

# Plant intentionality and the phenomenological framework of plant intelligence

Michael Marder

IKERBASQUE: Basque Foundation for Science & Department of Philosophy; The University of the Basque Country; Vitoria-Gasteiz, Basque Country

This article aims to bridge phenomenology and the study of plant intelligence with the view to enriching both disciplines. Besides considering the world from the perspective of sessile organisms, it would be necessary, in keeping with the phenomenological framework, to rethink (1) the meaning of being-sessile and being-in-a-place; (2) the concepts of sentience and attention; (3) how aboveground and underground environments appear to plants; (4) the significance of modular development for our understanding of intelligence; and (5) the concept of communication within and between plants and plant tissues. What emerges from these discussions is the image of a mind embodied in plant life.

*“It is utterly impossible for human reason [...] to hope to understand the generation even of a blade of grass from mere mechanical causes.”*

—Immanuel Kant, Critique of Judgment, § 77

## Introduction

Recent advances in plant neurobiology and plant intelligence studies require an integrated conceptual-methodological framework for the interpretation of new findings concerning plant behavior and communication. It is not enough to broaden the general definition of intelligence, in an attempt to account for the phenotypic plasticity of non-animal organisms, or to draw analogies between animal and plant behaviors. In the first case, computational, ecological and evolutionary models of intelligence fail to account for the

specificities of plant behavior, considered as a mere example of information processing, organism-plus-environment unit, or adaptability, respectively. In the second case, even if plant behavior is acknowledged as such, comparisons are prone to accusations of being metaphoric,<sup>1,2</sup> as the basis of any behavior is assumed to lie exclusively in animal conduct.

An alternative approach, proposed by Warwick<sup>3</sup> and supported by Trewavas,<sup>4</sup> calls for judging intelligent behavior in non-human organisms based on the capacities of the organism in question. Following this proposal, plant intelligence refers to what plants can do as well as to their unique perspective, expressed at the cellular, organismic and environmental levels. The challenge is to look at the world from a “plant point of view,”<sup>5-8</sup> for, if biology is to be “a science of living beings,”<sup>9</sup> it must investigate the particular perspectives correlated with each distinct form of life. This means that living beings, including unicellular organisms, would be not only the objects of scientific study but also its subjects.<sup>10</sup>

Nevertheless, the meaning of either subjectivity or intelligence is not unproblematic. It would be unwarranted to presuppose that subjects are necessarily autonomous or identical to “persons” and to build a theory of plant subjectivity upon this shaky supposition.<sup>11</sup> Philosophical reflection on subjectivity is, therefore, a *sine qua non* for biology. One of the most fertile bodies of work in this respect is phenomenology, which scrutinizes the diverse modes of experiencing lived environment. Proceeding through meticulous descriptions of ways in which the world is given

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Correspondence to: Michael Marder;  
Email: michael.marder@gmail.com

and appears to subjects acting within it, the phenomenologist reconstructs their specific experiential standpoints. The meaning of subjectivity becomes indissociable from the meaningfulness of the world for a given subject.

To argue for an extension of the phenomenological framework to plant intelligence studies is, in fact, to bring phenomenology back to its roots. Some of the most important figures in the twentieth-century segment of this intellectual movement, including Heidegger and Merleau-Ponty, drew heavily on the work of a biologist von Uexküll, author of *A Foray into the World of Animals and Humans*.<sup>10</sup> But Uexküll's work includes a fatal blind spot: he accepted the thesis of cross-species differences in perspectives on the environment among animals but did not entertain the possibility of a plant world-view. Indeed, in his book, plants remain relegated to the background of animal life, as its passive supports or habitats.

The goal of this article is to start bridging phenomenology and plant intelligence studies with the view to enriching both disciplines. Besides reconsidering the world from the perspective of sessile organisms, it would be necessary, in keeping with the phenomenological framework, to rethink (1) the very meaning of being-sessile and being-in-a-place; (2) the concepts of sentience and attention; (3) how aboveground and underground environments appear to plants; (4) the significance of modular development for our understanding of intelligence; and (5) the concept of communication within and between plants and plant tissues. What emerges as a result is, to paraphrase Thompson,<sup>12</sup> the picture of an embodied mind in plant life.

