

CHAPTER 9

Plant Research

Monika Bakke

*Associate Professor, Philosophy Department
Adam Mickiewicz University, Poznań, Poland*

Plants have always been integral to the survival of humans, but for plants “we are simply one of many external pressures that increase or decrease [their] chances for survival and reproduction success” (Chamovitz 2012, 171). In the Western context, knowledge about plants has been put into practice by female and male gardeners, cooks, healers, carpenters, perfumers, sculptors, musicians, and many others who knew what they wanted from plant bodies. Human existence relies on these peculiar bodies of indifferent beings who realize their own goals in life. Plants provide oxygen, food, and energy (fossil fuels), and they are humanity’s best hope for depolluting the planet. In “Reproducing Plant Bodies on the Great Plains” (2013), American literary scholar Aubrey Streit Krug correctly states, “Plant bodies produce human bodies by materially constituting them, serving as producers in the food web in which their role is to capture solar energy and transform it into the harvestable calories that allow human bodies to sustain life, to grow, and to reproduce” (258). Yet, by merely incorporating them as food, humans miss most of the sophistication of plants as vigilant living beings perfectly equipped with survival strategies quite alien to us.

Knowing plants for their own sake—inquiring into their ontological and epistemological status—was for ages restricted to male natural philosophers. Just three centuries ago, it also became entrusted to male and female botanists and, more recently, to plant biologists. Nowadays, we recognize in plants different sophisticated life-forms with very peculiar bodies and lifestyles, and not only do we want to learn more about them, but we also have much to learn from them. This chapter follows the troubled journey humans have taken to get to know plants in order to arrive at the present moment (in time and space) and the current recognition of them as autonomous and intelligent beings about whom, and from whom, we need to learn. This is a story of denial and exclusion as well as the twists and turns provided by women and men who, contrary to the omnipresent and overwhelming “plant blindness,” have contributed to the present recognition and rediscovery of plants in naturecultures.

Plants have remained mostly unaddressed in feminist theories, despite the fact that humans become who they are with plants and that plant-embodied lives are necessary for sustaining human lives. And yet plant lifestyles and bodies offer an inspiring array of morphological, metabolic, and sexual variety, most of which have not yet been fully explored outside plant biology. Although they share an evolutionary past with plants, humans rarely recognize them as life-forms with whom they have anything in common; hence, plants’ slow and quiet lives are widely ignored in theory and culture. When considered within feminist theories, plants are most likely to be either viewed as undifferentiated nonhuman others or

linked to historically grounded and well-functioning vegetal metaphors that often, but not always, reproduce gender stereotypes. Yet, in an expression of concern for nonhuman others, Australian ecofeminist Val Plumwood (1939–2008) has called on us to “recognize in their limitless heterogeneity beings who always outrun what we may know and want” (Plumwood 2002, 137). It is in the context of this tension—between knowing them more and wanting more from them—that feminist scholars are now rediscovering plants, informed both by new discoveries in biology about plant behavior and by the growing interest in post-anthropocentric attitudes toward nonhuman life-forms. Observations of plant lifestyles and peculiar body plans and modes of reproduction provide evidence that plants are autonomous beings—receptive, active, aware, and intelligent life-forms gathering information, remembering, and adapting their behavior accordingly. All this comes as a source of inspiration to post-anthropocentric efforts to attain what American biologist and feminist science studies scholar Donna Haraway calls “multispecies eco-justice,” suggesting that “it is high time that feminists exercise leadership in imagination, theory, and action to unravel the ties of both genealogy and kin, and kin and species” (Haraway 2015, 3). Finding ways of including plants in feminist theories is both an urgent and exciting task that coincides with the emerging field of critical plant studies.

This chapter addresses issues such as the history of plant knowledge within the Western context, the specificity of plants’ bodily functions, intelligent behavior and sensitivity in plants, their sex life and botanical queerness, technologically augmented plants, the future environments of plants on the earth and beyond, human-plant ethics, and finally, the imperative to “follow plants,” that is, to look to plants’ lives for inspiration on how to coexist with them and with others.

