

Do Plants Think?

Scientist Daniel Chamovitz unveils the surprising world of plants that see, feel, smell—and remember

How aware are plants? This is the central question behind a fascinating new book, “What a Plant Knows,” by Daniel Chamovitz, director of the Manna Center for Plant Biosciences at Tel Aviv University.

A plant, he argues, can see, smell and feel. It can mount a defense when under siege, and warn its neighbors of trouble on the way. A plant can even be said to have a memory. But does this mean that plants think — or that one can speak of a “neuroscience” of the flower? Chamovitz answered questions from Mind Matters editor Gareth Cook.

1. How did you first get interested in this topic?

My interest in the parallels between plant and human senses got their start when I was a young postdoctoral fellow in the laboratory of Xing-Wang Deng at Yale University in the mid 1990s. I was interested in studying a biological process that would be specific to plants, and would not be connected to human biology (probably as a response to the six other “doctors” in my family, all of whom are physicians). So I was **drawn to the question of how plants sense light to regulate their development.**

It had been **known for decades that plants use light** not only for photosynthesis, but also **as a signal that changes the way plants grow.** In my research I discovered a unique group of genes necessary for a plant to determine if it’s in the light or in the dark. When we **reported our findings, it appeared these genes were unique to the plant kingdom**, which fit well with my desire to avoid any thing touching on human biology. But much **to my surprise** and against all of my plans, I later discovered that this *same group of genes is also part of the human DNA.*

This led to the obvious question as to what these seemingly “plant-specific” genes do in people. Many years later, we now know that **these same genes are important in animals for the timing of cell division, the axonal growth of neurons, and the proper functioning of the immune system.**

But most amazingly, these genes **also regulate responses to light in animals!** While we don’t change our form in response to light as plants do, we are affected by lab at the level of our internal clock. Our internal circadian clocks keep us on a 24 hour rhythm, which is why when we travel half way around the world we experience jet lag. But this clock can be reset by light. **A few years ago I showed, in collaboration with Justin Blau at NYU, that mutant fruit flies that were missing some of these genes lost the ability to respond to light.** In other words, if we changed their clocks, they remained in jetlag.

This led me to realize **that the genetic difference between plants and animals is not as significant as I had once naively believed.** So while not actively researching this field, I began to question the parallels between plant and human biology even as my own research evolved from studying plant responses to light to leukemia in fruit flies.

2. How do think people should change how they think about plants?

People have to realize that **plants are complex organisms that live rich, sensual lives.** You know many of us relate to plants as inanimate objects, not much different from stones. Even the fact that many people substitute silk flowers for real ones, or artificial Christmas trees for a live one, is exemplary at some level of how we relate to plants. You know, I don't know anyone who keeps a stuffed dog in place of a real one!

But if we realize that all of plant biology arises from the evolutionary constriction of the “rootedness” that keep plants immobile, then we can start to appreciate the very sophisticated biology going on in leaves and flowers. If you think about it, **rootedness** is a huge evolutionary constraint. It means that plants *can't escape a bad environment, can't migrate in the search of food or a mate. So plants had to develop incredibly sensitive and complex sensory mechanisms that would let them survive in ever changing environments.* I mean if you're hungry or thirsty, you can walk to the nearest watering hole (or bar). If you're hot, you can move north, if you're looking for a mate, you can go out to a party. But plants are immobile. They need to see where their food is. They need to feel the weather, and they need to smell danger. And then they need to be able to integrate all of this very dynamic and changing information. Just because we don't see plants moving doesn't mean that there's not a very rich and dynamic world going on inside the plant.

3. You say that plants have a sense of smell?

Sure. But to answer this we **have to define for ourselves what “smell” is.** When we smell something, we sense a volatile chemical that's dissolved in the air, and then react in some way to this smell. The **clearest example in plants is what happens during fruit ripening.** You may have heard that if you put a ripe and an unripe fruit together in the same bag, the unripe one will ripen faster. This happens because the **ripe one releases a ripening pheromone into the air, and the green fruit smells it and then starts ripening itself.** This happens not only in our kitchens, but also, or even primarily, in nature. When one fruit starts to ripen, it releases **this hormone which is called ethylene,** which is sensed by neighboring fruits, until **entire trees and groves ripen more or less in synchrony.**

Another example of a plant using smell is how a **parasitic plant called dodder** finds its food. **Dodder can't do photosynthesis, and so has to live off of other plants.** The way it finds its host plant is by smelling. A dodder can detect minute amounts of chemicals released in the air by neighboring plants, and will actually pick the one that it finds tastiest! In one classic experiment scientists showed that dodder **prefers tomato to wheat because it prefers the smell.**

3B. How about hearing?

This is a bit trickier because while loads of research support the idea that plants see, smell, taste and feel, support for plant auditory prowess is indirectly proportional to the amount of anecdotal information we have about the ways in which music may influence how a plant grows. Many of us have heard stories about plants flourishing in rooms with classical music. Typically, though, much of the research on music and plants was, to put it mildly, not carried out by investigators grounded in the scientific method. Not surprisingly, in most of these studies, the plants thrived in music that the experimenter also preferred.

