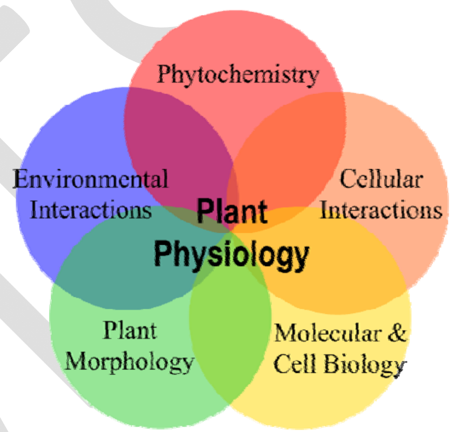
Plant Physiology 101

To effectively care for plants a manager needs to know more than just what to apply and when to apply it, they need a basic understanding of plant physiology. Without this basic understanding of soil and plant interactions, a plant care manager will not be able to make subtle adjustments to their plant and soil health programs to account for the ever-changing plant, soil and climate challenges. Although plant physiology is a very complex subject, the most important aspect to remember is that plants are **living** organisms. Just like humans, they are made up of millions and millions of living cells and each one of those tiny cells is critically sensitive to what you do to/or for them!



Perhaps the easiest way to understand plant physiology is to visualize plants as elaborate lego sets. At the beginning there is a fixed number of different legos that act as building blocks to create larger plant cells and structures. These building block legos are elements like Nitrogen, Potassium, Phosphorous, Calcium, and so forth. From these building blocks there are countless numbers of structures that can be made, both large and small.

One of the most critical structures formed from the building block legos is called an **enzyme**. At any given moment, the “work” being done inside a cell is being done by enzymes. By Nature, enzymes are designed to be powerful, chemical-reaction machines. Their main purpose is to allow a cell to carry out chemical reactions very quickly. These reactions allow the cell to build new structures or take old structures apart as needed. This is how a cell grows and reproduces. At the most basic level, a cell is really just a tiny container full of continual chemical reactions that are made possible by enzymes. Breaking the lego structures (molecules) apart and putting lego structures (molecules) together is what enzymes do. Just like there is a unique key to lock, or unlock each door, there is a specific enzyme structure for each chemical reaction needed to make the cell work properly.

There can be hundreds or even millions of copies of each different type of enzyme structure, depending on how important a specific reaction is to a cell, and how often that reaction is needed. In real terms these enzymes do things like break down glucose for energy to build cell walls or construct new enzymes to allow a cell to reproduce.

For example, it is not uncommon for a person to be **lactose intolerant**. When a person who is lactose intolerant drinks milk or eats ice cream, they usually experience discomfort. The cause of this problem is that the “lego structure” of sugar in milk, called lactose, does not get broken into its glucose components and therefore, it cannot be digested by the body. The reason is that the intestinal cells of lactose-intolerant people do not properly produce **lactase**, the specific enzyme structure needed to break down the lactose. This illustrates how the lack of just one enzyme structure can lead to significant problems.

To help further illustrate this concept, here are a few more enzymes structures and there roles:

- **Proteases** and **peptidases -** A protease is any enzyme that can break down a long protein into smaller chains called peptides (a peptide is simply a short amino acid chain). Peptidases break peptides down into individual amino acids. Proteases and peptidases are often found in laundry detergents -- they help remove things like blood stains from fabrics by breaking down the proteins. Some proteases are extremely specialized, while others break down just about any chain of amino acids. (You may have heard of **protease inhibitors** used in drugs that fight the AIDS virus. The AIDS virus uses very specialized proteases during part of its reproductive cycle, and protease inhibitors try to block them to shut down the reproduction of the virus.)
- **Amylases -** Amylases break down starch chains into smaller sugar molecules. Saliva contains amylase and so does the small intestine. Maltase, lactase, and sucrase finish breaking the simple sugars down into individual glucose molecules.
- **Lipases -** Lipases break down fats.

