**Understanding Plant Hormones**

**Hormones – Mighty Messengers!**

Hormones get things done. Think of them as chemical messengers that are made in one place in the body and deliver their message in a totally different place in the body. And just like hot sauce, a little goes a long way. Hormones are usually found in very small concentrations, but boy to they pack a punch! We know hormones cause a lot of changes in humans (ah, puberty), but did you know that plants have hormones, too? Plants miss out on all the fun of body hair, acne, and voice changes, but read on to learn about the amazing effects that hormones have on plant growth and development!

**The Big Five**

We’ll cover five major types of plant hormones: auxin, gibberellin, cytokinin, ethylene, and abscisic acid. These hormones can work together or independently to influence plant growth.

**AUXIN**

You’ve seen auxin in action. Well you haven’t seen the actual auxin molecule itself with the naked eye, but you’ve seen what it can do to a plant grown near a window. Have you ever wondered how a plant bends towards sunlight? Well, it has to do with auxin in the stem. Darwin and his son were curious about it, too. (Published in: The Power and Movement in Plants) However, they didn’t know at the time what exactly was causing plants to bend toward the light. Auxin itself wasn’t discovered until the late 1920s, and it was the first of the 5 major types of plant hormones to be studied. Auxin has lots of jobs but most importantly it stimulates growth, and if a plant doesn’t naturally produce auxin itself, it will die. So you can see auxin is pretty important. The technical alias for auxin is indole-3-acetic acid or IAA (just incase you ever see it written is “IAA” – it means the same thing as “Auxin”).



Auxin is involved in cell growth and cell expansion, so it is produced primarily in parts of the plant that are actively growing like the stem (specifically, the very tiptop of the stem). This is where it gets interesting. Auxin is transported (read: active process – requires energy) in one direction in a plant – downward from the top to the bottom, like a one-way road from the stem tip to the roots. It is the only plant hormone known to do this. Therefore the concentration of auxin is highest at the top of the plant and decreases as you get closer to the roots, this controls the overall shape of the plant and helps keep the primary stem of a plant the leader.

Have you ever seen the top of a single stem of tree that is pruned sprout into more than 20 new stems? That is because auxin maintains apical dominance it prevents lots of lateral buds and branches from growing on the side of the stem. When you prune the primary stem of a plant, the source of the auxin is removed, then no single stem is dominant anymore – apical dominance is removed.

Back to our bendy plant in the windowsill, remember how auxin is involved in making cells longer? Well auxin will move to the shaded side of the plant stem and cause those cells to grow longer, while the cells on the sunny side of the plant stay the same size. That will cause the plant to bend to one side – toward the sun!

**GIBBERELLIN**

Gibberellin causes some similar effects in plants as auxin, but it is a very different hormone. Gibberellins were discovered originally in Japan. A fungus called Gibberella fujikuroi infected rice plants and caused them to grow too tall and fall over. The infectious fungus produced a chemical that stimulated the growth in rice plants. The chemical was isolated and named Gibberellin after the fungus. It was later found that plants naturally produce variations of these chemicals!

Gibberellins play an important role in several developmental stages in plants, but their claim to fame is making stems longer. Gibberellins promote stem elongation between nodes on the stem. A node is a place on a stem where a leaf attaches, so gibberellins elongate the internodes. It is easiest to see the absence of gibberellin in dwarf plants and rosette plants – there is very little space between nodes on a stem and the leaves are clustered toward the base of the plant.

What’s the big deal about knowing how to control stem elongation in plants? Well, when would it be beneficial to know how to make a plant stem shorter or longer? Biologists can prevent plants in a greenhouse from making gibberellins to keep them a manageable size. That’s handy. Or what if you’re a farmer and your business is something that comes from the stem of a plant? Longer stems would mean more profit for you, right? Gibberellins sprayed on sugar cane in Hawaii elongate the stem between the nodes. Longer stems mean more stored sugar. More sugar to sell means more coin! Knowing about plant hormones just makes cents!

