The study of structure and function of human cell

Run Hu*

Rabun Gap Nacoochee School, Atlanta, the United States

*Corresponding author: jyeagermu84894@student.napavalley.edu

Abstract. Biological structure and function is the core field of life sciences, covering the complex organizational structure and various functions it undertakes. Cells are a very important structure and the basic unit of life activities, which means that without cells, all life activities cannot continue. So on this basis, we studied the function and structure of cells. The findings suggest that each organelle has a specific functional structure and that changes or mutations in the structure of these proteins or the arrangement of membrane proteins on the surface can lead to the development of related diseases, such as abnormalities in the Golgi apparatus leading to Alzheimer's disease Abnormalities in mitochondria can lead to lesions in muscles or the nervous system or even cancer, and mutations in the nucleus can cause babies to be born with various defects. Cells are the unit of life activities. Once the organelles are abnormal, different diseases will occur.

Keywords: human cell; structure; function.

1. Introduction

The fundamental structural and operational components of life are cells. As we all know, all organisms except viruses, including humans, animals, plants, and even some microorganisms, are composed of cells. However, the life activities of viruses must also depend on living cells. This undoubtedly proves that cells are the basis of all life activities. Generally speaking, most microorganisms, such as bacteria, paramecium, Escherichia coli, Etc., are composed of single cells; at the same time, higher-level animals and plants are multicellular organisms, such as human beings, which are composed of 34 trillion cells. Cells are so small that they can only be seen under a microscope and come in many shapes and structures [1].

Cells can be divided into animal cells, plant cells, and bacteria. Animal cells include the endoplasmic reticulum, which can undertake the role of intracellular material transport and synthesize proteins and some lipids; mitochondria, the central place for respiration, provide energy for the activities of organisms; Golgi apparatus, which carries out the protein synthesis of cells Processing and transportation to some specific locations; ribosome, which is the site of protein synthesis in the cell, can convert the genetic information contained in RNA into the sequence information of amino acids in protein to synthesize protein; lysosome, is a kind of protein in animal cells Organelles used to decompose biological macromolecules such as proteins, nucleic acids, polysaccharides; cell membranes, substances that control the movement of cells into and out of cells, and maintain the stability of the internal environment of cells; nuclei, which include a large amount of genetic material, which control the genetics and feature. From the color of our skin and hair to some genetic diseases that cannot be cured by medicine, it is determined by it. Compared with plant cells, they have many similarities, such as cell membranes, nuclei, and other structures. Nevertheless, there are also many special structures. Plant cells have a unique cell wall that keeps the plant its shape and firmness; chloroplasts, which play an integral role in plant photosynthesis and maintaining plant life; vacuoles, mainly found in plant cells, which not only store organic Metabolites are involved in the biochemical cycle of substances in cells, and vacuoles regulate the environment in cells; protoplasmic filaments are essential channels for material transport and information transmission between cells. These are not found in animal cells. The structure of bacteria is quite different from that of animals. Bacteria, for example, have flagella, a slender, curved structure found only on bacteria that also help them move (fig 1).

So if something goes wrong with a cell, the consequences can be catastrophic—for example, cells proliferate abnormally, leading to cancer. In the United States, 1 in 5 deaths per year is caused by cancer [2], compared to 100-350 per 100,000 globally [3]. The overall incidence of cancer worldwide is on the rise. Also included is AIDS, which attacks the body's immune cells, causing patients to die from complications of immunocompromise. 630,000 individuals will pass away by 2022 from HIV-related causes, and 1.3 million people will contract the virus [4-6]. Each case illustrates the importance of the proper functioning of each cell and its organelles in our body. However, although a large number of scientists and scholars have continued to research and explore related fields in the past few decades, there are still many unsolved problems. For example, the causes of many genetic diseases, or the cancers and AIDS mentioned above, have not yet been well treated.

Therefore, on the one hand, this paper studies and organizes the structure of human cells for the development of related research fields in the future; on the other hand, it summarizes and discusses the structure of cells.

