**Cellular Structure**

Introduction

How amazing it is that the basic unit of life, the structure with which all life begins as, is a little microscopic “factory” that is constantly working and performing intricate tasks to keep us alive and healthy? All around you, inside you, across the world, and in the sea, millions upon millions of cells are effortlessly performing their daily functions. Cellular respiration, DNA replication, mitosis, and meiosis are just a few examples of the remarkable things a tiny, undetectable to the naked eye, cell can do. In this section, you will learn how cells were discovered, the size of cells and why they are such a size, the structural differences between prokaryotic and eukaryotic cells, as well as extra-cellular structures.

History

The man given credit for discovering cells is Robert Hooke in 1665. Using a primitive compound microscope while looking at a slice of a cork, Hooke saw the first simple structure of a cell. We later learn that Hooke did not have the technology to view the organelles of a cell, but rather was viewing the cell wall of a dead cell- still a rather major breakthrough for the time!

Anton Van Leeuwenhoek was the one to view a live cell for the first time which included visualization of organelles within the cell. He was also the first to record muscle fibers, bacteria, spermatozoa, and blood flow in capillaries. His progress led to major breakthroughs for microbiology. He is often referred to as “The Father of Microbiology” even though this man made all these discoveries without higher education or a university degree.

Cell Theory

After the discovery of the cell, parameters for the classification of a cell were created into what is now known as the cell theory. It is unclear who first coined the cell theory, but a primitive version of it included three premises:

1. The cell is the unit of structure, physiology, and organization of living things.
2. The cell retains a dual existence as a distinct entity and a building block in the construction of organisms.
3. Cells form by free-cell-formation, similar to the formation of crystals (spontaneous generation).

We now know that the first two perimeters of the cell theory were correct, but the third one is far from true. Cells do not spontaneously generate but actually grow by organized cellular division. The modern, correct version of the theory of cell division is as follows.

1. All living beings are made up of one or more cells.
2. The cell is the building block (or basic unit) of life.
3. All cells come from preexisting cells.

Size of the Cell

All cells vary in size, but in general Eukaryotic (animal and plant) cells are ten times the size of prokaryotic (bacteria and archea) cells. Eukaryotic cells are typically around 10-100 micrometers in diameter. That is .00001 of a meter! This would be the approximate size of all the cells that make up your body- all 37.2 trillion (approximately) of them! Prokaryotic cells are typically .1-5 micrometers in diameter. (We will learn more in depth about prokaryotic and eukaryotic cells later in this chapter.)

But why are these cells so small? Why would our basic units of life be so small that we can’t even see them? Wouldn’t it be easier if we could see them so we could monitor our bodies and make sure everything is running smoothly? Or if they were bigger maybe they could spend less time replicating? One reason is for simple logistics. Cells die and reproduce frequently. If cells are extremely small, that means a rather large amount of cells could die and it would not affect the organism simply because there are so many other cells that can take the dead cells’ place. But the more important reason and the bigger answer lies in the ratio of surface area to volume of a cell. Cells perform an immense amount of functions, meaning it also has to import and export an immense amount of nutrients and waste. The communication from the cell’s organelles to the nucleus have to be quick, and for them to be quick they cannot be far apart. Also, cells have to be able to diffuse things quickly; the bigger a cell is, the farther something entering or exiting a cell has to travel, meaning the longer it takes.

Cells need to receive things and be able to rid of them as quickly as possible or else the cell would begin to have a buildup waste. For example, let us compare a cell to the kitchen of a restaurant. At a normal sized restaurant, people order their food and the servers take the food out to the customers and all is well. But now, imagine this restaurant has decided to expand to a whole mile. Now by the time a server takes one table their food, the kitchen already has out food for another fifteen tables. Noe the kitchen is backed up to where it cannot make any more food because the food that needs to go out to tables is taking up all room. The servers simply cannot get the food out to tables in an efficient amount of time because the tables are so far away. This is why we do not have mile-sized restaurants and also why cells are so small.

Prokaryotic and Eukaryotic Cells

As discussed earlier, prokaryotic and eukaryotic cells differ by size as well as the group of organisms they belong to. In a broad sense, prokaryotic cells belong to bacteria and archaea while eukaryotic cells belong to animals and plants. But, the difference between the two are deeper than just belonging to different kingdoms.

**Eukaryotic** cells have:

* membrane bound organelles (example- golgi apparatus)
* one membrane bound nucleus
* mitochondria
* double stranded DNA helix
* multiple chromosomes
* microtubules

Includes: animals, plants, fungi, protists

**Prokaryotic** cells have:

* nucleoid (non-membrane bound genetic information)
* single stranded, circular DNA
* plasmids instead of chromosomes

Includes: bacteria, archaea

Cell Structure

Cells even as simple and small as prokaryotes still have to contain some basic units to function that are found in eukaryotic cells as well. These would include the plasma membrane, cytoplasm, DNA, and ribosomes.

The plasma membrane is a covering around the cell that separates the insides of the cell from its environment. The plasma membrane is semi-permeable (meaning some things can easily diffuse through while others cannot) and made of a phospholipid bilayer. This means there are two layers of phospholipids making up the membrane. A single layer of a phospholipid contains a hydrophilic (water-loving) head, facing the environment outside of the cell, and a hydrophobic (water-hating) fatty-acid tail layer attached the head that points towards the inside of the cell. But since it is a bilayer, the second layer is the same, simply flipped. The tail of one meets up with the tail of the second layer so the second head faces the inside of the cell (see figure 1).

