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18/MHS06/058
Medical laboratory science
BCH 202

Question
BCH 202 Assignment 2 (2019/2020 session)
Stayhome staysafe

1. Which of the following is not a function of triacylglycerol.
   - Energy storage b. insulation c. shock absorption d. membrane structure
1. Fatty acids are ________________________________ acids.
2. The sterol nucleus of steroid is called a __________________________________ ring.
3. Chylomicrons transport ___________________ and _______________________ from the ____________________ to ______________________ and ____________________.
4. Write concisely on the functional characteristics of Nucleus, Mitochondria and Endoplasmic reticulum.
5. Explain the various classes of glycolipids and draw the structure of one.

ANSWER

1. d. Membrane structure. Triacylglycerol isn't a component of membrane structure
2. Fatty acids are carboxylic acids.
3. The sterol nucleus of steroid is called a Gonane, or steran or cyclopentanoperhydrophenanthrene ring.
4. Chylomicrons transport monoglycerides and fatty acids from the port of entry in the intestine(intestinal mucosa) to liver and adipose tissue.
5. FUNCTIONAL CHARACTERISTICS

NUCLEUS: The nucleus is a highly specialized organelle that serves as the information processing and administrative center of the cell. The nucleus is a membrane-bound organelle that contains genetic material (DNA) of eukaryotic organisms. As such, it serves to maintain the integrity of the cell by facilitating transcription and replication processes.

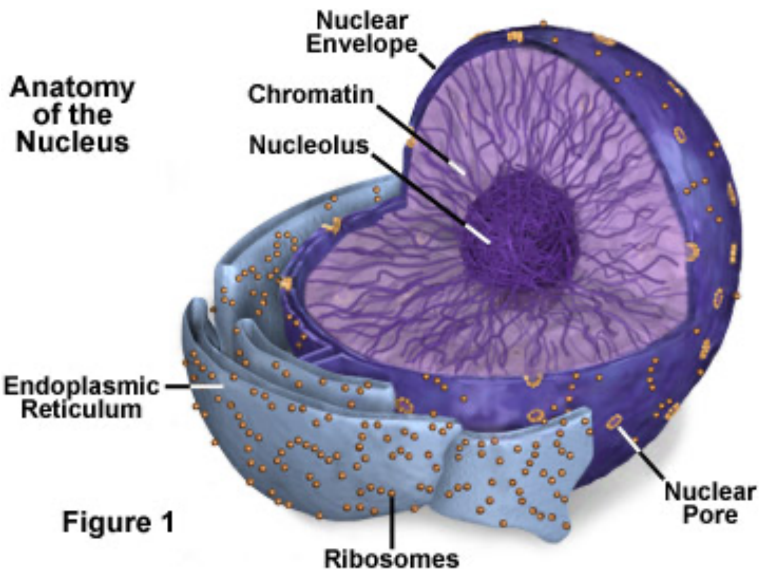
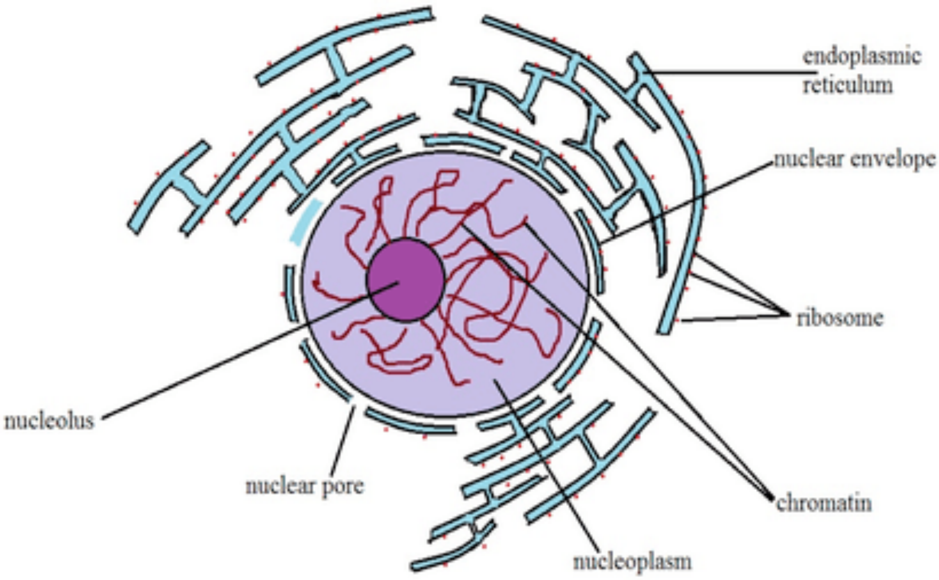