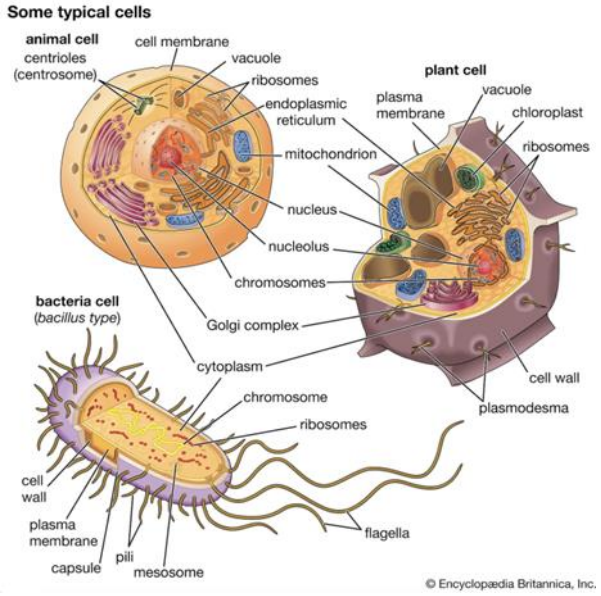

Fig. 1 Organelles that are membrane-bound, such as a separate nucleus, are found in both plant and animal cells. Organelles are absent from bacterial cells, in contrast [7].

2. Cell membrane

The cell membrane is a semipermeable structure composed of bilayer phospholipid molecules in the outer layer of human cells. Phospholipid molecules have a hydrophilic head and a hydrophobic tail. Both layers have the head on the outside and the tail on the inside, that is to say, the two heads face the outside and inside of the cell respectively. Such a structure makes it difficult for macromolecular substances and polar molecules to enter and exit. But there are also some channels on the cell membrane that are controlled by the membrane potential, allowing the corresponding molecules to enter. The cell membrane plays an extremely important physiological function in the cell structure. Not only does it regulate and select the movement of substances into and out of the cell, but the cell maintains a stable internal environment.

Pyroptosis is inseparable from the cell membrane. The constant swelling of the cells causes the cell membranes to rupture, which in turn stimulates massive inflammation in the body. However, excessive inflammation can lead to disorders of insulin metabolism pathways and even lead to diabetes. More studies have shown that pyroptosis drives cell consumption and inflammation through human immunodeficiency virus, promotes the development of HIV disease into AIDS [4], destroys human immune cells, and leads to a large number of complications and huge fatal risks.

3. Cytoplasm

Cytoplasm is the jelly-like substance of the cell that surrounds the cell membrane and fills the entire interior of the cell. It has several key functions and is also one of the important sites of many cellular diseases. First, let's look at the structure of the cytoplasm. The cytoplasm is mainly composed of water, ions, organic molecules (such as proteins, carbohydrates, and lipids), and organelles (such as mitochondria, endoplasmic reticulum, Golgi apparatus, etc.). This intracellular jelly-like substance provides support for the cell's internal structure, allows the cell to maintain its shape, and aids in the transport of substances. The water in the cytoplasm acts as a solvent, enabling chemical reactions to take place within it.

The functions of the cytoplasm are diverse. First, it is the site of many biochemical reactions. Many enzymes and metabolic pathways within cells require the cytoplasm to occur. In addition, the cytoplasm is also the site of intracellular molecular transport. This includes the transport of substances via vesicles that can move through the cytoplasm, delivering substances from one organelle to another. The cytoplasm also plays a role in supporting the organelles so that they can function properly. However, when abnormalities occur in the cytoplasm, serious diseases can result. For example, certain genetic diseases are associated with defects in specific proteins within the cytoplasm. The cytoplasm can also be affected by viral infection. Certain viruses require access to the cytoplasm in order to replicate and spread. They may promote their own growth by altering the cytoplasmic environment, leading to cellular dysfunction and ultimately disease.