### Plant Subjectivity in Western Philosophy: A Very Brief Overview

In the history of Western philosophy, the idea of plant subjectivity has a long and venerable genealogy. According to Aristotle, plants have a vegetative soul, *to threptikon*, with the signature capacities for nourishment and reproduction. It must be stated that the ancient Greek idea of "soul," *psukhé*, does not coincide

with a later, Judeo-Christian sense of this term. *Psukhé* is a set of active capacities of an organism, not an invisible entity connected to the divine. The capabilities of plants, for Aristotle, are common to all living beings, be they animal or human, who have other capacities—sensation and rational thought—superadded to the vegetative soul. There is, also, a clear continuity among the different classes of organisms, in that the "the earlier type always exists potentially (*dunamei*) in that which follows,"<sup>13</sup> implying that the vegetative soul carries on "potential" existence in the sensitive psyche of the animal and in the rational soul of the human.

When today plant behavior is defined in terms of activity, as what plants can do,<sup>4,14</sup> this definition harkens back to the Aristotelian capacities of *to threptikon*. Furthermore, if "[t]here should be... aspects of intelligent behavior in lower organisms from which our superlative capacities are but the latest evolutionary expression,"<sup>15</sup> then Aristotle's hypothesis of the continuity of capacities remains in effect, even as it is updated with reference to evolutionary theory. Where plant intelligence studies differ from Aristotle, however, is in the ascription of the so-called "higher capacities" to plants. In and of themselves, nourishment and reproduction entail complex decisions related to the availability of resources. For example, root foraging for rich soil patches,<sup>16</sup> kin recognition (rejection of pollen contributed by a related plant sharing the allele or by the rejecting plant itself),<sup>17</sup> or rapid morphological changes in response to environmental alterations (e.g., adjustment to drought by shedding leaves).<sup>14</sup> Additionally, plants express almost all known neurotransmitters,<sup>18</sup> confirming the extension of *to threptikon* well beyond the activities Aristotle and his followers allotted to them. Hence, the lines of demarcation between the "higher" and the "lower" capacities, between consciousness and non-consciousness and, by implication, between biological regna are not as rigid as classical thinkers believed.

Although Aristotle corroborated the existence of vegetative soul, he considered it to be inferior to human and animal capacities, so much so that he identified plants as "deficient animals." Due to the

static nature of metaphysical philosophy, this view had remained largely unchanged up until the nineteenth century, when it culminated in Hegel's philosophy of nature, according to which, in plants, "the objective organism and its subjectivity are still immediately identical."<sup>19</sup> The selfhood of plants, for Hegel, is negative, in that it is not autonomous, does not find completion in itself, but only in the inorganic "other" (sunlight or the world of minerals) to which it is physically and conceptually proximate. The relative undifferentiation of plant tissues, the absence of an organismic whole to which plant organs would be subordinated, the perceived passivity of plants rooted in the soil—Hegel conceives all these features of plant life as justifications for the deficient status of their subjectivity in the grip of the inorganic world.

Much of what philosophers such as Hegel have found to be inferior in plant morphology and physiology actually explains the plants' phenotypic plasticity, their ability to respond to changing environmental circumstances through often localized adjustment.<sup>14</sup> In fact, meristematic action and modular development (the first two objects of Hegel's critique) are the foundations of plant behavior and are responsible for the increase of genetic diversity within a single plant that lives with all of its mutations<sup>20</sup> and, therefore, for a virtually unlimited number of viable possibilities for its self-expression in comparison to animal genetics. The attribution of absolute passivity to plants, on the other hand, is downright erroneous, as research into defenses against herbivore predators through volatile plant chemicals has shown.<sup>21</sup>