From an evolutionary perspective, it also could be that plants haven't really needed to hear. The evolutionary advantage created from hearing in humans and other animals serves as one way our bodies warn us of potentially dangerous situations. Our early human ancestors could hear a dangerous predator stalking them through the forest, while today we hear the motor of an approaching car. Hearing also enables rapid communication between individuals and between animals. Elephants can find each other across vast distances by vocalizing subsonic waves that rumble around objects and travel for miles. A dolphin pod can find a dolphin pup lost in the ocean through its distress chirps. What's common in all of these situations is that sound enables a rapid communication of information and a response, which is often movement—fleeing from a fire, escaping from attack, finding family.

But **plants are rooted, sessile organisms**. While they can grow toward the sun, and bend with gravity, they can't flee. They can't escape. They don't migrate with the seasons. As such, **perhaps the audible signals we're used to in our world are irrelevant for a plant**.

All that being said, I have to *cover myself hear by pointing out that some very recent research hints that plants may respond to sounds*. Not to music mind you, which is irrelevant for a plant, but to certain vibrations. It will be very interesting to see how this pans out.

4. Do plants communicate with each other?

At a basic level, yes. But I guess it centers around how you define communication. There is no doubt that plants respond to cues from other plants. For example, if a **maple tree is attacked by bugs, it releases a pheromone into the air that is picked up by the neighboring trees**. This induces the **receiving trees to start making chemicals that will help it fight off the impending bug attack**. So on the face of it, this is definitely communication.

But I think we also have to ask the question of intent (if we can even use that word when describing plants, but humor me while I anthropomorphize). Are the trees communicating, meaning is that attacked tree warning its surrounding ones? Or could it be more subtle? Maybe it makes more sense that the attacked branch is communicating to the other branches of the same tree in an effort for self survival, while the neighboring trees, well they're just eavesdropping and benefiting from the signal.

There are also other examples of this type of communication. For example a very recent study **showed that plants also communicate through signals passed from root to root**. In this case the “talking” plant had been stressed by drought, and it “told” its neighboring plants to prepare for a lack of water. We know the signal went through the roots because this never happened if the two plants were simply in neighboring pots. They had to have neighboring roots.

5. Do plants have a memory?

Plants definitely have several different forms of memory, just like people do. They have short term memory, immune memory and even transgenerational memory! I know this is a **hard concept to grasp** for some people, but if **memory entails forming the memory (encoding information), retaining the memory (storing information), and recalling the memory (retrieving information)**, then plants definitely remember. For example a Venus Fly Trap needs to have two of the hairs on its leaves touched by a bug in order to shut, so it remembers that the first one has been touched. But this only lasts about 20 seconds, and then it forgets. Wheat seedlings remember that they’ve gone through winter before they start to flower and make seeds. And **some stressed plants give rise to progeny that are more resistant to the same stress**, a type of transgenerational memory that’s also been **recently shown also in animals**. While the short term memory in the venus fly trap is electricity-based, much like neural activity, the longer term memories are based in *epigenetics — changes in gene activity that don’t require alterations in the DNA code*, as mutations do, which are still passed down from parent to offspring.

6. Would you say, then, that plants “think”?

No I wouldn’t, but maybe that’s where I’m still limited in my own thinking! To me thinking and information processing are two different constructs. I have to be careful here since this is really bordering on the philosophical, but I think purposeful thinking necessitates a highly developed brain and autonoetic, or at least noetic, consciousness. Plants exhibit elements of anoetic consciousness which doesn’t include, in my understanding, the ability to think. Just as a *plant can’t suffer subjective pain in the absence of a brain, I also don’t think that it thinks*.

7. Do you see any analogy between what plants do and what the human brain does? Can there be a neuroscience of plants, minus the neurons?

First off, and at the risk of offending some of my closest friends, I think the term plant neurobiology is as ridiculous as say, human floral biology. Plants do not have neuron just as humans don’t have flowers!

But you don’t need neurons in order to have cell to cell communication and information storage and processing. Even in animals, not all information is processed or stored only in the brain. The brain is dominant in higher-order processing in more complex animals, but not in simple ones. Different parts of the plant communicate with each other, exchanging information on cellular, physiological and environmental states. For example root growth is dependent on a hormonal signal that’s generated in the tips of shoots and transported to the growing roots, while shoot development is partially dependent on a signal that’s generated in the roots. Leaves send signals to the tip of the shoot telling

them to start making flowers. In this way, if you really want to do some major hand waving, the entire plant is analogous to the brain.

But **while plants don't have neurons**, plants both **produce and are affected by neuroactive chemicals!** For example, the **glutamate receptor is a neuroreceptor in the human brain necessary for memory formation and learning.** **While plants don't have neurons, they do have glutamate receptors** and what's fascinating is that the same drugs that inhibit the human glutamate receptor also affect plants. **From studying these proteins in plants, scientists have learned how glutamate receptors mediate communication from cell to cell.** So maybe the question should be posed to a neurobiologist if there could be a botany of humans, minus the flowers!

Darwin, one of the great plant researchers, proposed what has become known as the "root-brain" hypothesis. Darwin proposed that the tip of the root, the part that we call the meristem, acts like the brain does in lower animals, receiving sensory input and directing movement. Several modern-day research groups are following up on this line of research.

Are you a scientist who specializes in neuroscience, cognitive science, or psychology? And have you read a recent peer-reviewed paper that you would like to write about? Please send suggestions to Mind Matters editor Gareth Cook, a Pulitzer prize-winning journalist at the Boston Globe. He can be reached at [garethideas AT gmail.com](mailto:garethideas@gmail.com) or Twitter [@garethideas](https://twitter.com/garethideas).