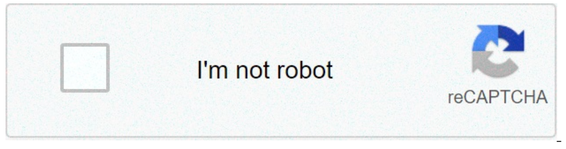

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Smooth er and rough er

The endoplasmic reticulum or ER is a maze of parallel membranous tubules and flattened sacs surrounding the nucleus that connects with the nuclear membrane and runs throughout the cytoplasm (Figure \(\PageIndex{33}\)). The ER functions to: provide a surface area for protein and lipid synthesis; form a pathway for transporting molecules within the cell; and provide a storage area for molecules the cell has synthesized. The endoplasmic reticulum connects to the pores of the nuclear envelope. The pores in the nuclear membrane allow ribosomal subunits and mRNA transcribed off genes in the DNA to leave the nucleus, enter the cytoplasm, and participate in protein synthesis. There are two distinct regions of the ER: the rough ER and the smooth ER. Figure \(\PageIndex{33}\): Role of the Endoplasmic Reticulum and Golgi Apparatus in the Movement of Molecules within and from Eukaryotic Cells. The genes in the DNA are transcribed into mRNA molecules that enter the cytoplasm through pores in the nuclear membrane. Ribosomal subunits attach to the mRNA molecules and the genetic message is translated into protein. Ribosomes attached to mRNA molecules coding for proteins to be secreted from the cell or enter lysosomes attach to receptors on the endoplasmic reticulum (ER). These proteins then enter the lumen of the ER where they can be transported elswhere within the ER. The proteins typically enter the smooth endoplasmic reticulum where they are placed in transition vesicles. The transition vesicles fuse with the Golgi complex where the proteins may be modified, sorted, and placed in secretion vesicles. The secretion vesicles, in turn, fuse with the cytoplasmic membrane releasing the proteins from the cell. ER with ribosomes attached is called rough endoplasmic reticulum (see Figure \(\PageIndex{31}\), Figure \(\PageIndex{30}\), and Figure \(\PageIndex{33}\)) and is involved in protein synthesis, production of new membrane, modification of newly formed proteins, and transport of these proteins and membrane to other locations within the cell. Ribosomal subunits and mRNA molecules transcribed off genes in the DNA leave the nucleus through pores in the nuclear membrane, enter the cytoplasm, and participate in protein synthesis. Ribosomes attached to mRNA molecules coding for proteins to be secreted from the cell or enter lysosomes attach to receptors on the ER. The ribosomes are tightly attached to the rough ER and contain a tunnel that connects to a pore in the ER called a translocon. The proteins that are synthesized by the ribosomes can then pass through the translocon and enter the lumen of the ER where they can be transported to other locations within the ER. Proteins secreted from the cell by exocytosis or destined for lysosomes are synthesized by the ribosomes on the surface of the rough ER (Figure \(\PageIndex{3}\).B.2). Proteins for use within the eukaryotic cell or intended for organelles such as mitochondria, chloroplasts, and peroxisomes are synthesized by mRNA molecules attached to ribosomes in the cytoplasm. Figure \(\PageIndex{3}\).B.2: Transmission electron micrograph of a thin section of the ribosome-studded rough endoplasmic reticulum of guinea pig pancreas. The ribosomes (small dots) were originally called Palade particles. Image made available by James D. Jamieson and the Department of Cell Biology, Yale University School of Medicine (CC-NY-SA-3.0). ER without ribosomes is called smooth endoplasmic reticulum (see Figure \(\PageIndex{31}\) and Figure \(\PageIndex{33}\)) and contains enzymes for lipid biosynthesis, especially the synthesis of phospholipids and steroids.The smooth endoplasmic reticulum forms transition vesicles to transfer molecules produced in the rough ER to the Golgi complex. (see Figure \(\PageIndex{31}\) and Figure \(\PageIndex{33}\)). Flash animation showing the endomembrane system. html5 version of animation for iPad showing the endomembrane system. Concept map for Eukaryotic Cell Structure The endoplasmic reticulum or ER is a maze of parallel membranous tubules and flattened sacs surrounding the nucleus that connects with the nuclear membrane and runs throughout the cytoplasm. ER with ribosomes attached is called rough endoplasmic reticulum and is involved in protein synthesis, production of new membrane, modification of newly formed proteins, and transport of these proteins and membrane to other locations within the cell. ER without ribosomes is called smooth endoplasmic reticulum and contains enzymes for lipid biosynthesis, especially the synthesis of phospholipids and steroids. The smooth endoplasmic reticulum forms transition vesicles to transfer molecules produced in the rough ER to the Golgi complex. Study the material in this section and then write out the answers to these questions. Do not just click on the answers and write them out. This will not test your understanding of this tutorial. Quick look Rough ER (RER) is involved in some protein production, protein folding, quality control and despatch. It is called ‘rough’ because it is studded with ribosomes Smooth E R (SER) is associated with the production and metabolism of fats and steroid hormones. It is ‘smooth’ because it is not studded with ribosomes and is associated with smooth slippery fats. To view a micrograph of ER interpreted using the Gridpoint cross-hairs device, click here. CELLS NEED THE ROUGH AND THE SMOOTH Think of a cell as a “multitude of membranes” we said in an earlier section. This statement certainly applies to the endoplasmic reticulum an organelle found in eukaryotic cells. About 50% of the total membrane surface in an animal cell is provided by endoplasmic reticulum (ER). The organelle called ‘endoplasmic reticulum’ occurs in both plants and animals and is a very important manufacturing site for lipids (fats) and many proteins. Many of these products are made for and exported to other organelles. This is an electron microscope image showing part of the rough endoplasmic reticulum in a plant root cell from maize. The dark spots are ribosomes.