Two other emblematic developments in nineteenth-century theorizations of plant life are worth mentioning, because, though they represent definite advances over the preceding conceptualizations, they also anticipate the current state of plant intelligence studies. First the Darwins' "root-brain hypothesis,"<sup>22</sup> which has been receiving much attention of late,<sup>23</sup> postulated the root apex as a brain-like organ, sensitive and capable of navigating the soil in search for resource-rich patches. Second, is Nietzsche's idea that the plant's nourishment and growth are the expressions of its will-to-power.<sup>24</sup>

While Darwin constructed a plant-animal analogy, Nietzsche, who was also influenced by Darwinism, relied on a broad general concept—akin to the contemporary cognitive emphasis on information processing—that represented the universal substratum for life at the price of obfuscating the unique texture of plant biology.

### Being-Sessile and Being-in-a-Place

One of the most obvious features of plant life is the fact that plants are sessile. All too often, sessility has been mistaken for the plants' immobility and impassiveness, with the notable exceptions of rapid movements observed in *Mimosa pudica* or *Dionaea muscipula*. This is a quintessentially modern prejudice, resulting from the exclusive identification of movement with locomotion. Aristotle, to his credit, recognized that the latter is only one of four types of movement, the other three being growth, decay and change of state (metamorphosis), all of which are present in plant life.<sup>25</sup> It is evident that the fixedness of plants is an impressionistic mistake, given their lateral and vertical extensions both above and below ground level. Although they appear to be anchored in a place, plants incessantly explore their environments, maximizing their exposure to sunlight, avoiding or growing toward the roots of their neighbors and monitoring and responding to changing environmental conditions.

The plants' being-in-a-place is far from a passive inclusion in a locale. The places occupied by organisms are not objectively fixed; they are inhabited, differentiated and constructed in the course of organismic life and development. Directional gravity sensing in gravitropism allows the plant to discern the difference between what is "up" and what is "down,"<sup>53,55</sup> introducing the first orientational differentiation into environmental space, imposing a meaningful grid onto it and transforming it into a place or a habitat. As phenomenology shows, lived space is relative to the bodily orientation of the subject, who is at the "degree-zero" of its milieu. The contours of place are also relative to the plant's orientation; they change as the

plant grows, extends its reach further both vertically and laterally and releases volatile airborne and belowground biochemical signals. Its sense of place therefore depends on the non-random, deliberate placement of new leaves and shoots.<sup>14</sup> In other words, the place dynamically emerges from the plant's living interpretation of and interaction with its environment.

Only when sessility is taken to be synonymous with passivity, does it point toward the general conclusion that plants live in a state of torpor, the conclusion buttressed by the fact that plant cells are enclosed within the walls of rigid cellulose.<sup>20</sup> From this, the philosopher Bergson extrapolates that plants are characterized by "consciousness asleep and by insensibility,"<sup>26</sup> though he immediately moderates this claim by considering plant insensibility to be nothing more than a reversible tendency, hinting at the possibility of plant behavior. Still, the dynamic nature of plant growth and adaptation requires plant cells that are "inherently excitable and sensory."<sup>18,27,28,49</sup> Even if cells do not circulate in the bodies of plants, as they do in animal bodies, they generate action potentials and synthesize the protein RHD3, responsible for the proper arrangement of root cell files underlying the direction of root growth.<sup>29</sup> It is this directionality of growth, along with its deliberate regulation, that will hold the clue to the intentionality inherent in plant life.

At the origins of phenomenology, intentionality was conceived as "consciousness of..." or, in strikingly spatial terms, as "directedness toward..." To be conscious is to intend something, that is to say, to be directed toward the intended object (the metaphysical concept this notion supplants is "will"). In light of this definition, the intentionality of plants may be understood as the movement of growth, directed toward the optimal patches of nutrient-rich soil and sources of light. Hegel, too, was aware of this feature of plant behavior; citing potatoes that sprouted in the cellar, he wondered at how the sprouts "climb up the wall as if they knew the way, in order to reach the opening where they could enjoy the light."<sup>19</sup> When animals intend something, they enact their directedness-toward by moving their muscles; when plants intend something, their

intentionality is expressed in modular growth and phenotypic plasticity. Plant and animal behaviors are the accomplishments of the goals set in their respective intentional compartments. The RHD3 ordering of root cell files exemplifies the directedness of intentionality, for which growth acts as an extended, spatial model. This is but one example of plant intentionality: the subsequent sections of the present article will describe other aspects of this crucial phenomenological concept, operative in plant life.