KNOWING PLANTS

The first inquiries into plant life can be traced back to ancient Greece, and, to some degree, we are still influenced by the Greeks’ outdated convictions that plants are passive and insensitive beings occupying the lowest position among the living. In his treatise *De anima*, Aristotle (385–322 BCE) put forth a concept that a soul is a system of abilities manifested by living beings ranging from metabolism, movement, and sense perception to reasoning. He distinguished three types of souls organized hierarchically and inherent to plants, nonhuman animals, and humans. The nutritive or vegetative soul, on the lowest, most basic level, is attributed to all living beings. It is linked with the ability to feed and reproduce, to which plants were believed to be limited. Understood as passive and insensitive beings, plants are unlike animals, which possess both a nutritive and a perceptive soul. Based on a zoocentric bias, Aristotle defined plants in terms of their lacking the abilities of animals and humans. The legacy of the vegetative soul has been analyzed by American philosopher Elaine P. Miller, who has demonstrated that eighteenth- and nineteenth-century philosophers and poets were interested in plant lives as an alternative to a dominant reductionist understanding of organicity. Metamorphosis, indetermination, and plurality have all been among the recognized features of vegetal lives as well as “the unfolding of the plant as the form that literary and philosophical creation and human subjectivity take” (Miller 2002, 10). The concept of the vegetative soul resonates also in contemporary feminist approaches to subjectivity, as discussed later in this chapter.

The Greek philosopher Theophrastus (371–287 BCE) is considered the founder of botanical research in the West. He continued the work of Aristotle but gave special attention

to plants. Being more observant and enthusiastic about their sophisticated lives and body architecture, based on the principle of repetition (modularity) he recognized in them a colony rather than a single organism. Two of his books, *Historia plantarum* and *De causis plantarum*, mark the beginning of botany. Unlike Plato and Aristotle, he avoided evaluating plants from a zoocentric perspective, choosing instead to deal with them on their own terms. Plants were viewed as autonomous beings existing not only to serve humans. As British-born plant biologist Matthew Hall suggests, “Theophrastus’s studies lead to the recognition that plants have their own goals in life” (2011, 31). However, it was an Aristotelian authority, and not a Theophrasteian way of seeing plants, that dominated botanical studies over the next centuries, from the Roman natural philosopher Pliny the Elder (23–79) to the Swedish botanist and zoologist Carl Linnaeus (1707–1778). Medieval scholasticism adopted a hierarchical order for nonliving matter and living beings in the form of the Great Chain of Being—a concept of nature based on three principles: plenitude, continuity, and gradation of all existing forms of being. In this context, plants were situated at the very bottom of the living world, between minerals and animals, and hierarchically organized from the most superior, such as trees, to the lowest, that is, fungi, which at that time were counted as plants.

The modern rediscovery of plants coincided with the wide reception of the revolutionary taxonomic system of botanical classification developed by Linnaeus. However, exploration and scientific travel also led to increased interest in exotic plants and their presence in European botanical gardens (brought by explorers Captain James Cook, Sir Joseph Banks, Johann Reinhold Forster and his son Georg Forster, and others). Linnaeus (in *Philosophia botanica*, 224) argued against the old way of classifying by strongly stating, “We denounce, as *erroneous, specific names* that emphasise a similarity to another plant, in *herbage, fruit-body, or habit*, in Greek or Latin.” Indeed, in the premodern era, as indicated by the French philosopher Michel Foucault (1926–1984), “the history of the living being was that being itself, within the whole semantic network that connected it to the world” (Foucault 2002, 140). In other words, a living being was characterized not only by its actual body features but also by all sorts of old and new stories involving it, such as travel, medical, literary, and philosophical narratives. Linnaeus’s taxonomy, however, offered a clear and easy-to-learn system focused solely on the visible features of the plant body. Today, Linnaean taxonomical efforts are viewed as a reflection of the desire for epistemological mastery over human and nonhuman others that is typical of Western modernity.

