Chapter One: Cell Overview

Introduction

 Have you ever wondered how your body was able to heal a wound you received? Or, perhaps, you’ve wondered how your lungs are able to keep air inside of them. Cells make the remarkable feats that your body is able to accomplish possible. Cells make up everything in your body and each cell has a purpose. There are skin cells, muscles cells, brain cells and so on. Without cells, an object could not exist. Cells serve a variety of functions that include more than just making up an object. They serve important biological processes- such as the acquisition of energy, oxygen, and every other chemical process required to live. In this chapter, we will be looking at the composition of a typical eukaryotic cell, the role that each component of the cell plays in overall function of the cell, and how a typical cell will behave in a standard environment.

* 1. Different Cell Types

Cells can be divided into two main cell types. Those two cell types are **eukaryotic** and **prokaryotic** cells. We will be examining a typical eukaryotic cell for this chapter. Within the eukaryotic cell classification there are other sub classifications of cells. These cells include muscle cells, bone cells, nerve cells, skin cells, and the list goes on and on. They can be divided and distinguished based on their internal structures, which are called **organelles**. The characteristic found in eukaryotic cells that distinguish them from prokaryotic cells, is the presence of a membrane bound nucleus. We will go into more detail about the nucleus and all the other organelles in the next section.

The simplest way to think about a generic cell, for learning purposes, is to think about an enclosed circle. Organelles are found within that circle. Organelles have specific jobs within the cell that allows the cell to function properly and perform the biological processes that are required for sustaining life. They are held in place within the cell by **cytoplasm** (Khan Academy**).**

1.2 Cytoplasm

 **Cytoplasm** is the area within the cell that surrounds the organelles and fills space in the area within the cell that does not have any organelles. Cytoplasm is composed of two main substances. These substances are the **cytosol** and the **cytoskeleton**. Cytosol is a jelly-like substance that is used to keep organelles in their appropriate location. This is the substance that you most likely picture when you think about the cytoplasm. The other component of cytoplasm is the cytoskeleton. As you probably have guessed based off of its name, the cytoskeleton is the potion of the cytoplasm that gives the cell its shape. It is the skeleton of the cell, which is composed of smaller tubes and filaments that help give the cytoskeleton a more rigid shape. The cytoskeleton of the cell will also move and change based off of the needs of the cell at that specific time.

 The cytoskeleton of the cell is further divided into subunits that allow it to move to meet the needs of the cell. There are three subunits found within the cytoskeleton, which are **microtubules**, **intermediate filaments**, and **microfilaments**. Microtubules are the biggest element of the cytoskeleton. They are long tubes that are hollow that give the cell its shape and also move organelles along the hollow tube in a train track manner. Microtubules also help in the separation of DNA. Intermediate filaments main job is to give the cell its rigid shape and helps with the cells overall strength. Microfilaments are the smallest of all three structures and their main function is to help the cell move and assist in cell division (Wickstead, Gull 2011).

1.3 Cell Membrane and Nucleus

 The cytoplasm and all the organelles within the cell are held in place by an outer layer that is known as the **cell membrane.** The cell membrane circles the entire outer surface of a cell to keep all the components inside of the cell. It acts as a protective layer for the cell that lets select substances enter and exit the cell. The cell membrane also helps protect the cell and provides structural support. A cell membrane should not be confused with a **cell wall.**

 A cell wall is a rigid outer layer that surrounds the membrane of a cell. Cell walls are found in plant cells while most animal cells do not posses one. Most animal cells only have a cell membrane while all plants cells will have a cell wall.

Now that we have an understanding of the structural components within a cell, it is time to look at organelles that perform biological functions that contribute to the possibility of life.

 The **nucleus** is perhaps the most important part of a cell’s composition. Without a nucleus a cell cannot function in the way it is suppose to function. The nucleus of a cell is where the genetic material is encoded. What this means is that the template to form a new cell is found within the nucleus. The genetic material that is found inside the nucleus is referred to as DNA, which means deoxyribonucleic acid.