**CYTOKININ**

Who knew that fish could play a role in the discovery of a plant hormone? Aged herring sperm DNA can promote cell division. The molecule that is responsible for this was named kinetin. Soon after, a substance that had the same biological effect as kinetin was found in plants, it stimulated plant cells to divide when in culture with auxin. The substance was named cytokinin and it is involved in cell division and in the making of new plant organs, like a root or a shoot. Cytokinins are produced in the root apical meristems (very tip of the roots) and travel upward hitching a ride with water and traveling up the stem through the xylem. The movement of cytokinins is passive – it does not require energy!

Cytokinins are like the fountain of youth in plants. They delay senescence or the natural aging process that leads to death in plants. In the cell cycle, cytokinins promote the movement from the G2 phase to the M phase. In other words, they encourage cells to divide!

Cytokinins are involved in repair, too. If a plant becomes wounded, it can fix itself with the help of cytokinins and auxin. Remember how some hormones work together to affect plants? Well if the concentration of auxin and cytokinin are equal, then normal cell division will take place. If the concentration of auxin is greater than cytokinin then roots will form. If the concentration of auxin is less than cytokinin then shoots will form.

**ETYLENE**

Have you ever noticed that if you put a really ripe, brown banana right next to a bunch of green bananas, the unripe bananas will ripen and turn yellow much faster? How does that happen? Well, the brown banana is communicating with the green bananas using a hormone called ethylene. Ethylene is a plant hormone that affects ripening and rotting in plants. It is a particularly interesting plant hormone because it exists as a gas. No other plant hormone is gaseous! Ethylene can be produced in almost any part of a plant, and can diffuse through the plant’s tissue, outside the plant, and travel through the air to affect a totally different plant. How cool is that!

Here’s how it was discovered. Tomato farmers noticed something weird happening with their crops. Back in the day many farmers used kerosene heaters in their greenhouses to warm the air so that they could grow tomatoes during the winter. With the advent of electricity, some farmers switched to new, fancy electric heaters, but they soon found that their tomatoes were not ready to be picked at the same time the way they were when the greenhouses were warmed with kerosene heaters. The burning of the kerosene in the heaters produced a molecule similar to ethylene that synchronized the ripening of the tomatoes!

The formation of ethylene requires oxygen, and the agricultural industry has used this tidbit of information to their advantage. If you control the partial pressure of oxygen and carbon dioxide in a truck carrying produce (specifically low O2 high CO2) you can prevent ethylene synthesis and thus slow the ripening process. This is helpful when fruits and vegetables are grown in one region of the world and then shipped many miles away to be sold. Growers don’t want their produce to go bad before you even have a chance to buy it!

**ABSCISIC ACID**

When our bodies need water we feel thirsty. The “thirst signal” signifies that we’re dehydrated and we need a drink of water. When a plant needs water, for example during a drought, it doesn’t have too many options. A rain dance is pretty much out of the question. Plants produce a chemical messenger, called abscisic acid, to alert the rest of the plant that it is water stressed. Abscisic acid is made in droughted leaves, droughted roots, and developing seeds and it can travel both up and down in a plant stem in the xylem or phloem sounding the alarm.

Think back to transport in plants, how does water typically move through a plant? (Reminder: soil -> roots -> stem -> leaves -> air) Water molecules exit a plant through tiny pores in the leaves called stomata. Each stoma (singular) has two kidney bean shaped bodyguards on either side of the pore, whose job it is to open and close the stoma. When the guard cells are full of water, or turgid, the stoma is open. When water leaves the guard cells, they become flaccid, and the stoma is closed.

Now imagine you’re a thirsty plant. It hasn’t rained in weeks and there is no moisture in the soil around your roots. You’re running dangerously low on water. What can you do to prevent yourself from losing any more precious H2O? Close the stomata! How do plants do it? Abscisic acid travels to the guard cells, sending a message that water is scarce. The guard cells spring to attention, and a rush of charged particles exit the guard cells, which subsequently triggers water inside the guard cell to leave, too. The guard cells shrivel and the stomata close! No more water is able to exit the plant through the stomata.

That’s a brief overview on the five major types of plant hormones: auxin, gibberellin, cytokinin, ethylene, and abscisic acid. Remember that hormones are potent little chemical messengers, but they would lose their effectiveness if they hung around and built up in the tissues of the plant. So they are broken down and replaced over time.

There is so much more to learn about plant hormones! A great textbook for those who want all the wonderful nitty-gritty details is Plant Physiology by Taiz and Zeiger.