4. Cell nucleus

4.1. Karyotheca

The nuclear envelope is a key component. The nuclear envelope is the outer covering of the nucleus, which plays multiple important roles within the cell. This will introduce the structure and function of the nuclear membrane, and some diseases that may be caused by nuclear membrane lesions. The inner nuclear membrane and the outer nuclear membrane, which make up the nuclear membrane gap between them, are two phospholipid bilayers that make up the nuclear membrane. This structure separates the nucleus from the cytoplasm, protecting and isolating the genetic material within the nucleus. In addition, there are nuclear pores on the nuclear membrane, which allow molecules such as RNA and ribonucleoprotein to pass through the nuclear membrane and enter or leave the nucleus for gene expression and ribosome synthesis. Second, the function of the nuclear envelope is very important. First, it maintains a stable environment in the nucleus, preventing molecules in the cytoplasm from entering the nucleus directly, thus protecting the genetic material from damage. Second, the nuclear pores on the nuclear envelope regulate the transport of substances, ensuring orderly exchange of molecules inside and outside the nucleus, which is essential for maintaining normal cellular functions. Finally, the nuclear envelope is also involved in the process of cell division, since during cell division the nuclear envelope must disassemble to allow chromosomes to segregate properly and reassemble after division.

However, the nuclear envelope is also susceptible to some lesions that can lead to serious disease. A common nuclear membrane lesion is the mutation of nuclear membrane proteins, which may lead to abnormal morphology and function of the nuclear membrane, which in turn affects the stability of the nucleus. These mutations are associated with genetic disorders such as Emrick muscular dystrophy and Lipmann-Sachs syndrome [8]. In addition, some viruses can also use nuclear pores to enter the nucleus, thereby causing infectious diseases. To sum up, the nuclear membrane is a crucial structure in the cell, which plays an important role in maintaining a stable environment in the nucleus, regulating material transport, and participating in cell division.

4.2. Chromatin

Chromatin is the intricate and dynamic structure found within the nucleus of eukaryotic cells, primarily composed of DNA and associated proteins. Its primary function is to package and organize genetic material efficiently. The chromatin structure can be divided into two states: euchromatin, which is loosely packed and allows for gene expression, and heterochromatin, which is densely packed and represses gene expression. If chromatin becomes damaged, it can have profound consequences. DNA repair mechanisms might be compromised, leading to mutations or genomic instability. Additionally, gene expression can be disrupted, potentially causing various diseases or developmental issues. Proper chromatin maintenance is crucial for the accurate transmission of genetic information and the overall health of cells and organisms.

4.3. Nucleolus

The nucleolus is a small organ inside the nucleus. Although it is called a small organ in cytology, its role in cell biology is extremely important. Nucleoli are located primarily within the nucleus, and each nucleus usually contains one or more nucleoli. Here's what the nucleolus is, its function, and the diseases they can cause. The nucleolus is a complex structure composed of proteins and ribonucleic acid. It usually consists of three main parts: particle region, fiber region and particle-fiber region. The granule region is rich in rRNA, which is an important component for the synthesis of cellular ribosomes. The fiber region contains precursors of rRNAs, where they are further processed and modified. The granule-fiber region is the transition region between the granule region and the fiber region, which contains some key proteins for maintaining the structure and function of the nucleolus.

The nucleolus has several important functions in the cell. One of its main functions is to synthesize and assemble cellular ribosomes. Cellular ribosomes are the protein synthesis factories inside the cell, they are composed of rRNA and protein. In the nucleolus, rRNA is further processed and bound to proteins to form the mature ribosomal subunit. These subunits then leave the nucleolus and converge to form fully functional ribosomes in the cytoplasm to complete the protein synthesis process. In addition, the nucleolus is also involved in the regulation of the cell cycle. It is disassembled during cell division and reformed at other stages of the cell cycle. This is closely related to the cell's DNA replication and cell division, ensuring that each new cell receives enough ribosomes to support its protein synthesis needs.

Abnormal function or structural abnormalities of the nucleolus may lead to a variety of diseases. For example, several studies have shown that the nucleolus is closely related to the development of cancer. Abnormalities in the nucleolus may contribute to the formation of tumors by causing cells to lose normal control over growth and division. In addition, some rare genetic disorders, such as Treacher Collins syndrome [9], are associated with nucleolar dysfunction. The disorder causes facial deformities and other physical deformities, in part due to abnormal function of the nucleolus in embryonic development. In summary, the nucleolus, although tiny, plays an integral role in cell biology. They are involved in the synthesis and maintenance of cellular ribosomes, and are also closely related to the development of some diseases

5. Endoplasmic Reticulum (ER)

In eukaryotic cells, the endoplasmic reticulum (ER), an essential organelle, takes part in several cellular activities. This vast network of membranes is composed of the smooth endoplasmic reticulum (SER) and the rough endoplasmic reticulum (RER). Each of these sections carries out certain functions for the cell. A group of flattened sacs called cisternae that are joined by a web of tubules define the endoplasmic reticulum's structure. The RER has a rough look because it is covered in ribosomes on its cytoplasmic surface. Protein synthesis is carried out by these ribosomes. On the other side, the SER doesn't have ribosomes and seems smooth. Since the two types of ER are physically linked to one another, lipids and other molecules can be transferred between them.