**Figure 1**

The plasma membrane is an extremely important component to the cell. It keeps the things that need to remain in the cell inside the cell while also keeping things from the environment outside the cell. Without the phospholipid bilayer the cell would not be separated from its environment, meaning it would have no protection from its surroundings.

The cytoplasm of the cell is the jelly-like fluid that is inside the cell. Imagine those fruit jello-plates that you see around the holidays. They typically have fruit suspended (or looks to be floating around) in the jello. The suspended whole pieces of fruit are like the organelles of the cell and all the jello around it is like the cytoplasm of a cell. While the cytoplasm can seem unimportant, almost all of the important activities occur in the cytoplasm. The cytoplasm also contains important enzymes which can do things like break down water or aid in the metabolic pathway. Cytoplasm also gives the cell its shape, provides structural support, and helps hold the organelles in place so they aren’t floating around everywhere.

DNA (deoxyribonucleic acid) is the genetic material of the cell that codes for proteins. It is like the blueprint of a building. The DNA information is stored in four chemical bases: adenine (A), guanine (G), cytosine (C), and thymine (T). The order of these bases determines the genetic makeup of the organism, just like the way letters of the alphabet combine to form a word and sentences. In prokaryotes, the DNA is lumped together in what is called the nucleoid. While it is grouped together it is now bound by a membrane. In eukaryotes, the DNA is found in the membrane-bound nucleus.

Ribosomes are molecular machines that synthesize proteins. Ribosomes can be floating in the cytoplasm in prokaryotic cells. This is also the site of protein synthesis, where RNA is translated into protein. Since protein plays an important role in our bodies, there are large number of ribosomes to provide our cells with what they need.

While these previous structures are basic and found in prokaryotic and eukaryotic cells, there are more fundamental structures that are only found in eukaryotic that remain just as important. These will be listed in the following figure 2.

**Figure 2**

|  |  |
| --- | --- |
| **Organelle** | **Function** |
| Nucleus | DNA Storage |
| Mitochondria | ATP production |
| Smooth Endoplasmic Reticulum | Lipid-production |
| Rough Endoplasmic  Reticulum | Protein-production for export |
| Golgi Apparatus | Protein modification, packaging and export |
| Peroxisome | Lipid destruction |
| Lysosome | Protein destruction |
| Vacuoles | Storage |
| Chloroplasts | (Plants only) Production of ATP photosynthesis |
| Cytoskeleton | Structural support, movement of materials |

Extracellular Structures

Outside of the cell membrane, plants and fungi have a cell wall for extra support and protection while animal cells have an extracellular matrix which is a meshwork of macromolecules. A major component of the extracellular matrix is collagen. This collagen helps create strength and structural integrity for the cell. In plants, the cell wall provides rigidity and structure. It is also what gives things like raw vegetables a crunch. Like if you were to bite into a celery, the crunch would mostly be from the cell wall. Fungi and some protists also have cell walls.

Cell, or not?

We now know how cells are classified via the cell theory. But there does remain a group we encounter every single day of our lives that does not really fit in the category of a cell, but it is in fact living. This would be viruses. The very root of the common cold we all despise.

Viruses are the robot hackers of the biology world. They are very, very small at around 100 times smaller than one single bacteria. Viruses either have DNA or RNA for their genetic material, but they do not have any cellular organelles, meaning they don’t metabolize. Instead, viruses use other living things as a host. Another unique quality of viruses is that they cannot reproduce. This makes them unable to be classified as a cell (think back to the cell theory).

Viruses do not fall under prokaryotic or eukaryotic guidelines, therefore they remain in a grey, uncategorized area. Almost like a classic movie zombie, viruses seem to be the living dead that feast off of healthy cells. Regardless of their lack of basic cellular functions, viruses do indeed have a large impact on our lives- from small things like a cold or wart, to large, even fatal things such as AIDS.

Overview

* Hooke viewed the first outline (cell wall) of a cell
* Leeuwenhoek viewed the first live cell including organelles
* Cells are small because of surface area to volume ratio
* Cell theory:
  + All living things are made of cells
  + Cells are the basic unit of life
  + Cells come from preexisting cells
* Two types of cells- prokaryotic (archaea and bacteria) and eukaryotic (plants, animals, etc.)
* Prokaryotic cells are smaller with no membrane bound organelles or nucleus with single stranded DNA
* Eukaryotic have membrane bound organelles, defined nucleus, double helix DNA, and microtubules
* Plants have cell wall
* Animal cells have extracellular matrix

Discussion

Cells are truly amazing. These tiny, microscopic things are what support every aspect of life on this earth. Cells communicate with each other, produce energy, reproduce themselves, and even perform their own cell death. It is fascinating that such intricate processes and work is going in your body and all around you 24/7.

Something even crazier to think about is that you, your cat, and even the chicken you had for lunch started out life as one tiny cell. That one tiny cell has replicated and organized itself into the intricate machine that you are today.

References:

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