Figure 1

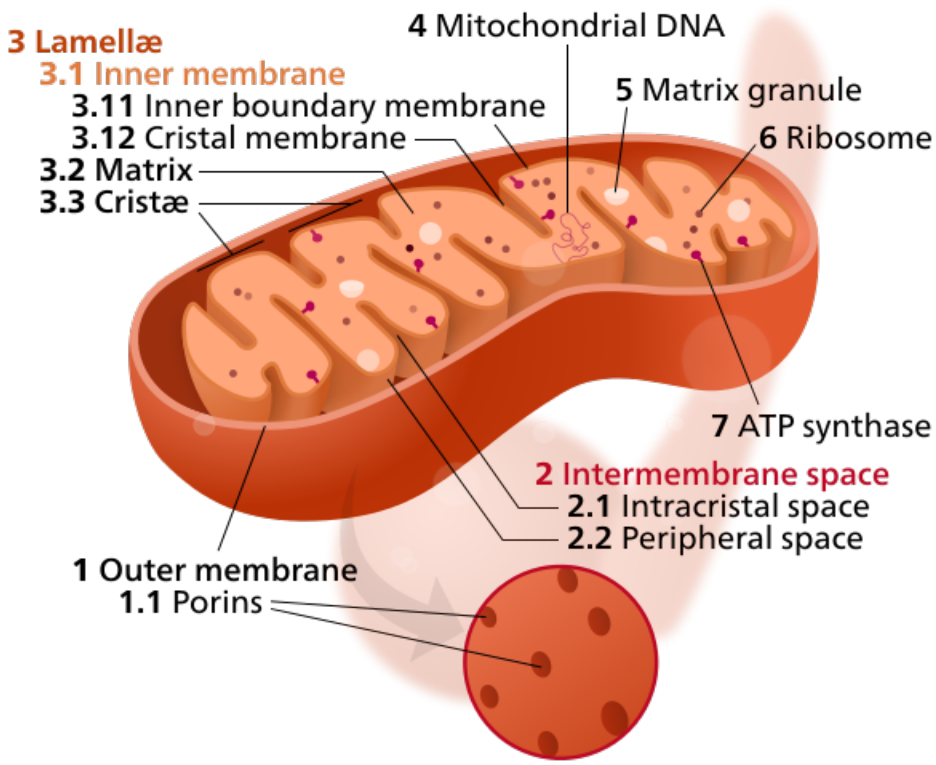
Only the cells of advanced organisms, known as eukaryotes, have a nucleus. Generally there is only one nucleus per cell, but there are exceptions, such as the cells of slime molds and the Siphonales group of algae. Simpler one-celled organisms (prokaryotes), like the bacteria and cyanobacteria, don't have a nucleus. In these organisms, all of the cell's information and administrative functions are dispersed throughout the cytoplasm.
This organelle has two major functions: it stores the cell's hereditary material, or DNA, and it coordinates the cell's activities, which include growth, intermediary metabolism, protein synthesis, and reproduction (cell division). The major components of a nucleus are:
Chromatin and chromosome are found in the nucleus. For DNA to function, it can't be crammed into the nucleus like a ball of string. Instead, it is combined with proteins and organized into a precise, compact structure, a dense string-like fiber called chromatin.
Nucleolus is a membrane-less organelle within the nucleus that manufactures ribosomes, the cell's protein-producing structures.
Nuclear envelope and nuclear pores- The nuclear envelope is a double-layered membrane that encloses the contents of the nucleus during most of the cell's lifecycle. The envelope is perforated with tiny holes called nuclear pores. These pores regulate the passage of molecules between the nucleus and cytoplasm, permitting some to pass through the membrane, but not others.
Nucleoplasm is a type of protoplasm composed of enzymes, dissolved salts, and several organic molecules. In addition, the nucleoplasm helps cushion and thus protect the nucleolus and chromosomes while also helping maintain the general shape of the nucleus. It is also called nucleus sap.



MITOCHONDRION
The mitochondrion is a semi autonomous double-membrane-bound organelle found in most eukaryotic organisms. Some cells in some multicellular organisms may, however, lack mitochondria (for example, mature mammalian red blood cells).