- **Cellulases** - Cellulases break cellulose molecules down into simpler sugars. Bacteria in the guts of cows and termites excrete cellulases, and this is how cows and termites are able to eat things like grass and wood.

These powerful enzymes structures are actually made from smaller structures called **amino acids**. When an enzyme is formed, it is made by stringing together just a few or as many as a thousand amino acid structures in a very specific and unique order. The chain of amino acids then folds into a unique shape. That shape (just like a key for a door) allows the enzyme to carry out its specific chemical reactions. Although it is possible for a cell to eventually create the needed reaction without a specific enzyme, having the right one present, speeds that reaction up tremendously. It is simply having the right tool for the job. For example, a piece of wood can be cut with a butter knife but having a saw handy will allow the wood to be cut much more quickly!

Amino acids are the most basic structures formed from the building block legos and are used to build different structures in a cell depending on what is needed. One such structure you may have heard of is called a **protein,** which is simply a specific chain of amino acids put together. When one speaks of adding proteins, one is simply supplying a pre-formed structure of amino acids which can be used or broken down as needed by the plant. Another term you may hear is "**plant growth hormone**". Quite simply, hormones are chemical messengers that tell a cell to do different tasks. Hormones are actually proteins, which are in turn, made up of chains of amino acids. Hormones are produced by a plant and then sent all over its structure to stimulate certain activities. For example, in humans, Insulin is a well-known hormone that helps our body digest food. Growth, nutrient assimilation, and reproduction functions are all triggered by hormones.

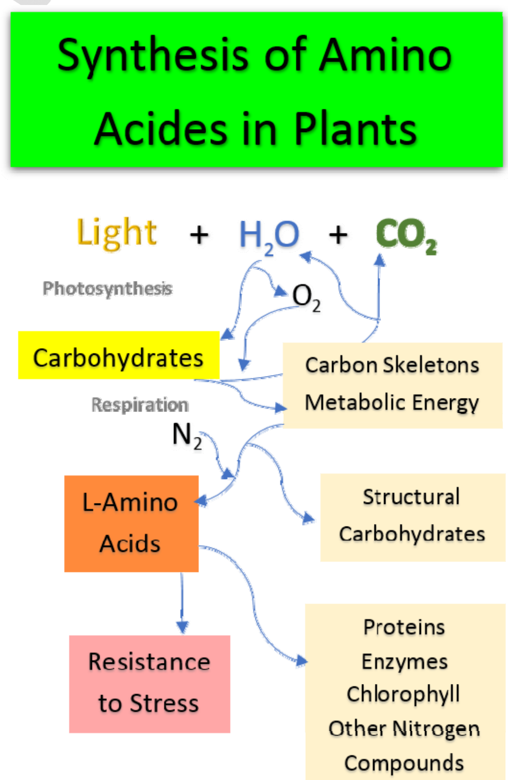
Because amino acids are so important in all plant functions, they are broken into two groups: essential and non-essential. Non-essential amino acids are ones that can be created out of other compounds found in plant tissues. Essential amino acids cannot be created within a plant, and therefore the only way to get them is through the soil (or by adding them to a plant directly). The following are the different amino acids:

Non-essential:

- Alanine (synthesized from pyruvic acid)
- Arginine (synthesized from glutamic acid)
- Asparagine (synthesized from aspartic acid)
- Aspartic acid (synthesized from oxaloacetic acid)
- Cysteine (synthesized from homocysteine, which comes from methionine)
- Glutamic acid (synthesized from oxoglutaric acid)
- Glutamine (synthesized from glutamic acid)
- Glycine (synthesized from serine and threonine)
- Proline (synthesized from glutamic acid)
- Serine (synthesized from glucose)
- Tryosine (synthesized from phenylalanine)

Essential:

- Histidine
- Isoleucine
- Leucine
- Lysine
- Methionine
- Phenylalanine
- Threonine
- Tryptophan
- Valine



In order for a plant to grow and thrive, it needs a steady supply of the building block legos so that it can make the amino acid structures, which then make the enzyme structures, protein structures, hormones, and so forth. The most important building block legos in plants are:

- Carbon, hydrogen and oxygen - These are available from the air and water and are in plentiful supply as long as soil compaction or drought does not cause specific shortages.

