The Cell Components: Back to the Basics

By Michael Semler

In the seventeenth century, Robert Hooke, using a microscope of his own construction, noted that cork and plant tissues are made of small cavities. He was the first to call these cavities "cells", meaning "little rooms". Three hundred years later, we still subscribe to Hookes' foundation.

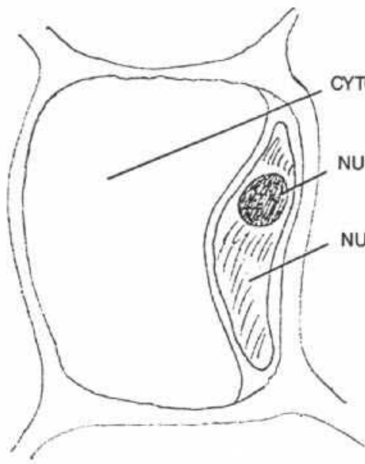
Much of the current education philosophy revolves around getting back to the basics in teaching. Hand held calculators are great, but we still need to know the principles of multiplication and division. Such is the case for us. In order to manage turfgrass properly, we must have a basic understanding of the plant and its cells. This is the basis for this article. It is intended as a review of plant cell structure and a "back to the basics" opportunity.

The plant cell consists of protoplasm and the cell wall. The protoplasm consists of the cytoplasm and the nucleus. The cytoplasm contains certain distinct organelles (such as: ribosomes, plastids, and mitochondria) and membrane systems (endoplasmic reticulum and golgie bodies) which can be seen in detail only with an electron microscope. In addition, the cytoplasm consists of a ground substance, which suspends the organelles and mem— branes. In contrast to most animal cells, plant cells develop liquid filled vacuoles within the cytoplasm.

The ground substance is frequently in motion and compounds can be seen being swept along in an orderly fashion. This motion is known as cyclosis and may help exchange materials between cells and within the cell.

In the cytoplasm, the most distinct structure is the nucleus. The nucleus serves two important functions: first, it controls the ongoing functions of the cell, determining which protein molecules are produced and when; second, it stores the genetic information and passes it along to daughter cells in cell division.

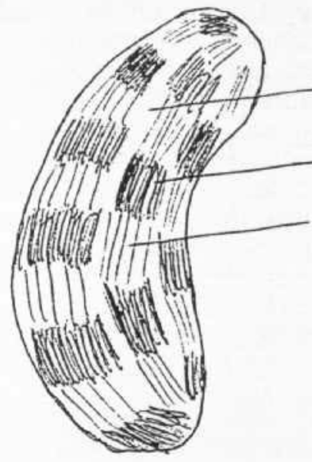
Inside the nucleus, chromatin, visible with certain strains, are thin strands of DNA and protein molecules and are distinguishable from the nucleoplasm, or nuclear ground substance. During cell division, the chromatin become progressively more condensed until they take the form of chromosomes. The hereditary information passed along during cell division is carried in the molecules of DNA.



More often, the only structures visible in the nucleus with a light microscope are the nucleoli (singular - nucleolus). Nucleoli are present in nondividing nuclei and are responsible for ribosome formation. The number of nucleoli present in the nucleus is variable and often they fuse together to form one large nucleoli.

One characteristic which distinguishes plant cells from animal cells is the presence of plastids. Mature plastids are classified on the basis of the pigments they contain. The first type are the chloroplasts, which are the primary site of photosynthesis and contain the chlorophyl and carotenoid pigments.

The internal structure of chloroplasts is complex. The ground substance, or stroma, is filled with an elaborate mem-

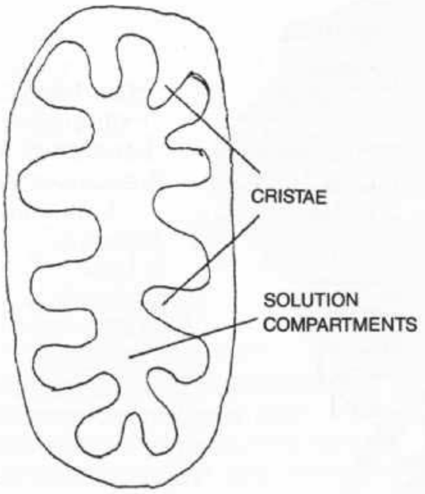


brane system in the form of flattened sacks called thylakoids. Characteristic of chloroplasts is the presence of grana, which are stacks of thylakoids. The thylakoids of various grana are connected to each other by singular thylakoids called stroma thylakoids. The thylakoids are thought to form a single, interconnected system. The pigments chlorophyl and carotenoid are found in the thylakoid membranes.

A second type of plastid are the chromoplasts. They are also pigmented and synthesize and retain the yellow, orange and red carotenoid pigments. Chromoplasts may develop from previously existing green chloroplasts by which the chlorophyl and existing membranes disappear and masses of carotenoids accumulate, as occurs during the ripening of many fruits.

A third type of plastid are the luecoplasts. These are nonpigmented and are believed to synthesize starch. Others may form a variety of substances including oils and proteins. Luecoplasts may develop into chloroplasts if exposed to light.

Mitochondria are another important structure in the cell. The mitochondria are the so-called "powerhouses" of the cell because they are the site of respiration - the means by which energy of carbohydrates (sucrose and its building block glucose) is transferred to ATP. ATP is the universal energy carrier molecule and is made available for the energy requirements of the cell. The Krebs cycle and the Electron Transport Chain, the two aerobic respiration pathways yielding complete oxidation of the glucose molecule, occur in the mitochondria.