Components of a typical mitochondrion
1 Outer membrane:
Porin
2 Intermembrane space:
Intracristal space
Peripheral space
3 Lamella:
Inner membrane

Inner boundary membrane
Cristal membrane
Matrix
Cristæ
4 Mitochondrial DNA
5 Matrix granule
6 Ribosome
7 ATP synthase



The most prominent roles of mitochondria are to produce the energy currency of the cell, ATP (i.e., phosphorylation of ADP), through respiration, and to regulate cellular metabolism. The central set of reactions involved in ATP production are collectively known as the citric acid cycle, or the Krebs cycle. However, the mitochondrion has many other functions in addition to the production of ATP.

Energy conversion
A dominant role for the mitochondria is the production of ATP, as reflected by the large number of proteins in the inner membrane for this task. This is done by oxidizing the major products of glucose: pyruvate, and NADH, which are produced in the cytosol.[18] This type of cellular respiration known as aerobic respiration, is dependent on the presence of oxygen, which provides most of the energy released. When oxygen is limited, the glycolytic products will be metabolized by anaerobic fermentation, a process that is independent of the mitochondria. The production of ATP from glucose and oxygen has an approximately 13-times higher yield during aerobic respiration compared to fermentation. Plant mitochondria can also produce a limited amount of ATP without oxygen by using the alternate substrate nitrite. ATP crosses out through the inner membrane with the help of a specific protein, and across the outer membrane via porins. ADP returns via the same route.

Heat production
Under certain conditions, protons can re-enter the mitochondrial matrix without contributing to ATP synthesis. This process is known as proton leak or mitochondrial uncoupling and is due to the facilitated diffusion of protons into the matrix. The process results in the unharnessed potential energy of the proton electrochemical gradient being released as heat. The process is mediated by a proton channel called thermogenin, or UCP1. Thermogenin is a 33 kDa protein first discovered in 1973. Thermogenin is primarily found in brown adipose tissue, or brown fat, and is responsible for non-shivering thermogenesis. Brown adipose tissue is found in mammals, and is at its highest levels in early life and in hibernating animals. In humans, brown adipose tissue is present at birth and decreases with age.

Storage of calcium ions

Transmission electron micrograph of a chondrocyte, stained for calcium, showing its nucleus (N) and mitochondria (M).

The concentrations of free calcium in the cell can regulate an array of reactions and is important for signal transduction in the cell. Mitochondria can transiently store calcium, a contributing process for the cell's homeostasis of calcium. In fact, their ability to rapidly take in calcium for later release makes them very good "cytosolic buffers" for calcium. The endoplasmic reticulum (ER) is the most significant storage site of calcium, and there is a significant interplay between the mitochondrion and ER with regard to calcium. The calcium is taken up into the matrix by the mitochondrial calcium uniporter on the inner mitochondrial membrane. It is primarily driven by the mitochondrial membrane potential. Release of this calcium back into the cell's interior can occur via a sodium-calcium exchange protein or via "calcium-induced-calcium-release" pathways. This can initiate calcium spikes or calcium waves with large changes in the membrane potential. These can activate a series of second messenger system proteins that can coordinate processes such as neurotransmitter release in nerve cells and release of hormones in endocrine cells.

Ca2+ influx to the mitochondrial matrix has recently been implicated as a mechanism to regulate respiratory bioenergetics by allowing the electrochemical potential across the membrane to transiently "pulse" from ΔΨ-dominated to pH-dominated, facilitating a reduction of oxidative stress. In neurons, concomitant increases in cytosolic and mitochondrial calcium act to synchronize neuronal activity with mitochondrial energy metabolism. Mitochondrial matrix calcium levels can reach the tens of micromolar levels, which is necessary for the activation of isocitrate dehydrogenase, one of the key regulatory enzymes of the Krebs cycle.

Additional functions

Mitochondria play a central role in many other metabolic tasks, such as:

Signaling through mitochondrial reactive oxygen species

Regulation of the membrane potential

Apoptosis-programmed cell death

Calcium signaling (including calcium-evoked apoptosis

Regulation of cellular metabolism

Certain heme synthesis reactions

Steroid synthesis.

Hormonal signaling Mitochondria are sensitive and responsive to hormones, in part by the action of mitochondrial estrogen receptors (mtERs). These receptors have been found in various tissues and cell types, including brain and heart

Immune signaling

Neuronal mitochondria also contribute to cellular quality control by reporting neuronal status towards microglia through specialised somatic-junctions

Some mitochondrial functions are performed only in specific types of cells. For example, mitochondria in liver cells contain enzymes that allow them to detoxify ammonia, a waste product of protein metabolism. A mutation in the genes regulating any of these functions can result in mitochondrial diseases.