The chief cause behind the illusion of plant immobility is the difference in the time scales of human and plant lives. In everyday settings it is impossible to perceive the growth of plants, since many plant responses may take days or even weeks. From the phenomenological vantage point, not only the sense of place but also that of time is indexed to the subject who experiences it. In contrast to the objective "clock time," Husserl, who stood at the origins of this intellectual movement, put emphasis on "internal time consciousness," or on how subjects experience the passage of time as either fast or slow depending, for example, on their mood at any given moment. It is likely that such variations in temporal perspectives are not only interpersonal but also extend to cross-species and cross-kingdoms differences. If the phenomenology of plant intelligence is relative to the capacities of plants, then these, too, must be relative to the specific temporal framework, wherein these capacities are enacted.

One area where there is a partial overlap between the internal time consciousness of animals and plants is time estimation with the help of circadian clocks.<sup>30,31</sup> Besides the fact that the same molecular mechanisms permit plants and animals to exploit circadian clocks, leaves of some plants, such as *Lavatera cretica*, can anticipate the direction of sunrise, even after they have been prevented from solar tracking for several days.<sup>32</sup> The combination of memory and anticipation is consistent with the phenomenological description of time as the retention of a past "now-moment" and the projection into a future "now-moment" by a conscious subject. The sense of place remains incomplete without this, its experiential temporal dimension.

Plant intelligence entails, at the most basic level, the subjective constitution of lived space and time by the plants themselves. Plant behavior is marked by a successful (from the practical or pragmatic point of view) orientation in local environment, taking into account minute changes in temperature, humidity gradients and so forth.<sup>15</sup> One of the reasons behind this success is that plants grow not so much in opposition as in contiguity with the ecological niche they inhabit, as evidenced by the maximization of their surface exposure. A rooted mode of being and thinking is, then, characterized by extreme attention to the place and context of growth and, hence, by a sensitivity that at times exceeds that of animals.

### Plant Sentience and Bio-Attention

It is possible to infer plant sentience from the fact that plants explore and pursue unevenly distributed resource gradients, assess environmental dangers from biotic and abiotic stressors and gather and constantly update various types of information about their surroundings.<sup>33</sup> As Trewavas states, “[b]ecause plants are sessile organisms, they may perceive more environmental signals and with greater sensitivity and discrimination than the roaming animal.”<sup>24</sup> Electrical long-distance signaling and the existence of action potentials in plant cells and tissues further support the view that their abilities of sensing are not at all limited.<sup>29,56</sup> In the phenomenological vernacular, each type of plant perception expresses a mode of its intentionality: directedness toward light in photosensitivity, directedness toward sources of heat in thermo-sensitivity, as well as toward (or away from) self and other in kin recognition. In each case, it is a matter not only of receiving but also of interpreting the signals and deciding among conflicting signals in a non-automatic manner.<sup>4</sup> Intentionality here assumes the more colloquial sense of a deliberate prioritization and choice of some intended objects over others.

For Husserl, there is a significant overlap between the concept of intentionality and the sphere of attention. Both imply selectivity: a particular signal or object stands out from the undifferentiated background of other stimuli and thus becomes

meaningful. Monitoring moisture levels in the soil or the levels of threat from a predator attack are significant to plants because these factors bear directly upon their survival, just as being attentive to passing vehicles before crossing a busy road is existentially important for human subjects. It is through an attentive attitude that either beneficial or detrimental objects first acquire significance, from the perspective of the attentive subject. For example, the existing evidence that plants detect and react to different sounds, bending root tips toward sound source,<sup>34</sup> suggests that acoustic signals are significant for plants, even though the exact reason underlying this instance of bio-attention remains debatable.