The mitochondria are double membraned, like the plastids, with the inner membrane folded inward into pleats called cristae. The cristae serve to increase the surface area available to the enzymes and the reactions associated with respiration. The compartments around the cristae contain a solution with the enzymes, water, phosphates and molecules involved with respiration.

Mitochondria move and twist within the cell and tend to congregate where energy is required. The amount of cristae in the mitochondria depends on the energy requirements of the cell. The greater the energy needs, the more cristae they contain.

Unlike plastids and mitochondria, the microbodies are single membraned, spherical organelles. They are associated with one or two segments of the endoplasmic reticulum. Some microbodies, called peroxisomes, play a role in glycolic acid metabolism, associated with photorespiration. Like the respiratory processes that take place in the mitochondria, photorespiration involves the oxidation of carbohydrates. However, unlike other respiration processes, it yields no usable energy and may actually cause a loss of energy. Others, called glyoxisomes, are important in the conversion of fats into carbohydrates in germinating seeds.

Ribosomes are the site at which amino acids are linked to form proteins. Like microbodies, some may be attached to the endoplasmic reticulum, or they may be freely occurring in the cytoplasm. Ribosomes are usually abundant in metabolically active cells.

The endoplasmic reticulum is a 3-dimensional membrane system of infinite extent within the cell. It appears to function as a communicative system and is involved with channeling materials, fats and lipids to different cell parts. Also, the endoplasmic reticulum of adjacent cells is interconnected by way of the plasmodesmata. The plasmodesmata are minute canals in the cell wall with a small portion of the endoplasmic reticulum running through it called the desmotubule. As mentioned before, ribosomes are commonly attached to the endoplasmic reticulum. This endoplasmic reticulum is called rough endoplasmic reticulum: that lacking ribosomes is called smooth endoplasmic reticulum.

The golgi bodies are groups of flat, disk shaped sacs, called cistrenae, which function as secretory organelles. They are often branched into a complex series of tubules at their margins. Numerous vesicles are formed and pinched off at the edges, which then migrate and fuse with the plasma membrane of the cell wall. The vesicle contents are discharged outside the cell and the polysaccharide contents become part of the cell wall.

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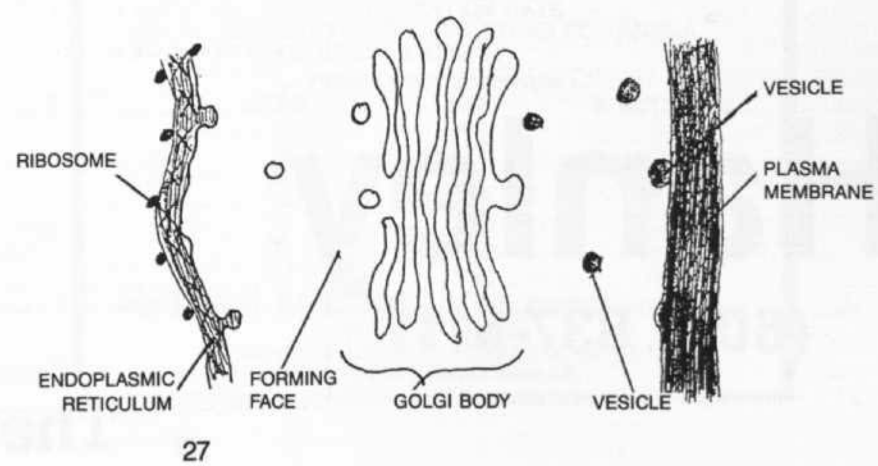

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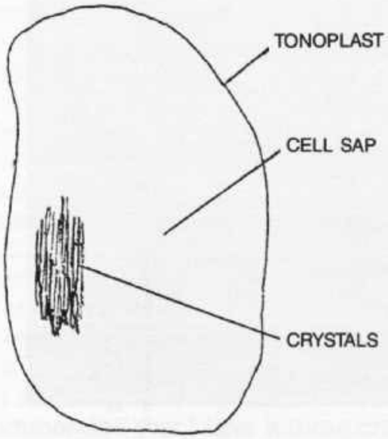

vacular membrane.

The principal component of the fluid, called the cell sap, is water, with other components varying in concentration according to the type of plant and its physiological state. Vacuoles typically contain salts, sugars and some dissolved proteins. The tonoplast plays an important role in the active transport of ions into the vacuole. Thus, ions may accumulate inside in concentrations far in excess of those in the cytoplasm. At times, crystals may form, depending on the material, in response to the increased concentration. The vacuole may also be the site of the water soluble anthocyanin pigments. Anthocyanins are responsible for the blue, violet, purple and dark red coloration, usually masked by the more abundant chlorophyl pigments.

In addition to being involved with ion accumulation and the water balance of the cell, the vacuole may be involved with the breakdown of molecules and entire components of the cell. After being digested by the vacuole, the components are then recycled and used within the cell.

The talk so far concerning the membranes and membrane structures may have given the idea that they are static in nature. This is by no means the case. The cell membranes are in fact dynamic structures, constantly changing their shape and surface area. Internal cytoplasmic membranes represent a continum, with the endoplasmic reticulum being the initial source of membranes. New cisternae are added to golgi bodies from the endoplasmic reticulum. Golgi vesicles then pinch off, migrate and fuse with the plasma membrane, contributing to its growth. Even in tissues undergoing little growth or cell division, the membranes are constantly being replaced. Even though the membranes persist, the molecules are continuously replaced.

By themselves, the cell components constitute but a small portion of the complex system of the plant. The components' complexity is indicative of the importance they play and the need to understand what they are and how they function. Understanding the basics is critical if we are to understand the overall picture. They go hand in hand. It is hoped this article will inspire all of us to "get back to the basics".

The Typical Plant Cell
(not to scale)