**Cellular Reproduction and the Functions of Organelles**

**Word Bank:**

**Prokaryotes**

**Eukaryotes**

**Nucleus**

**Rough E.R.**

**Smooth E.R.**

**Golgi apparatus**

**Mitochondria**

**Vacuole**

**Lysozyme**

**Meiosis**

**Mitosis**

**Introduction:**

The cell is the most basic unit of all living organisms. It is the sole make up of single celled organisms such as bacteria, as well as the building blocks of tissues and organs in multicellular organisms such as humans, and plants.

Robert Hooke was the first scientist to describe cells in 1665, thanks to the invention of the microscope. This was achieved after Hooke viewed thinly sliced cork under a microscope, which appeared as small boxes or “cells” (2). Further microscopic viewings were then conducted on plant cells, which were observed to have structures within them, this eventually lead to the development of the cell theory which stated that “the cell is the fundamental structural and functional unit of living matter and that the organism is composed of autonomous cells with its properties being the sum of those of its cells” (3). This theory is essentially saying that when cells come together to form multicellular systems such as tissues and organs the multicellular systems are doing the same job as a single cell but in unison.

There are two cell types that are recognized by the scientific community. The first being **Prokaryotes**, which are single celled organisms such as bacteria or algae and the second being **Eukaryotes,** which are multicellular organisms that contain specific membrane bound organelles (1).

**Prokaryotes vs. Eukaryotes:**

Prokaryotes and Eukaryotes have many differences. Prokaryotes do not contain a nucleus nor do they have any membrane bound organelles, they are very small in size and are thought to be the first living organisms on Earth. Prokaryotic cells are relatively primitive, functioning with very few cellular structures, as well as having free-floating DNA molecules in the cytoplasm of the cell membrane. The main cell structures of the prokaryotic cell include the cell wall, cell membrane, cytoplasm, flagellum and ribosome. The cell wall is used to give the single celled organism its shape as well as protects it. The cell membrane can be found surrounding the cytoplasm (a gel substance composed of organic molecules) and is used as a flow gradient to monitor what comes into and out of the cell. The ribosome is used for the synthesis of proteins and the flagellum is used solely for the purpose of mobility (4).

The main difference of eukaryotic cells from prokaryotic cells is the presence of a nucleus, as well as specific, membrane bound organelles. Eukaryotic cells are thought to have evolved from prokaryotic cells, this idea is called the Endosymbiotic theory, which states that the membrane bound organelles contained within eukaryotes were once free living prokaryotes that were taken up by other free-living prokaryotes (4). An organelle is defined as “ a specialized cellular part that has a specific function and is considered analogous to an organ.” (3). The major organelles contained within human eukaryotic cells are the nucleus, rough and smooth endoplasmic reticulum (E.R.), golgi apparatus, mitochondria, nucleus, vacuole, and the lysosome. The functions of these organelles are vital in maintaining a healthy multicellular complex and work as follows: The **nucleus** contains nearly all of the cells genetic material (i.e. chromosomes, proteins). The **rough E.R.** functions by translating and folding polypeptide chains into proteins and is rough due to the presence of ribosomes on the surface of the organelle, the **smooth E.R.** is used to express lipids and is folded and tubular in shape (4). The **golgi apparatus** is used to package and sort proteins that will be needed for later use by the cell. The **mitochondria** is probably the single most important organelle within the eukaryotic cell, its function is to create ATP for the cell, which is the main energy source of the cell to maintain cellular function. The **vacuole** is used to store as well as transport proteins throughout the cell and the **lysosome** functions in breaking down large foreign molecules within the cell (4).

Although it can be confusing at first when it comes to remembering the differences between prokaryotes and eukaryotes it is easier to remember at first what they do have in common, which is a plasma membrane, cytoplasm, ribosome, and cell wall. Once the similarities have been identified it is easier to recognize what sets them apart which is the presence of organelle bound membranes and a nucleus. Table 1 is a visual representation of the physical differences between the two.

|  |  |
| --- | --- |
| Prokaryotic Cell | Eukaryotic Cell |
| * **Bacteria or algae** * **Single celled** * **Free-floating DNA** * **No Nucleus** * **No membrane bound organelles** * **Much smaller** | * **Presence of Mitochondria** * **Nucleus** * **Rough and Smooth E.R.** * **Golgi apparatus** * **Vacuoles** * **Lysosome** * **Multicellular organisms** |