The sphere of attention is dynamic to the extent that some stimuli recede to the background of relative indifference and others take their place by being highlighted for the attentive subject, only to recede to the same background and give way to new encroaching stimuli. Given that plants respond to roughly 15 environmental factors acting in different degrees and affecting perceptions of each other,<sup>15</sup> their bio-attention results in infinite variations of selectively variable responses that constitute their behavior. Moreover, plants are capable of discriminating between prolonged signals and transient background noise,<sup>35</sup> that is to say, of drawing meaningful targets of attention not only from a spatial but also from a temporal background. Discernment, a key feature of intelligence, is similarly manifest in the plant’s ability to differentiate between herbivore damage and a mechanically induced wound that does not provoke the elicitors associated with insect feeding.<sup>21</sup>

One of the advantages of phenomenological reconstruction is that it does not stop at the objective causal explanation of the bases for behavior. More importantly, it discusses how the objective environment is narrowed down to the worlds of distinct subjects, meaningful from their own standpoints. Although there is a substantial overlap between the worlds of various human subjects, the perspectives of any two people are never identical: even when dealing with the same object, they approach it from slightly different angles and pay attention to its distinct

aspects. Uexküll extended these differences to cross-species contexts. The smell of butyric acid meaningful for a tick, for instance, is not likely to capture the attention of mammals, while many stimuli that receive the status of “directional signs” prompting mammal responses will be meaningless for a tick.<sup>10</sup> The life-world of each animal is assembled from those elements of its environment that “light up” before its attention, synonymous with life itself, and are significant for its survival.

Tellingly, this idea of attention does not require as its preconditions either abstract thought or, even, animal perceptual apparatus. Sensitive to a manifold of environmental signals, plants construct their own life-world through those stimuli that are most salient to them. What comes into their sphere of attention and is, thus, imbued with meaning will, in most instances, diverge from what an animal would be attentive to. At the same time, human subjects are attentive to numerous environmental factors, such as the temperature, without taking cognizance of the fact. This somatic attention perhaps comes closest to that of plants, and for good genetic reasons as well: besides regulating animal responses to light, plant genes responsible for photosensitivity control axonal growth of neurons, the timing of cell division and the functioning of the immune system.<sup>36</sup>

Taken in its entirety, the world of and for a plant is a product of its signal integration. For instance, the complex interactions between light signals, hormonal signaling (jasmonate) and signals emitted by encroaching neighbors prompt plants deliberately to modify their growth and development.<sup>37,38</sup> In other words, competing signals vie for the plant’s attention, localized and dispersed throughout all its organs without exception, though the root remain the sensitive organ par excellence. Those that are accorded the highest priority turn into what Uexküll called “directional signs” and pass from merely intended objects to the precipitating factors of plant behavior.

### The Appearance of Plant World

One of the crucial questions of phenomenology is not what appears to the subjects

of perception but the how of this appearance. And so, *how* does the world appear to plants?

If, for plants, the environment appears as a complex spatial and temporal mosaic of resources,<sup>15,16</sup> as well as of light and shadow, then, from the plant perspective, it does not present itself as a conglomeration of discrete objects. This is not necessarily a limitation, as Bergson has argued that objective representations are impositions onto the flux of pure perception that delimit reality in keeping with the limits of human need.<sup>39</sup> That representational thought is not required for consciousness is also a conclusion of phenomenologists, who propose that what appears to human subjects is not a representation of the thing (“picture-consciousness”) but the thing itself. Similarly, plants do not register a representation of light, but light itself, and their cellular light memory is a memory of light itself, as it permits plants to use the photon energy absorbed in excess by some leaves to improve the chances of survival for the whole plant (e.g., *Arabidopsis*) in the future.<sup>40</sup>

