**The Plant Cell**

**Introduction**

When internally depicting the word “cell” one may generally create an image of a small, probably round, or pill shaped, glob of mostly slime encompassed in an equally slimy sack or membrane. Unfortunately, this general depiction falls short of the wonderfully diverse and complex cell community in the world around us. In this chapter we will focus primarily on the structure of the cells making up most plants. The plant cell is considered eukaryotic, possessing both a membrane bound nucleus, as well as membrane bound organelles. Plant cells are generally larger, anywhere from 10-100 micrometers, and more symmetric than the cells that make up animals. Throughout this chapter we will discuss the key components making up plant cells, as well as their function. We are going to highlight structures that make plant cells unique from other cells, and how these structures are specifically utilized for plant life.

**Cell Structures**

**1. Cell Wall and Plasma Membrane**

The cell wall is a distinct outermost structure in plant cells. Some species of prokaryotes may possess a cell wall, however the cell walls seen in plants are much larger and complex. The cell wall in most plants is composed of two components: the primary and secondary cell walls. The internal, flexible layer is known as the primary cell wall. The flexibility of this layer helps to accommodate cell growth. Although flexible, the primary cell wall is also strong enough to withstand and maintain internal cell pressure. Once growth has slowed and the cell has further matured, a stronger, more rigid secondary cell wall develops outside of the primary cell wall. This cell wall is chiefly responsible for overall cell protection, maintaining cell shape, and the initial barrier between internal and external cell transport. The cell wall generally maintains a square or rectangular shape, but this can change, should the cell become more specialized.

Plant cell walls are primarily comprised of a variety of polymers. The specific polymer can vary, depending on the type of plant the cells make up. Two example polymers are lignin and cellulose. Polymers like these make intricate combined structures giving plants the strength and structure they need to be successful. This can range from small flowers, to massive trees. Inter-webbed polymers combine in appropriate manner and amount to form the ideal specific plant form.

Moving a step farther in, plant cells possess a plasma membrane. The plasma membrane is a common feature to most species of cells and is not unique to plants. The plasma membrane is composed of a lipid bilayer. Each unit is composed of a hydrophilic (water loving) head and hydrophobic (water fearing) tail. This affinity for water leads to the bilayer development because the heads want to be exposed to water molecules while the tails do not. This leads to similar groupings, consistent throughout the membrane. The plasma membrane is also a key role player in protection and many of the chemical reactions of the cell. Once a molecule has passed through the cell wall, it is up to the plasma membrane to decide if the molecule can progress any further. The membrane also houses many specialized proteins and other components, crucial for cell survival. Many of the other organelles discussed in this chapter are also membrane bound. The importance of these membranes will become increasingly apparent throughout.

**2. Cell Nucleus**

Another organelle not specific to plant cells is the nucleus. Because of its vast importance it is easy to understand why this organelle is common in all eukaryotic organisms. The nucleus can be compared to the headquarters of a large corporation, responsible for governing the daily activity of the cell as a whole. Nuclear membranes largely encompasses the DNA of the cell. The exact form the DNA rests in is dependent on cycles the cell passes through such as periods of replication. The nucleus is primarily composed of three key components, the nucleolus, the nuclear membranes and the nuclear pores. The nucleolus is a part of the nucleus, enclosed within the nuclear membrane. This structure is responsible for production of ribosomes. Ribosomes are then used elsewhere within the cell to produce proteins. The second component of the nucleus is the nuclear membranes consist of two layers, which are jointly named the nuclear envelope. The nuclear envelope is the primary passage barrier, governing what moves in and out of the nuclear body. Passages through the nuclear envelope are called nuclear pores. These physical passageways are the direct ports from the interior of the nucleus to the external cytoplasm. Although the envelope is riddled with these pores, there is still highly exclusive regulation of what can pass in and out of each opening. Key elements for building the overall genetic material are allowed in, while products of this genetic material are allowed to exit.

Interestingly, the entire nuclear make up undergoes drastic changes when the cell prepares to replicate. Genetic material condenses into structures known as chromosomes, and the envelope itself disappears all together. The cell then replicates, sharing genetic material, and all genetic material and nuclear bodies are restored. This is of upmost importance in both cell and human survival.

**3. Endoplasmic Reticulum**

Just a step outside the nucleus lays the endoplasmic reticulum. This organelle is a system of membranes that functions to produce vital proteins and lipids for use throughout the cell. The endoplasmic reticulum is divided into two sections: the smooth and rough endoplasmic reticulum. These two sections are named according to their obvious appearance. The rough E.R. is studded through out its membrane with ribosomes. These ribosomes are permanently embedded in the membrane side closest to the cytoplasm. These partially exposed ribosomes produce a wide variety of proteins for the cell that carry out a diverse range of functions. The more a specialized cell is concerned with protein production, the more ribosomes it will possess in the rough E.R.

