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Are Plants Conscious?

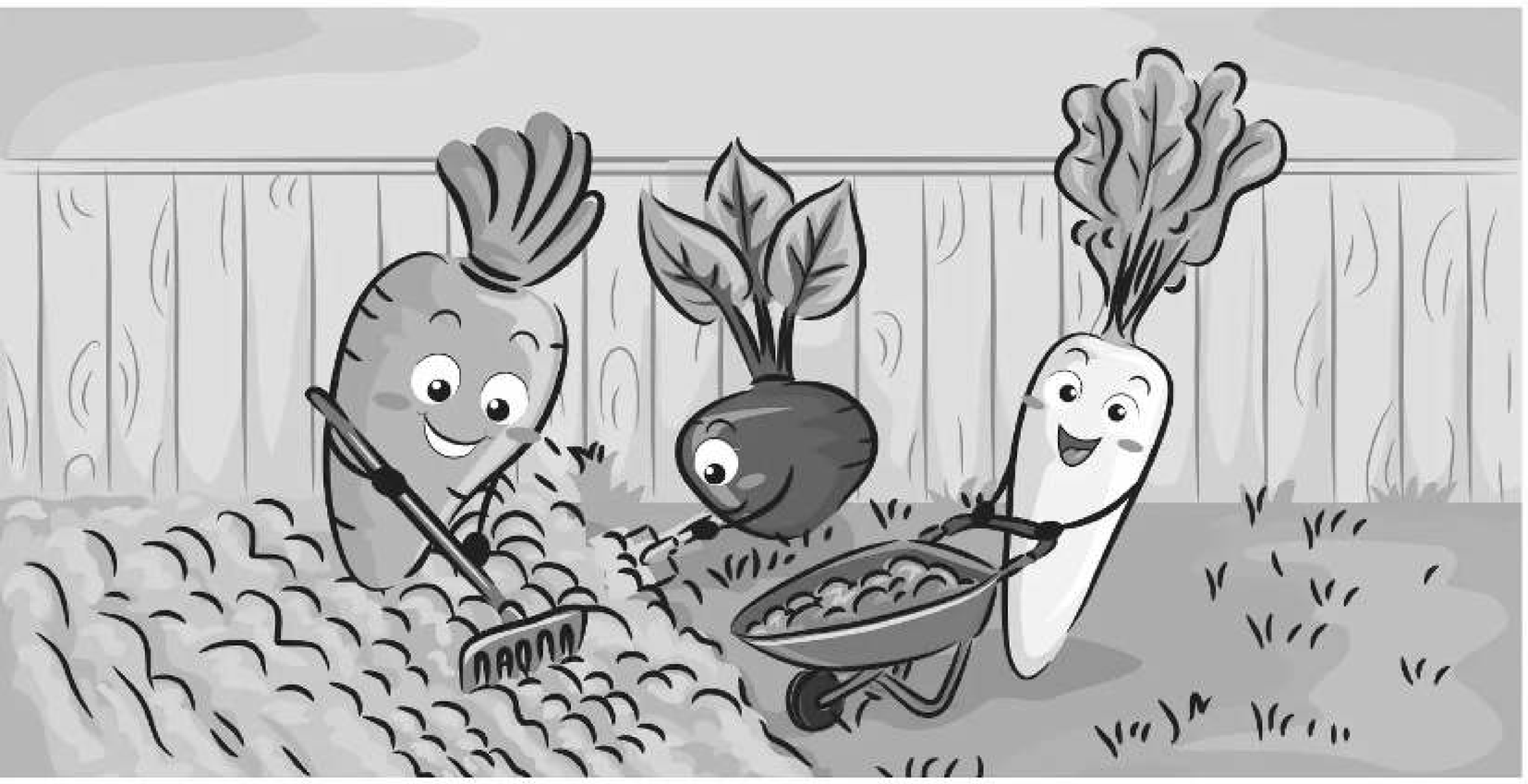
When scientific skeptics think of a purveyor of pseudoscience, they may visualize a somewhat socially awkward dude with a tinfoil hat. Oddly, however, sometimes pseudoscience claims come from credentialed scientists who ought to know better. The ongoing question of plant consciousness is one such instance.

In 2006, E.D. Brenner and colleagues published a controversial article in the mainstream journal *Trends in Plant Science* titled "Plant Neurobiology: An Integrated View of Plant Signaling." Ever since then, the idea that "plants think and feel" has been a small cottage industry that has, predictably, spilled over into general public discourse through podcasts, YouTube videos, and the like.

I am a plant biologist by training and have carried out research that some of my colleagues considered controversial on phenomena such as phenotypic plasticity (the ability of organisms of the same genotype to produce different phenotypes in response to distinct environmental stimuli) and epigenetics (the phenomenon that shows that evolutionarily relevant inheritance is not limited to genes). So this isn't an instance of a conservative scientist set in his ways defending the orthodoxy—at least, I hope not!

But the very notion of plant neurobiology struck me from the beginning as what philosophers call a category mistake: a situation in which someone applies a category where it doesn't belong, such as asking for *the* color of triangles. Triangles qua geometrical figures are characterized by several attributes (three sides, internal sum of the angles equaling 180), but color ain't one of 'em.

Plants have been known to "behave" in complex fashions for centuries, and Charles Darwin himself carried out landmark experiments in this field. But the prefix *neuro-* in biology has always indicated the physiological and anatomical apparatus that allows animals to behave: brains and their associated nervous systems. Plants don't have those, so what could it possibly mean to talk about plant neuroscience?



I wasn't the only one to react that way to Brenner et al.'s paper, and the controversy reached such a pitch that the newly formed Society for Plant Neurobiology quickly changed its name to the more acceptable—if patently disingenuous—Society for Plant Signaling and Behavior.