But what about spatial representations of the environment? Is it necessary to postulate the existence of a complete cognitive map or a coherent global representation of foraging space in plants to account for their spatial orientation? Just as insect navigation may rely on a decentralized memory without the assumption of path integration,<sup>41</sup> so maze navigation by the roots in search of resource-rich soil patches may operate with a plant version of such decentralized memory, as roots “integrate the signals of soil hardness, stones, light penetration, temperature, invertebrates, the polarized distribution of water, calcium or nitrate, the presence of gases like carbon dioxide or even nitrous oxide and numerous internal signals into the decisions necessary about new root growth and direction.”<sup>42</sup> The choice between highly localized tissue responses<sup>43</sup> and physiological or morphological changes at the level of the entire plant is predicated on a false premise, viz., that a global response is possible only thanks to information being integrated into a cognitive map. But, as we know from phenomenological investigations, bodily orientation as a whole does not depend either on the explicit

cognition of space or on the analysis of movement into its constitutive elements; in fact, deliberate mental reconstruction of the body’s routine operations interferes with their fluid execution. The body with its movements and the plant with its morphological changes can be behaviorally involved as a whole without an integrated cognitive map of the space wherein they live and grow. Via the route of “embodied cognitive science,” which dovetails with phenomenology, Garzón reaches a similar conclusion regarding the decentralized intelligence of plants.<sup>31</sup>

In other words, space does not appear from the perspective of plants as an undifferentiated totality but as a complex network of sites, some of them more preferential for foraging. In this, the life-world of higher plants parallels their modular construction that objectively evinces the history of choices made in favor of resource-rich places. (This is why Nietzsche is correct in his assertion that, “to the plant, the whole world is plant; to us man.”<sup>44</sup>) Still, this spatial archive is not limited to past events alone, as Firn argues.<sup>43</sup> According to Bell et al., both roots and shoots located at the ends of branches, or “spacers,” are projected into habitat space in search of optimal feeding sites.<sup>16,45</sup> Spacers are, indeed, the organic exemplars of plant intentionality and they create the sense of space for a plant that is far from an impassive thing-like being deposited in the environment.

Plants’ spatial relation to the places of their growth is not unidirectional: in a feedback loop, spacers shorten and branching intensifies under the conditions of high resource availability.<sup>16</sup> Periods of phenomenological space-construction and vertical growth alternate with phases of lateral or horizontal space-occupation, although shade tolerant species may not exhibit the same plasticity in their relation to space as their shade intolerant counterparts. And, just as the spatiality of plants is irreducible to an abstract totality, so their temporality is not an empty continuum filled with successive developmental events but a variable rhythm attuned to the environmental conditions, the proximity of neighboring plants, past developmental history and future-oriented goals. If space appears as a mosaic of resources, then time is

experienced in keeping with the phenomenological retention-protection model, i.e., the retrieval of past memorialized events and their projection into the future (or, in Garzón’s terms, the assessment of environmental regularities in order to predict the future<sup>31</sup>). The events of plant development and adaptation do not fill a preexisting temporal axis but form, across their multiple interactions, the inner time consciousness of plant life.

### Modular Development and Dispersed Intelligence

Much confusion in botany, on the subject of plant intelligence, has to do with the philosophical (more concretely, epistemological) issues pertaining to the conditions of possibility for intelligence. In the now classic exchange between Trewavas and Firn, both interlocutors assumed that the burden of proof lies with the proponents of the new paradigm and their ability to argue convincingly that the entire plant is an individual entity. Actually, Trewavas was careful enough to liken a plant to a “democratic confederacy,”<sup>15</sup> in keeping with the model of a meta-population.<sup>42</sup> Firn, conversely, submitted the multiplicity inherent in this model to a *reductio ad absurdum* by negating any meaningful interconnection within meta-populations. A trace of this presupposition is also visible in the cognitive scientific approach that emphasizes the central processing of information by intelligent systems, albeit with a greater degree of flexibility and openness to decentralization. Nonetheless, recently, there has been a marked departure from the idea that intelligence is an emergent property of individuals in discussions of plant signaling and behavior, for example in the studies of swarming behavior in plant roots.<sup>46</sup>