ENDOPLASMIC RETICULUM

Endoplasmic reticulum (ER), a continuous membrane system that forms a series of flattened sacs within the cytoplasm of eukaryotic cells and serves multiple functions, being important particularly in the synthesis, folding, modification, and transport of proteins . All eukaryotic cells contain an endoplasmic reticulum (ER).

It is an interconnected network of flattened sacs or tubes encased in membranes. These membranes are continuous, joining with the outer membrane of the nuclear membrane. ER occurs in almost every type of eukaryotic cell except red blood cells and sperm cells.

Endoplasmic reticulum has two types, rough endoplasmic reticulum (RER) and smooth endoplasmic reticulum (SER). Rough ER is studded with ribosomes, the site of protein synthesis. This type of ER is especially prominent in certain kinds of cells like hepatocytes where active protein synthesis occurs. Smooth ER doesn't have ribosomes and is very important to the process of metabolism.

The ER plays a number of roles within the cell, from protein synthesis and lipid metabolism to detoxification of the cell. Cisternae, each of the small folds of the endoplasmic reticulum, are commonly associated with lipid metabolism. This creates the plasma membrane of the cell, as well as additional endoplasmic reticulum and organelles. They also appear to be important in maintaining the Ca^{2+} balance within the cell and in the interaction of the ER with mitochondria. This interaction also influences the aerobic status of the cell. ER sheets appear to be crucial in the response of the organelle to stress, especially since cells alter their tubules-to-sheets ratio when the number of unfolded proteins increases. Occasionally, apoptosis is induced by the ER in response to an excess of unfolded protein within the cell. When ribosomes detach from ER sheets, these structures can disperse and form tubular cisternae.

Although ER sheets and tubules appear to have distinct functions, there isn't a perfect delineation of roles. For instance, in mammals tubules and sheets can interconvert, making the cells adaptable to various conditions. The relationship between structure and function in the ER has not been completely elucidated.

Protein Synthesis and Folding
Protein synthesis occurs in the rough endoplasmic reticulum. Although translation for all proteins begins in the cytoplasm, some are moved into the ER in order to be folded and sorted for different destinations. Proteins that are translocated into the ER during translation are often destined for secretion. Initially, these proteins are folded within the ER and then moved into the Golgi apparatus where they can be dispatched towards other organelles.
For instance, the hydrolytic enzymes in the lysosome are generated in this manner. Alternately, these proteins could be secreted from the cell. This is the origin of the enzymes of the digestive tract. The third potential role for proteins translated in the ER is to remain within the endomembrane system itself. This is particularly true for chaperone proteins that assist in the folding of other proteins. The genes encoding these proteins are upregulated when the cell is under stress from unfolded proteins.

Lipid synthesis
The smooth endoplasmic reticulum plays an important role in cholesterol and phospholipid biosynthesis. Therefore, this section of the ER is important not only for the generation and maintenance of the plasma membrane but of the extensive endomembrane system of the ER itself.
The SER is enriched in enzymes involved in sterol and steroid biosynthetic pathways and is also necessary for the synthesis of steroid hormones. Therefore the SER is extremely prominent in the cells of the adrenal gland that secrete five different groups of steroid hormones that influence the metabolism of the entire body. The synthesis of these hormones also involves enzymes within the mitochondria, further underscoring the relationship between these two organelles.

Calcium Store
The SER is an important site for the storage and release of calcium in the cell. A modified form of the SER called sarcoplasmic reticulum forms an extensive network in contractile cells such as muscle fibers. Calcium ions are also involved in the regulation of metabolism in the cell and can change cytoskeletal dynamics.
The extensive nature of the ER network allows it to interact with the plasma membrane and use Ca^{2+} for signal transduction and modulation of nuclear activity. In association with mitochondria, the ER can also use its calcium stores to induce apoptosis in response to stress.

5. CLASSES OF GLYCOLIPID

Glycolipids are lipids with a carbohydrate attached by a glycosidic (covalent) bond. Glycolipids are widely distributed in every tissue of the body, particularly in nervous tissue such as brain. Their role is to maintain the stability of the cell membrane and to facilitate cellular recognition, which is crucial to the immune response and in the connections that allow cells to connect to one another to form tissues. Glycolipids are also found on the surface of all eukaryotic cell membranes, where they extend from the phospholipid bilayer into the extracellular environment.