It appears that women enthusiastically joined in the botanical research of the eighteenth century, becoming involved in botanical illustration, the collecting and naming of plants, and translating and commenting on botanical texts—both as professionals and as amateurs. They were also translators of scientific texts that greatly helped the transmission of botanical knowledge throughout Europe. Women’s enthusiasm for botany was generally accepted but not completely free from controversy, as it was not obvious to everyone that botany was suitable for women. As British literary scholars Sam George and Alison E. Martin point out in “Botanising Women: Transmission, Translation and European Exchange” (2011), there were voices among male naturalists warning that “botanizing girls anatomizing the sexual parts of the flower were indulging in acts of wanton titillation” and doubting that “an examination of plant’s organs of generation could be conducive to female modesty” (2). Botany, however, became “an outdoor pursuit that offered women (limited) freedom to investigate the natural world” (George and Martin 2011, 4), but the more theoretical work, such as inventing systems of classification, was reserved for male naturalists. Women wrote botanical texts, often in the more private and polite format of a letter, a confession, or a

conversation that was viewed as more appropriate. Hence, during the Enlightenment period botanical texts were written specifically for either sex, and at the same time botanical texts by and for women gained visibility.

The British naturalist and geologist Charles Darwin (1809–1882) finally challenged the Aristotelian tradition of the hierarchy of souls, carried on through the centuries in the Christian concept of the Great Chain of Being and in artificial systems based on a few conveniently chosen traits, such as the shape of a plant's reproductive organs in the case of Linnaean taxonomy. The key concepts for plant research in this new Darwinian opening, such as the movement of plants, plant cognitive abilities ("root brain"), and the notion of common descent, are discussed later in this chapter.

WHAT IS A PLANT?

Dealing with plant bodies on an everyday basis, all humans are very familiar with their smell, their taste, and the texture of their body parts. People want to smell like flowers, like wood, like freshly cut grass, but as Russian-born philosopher Michael Marder rightly notices, "The absolute familiarity of plants coincides with their sheer strangeness" (2013, 4). Indeed, for a nonbiologist, plant bodies may seem rather obscure, as at first glance humans and plants do not really have much in common. However, according to American-born plant biologist Daniel Chamovitz, "on a broad level we share *biology* not only with chimps and dogs, but also with begonias and sequoias" (Chamovitz 2012, 174), which indicates a common evolutionary past with plants. Animal and human-animal lifestyles and body plans are very different, with the evolutionary paths of plants and animals splitting some two billion years ago. The oldest plants are algae and mosses, which were followed by ferns and then needle trees and leaf trees, while flowering plants were the latest arrival. Human-animals share not only a common ancestry with plants but also interconnectivity, coadaptation, and coevolution. American cultural theorist Richard Doyle claims that "if mammalian and primate evolution is enmeshed in a systemic way with angiosperms (flowering plants), so too have humans and other primates been constantly constituted by interaction with plants" (2011, 14). But he goes even further to suggest that psychedelic compounds produced by plants, and also by the human brain itself, catalyzed human evolution and technoscientific change. To evolve, one needs to be ecstatic, to experience deep interconnection with the ecosystem, to be more than oneself.

In the 1960s, Lynn Margulis (1938–2011), one of the most important American biologists of the twentieth century, proposed a hypothesis of symbiogenesis to explain the symbiotic origin of plant, animal, and other cells containing nuclei. At first strongly contested, this theory is now widely accepted and confirmed by contemporary research recognizing plant cells as actually being chimeras. They came into existence as a result of a symbiotic union between algae and cyanobacteria, aided by a bacterial parasite. Now plant bodies come in a huge variety of forms and structures, the smallest being the unicellular aquatic algae and the largest being trees, the multicellular and vascular terrestrial organisms. Thus, on one side of the spectrum is the microscopic scale and, on the other, are some of the largest life-forms on the earth, such as sequoia trees. Plants also differ significantly in terms of their life span: from hours in the case of microscopic phytoplankton cells to centuries for some trees.