**Table 1**: Differences between prokaryotic cell and eukaryotic cell

**Cellular Reproduction:**

Prokaryotic and eukaryotic cells reproduce in different ways, with prokaryotic cells undergoing binary fission, where as eukaryotic cells have two different processes for cell reproduction called **meiosis** and **mitosis**. Prokaryotic reproduction is far easier then eukaryotic reproduction due to the fact that there are no organelles with far less DNA. The process of binary fission begins with the origin of replication, which is found on the DNA molecule present in the cell called a chromosome. This causes the cell to elongate creating a midpoint in the cellular organism. Once the DNA molecule (or chromosome) is replicated they begin to move apart from each other in the cell forming a ring around the midpoint and creating what is called a septum, which forms a separation type wall between the two newly formed plasma membranes. The septum is then fully pinched creating two separate but identical prokaryotic cells (5).

The process of mitosis involves 5 steps and is utilized by eukaryotic cells to generate two genetically identical daughter cells. Mitosis is used strictly as a way of generating somatic cells, which are typically skin and muscle cells. The first step of mitosis is called prophase, which involves the coiling of chromosomes and the formation of vital mechanisms called spindle fibers. The newly generated spindle fibers are then used during the next stage of metaphase in order to pull the chromosomes to the center of the cell and align them in a nice straight line. Once aligned the anaphase step begins which involves the spindle fibers pulling the chromosomes from the center of the cell to opposite sides of the cell. Once the chromosomes are pulled to opposite sides the telophase step begins, which involves the development of a new nucleus at the two opposite ends of the now elongating cell. The process then comes to an end during the cytokinesis stage in which the elongated cell containing two identical chromosomes and nuclei at opposite ends is cleaved in the middle of the cell in order to generate 2 identical daughter cells (6).

Meiosis is a process performed only by eukaryotic organisms that reproduce sexually. This process requires that two individuals give their genetic material in the form of sperm and eggs, which only contains half of the number of chromosomes as the original (7). The process of meiosis is much more complicated the mitosis but can be thought of in relatively the same way due to the fact that all of the stages are named the same things except there are now 2 of each (i.e. prophase 2, metaphase 2 etc.). Step one is prophase 1 and involves the condensing of chromosomes as well as the break down of the nucleus. The next step is metaphase 1, which involves the alignment of chromosomes in the center of the cell just as in mitosis except this time the chromosomes are paired with other chromosomes. Anaphase 1 involves these pairs getting pulled to opposite sides of the cell by the spindle fibers. Telophase 1 then occurs which divides the newly developed cytoplasm separating the two opposite sides of the cell containing the paired chromosomes from anaphase 1. The same steps are followed as above in Prophase 2, Metaphase 2, Anaphase 2 and Telophase 2 with the end result of meiosis being four total cells each only containing half of the amount of genetic material as the original cell (7).

Although all of these processes and steps can seem extremely overwhelming, the most important thing to take away from this is the fundamental end goals of each process is. Which is binary fission is only for prokaryotic cells to reproduce, where as muscle and skin cells are regenerated via mitosis and human reproductive cells are generated through the process of meiosis.

**How cell growth relates to Cancer:**

Cancer can start nearly anywhere in the body and is the result of uncontrollable cell growth that form tumors (8). During the process of healthy somatic cell growth the old or damaged cells are supposed to die as they are replaced with the new cells. However, when cancer develops the damaged or dying cells do not die while regular somatic growth continues forming solid masses of tissues called tumors (8). Cancer cells are much different than normal cells due to the fact that they grow uncontrollably and can also spread throughout the body. Cancer cells are far less specialized than normal somatic cells, meaning that the somatic cells have specific jobs where as the cancer cells do not which makes their cell division much harder to control. The cancer cells are able to ignore the process of cell death and regeneration, which is a vital need in getting rid of non-useful cells (8). This disruption of cellular balances causes other proteins and molecules to have effects on other cells in other parts of the body, which leads to the ability of the disease to spread throughout.

Although the cell is the building block of life in all-living organisms, it can also be the very reason a living organism can die. This is because the processes of somatic cell growth are extremely tedious and complex, yet these processes are carried out billions of times a day by the trillions of cells existing in the human body. It is only natural that something as complex as cellular reproduction can lead to mistakes that have devastating affects over long periods of time. It is truly fascinating to see the building blocks of life in action as the processes of mitosis and meiosis take place every single day in every living organism.

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