Classes of Glycolipid.
Glyceroglycolipids

a. Galactolipids
b. Sulfolipids

Glycosphingolipids

a. Cerebrosides: which includes; Galactocerebrosides, Glucocerebrosides, Sulfatides.
b. Gangliosides
c. Globosides
d. Glycophosphosphingolipids
e. Glycophosphatidylinositols.

Glyceroglycolipids is defined as a sub-group of glycolipids characterized by an acetylated or non-acetylated glycerol with at least one fatty acid as the lipid complex. Glyceroglycolipids are often associated with photosynthetic membranes and their functions. The subcategories of glyceroglycolipids depend on the carbohydrate attached.

a. Galactolipids: are a type of glycolipid whose sugar group is galactose. It is described as galactose sugar attached to a glycerol lipid molecule. They are found in chloroplast membranes and are associated with photosynthetic properties. They are the main part of plant membrane lipids where they substitute phospholipids to conserve phosphate for other essential processes. These chloroplast membranes contain a high quantity of monogalactosyldiacylglycerol (MGDG) and digalactosyldiacylglycerol (DGDG).

They also assume a direct role in photosynthesis, as they have been found in the X-ray structures of photosynthetic complexes.

b. Sulfolipids: Sulfolipids are a class of lipids which possess a sulfur-containing functional group in the sugar moiety attached to a lipid. An important group is the sulfoquinovosyl diacylglycerols which are associated with the sulfur cycle in plants. It is an abundant sulfolipid which is composed of a glycoside of sulfoquinovose and diacylglycerol. In plants, sulfoquinovosyl diacylglycerides (SQDG) are important members of the sulfur cycle. Other important sulfolipids include sulfatide and seminolipid, each of which are sulfated glycolipids.

Glycosphingolipids: a sub-group of glycolipids based on sphingolipids. They may be considered as sphingolipids with an attached carbohydrate. These glycolipids consist of amino alcohol “sphingosine”. The amino group of sphingosine is esterified by a fatty acid and one more sugar units are attached to the hydroxyl group of sphingosine. They are a part of the cell membrane. They consist of a hydrophobic ceramide part and a glycosidically bound carbohydrate part. This oligosaccharide content remains on the outside of the cell membrane where it is important for biological processes such as cell adhesion or cell–cell interactions. Glycosphingolipids are widely distributed in every tissue of the body, particularly located in nervous tissue such as brain and are responsible for cell signaling. Glycosphingolipids play also important role in oncogenesis and ontogenesis.

Sphingosine

a. Cerebrosides: Cerebrosides is the common name for a group of glycosphingolipids called monoglycosylceramides which are important components in animal muscle and nerve cell membranes. They consist of a ceramide with a single sugar residue at the 1-hydroxyl moiety. The sugar residue can be either glucose or galactose; the two major types are therefore called glucocerebrosides (glucosylceramides) and galactocerebrosides (galactosylceramides). Galactocerebrosides are typically found in neural tissue, while glucocerebrosides are found in other tissues.

-Galactocerebrosides: a type of cerebroside with galactose as the saccharide moiety

-Glucocerebrosides: a type of cerebroside with glucose as the saccharide moiety; often found in non-neural tissue.

-Sulfatides (ceramide + monosaccharide + sulfate): are cerebrosides in which the monosaccharide contains a sulfate ester. It is a class of glycolipids containing a sulfate group in the carbohydrate with a ceramide lipid backbone. They are involved in numerous biological functions ranging from immune response to nervous system signaling.

b. Gangliosides (cerebroside + oligosaccharides + NANA): the most complex animal glycolipids derived from glucocerebrosides. They contain negatively charged oligosacchrides with one or more sialic acid residues; which is usually N-acetylneuraminic acid (NANA) attached to ceramide. More than 200 different gangliosides have been identified such as GM1, GM2, GM3 etc. They are most abundant in nerve cells.

c. Globosides (ceramide + oligosaccharide) : it contain two or more sugar molecules attached to ceramide. These glycolipids are important constituents of the RBC-membrane and are déterminants of the A,B,O blood group system. They have a variety of functions; failure to degrade these molecules leads to Fabry disease.

d. Glycophosphosphingolipids: are complex glycophospholipids from fungi, yeasts, and plants, where they were originally called "phytoglycolipids". They may be as complicated a set of compounds as the negatively charged gangliosides in animals.

e. Glycophosphatidylinositols: a sub-group of glycolipids defined by a phosphatidylinositol lipid moiety bound to a carbohydrate complex. They can be bound to the C-terminus of a protein and have various functions associated with the different proteins they can be bound to.

Structure of ganglioside