One of the primary functions of the endoplasmic reticulum is protein synthesis and processing. The RER ribosomes synthesize proteins destined for secretion, membrane insertion, or use within the cell. These newly synthesized proteins enter the ER lumen, undergoing various modifications, such as folding and glycosylation, to ensure their proper structure and function. The smooth endoplasmic reticulum, in contrast, is involved in lipid metabolism and detoxification processes. It plays a crucial role in synthesizing lipids, including phospholipids and steroids. Additionally, the SER is responsible for detoxifying drugs and toxins by enzymatic reactions, making it essential for the overall health and functioning of the cell. When the endoplasmic reticulum experiences stress or malfunctions, it can lead to various diseases and health problems. One well-known condition associated with ER stress is protein misfolding, which can result in a group of disorders collectively known as ER storage diseases. These conditions include cystic fibrosis and certain types of diabetes. In these cases, misfolded proteins accumulate in the ER, causing cellular dysfunction and often leading to severe health issues.

Another notable disease linked to the ER is Alzheimer's disease [10]. Research suggests that the buildup of abnormal proteins in the endoplasmic reticulum contributes to the progression of this neurodegenerative disorder. Furthermore, disturbances in ER calcium regulation have been implicated in various neurodegenerative diseases and cardiac disorders.

6. Mitochondria

The food including carbohydrates, proteins and fats, is converted into energy through aerobic digestion and metabolism in the body. The operation of various functions of the body comes directly from the energy provided by the hydrolysis of ATP. The human body needs about 100 to 150 moles of ATP every day to provide energy, but in fact, there is only about 0.2 moles of ATP in the body. That is, ATP is constantly charging and discharging like a battery in body every day. This whole process takes place in the mitochondria. Therefore, mitochondria are called "the power station of cells". Mitochondria also contain their own unique DNA, so each mitochondria is unique. Mitochondrial disorders may be brought on by mutations in these genes. Although disease symptoms can vary, they frequently impact energy-demanding organs like the heart, muscles, and brain. In addition to giving cells energy, mitochondria are also engaged in functions like cell differentiation, information transfer within cells, and apoptosis. They can also control cell development and the cell cycle.

The results of mitochondrial mutation are also unthinkable. such as Kaiser syndrome or mobility problems (exercise intolerance). While the second is more dangerous, the former will result in a major loss in the patient's ability to exercise, which might significantly result in psychological issues for the patient. It can result in hearing loss, ataxia, minor skeletal muscular weakness, heart block (heart conduction disorder), low stature, hearing loss, and even diminished cognitive function. Even lung cancer, which has an average five-year survival rate of only 18.6%, has been linked to mitochondrial DNA in research [11].

7. Ribosome

Ribosomes are fundamental cellular structures responsible for protein synthesis, a critical process in all living organisms. These tiny molecular machines consist of ribosomal RNA (rRNA) and proteins, working together to assemble amino acids into proteins based on the instructions provided by messenger RNA (mRNA). Understanding the structure, function, and mutations of ribosomes offers valuable insights into the machinery of life and its implications for health and disease. Ribosomes are composed of two subunits: a smaller subunit and a larger subunit. These subunits combine to form the functional ribosome during protein synthesis. The small subunit reads the mRNA sequence, while the large subunit catalyzes the formation of peptide bonds between amino acids, creating a polypeptide chain.

Ribosomes' main purpose is to convert the genetic data present in mRNA into useful proteins. Initiation, elongation, and termination are the three main stages of this translation process. The ribosome forms around the mRNA's start codon during initiation. In elongation, the ribosome binds to tRNA molecules carrying certain amino acids, and the ribosome helps the amino acids create peptide bonds to produce a lengthening polypeptide chain. When the ribosome comes across a stop codon on the messenger RNA, the process is terminated, resulting in the release of the finished protein.

