoplasmic reticulum. This type of ER occurs in those cells which are actively involved in the protein synthesis.

Chemical composition-. It has high lipid content. There is more Lipid relative to proteins in the smooth endoplasmic reticulum then in the rough endoplasmic reticulum

Import of proteins into ER-The production of almost all of the cell's lipids occurs in ER. A major portion of the cell's protein synthesis occurs on the cytosolic surface of the ER. All proteins destined for secretion and all proteins destined for the ER itself, the Golgi apparatus, the lysosomes, the endosomes, and the plasma membrane are first imported into the ER from the cytosol. In the ER lumen, the proteins fold and oligomerize, disulfide bonds are formed, and N-linked oligosaccharides are added. The pattern of N-linked glycosylation is used to indicate the extent of protein folding, so that proteins leave the ER only when they are properly folded. Proteins that do not fold or oligomerize correctly are translocated back into the cytosol, where they are degraded in proteasomes. Only proteins that carry a special ER signal sequence are imported into the ER. The signal sequence is recognized by a signal recognition particle (SRP), which binds both the growing polypeptide chain and a ribosome and directs them to a receptor protein on the cytosolic surface of the rough ER membrane. Soluble proteins—destined for the ER lumen, for secretion, or for transfer to the lumen of other organelles—pass

completely into the ER lumen. Transmembrane proteins destined for the ER or for other cell membranes are translocated partway across the ER membrane and remain anchored there by one or more membrane-spanning a - helical regions in their polypeptide chains. These hydrophobic portions of the protein can act either as start-transfer or stop-transfer signals during the translocation process. When a polypeptide contains multiple, alternating start-transfer and stop-transfer signals, it will pass back and forth across the bilayer multiple times as a multipass transmembrane protein. The asymmetry of protein insertion and glycosylation in the ER establishes the sidedness of the membranes of all the other organelles that the ER supplies with membrane proteins.

Common Functions of ER-

1. Mechanical support- It functions as cytoskeleton or intracellular and ultra-structural skeletal framework by providing mechanical support to colloidal cytoplasmic matrix. It keeps the various organelles in their position.

2. Exchange and translocation- It provides a large surface inside the cell for various physiological activities. The movement of materials between two adjacent protoplasts through plasmodesmata is controlled by ER. It acts as an intracellular transporting system. In cells, endoplasmic reticulum conducts information from cell exterior to inside and from one part of the cell to another, e.g., cytoplasm to nucleus and vice versa.

3. Formation of components- It forms the new nuclear membrane after each nuclear division. It provides precursors of different secretory substances to Golgi apparatus. It gives membranes to Golgi apparatus for the formation of vesicles and lysosomes. It gives rise to vacuoles.

Functions of Rough Endoplasmic Reticulum (RER)-

1. Protein synthesis- The major function of RER is the synthesis of proteins. Almost all of the proteins that will be secreted to the cell exterior and those destined for lumen of ER, Golgi complex or lysosomes are initially delivered to the ER.

2. Modification of proteins- The folding of many proteins is more efficient by molecular chaperones. It binds to nascent or unfolded polypeptides and ensure correct folding and transmembrane translocation of other proteins. These are hsp60 and hsp70 (heat shock proteins, 60 K Da and 70 K Da their molecular weight respectively). During N-Linked glycosylation, an oligosaccharide is transferred to the NH2 group on the side chain of an asparagine amino acid of the proteins. Formation of disulfide bonds, specific proteolytic cleavages and assembly into multimeric proteins also take place in RER.

Functions of Smooth Endoplasmic Reticulum (SER):

1. Synthesis of lipids, glycogen, lipoprotein etc-It is responsible for synthesis of fats inside the cells of adipose tissue, synthesis of glycogen as well as glycogenolysis (hydrolysis of glycogen) in liver cells, synthesis of ascorbic acid, synthesis of sterols and steroid hormones as in the interstitial cells of testis and ovary and formation of visual pigments from vitamin A in retinal cells.

2. Release, uptake and storage of Ca++ - The important function of the ER in most Eukaryotic cells is to sequester Ca++ from the cytosol. The release of Ca++ into the cytosol from the ER, and its subsequent reuptake, occurs in many rapid responses to extracellular signals. A Ca++ pump transports from Ca++ the cytosol into the ER lumen. A high concentration of Ca++ -binding proteins in the ER facilitates Ca++ storage. Muscle cells have an abundant, modified smooth ER, called the sarcoplasmic reticulum. The release and reuptake of Ca++ by the sarcoplasmic reticulum trigger myofibril contraction and relaxation, respectively, during each round of muscle contraction.

3. Detoxification reactions- The membrane of the smooth ER also contains enzymes that catalyze a series of reactions to detoxify both lipid-soluble drugs and various harmful compounds produced by metabolism. These detoxification reactions are carried out by the cytochrome P450 family of enzymes, which catalyze a series of reactions in which water-insoluble drugs or metabolites that would otherwise accumulate to toxic levels in cell membranes are rendered sufficiently water-soluble to leave the cell and be excreted in the urine.

References

1. Alberts B et al. (2015) in "The Molecular biology of the cell", sixth edition. Garland Science, New York.

2. https://www.biologydicussion.com