

# Are Plants Aware?

**Plants may experience consciousness, albeit in a different fashion from us.**

**Robert Lanza M.D., Biocentrism, Posted Mar 11, 2017, Share**

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In the movie *Avatar*, humans mine a lush moon inhabited by blue-skinned extraterrestrials, the Na'vi, who live in harmony with nature. Human military forces destroy their habitat, despite objections that it could affect the bio-network connecting its organisms. On the eve of the big battle, the protagonist Jake communicates via a neural connection with the Tree of Souls, which intercedes on behalf of the Na'vi. We think of time and consciousness in human terms. But like us, plants possess receptors, microtubules, and sophisticated intercellular systems that likely facilitate a degree of spatio-temporal consciousness. The movie suggests that we don't understand the conscious nature of the life that surrounds us.

Although I saw the movie three times, I still cringe whenever someone tells me that a plant has consciousness. As a biologist, I can accept that consciousness exists in cats, dogs, and other animals with sophisticated brains. Studies show that dogs have a level of intelligence — and consciousness — on par with a two- or three-year-old human child. In fact, in 1981, Harvard psychologist B.F. Skinner and I published a paper in the journal *Science* showing that even pigeons were capable of certain aspects of self-awareness. But a plant or a tree? To consider the possibility seemed absurd — until the other day.

My kitchen merges into a conservatory, a mini-rainforest with palms and ferns. While having breakfast, I looked up at one of my prize specimens, a Queen Sago tree. For the last several months, I'd been watching it send up new fronds, which, since the winter solstice, have been repositioning themselves towards the shifting

sun. During that time, I also watched it respond to an injury to its trunk by sending out air-roots in search of new soil to re-root itself. It was a clever life-form, but clearly not conscious in any known biological way.

Then I remembered the episode of *Star Trek* called “Wink of an Eye.” In this episode, Captain Kirk beams down to a planet and finds an empty metropolis. The only trace of life is the mysterious buzzing of unseen insects. When he returns to the ship, the crew continues to hear the same strange buzzing sound. Suddenly, Kirk notices that the movements of the crew slow down to a stop, as if time itself were being manipulated. A beautiful woman appears and explains to Kirk that the bridge crew hasn’t slowed down, but rather, he has been sped up, having been matched to the Scalosians’ hyper-accelerated physical existence. Back in real time, Spock and Dr. McCoy figure out that the strange buzzing is the hyper-accelerated conversations of aliens that exist outside normal physics.

We think of time — and thus consciousness — in human terms. In my mind, I could easily accelerate the plant’s behavior, like a botanist does with time-lapse photography. The feathery creature, there in my conservatory, responded to the environment much like a primitive invertebrate. But there was more to it than that. We think time is an object, an invisible matrix that ticks away regardless of whether there are any objects or life. Not so, says biocentrism. Time isn’t an object or thing; it’s a biological concept, the way life relates to physical reality. It only exists relative to the observer.

Consider your own consciousness: Without your eyes, ears, or other sense organs, you would still be able to experience consciousness, albeit in a radically different form. Even without thoughts, you would still be conscious, although the image of a person or tree would have no meaning. Indeed, you wouldn’t be able to discern objects from each other, but rather would visually experience the world as a kaleidoscope of changing colors.

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Now consider a plant. Instead of generating a pattern of colors, the particles of light bouncing off a plant produce a pattern of energy molecules — sugar — in the chlorophyll in its stems and leaves. Light-stimulating chemical reactions in one leaf cause a chain reaction of signals to the entire organism via vascular bundles.

Neurobiologists have discovered that plants also have rudimentary neural nets and the capacity for primary perceptions. Indeed, the sundew plant (*Drosera*) will grasp at a fly with incredible accuracy — much better than you can do with a fly-swatter. Some plants even know when ants are coming towards them to steal their nectar and have mechanisms to close up when they approach. Scientists at Cornell University discovered that when a hornworm starts eating sagebrush (*Artemisia tridentata*), the wounded plant will send out a blast of scent that warns surrounding plants — in the case of the study, wild tobacco (*Nicotiana attenuata*) — that trouble is on its way. Those plants, in turn, prepare chemical defenses that send the hungry critters in the opposite direction. Andre Kessler, the lead researcher, called this “priming its defense response.” “This could be a crucial mechanism of plant-plant communication,” he said.

As I sat in the kitchen that day, the early-morning sun slanted down through the skylights, throwing the entire room into gleaming brightness. The Queen Sago tree and I were both “happy” the sun was out.