The smooth endoplasmic reticulum, although directly connected to the rough E.R., serves a very different function. The smooth E.R. serves as a primary lipid producer. The smooth E.R. does not possess ribosomes in its membrane, hence the smooth title. This lack of ribosomes also makes it easy to see why this section of the endoplasmic reticulum serves a different purpose. The lipids produced here are distributed through out the cell to serve many uses, including membrane development. Cells concerned with the production of cholesterol and other steroids will focus more heavily on their smooth E.R. and less on their rough sections. The smooth E.R. also serves to detoxify certain compounds that may appear in the cell. Luckily the smooth E.R. possesses the ability to convert these normally toxic compounds into ones the body and cells can more readily handle. To make this more efficient the smooth E.R. can change its size, via expansion of surface area, in times of heavy detoxification.

**4. Vacuoles**

Perhaps one of the most important organelles in all plant cells is the vacuole. Although not specific to plant cells alone, the style of vacuole in plant cells is unique. Plant cells generally contain one large vacuole, centrally located inside the cell. This can account for well over half of the cell’s entire volume. The vacuole exists as a membrane bound sack. Like most other membranes inside a plant cell, this one is selective as to what molecules can diffuse through the membrane. In maturing cells, the vacuole grows by addition of smaller vacuoles the cell internally produces. These smaller vacuoles merge with the larger, already existing vacuole to make one larger unit. The vacuole is an extremely important storage device in the cell. The components stored within can vary based on the type of plant the cells make up, and the level of specialization in the cell. Anything from plant waste to salts to various pigments can exist inside the vacuole. These pigments can play roles such as giving plants and flowers distinct colors, and containing compounds making them taste less desirable to other animals that may attempt to consume them.

Aside from simple storage the vacuole is also an important regulator of internal pressure for the cell. When the cell finds itself in favorable conditions it may be largely filled with water. This mass of water inside the cell generates a large pressure on the cell wall. This pressure is known as turgor pressure. The cell wall is equipped to handle this pressure in healthy cells and thus the contained pressure makes the cell more solid and rigid. This is very important in maintaining structural integrity of the cell, and the plant over all.

**5. Golgi Apparatus**

Just as large cities rely on transportation methods to ship products from one location to another, a cell must do the same to ensure proper distribution of molecules necessary for survival. The Golgi apparatus in the cell can be compared to the post office in a bustling city. Primarily, the Golgi is responsible for intake of proteins and other molecules developed in the endoplasmic reticulum essential for cell function, and packages them in membrane bound sacks known as vesicles. These vesicles are then taken from the Golgi body and moved to other locations inside the cell, or taken to the outer cell membrane to be disposed of externally. The Golgi is physically comprised of several cup shaped folds that intake the molecules to be packaged, and alter them internally to make shipping easier. The number of Golgi bodies in a cell can vary, depending on cell specificity and desired function.

**6. Microfilaments and microtubules**

Microfilament and microtubules are most easily compared to the skeleton in a human. These structures help maintain over all structure of the plant cells. They also aid in transport of certain molecules throughout the cell, and even cell division. All microfilaments are long fibers composed of a special protein known as actin. These units undergo polymerization to form long fibrous units. These fibers also possess plus and minus ends. These specified ends are locations for growth and decay. The plus end of the microfilament grows at a rate faster than the minus end that decays as the fiber ages and needs to be replaced. The offset of these rates ensures that parts of the fibers will remain polymerized at all times, ensuring cellular stability.

Like microfilaments, microtubules are skeletal structures at the cellular level. Microtubules help maintain cellular stability and aid in cellular transport. Microtubules also play a role in cellular division in developing spindle fibers. Microtubules are comprised of polymerized molecules know as tubulin arranged into a hollow tube. These tubes are major role players in transporting organelles and various molecules. Proteins attach to the structure being moved, and then attach to the microtubule carry out this transport. The protein can then engage in a walking motion to literally walk the molecule or organelle down the fiber!

Microtubules are also important in development of cilia and flagella. Cilia are small hair like structures that aid the cell in attachment and some mobility. They usually occur in high quantity, and are dispersed around the exterior of the cell. Flagella are larger, longer extracellular extension. These structures can also be used for attachment, but primarily serves as means of mobility. These usually occur in fewer numbers than cilia, and are normally located regionally on the cells exterior, however this does not always have to be the case. Both microtubules and microfilaments possess extremely important roles in maintaining a healthy cell.