 The nucleus will also be in charge of regulating gene expression. This means that the nucleus is in charge of everything that happens within the cell. Because of this reason the nucleus is often referred to as the control center of the cell. Since it is so important to the over all function of the cell, the nucleus is protected as much as possible with its main defense being the impressive cell membrane that selectively allows substances in.

 There are other components that go into making up the cell nucleus that also provide extra protection. One of the structures is referred to as the **nuclear envelope**. The nuclear envelope is found immediately on the outer surface of the nucleus and covers the nucleus in a double bound membrane. On the outer surface of the nuclear envelope are pores. These pores are required in order to get material from the cytoplasm into the nucleus because large materials are not permeable to the nucleus.

 Also found within the nucleus, is a structure called the **nucleolus.** The nucleolus is a part of the nucleus that is only distinguishable because it is a denser portion in the center of the nucleus. Small organelles are made here that are essential to protein production.

1.4 Ribosomes

 Ribosomes perform an important task for the cell. **Ribosomes** are the site where protein synthesis takes place. This means that proteins are made within the ribosome. Ribosomes themselves are made inside of the nucleolus and then pass through the pores on the nucleus to become free within the cytoplasm. Ribosomes can be free inside the cytoplasm or they can be attached to another organelle such as rough endoplasmic reticulum.

 Protein synthesis is accomplished by linking amino acids together to form a functional protein. Protein synthesis is helped by the structure of the ribosome. Typically, ribosomes will be composed of two separate subunits- one bigger than the other. These components are referred to as the large and small subunits of ribosome. The subunits of the ribosome are composed of rRNA (ribosomal RNA) and ribosomal proteins.

Ribosomes are measured in units called Svedberg (S). For eukaryotic cells the measurement is 80S ribosomes and prokaryotes have 70S ribosomes. The small subunit for eukaryotic cells is 40S and the large subunit is 60S.

 As stated above, **Endoplasmic reticulum** is found in two different varieties. Those categories are rough ER and smooth ER. Rough endoplasmic reticulum is connected to the outer surface of the cell envelope. Rough ER is designated rough because throughout the surface of the rough ER, are ribosomes. These ribosomes give the endoplasmic reticulum their rough look. Smooth ER is named so because of the lack of ribosomes found on the surface of the organelle.

 **Rough endoplasmic reticulum** is a major site for protein synthesis because of the membrane bound ribosomes found on the surface of the ER. The ER is a series of maze like tubes that surround the nucleus. The inner portion of the maze tube is called the lumen. Protein synthesis takes place in both the lumen and on the surface of the ER.

 **Smooth endoplasmic reticulum** is connected to the rough ER, but it is not formed in the maze-like structure the way rough ER is. Instead it is much more linear however it does still connect throughout the structure to form canals with itself. The major difference between rough ER and smooth ER, other than the presence of ribosomes, is the products that are being synthesized. Smooth ER synthesizes lipids. Lipids include cholesterol and phospholipids. The cholesterol that is synthesized here contributes to the formation of steroid hormones. Smooth ER also contributes to drug detoxification especially in the liver.

1.4 Golgi apparatus and Mitochondria

 The **Golgi apparatus** is the next step in protein synthesis after they go through the endoplasmic reticulum. The Golgi apparatus is similar in structure to the rough endoplasmic reticulum. They are similar to each other because they both form a folded up maze type structure. Proteins are sent to the Golgi apparatus to decide if the proteins need any sort of modification. If they need to be modified, then they will be modified right at the site. If they do not need to be modified then the Golgi apparatus will package the proteins and then send them to the appropriate organelles. If no organelles need proteins then the Golgi apparatus will store those proteins until an organelle needs them for later use.

 Because the Golgi apparatus is so heavily involved in the transport of proteins, there had to be some sort of method that could be used in order to more effectively transport the proteins. The method of transport that the cells eventually evolved to tackle this problem is referred to as a **vesicle.** A vesicle is a protein or whatever substance needs to be transported that has become surrounded by a membrane in order to be transported. This is accomplished by the membrane bound structure pinching itself off away from the membrane that it is trying to transport itself away from.