My turnaround in my appraisal of our chlorophyllic companions, and the idea that we may have previously limited ourselves in what we've allowed into the "conscious life" fraternity, has been gaining scientific respectability for years. The subject has been widely popularized by the likes of UC Berkeley professor Michael Pollan, who has written about how plant science is increasingly pointing to a high degree of botanical intelligence.

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All this is a bit of a resurrection of the hippie idea of the 1960s, that plants respond if you talk to them. When the environmental movement burgeoned in the decades to follow, and forests started to

be seen as more than mere unprocessed lumber, such plant-kingdom spokespeople were pejoratively called "Tree huggers."

It all gave way to a new field of science, sometimes called plant neurobiology, which starts off a bit controversially, because not even the most ardent plant-boosters claim that plants have neurons (nerve cells) — let alone actual brains.

"They have analagous structures," Pollan explained in a *New Yorker* piece. "They take... the sensory data they gather in their everyday lives... integrate it and then behave in an appropriate way in response. And they do this without brains, which, in a way, is what's incredible about it, because we automatically assume you need a brain to process information."

Neurons aren't necessary in order to have cell-to-cell communication — and even information processing and storage! In a 2012 *Scientific American* article titled "Do Plants Think?" Israeli botanist Daniel Chamovitz insisted that plants "see, feel, smell — and remember." But how is this possible without neurons?

Explained Chamovitz, "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... exchange 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 [while] 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 produce and are affected by neuroactive chemicals!"

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But what about experience? Consciousness. The experience of sounds. We assume you cannot hear anything without ears. But according to Pollan's *New Yorker* piece, researchers have played a recording to plants "of a caterpillar munching on a leaf — and the plants react. They begin to secrete defensive chemicals."

Pollan and others claim that plants possess all the human senses and also some additional ones. Plants even have a memory. And not just simple reflex. "Plants definitely have several different forms of memory, just like people do," said Chamovitz. "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 encoding information, retaining the memory (storing information), and recalling the memory (retrieving information), then plants definitely remember."

We naturally hold ourselves as humans as the epitome of conscious intelligence. Most of us would include other mammals as well, especially cats, dogs, and other favorite people pets. But is this bias borne solely of their familiarity — the fact that we can recognize a face in a way we do not perceive when watching, say, a worm? Or do we instead regard ownership of a brain as a prerequisite for joining the club?

Time is relative to the observer, and despite our human preconceptions, lower animals — and even plants — may experience consciousness, albeit in a considerably different fashion from us. Space and time relationships depend on the entirety of the detector, even if that logic is diffuse and not concentrated into a brain-like structure. Plants clearly have a different information and archiving process from the brain, but time is relative to the observer and need not operate on our human timescale. According to biocentrism, time is bio-logical — completely subjective and invariably emerges from a unitary co-relative process. All knowledge amounts to relationships of information, with the observer alone imparting spatiotemporal meaning. Since time doesn't actually exist outside of perception, there is no experiential "after death," even for a plant, except the death of its physical structure in our "now." You can't say the plant or animal observer comes or goes or dies, since these are merely temporal concepts.

People have long wondered whether plants "feel," even though it's obvious they're very aware of things like gravity, water sources, and light. It's also obvious that they accomplish these perceptions in very different ways from us mammals, or even so-called lower life-

forms. Tadpoles and other amphibians detect light with pigmented cells in their skin, so they can adapt their camouflage to different backgrounds; sparrows can adjust their circadian rhythms without using their eyes at all. They can sense light through feathers, skin, and bone! And mice can do the same thing, even when blind.

Life-forms lacking eyes, such as plants, obviously rely exclusively on other kinds of sensory methods to experience reality. How they perceive time in the world involves sensing and responding to light in a non-visual way. In higher-order animals, the brain keeps track of time. But a plant doesn't have a brain, so information and "memories" must be stored in other ways — perhaps in the same way a plant knows in what direction it should grow.

How we humans record our sensations of time is still mysterious. So it will be even harder to figure out how plants "stretch and twist" all this information to serve their survival needs. Since the passage of "time," in the final analysis, is just a tool organisms create and utilize to perceive what's happening around them and to effectively respond to the flow of their physical environment, plants have obviously done a good enough job at it to survive for 700 million years.

We usually only call something sentient if it talks or responds to us on the biologic timescale we humans use. But we may have much to learn about the nature of life from the fictional Na'vi, where the plants have an exaggerated sense of touch sensitivity and can communicate through "signal transduction."

"The plants in the film are fake," says Jodie Holt, a plant physiologist from the University of California, Riverside, "but the science is real."

**Adapted from *Beyond Biocentrism: Rethinking Time, Space, Consciousness, and the Illusion of Death*, by Robert Lanza with Bob Berman (BenBella Books 2016).**