Phenomenologists interested in the questions of embodiment and everyday life have long accepted the thesis of a dispersed intentionality, the oft-disjointed striving or directedness of subjects to multiple goals at once. Scattered trajectories of intentionality are also characteristic of plant life. Colonies of lower plants feature social intelligence, akin to that of a beehive or an anthill. Similarly, the world of higher plants furnishes a perfect image of

dispersed intentionality in modular development or iterative growth:<sup>20</sup> adaptively variable growth is uneven and involves complex branching patterns that effectively respond to sub-optimal niche conditions in order to recover the optimal niche for a given plant.<sup>15</sup> Each shoot and part of root pursues its own trajectory of intentionality, reflecting the uneven distribution of resources to which it strives and, most often, contributing to the asymmetry of the whole. Only those who idealize the animal style of growth and development present the plant as a “poorly integrated organism” or a “population of redundant organs competing with one another.”<sup>20,47</sup> The limited organismic model is simply incompatible with modular development that draws its behavioral plasticity from active meristems, capable of growing into organs of undetermined characteristics<sup>14</sup>—and the same incompatibility applies to the two modes of intelligent engagement in the life-worlds of organisms and vegetal meta-populations.

The dispersion of intentionality in plants does not signify a permanent state of distraction due to their inability to achieve anything like lasting concentration. Rather, their bio-attention is what we may call “hyper-attention,” as every vertical shoot, leaf and rootlet monitors the minutest environmental variations proximate to it. Far from a redundancy, the plant’s non-totalized intelligence is explicable, in cognitive terms, as a paralleling processing model, with every organ of intentionality playing the role of a parallel processor. Phenomenologically, the dispersion of attention and intentionality in lived space and time betokens the dispersion of life itself, which is only overcome at the moment of death. In turn, the organismic aggregate with its total integration of parts subjugated to the demands of the whole leads to a modeling of animal life on a figure of death. If the plant does not live up to this ideal image, this “deficiency” is a testimony to the exquisitely lively character of its intentionality, bio-attention and modular plasticity. It follows that a modular structure of higher plants implies the existence of modular memory and modular intelligence that, likewise, do not correspond to the organismic logic.

The dispersion of intentionality in its striving (directedness) toward the outside world resonates with what Trewavas and Baluška define as consciousness or awareness that extends all the way down to the cellular level.<sup>33</sup> The intelligence of such consciousness hinges on the appropriateness of the response by cells or by communities of cells to their environment. Modular development is merely an expression of this attunement by the cells of the meristems interacting with each other and with their milieu to ensure optimal growth through local—and sometimes global: cf. the example of stilt palm<sup>15,42</sup>—behavioral modification. Neither consciousness nor memory is a hidden sphere of subjective interiority; whereas consciousness, in the simplest terms, is a tendency toward exteriority, memory is the accessible inscription or the trace of an exterior event on the body that has experienced it. It is in this way that phenomenology and plant neurobiology may join forces in a struggle against some of the most pernicious metaphysical and scientific prejudices, namely the concept of a hidden or withdrawn (free) will, the encompassing totality of an organism, and so forth.

### Plant Communication and Partially Overlapping Worlds

When it is observed that intelligence is not concentrated in a single organ but is a property of the entire living being and, moreover, that intelligent behavior cannot be divorced from the context that elicits it,<sup>4</sup> several longstanding Western biases are disrupted. Unlike the presumably context-free abstract rationality, plant intelligence is as context-dependent as the sessile plant itself. Its decentralized structure means that, besides being non-hierarchical, it does not fall under the category of organismic life, succinctly expressed by French philosopher and physician, Canguilhem: “To live is to radiate; it is to organize the milieu from and around a center of reference, which cannot itself be referred to without losing its original meaning.”<sup>48</sup> The plant does not organize its milieu; it is comprised of a series of internal communicative networks (e.g., biochemical and hormonal channels,<sup>37</sup> or synaptic cell-cell communication<sup>18,49</sup>) and external

communication pathways that connect it to its environment. It is, thus, an open system, coupled with its environment.<sup>31</sup>