But science isn't about personal opinions or PR gimmicks; it's about empirical facts and reasoned discourse. One of the most sensible and evidence-based discussions of the whole plant neurobiology controversy that I have read is a critical review, also published in *Trends in Plant Science*, by Lincoln Taiz and collaborators (Taiz et al. 2019). It's a must read for anyone seriously interested in the topic.

Taiz and colleagues point out that much here hinges on semantics, i.e., the meaning of words. While it is fashionable in certain quarters to dismiss such discussions ("It's just semantics!") as irrelevant and pedantic, semantics is important; we communicate with each other using words. If we disagree on their meaning, we risk frustratingly talking past each other.

Plant "neuroscientists" love to use words such as *intelligence*, *cognition*, and even *feelings* liberally, thus constantly underscoring the alleged similarities between plants and animals. But such words have rather specific meanings—especially in a scientific context—and those meanings can't unilaterally be expanded at will just to score a rhetorical point.

For instance, these days *intelligence* has acquired the very general meaning of processing information, as in the phrase *artificial intelligence*. Okay, but then people suddenly shift to the more traditional, limited meaning and tell us that Skynet is about to attack us or that "the Singularity" will surely soon take place. If we want to use *intelligence* broadly, fine, let us agree. But then we also need new words, or at the very least modifiers, for more specific types of processing information, such as those going on inside animal brains.

The same goes for *cognition*, a process that plant neuroscientists say plants engage in because they respond to environmental cues. They most certainly do; *every* living organism does. But we typically reserve *cognition* for some thinking process, not necessarily limited to human beings but definitely requiring a brain. And so on.

Plants are fascinating in part precisely because they are so different from animals. They display a remarkable range of behaviors, which involve internal and external signaling done via hormones and environmental receptors. But these mechanisms are not analogous to animal neurons, synapses, and the like.

Taiz and collaborators mention a paper published by František Baluska and colleagues in 2009 in which the authors liken the root tip to a "brain-like command center." Suggestive and impressive, no? But false. The following year, Hubert Rehm and Dietrich Gradmann (Rehm and Gradmann 2010) demonstrated that the data allegedly supporting the initial conclusions were the result of artifacts generated by the experimental electrodes used by the researchers. Extraordinary claims require extraordinary evidence, and plant neuroscientists have simply not met that basic epistemic demand.

One of the big names in the field of so-called plant neuroscience is Monica Gagliano, who made a splash with the publication in 2016 of a paper in which she appeared to have demonstrated Pavlov-type classical conditioning in pea plants (Gagliano et al. 2016). You will not be surprised to learn that an attempt to replicate the results by K. Markel (2020) failed—suggesting, again, experimental artifacts as the real cause.

Gagliano upped the ante in 2017 by claiming that plants have full-fledged consciousness:

> The ability to learn through the formation of associations involves the ability to detect, discriminate and categorize cues according to a dynamic *internal value system*. This is *a subjective system of feelings and experiences*. … [Since] feelings account for the integration of behavior and have long been recognized as critical agents of selection, plants too must evaluate their world *subjectively* and use *their own experiences and feelings* as functional states that *motivate their choices*. (Gagliano 2017, emphasis added).

There is absolutely no evidence of this. As far as we can tell, plants don't have value systems, do not experience feelings, and have no motivations.

Plant "neurobiologists" make the stunning claim that plants feel pain. On what basis? Because plant responses are reduced by anesthetics such as diethyl ether. But these chemicals are known to have a large spectrum of biological effects, and it simply doesn't follow from observing such effects that a given living organism feels pain. Pain, all the evidence suggests, requires a nervous system.

This has very practical consequences. If plants really do feel pain, the finding would carry gigantic ethical implications, for instance for vegetarians. We better not make such claims without sufficient epistemic warrant.

Taiz and colleagues ask: What do we actually *know* about consciousness? It's popular these days to claim that we

have no clue how consciousness works, but this is simply false. A paper by Todd Feinberg and Jon Mallatt, for instance, summarized the vast literature on the evolution of consciousness (Feinberg and Mallatt 2016). They show that there is an emerging consensus among real neuroscientists that includes the following points:

1. Consciousness is, as far as we can tell, grounded in living processes. So no, you won't be able to upload yourself into a computer, whatever that means.
2. On the basis of what we know so far, consciousness is a phenomenon generated by animals equipped with a complex nervous system.
3. Consciousness seems to require the presence of a brain system overseeing a complex set of neural pathways.
4. The evolution of consciousness has been coupled with a veritable explosion of sensorial modalities in the animal kingdom. Such modalities have required further complexification of the central nervous system as well as the evolution of innumerable feedback mechanisms between the brain and its sensory channels.

Feinberg and Mallatt concluded that the only living organisms that can be reliably said to have consciousness are vertebrates (including fish), arthropods (insects and crustaceans), and cephalopods (octopuses, squids, and the like). Not plants, fungi, or bacteria.

As Taiz and colleagues noted, there is nothing new here. The Romantics of the eighteenth and nineteenth centuries also ascribed feelings and intentionality to plants, in reaction to what they saw as the cold mechanistic philosophy of Descartes and later of the Enlightenment thinkers. Sure enough, contemporary plant neurobiologists tell us to think more like poets and embrace metaphors. Ironically, they accuse mainstream scientists of being animal chauvinists, while in fact it is they who blatantly anthropomorphize plants. And they claim their approach will lead to more concern for biodiversity. But do we need to project ourselves onto other living organisms to care about the environment? Do we want to do so at the expense of sound science? ■

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