**7. Mitochondria**

Mitochondria are perhaps one of the most important organelles in any plant cell. These specialized structures serve as a power source, driving the cell to carry out vital functions for survival. Mitochondria are small oval shaped organelles scattered through out plant cells. Their numbers can vary based on specialization and over all needs of the cell they are contained in. It is believed mitochondria were once their own prokaryotic cells that over time became a part of larger more complex eukaryotes, in symbiotic relationships. Evidence for this hypothesis is related to the fact that mitochondria possess their own genetic material in the form of DNA.

Mitochondria provide the energy needed by the cell through the production of ATP. ATP serves as the main energy component that can store and then release energy contained in phosphate bonds. These molecules are generated through electron transport in the membranes of these mitochondria. Specific proteins are located in these regions that carry out specific chemical reactions to generate ATP that can be used as needed. Plants undergo respiratory processes similar to most animals, so under certain circumstances the plant may rely on specific uptake up nutrients and sugars that are broken apart, into smaller components that the cell can find more usable for production of raw energy molecules.

One interesting aspect about ATP is that because they possess their own genetic material, they can replicate in cycles independent of the entire cell. This is a very important evolutionary step as it allows plant cells to become more adaptable to the demands of the environment it finds it self in, so long as it can maintain regular nutrient uptake. The number of mitochondria contained within a cell can be drastically different, depending on the cell type. This can range from a single mitochondria to fit basic needs, comparative to a small community possessing one small power plant, or tens of thousands, like a large busting metropolis may require. Despite the number inside the cell, a mitochondrial presence is extremely important in all eukaryotes.

**8. Chloroplasts**

Finally, what could be considered the most defining organelle in all plant cells is the chloroplast. Chloroplasts are the housing unit of the most famous plant activity: Photosynthesis. Photosynthesis is the ability for chloroplast containing cells to produce their own energy by using light provided by the sun. The chloroplasts are composed of a two-membrane exterior that house internal components. Inside the double membrane lie the thylakoids, which stack up like pancakes to form structures known as granum. In the open space between membrane and granum is a fluid like material known as stroma. These structures all work together to carry out the famous photosynthetic reactions. Specialized pigments known as chlorophylls kick start this process by absorbing light and using it to gather electrons. These electrons then undergo a sequence of excitation states. The rise and fall in energy levels of these electrons, charged by the sunlight release energy that is then harnessed and converted into chemical energy in the form of ATP. Hydrogen ions are enticed to move because of this electron movement. These are all internal mechanisms for the final ATP product. These electrons are gathered via the breakage of water molecules, giving oxygen as a byproduct. It is easy to see why this type of energy production is so important to other living organisms.

Photosynthetic organisms can also undergo reactions deemed light independent. These reactions occur in the stroma of the chloroplast. These reactions, which occur more heavily at night, use some energy to collect and convert CO2 molecules into more usable forms of carbon. In this case that form is sugar in the form of glucose.

These light independent reactions make plant cells extremely efficient in the real of energy production because of their ability to literally work around the clock, if given the proper resources.

**Summary**

In this chapter we have addressed the major structuctures that plant cells are comprised of. Each organelle possesses specific qualities that help it carry out certain functions to benefit the cell as a whole. Although each examined individually, it becomes apparent that each organelle is interconnected to another to help the cell function like a perfectly synchronized machine. The specific qualities unique to plant cells make them even more extraordinary. Their two-component energy production system, and structurally stabilizing cell walls have helped all plants diversify and withstand the tests of time in extremely diverse environments. From the original genetic material, to vesicles dumping cellular waste, the intricacies at the microscopic level have given us both beautiful garden flowers and powerful, towering red woods.

**References**

Alberts B, Johnson A, Lewis J, et al. Molecular Biology of the Cell. 4th edition. New York:

Garland Science; 2002. The Plant Cell Wall. Available from:

http://www.ncbi.nlm.nih.gov/books/NBK26928/

"Endoplasmic Reticulum (Rough and Smooth)." *British Society for Cell Biology*. British Society

for Cell Biology, 19 Nov. 2015. Web. 04 Mar. 2016.

Mackenzie, S. "Higher Plant Mitochondria." *The Plant Cell Online* 11.4 (1999): 571-86. *The*

*Plant Cell*. Web. 4 Mar. 2016.

"Molecular Expressions Cell Biology: Plant Cell Structure." *Molecular Expressions Cell*

*Biology: Plant Cell Structure*. Molecular Expressions, 13 Nov. 2015. Web. 04 Mar. 2016.

"Plant Cell Membrane." *Plant Cell Membrane*. N.p., n.d. Web. 04 Mar. 2016.