The phenomenological word for this open system is “world” or “life-world,” referring to the world of and for the living subject in question and inseparable from this subject. Both plants, conceived as meta-populations, and plant communities are worlds in the phenomenological sense. Their capacity for kin recognition is perhaps best understood not in the categories of “self” and “other” but in terms of the construction of a world in common and a clash between various life-worlds. Examples of this phenomenon abound. Crown shyness in trees of the same species, such as *Dryobalanops aromatica* and *Pinus pinea*, or within a single crown of Shorea,<sup>20</sup> confirms that both individual tree specimen and the meta-population comprising the same tree act as subjects of a common world. The same applies to the more modest rooting volumes of *Cakile edentula* grown with kin plants.<sup>17,50</sup> Conversely, the more aggressive roots of *Cakile edentula* grown in the same pots with stranger plants, as well as the release of volatiles as a defense against insect herbivores, indicate the encroachment of another world, whether that of animal species or of another plant species. In a drought, specimen of *Pisum sativum* communicate the onset of adverse environmental conditions through biochemical messages emitted by the roots to other pea plants unaffected by this abiotic stress factor.<sup>52</sup> Their world-construction is accomplished in common. Communication of mechanical trauma from a wounded to the unwounded leaves of the same tomato plant, as evidenced by the activation of proteinase inhibitor at the site of injury and in other distal aerial regions of the plant,<sup>53,54</sup> is equally an example of a joint constitution of the world by a meta-population grouped as a tomato plant.

In light of modular development introducing a set of ambiguities into conceptions of individuality—particularly, into the difference between “self” and “non-self” within and between plant meta-populations and plant communities—the phenomenological notion of the world resolves a terminological and methodological problem in the study of plant

signaling and behavior. This phenomenological term is applicable to lower plants that live in colonies as much as to higher plants, such as trees, that are at the same time colonies and individual units.<sup>20,51</sup> A world is a complex of mutually interacting multiple intentionalities (co-intentionality) and the environment to which they are directed. Unlike the unity of the will, co-intentionality preserves the sense of multiplicity of initiatives by the constituent members of a meta-population or a plant colony. Note, in this respect, that the same ecosystem usually accommodates several partially overlapping or even clashing worlds with divergent intentionalities or with structures directed toward the same intended targets (e.g., limited resources). Note, also, that parts of the so-called “other worlds” do not need to be perceived as a threat, but may be utilized for the furthering of the goals—thus, the enhancement of intentional fulfillment—of the phenomenological life-world that communicates to them. The abovementioned example of volatiles from insect-damaged plants that attract natural enemies of the herbivores corroborates this, as do most plant-pollinator interactions.

### Conclusion: The Promises of Phenomenological Plant Intelligence Research

This article provided no more than the prolegomena to the fruitful interdisciplinary combination of phenomenology, botany and population ecology—an approach we may term *phytophenomenology*. Each of the phenomenological themes under discussion here merits further consideration, so as to inform current debates surrounding plant decisions, choices and behaviors that are not determined in linear and mechanistic ways. A crucial methodological advantage of phytophenomenology is that it neither treats plants as passive objects (or quasi-mechanical structures relegated to the background of animal life) nor accepts the Western metaphysical equation of subjectivity with autonomy, unity, individuality, personhood or will. The centerpiece of this approach is the phenomenological concept of intentionality and its relevance to plant life: the directedness-toward of intentionality as a

general descriptor of behaviors characteristic of sessile and mobile beings; the dispersion of plant intentionality in vegetal sentience and bio-attention; the spatial and temporal construction of plant world through a network of dispersed intentionalities; the appropriateness of modular development to this dispersion; and, finally, plant co-intentionality and clashing intentionalities as theoretical descriptions of communication, kin recognition and cross-species/cross-kingdoms interactions. A supplement to the cognitive (information-processing), evolutionary and ecological perspectives on plant intelligence, phytophenomenology is thus capable of synthesizing large amounts of scientific data into a coherent explanatory framework.

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