Mutations in ribosomal RNA and protein genes can have profound effects. One example is Diamond-Blackfan anemia (DBA), a rare genetic disorder characterized by a deficiency in red blood cell production [12]. Mutations in ribosomal protein genes disrupt normal ribosome assembly and function, leading to inefficient protein synthesis and impaired cell proliferation. Another ribosomopathy is Shwachman-Diamond syndrome (SDS), which affects bone marrow function, leading to reduced production of blood cells and impaired digestive function due to defective ribosome biogenesis. Understanding ribosomal mutations also has broader implications for cancer research. Mutations in ribosomal protein genes have been found in several types of cancers, suggesting a potential link between ribosome dysfunction and uncontrolled cell growth. These mutations can alter the balance between protein synthesis and other cellular processes, contributing to cancer development and progression.

8. Golgi apparatus

The Golgi apparatus, often referred to as the Golgi complex or Golgi body, is a crucial organelle found in eukaryotic cells. Named after its discoverer, Camillo Golgi, this cellular structure plays a central role in processing, modifying, and transporting proteins and lipids within the cell. The Golgi apparatus is a stack of flattened, membranous sacs known as cisternae. These cisternae are typically organized in a series of stacks, with each stack containing several layers. The Golgi apparatus has two distinct faces: the cis face, which is the receiving end, and the trans face, which is the shipping end. Vesicles transport materials from the endoplasmic reticulum (ER) to the cis face of the Golgi apparatus for processing and modification

First is Protein Modification: One of its primary roles is to modify proteins synthesized in the endoplasmic reticulum. These modifications can include adding carbohydrates (glycosylation), phosphorylation, and sulfation, which are essential for the proper functioning of proteins. The second is Sorting and Packaging. After modification, the Golgi apparatus sorts proteins and lipids and packages them into vesicles for transport to their final destinations. These vesicles can either be transported within the cell or exported outside the cell. Also include Lipid Metabolism: In addition to processing proteins, the Golgi apparatus also plays a role in lipid metabolism, synthesizing various lipids required for the cell membrane and other cellular functions. When the Golgi apparatus malfunctions, it can lead to various diseases and cellular dysfunctions. Some notable examples include:

Golgi Storage Diseases are a group of rare genetic disorders characterized by the abnormal accumulation of macromolecules within the Golgi apparatus. One example is sialidosis, which leads to the buildup of sialic acid within the Golgi and causes a range of neurological and systemic symptoms. Research suggests that dysfunction in the Golgi apparatus may contribute to the development of Alzheimer's disease. Disruptions in protein processing and trafficking within neurons can lead to the accumulation of toxic protein aggregates. In the meantime, Golgi apparatus dysfunction has also been implicated in various neurological disorders, including some types of hereditary spastic paraplegia, which affect the long nerve fibers in the legs, causing muscle weakness and stiffness.

9. Conclusion

In conclusion, the intricate structure and functions of human cells play a pivotal role in the foundation of life and the maintenance of our physiological processes. Our understanding of cell biology has advanced significantly, uncovering the intricate networks of organelles, proteins, and genetic material that orchestrate life itself. This knowledge has not only revolutionized medical science but also holds immense potential for the future. As we delve deeper into the complexities of cellular biology, we can anticipate breakthroughs in disease treatment, regenerative medicine, and biotechnology. The structure and function of human cells are at the forefront of scientific exploration, offering a promising pathway toward unlocking the mysteries of health, disease, and the advancement of human well-being. The future promises exciting discoveries that will continue to shape our understanding of life at its most fundamental level. In conclusion, the intricate structure and functions of human cells play a pivotal role in the foundation of life and the maintenance of our physiological processes. Our understanding of cell biology has advanced significantly, uncovering the intricate networks of organelles, proteins, and genetic material that orchestrate life itself. This knowledge has not only revolutionized medical science but also holds immense potential for the future. As we delve deeper into the complexities of cellular biology, we can anticipate breakthroughs in disease treatment, regenerative medicine, and biotechnology. The structure and function of human cells are at the forefront of scientific exploration, offering a promising pathway toward unlocking the mysteries of health, disease, and the advancement of human well-being. The future promises exciting discoveries that will continue to shape our understanding of life at its most fundamental level.

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