- Nitrogen, phosphorus, potassium - Because of the quantity needed, these are called **macronutrients,** and are the three elements you find most commonly referred to in packaged fertilizers.
- Sulfur, calcium, and magnesium - These are called **secondary nutrients** because they are needed in significant amounts, but less than the macronutrients.
- Boron, cobalt, copper, iron, manganese, molybdenum and zinc - These are called **micronutrients** because they are needed in much smaller quantities compared to the others above.
- Other elements used are usually referred to as **trace elements** because the reactions or structures they are involved in are extremely specific or are not critical to a plant's survival. However, overall plant health may be increased by having trace elements available.

Nitrogen, **phosphorus** and **potassium** are the most recognized building blocks because:

- Every amino acid structure contains nitrogen.
- The main energy source for all cells (Adenosine Triphosphate or "ATP") and the membranes of all cells are made with phosphorous.
- Potassium makes up 1 percent to 2 percent of the weight of any plant and is essential to plant metabolism.

However, if any of the macronutrients, secondary nutrients, or micronutrients are missing or hard to obtain from the soil, this will limit the growth of the plant in some capacity. Therefore, optimal plant health can only be achieved if a plant has access to all of the structures it needs to perform its countless daily functions. In addition, the plants must have a relatively proportionate amount of each structure present so that one reaction is not overly favored over another.

A plant care manager must continually monitor plant health, which is typically done through visual observation. The problem, however, is that a plant can sometimes look healthier than it really is, especially if treatments over emphasize specific reactions in the plant. For example, if we apply a lot of nitrogen to plants, we create a series of reactions that leads to a dark green color, which we visually consider healthy. However, just like a human can take steroids and look incredibly healthy, there may be underlying problems that do not visually surface until later. In the case of plants, excessive nitrogen can lead to reduced root growth, increased disease susceptibility, and in extreme cases, yellowing and burnout.

So with thousands of different plants and millions of different structures needed within those plants, how does someone begin to create an effective care program? The reality is that it is impossible to try and create a program to provide a plant with everything it needs in the right proportions and at the right time. The best way to approach plant care is to think about how Nature works. Plants obviously survive in nature without our specific care, so how are all of these different structures manufactured and how do they get to the plant?

Quite simply, all of the structures needed by plants are formed through the natural decomposition of organic materials in the soil by microorganisms. Whether it is leaves decomposing on the forest floor, or a pile of waste decomposing in a compost pile, it is all made possible by microorganisms. There are many types of microorganisms, but the four in the largest proportions are algae, bacteria, fungi, and actinomycetes. Just a gram of healthy soil can have as many as 300,000 algae, 4 billion bacteria, 1 million fungi, and 20 million actinomycetes organisms! These tiny microorganisms are responsible for bridging the gap between life and death by recycling everything that once was living! They feed on very large structures (organic compounds) and break them down into their smaller components, which in turn, become re-useable sugars, starches, fatty acids, amino acids, proteins, etc, that make a plant function. Without these microorganisms, Nature would not be able to recycle its used-up building block legos from past living creatures, and eventually, the supply would be diminished, and life would cease to exist.

As you can see, life as we know it is simply a never-ending cycle of chemical reactions. Building block legos are used to create plant life and once that plant eventually dies, microorganisms are needed to break them back down such that future plants can find the key structures they need to grow. This is why a biological program for plant care is the most effective program that can be implemented. By mimicking Nature and using natural compounds and microorganisms, a plant care manager can introduce countless structures to the soil and plants. Many of these structures will be ones we could never create synthetically, many will be ones we did not know the plant needed, and many will be ones we do not even know what they do inside the plant. Yet by allowing Nature to do its work rather than assuming we know what a plant needs, the end result is always healthier plants with fewer problems - and that is the goal of every plant care manager! Natural and organic products, like ours, make great amino building blocks.