**Mitochondria** are one of the most important organelles. Its main function is to provide energy to the cell. It is oval in shape and it has two membranes, an inner membrane and an outer membrane. The inner membrane is folded in on itself repeatedly, which increases the surface area of the inner membrane. The difference between the inner membrane and the outer membrane is that the outer membrane serves the purpose of protecting the cell and providing stability.

 Within the inner membrane, a series of biochemical reactions are going on in order to convert the food that we eat into energy for your entire body. It is worth noting that mitochondria have their own set of DNA as well as its own ribosomes. This suggests that at some point, way back when life on earth was beginning, mitochondria were free-living organisms that were ingested inside of bigger cells and they were able to carry on their normal function as well as benefit the cell that it was ingested by. This mutually beneficial relationship was so important that the cells and the mitochondria evolved together so that no free-living mitochondria exist anymore.

1.5 Vacuole and Lysosomes

 **Vacuoles** are found throughout the cytoplasm of the cell. They can be large or small and are sacs filled with fluid. The function of a vacuole is to store material until the cell needs it. Vacuoles store many different materials such as, food, water, enzymes, and inorganic ions. Small vacuoles are found within animal cells, while plant cells usually have huge vacuoles.

 The vacuoles within a plant cell are such large structures that they usually only contain a few and the biggest one is referred to as a **central vacuole.** This is crucial to plant cells because it stores water inside of it, which provides structure and support for the entire plant. A central vacuole is not limited to only storing water. It can also store color pigment that provides plant color, harmful substances to itself, and harmful substances to a possible predator.

 **Lysosomes** are found throughout the cytoplasm of most animal cells. They have a bound membrane that stores enzymes. These enzymes are destructive to materials that enter into the cell and could be a potential threat to the cell. The main purpose of a lysosome is to find potentially dangerous material that is floating around on the inside of the cell, surround it, and then destroy it with its destructive enzymes. Lysosomes are synthesized in the rough ER then go to the Golgi apparatus to be released inside of a vesicle. From here they search for cell parts or broken down cell components so they can help keep the cell from damage and to keep them working properly.

1.6 Structures in Plant Cells

 Chloroplasts are unique to plant cells and they are the site where photosynthesis takes place. **Photosynthesis** is the process of turning solar energy into energy that is readily available for use inside of the plant cell. Chloroplasts are composed of two membranes just like mitochondria. They have an inner membrane as well as an outer membrane and the inner membrane does work to acquire energy for the cell.

 Within the inner membrane are structures called thylakoids. **Thylakoids** are disc shaped sacs that stack on top of one another within the inner membrane. Within these structures, chlorophyll is found. **Chlorophyll** is responsible for the characteristic green color of plants because it absorbs all light except green. Chlorophyll is a key component of photosynthesis because of its light absorbing abilities.

 Chloroplasts also contain their own set of DNA and ribosomes just like mitochondria. Because of this reason, scientists have also speculated that they were also free living and taken in by other larger cells just like mitochondria.

1.7 Summary

 Hopefully after reading this chapter you are able to distinguish the various components and organelles of eukaryotic cells. Along with being able to distinguish one structure from another, you should also be able to tell what the overall function and purpose of any organelle is. This chapter is meant to provide you with crucial information about how cells operate. This is an important concept to understand especially if you are planning on joining the medical field or go into research. All in all, each cell is a perfect little machine that operates to keep you alive, and the best way to remember this is to know how every organelle relates to one another and which organelles are found in which type of cell.

References

Nowicki, S. (2015). *Biology.* Orlando, Florida: Houghton Mifflin Harcourt. 03-17-2017

Khan Academy. (n.d.). Retrieved April 07, 2017, from https://www.khanacademy.org/science/biology/structure-of-a-cell/prokaryotic-and-eukaryotic-cells/a/intro-to-eukaryotic-cells

Wickstead, B., & Gull, K. (2011). The evolution of the cytoskeleton. *The Journal of Cell Biology,194*(4), 513-525. doi:10.1083/jcb.201102065