(courtesy of Chris Hawes, The Research School of Biology & Molecular Sciences, Oxford Brookes University, Oxford, UK) There are two types of endoplasmic reticulum: rough endoplasmic reticulum (rough ER) and smooth endoplasmic reticulum (smooth ER). Both types are present in plant and animal cells. The two types of ER often appear as if separate, but they are sub-compartments of the same organelle. Cells specialising in the production of proteins will tend to have a larger amount of rough ER whilst cells producing lipids (fats) and steroid hormones will have a greater amount of smooth ER. Part of the ER is contiguous with the nuclear envelope. The Golgi apparatus is also closely associated with the ER and recent observations suggest that parts of the two organelles, i.e. the ER and the Golgi complex, are so close that some chemical products probably pass directly between them instead of being packaged into vesicles (droplets enclosed within a membrane) and transported to them through the cytoplasm ROUGH ENDOPLASMIC RETICULUM This is an extensive organelle composed of greatly convoluted but flattish sealed sacs, which are contiguous with the nuclear membrane. It is called ‘rough’ endoplasmic reticulum because it is studded on its outer surface (the surface in contact with the cytosol) with ribosomes. These are called membrane bound ribosomes and are firmly attached to the outer cytosolic side of the ER About 13 million ribosomes are present on the RER in the average liver cell. Rough ER is found throughout the cell but the density is higher near the nucleus and the Golgi apparatus. Ribosomes on the rough endoplasmic reticulum are called ‘membrane bound’ and are responsible for the assembly of many proteins. This process is called translation. Certain cells of the pancreas and digestive tract produce a high volume of protein as enzymes. Many of the proteins are produced in quantity in the cells of the pancreas and the digestive tract and function as digestive enzymes. The rough ER working with membrane bound ribosomes takes polypeptides and amino acids from the cytosol and continues protein assembly including, at an early stage, recognising a ‘destination label’ attached to each of them. Proteins are produced for the plasma membrane, Golgi apparatus, secretory vesicles, plant vacuoles, lysosomes, endosomes and the endoplasmic reticulum itself. Some of the proteins are delivered into the lumen or space inside the ER whilst others are processed within the ER membrane itself. In the lumen some proteins have sugar groups added to them to form glycoproteins. Some have metal groups added to them. It is in the rough ER for example that four polypeptide chains are brought together to form haemoglobin. Protein folding unit It is in the lumen of the rough ER that proteins are folded to produce the highly important biochemical architecture which will provide ‘lock and key’ and other recognition and linking sites. Protein quality control section It is also in the lumen that an amazing process of quality control checking is carried out. Proteins are subjected to a quality control check and any that are found to be incorrectly formed or incorrectly folded are rejected. These rejects are stored in the lumen or sent for recycling for eventual breakdown to amino acids. A type of emphysema (a lung problem) is caused by the ER quality control section continually rejecting an incorrectly folded protein. The protein is wrongly folded as a result of receiving an altered genetic message. The required protein is never exported from the lumen of rough ER. Research into protein structure failures relating to HIV are also focusing on reactions in the ER. Rigorous quality control plays a part in cystic fibrosis A form of cystic fibrosis is caused by a missing single amino acid, phenylanaline, in a particular position in the protein construction. The protein might work well without the amino acid but the very exacting service provided by the quality control section spots the error and rejects the protein retaining it in the lumen of the rough ER. In this case the customer (the person with cystic fibrosis) loses out completely due to high standards when a slightly poorer product would have been better than no product at all. From Rough ER to Golgi In most cases proteins are transferred to the Golgi apparatus for ‘finishing’. They are conveyed in vesicles or possibly directly between the ER and Golgi surfaces. After ‘finishing’ they are delivered to specific locations. SMOOTH ENDOPLASMIC RETICULUM Smooth ER is more tubular than rough ER and forms an interconnecting network sub-compartment of ER. It is found fairly evenly distributed throughout the cytoplasm. It is not studded with ribosomes hence ‘smooth’ ER. Smooth ER is devoted almost exclusively to the manufacture of lipids and in some cases to the metabolism of them and associated products. In liver cells for example smooth ER enables glycogen that is stored as granules on the external surface of smooth ER to be broken down to glucose. Smooth ER is also involved in the production of steroid hormones in the adrenal cortex and endocrine glands.

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