Unlike animals, plants are autotrophs, feeding on nonorganic matter and solar energy (with the exception of parasitic species). Plants feed on air, light, and minerals and, in doing so, provide almost all the organic carbon used by heterotrophs, which are unable to produce

their own food. Plants' relation to the mineral world is not limited to their metabolism (absorbing minerals); it is also visible in their peculiar mode of body growth, resembling that of crystals. Multicellular plants increase in size indefinitely by cyclically adding organs (modules) like crystal units in growing crystals. This proves to be a very useful body architecture, as a new module may easily replace a damaged one. Modules, in contrast, may be morphologically and anatomically modified according to environmental conditions, and, on an evolutionary time scale, modules may develop specific functions. This highly repetitive structure of the plant body has been known since the work of Theophrastus, though the ability to modify one's body in terms of metamorphosis was taken up by the German writer Johann Wolfgang von Goethe (1749–1832) and “characterized by an alterity inscribed into identity. This means that a plant has no strict identity over time in the way an animal does” (Miller 2002, 9).

INTELLIGENT BEHAVIOR OF SENSITIVE BODIES

Sensitivity in plants has been known for a long time, and not only in the Western context, but the mechanisms of plants' responses were not known. The Indian scientist and inventor Jagadish Chandra Bose (1858–1937) investigated plant response to various stimuli and made an important discovery that explains how plants such as *Mimosa pudica* and Venus flytrap can move without any muscles. His claim that touch initiates an electric signal that causes a rapid movement was rejected by the Royal Society of London in 1901, acting as a scientific authority, but later studies have demonstrated that Bose was correct. In recent decades, the interest in and the understanding of plant behavior has increased greatly. The new science of plant behavior and signaling, still contested by some scientists but enthusiastically welcomed by others, addresses various issues related to adaptive behaviors in plants, including sensory perception, communication, memory, and intelligence. Plants are now considered sensitive and dynamic beings capable of responding to environmental stimuli such as touch, temperature, gravity, water, and chemicals in various ways. They can display rapid movement (as in the mimosa's closing leaflets in its defense or the Venus flytrap's catching animals) and changes in their body shape, among others.

In 2003, Anthony Trewavas, a plant biologist from the United Kingdom, caused a major controversy in the academic world by declaring the need to recognize “plant intelligence,” which he defines as “adaptive variable growth and development during the lifetime of the individual” (Trewavas 2003, 1). He believes that the hostility toward the concept of an “intelligent plant” comes from “a mind-set, common in plant scientists, that regards plants basically as automatons” (2). However, in recent years, scientists interested in plant signaling and behavior have provided significant evidence that plants behave intelligently and that some decision making is taking place in the roots. It was actually Charles Darwin assisted by his son, Francis Darwin (1848–1925), in *The Power of Movement in Plants* (1880), who came up with the term *root brain*, though they compared it to the brain of a lower animal. However, contemporary research finds the decentralized “assessment and response system” specific to plants more effective for their survival. As Hall puts it, “plants may actually have thousands of brain-like entities that are involved in the emergence of intelligent behavior” (2011, 147). The root brain is, in fact, a decentralized communicative network that is absolutely unlike the centralized and hierarchically structured self supposedly governing our own animal bodies.

Italian plant biologist Stefano Mancuso and science journalist Alessandra Viola, in their book *Brilliant Green* (2015), explain that plants “manifest a kind of ‘swarm intelligence’ that enables them to behave not as individuals but as a multitude—the same behavior is seen in an ant colony, a shoal of fish, or a flock of birds” (5). Do plants exhibit a form of consciousness then? Whereas Trewavas would give a positive answer to this question, Daniel Chamovitz thinks that such statement goes too far in making parallels between plants and animals. Chamovitz prefers to talk about “plant awareness,” because thanks to their sophisticated sensual perception “plants are actually aware of the world around them” (Chamovitz 2012, 140) as well as of their past. These controversial ideas are already resonating in cognitive studies, with Spanish and Dutch philosophers Paco Calvo Garzon and Fred Keijzer considering plants to be minimally cognitive. Research on cognitive abilities of beings so different from (human) animals contributes to a broader inquiry into intelligence in general and may be helpful in searching for alien forms of intelligence and life.

SEX LIFE OF PLANTS AND BOTANICAL QUEERNESS

Although it has been known that plants have reproductive organs, it was not until Linnaeus proposed a so-called sexual system of botanical classification that this issue became so visible. In his book *Species plantarum* (1753), Linnaeus established a formal methodology based on a binominal (binary) nomenclature to refer to the number of male and female sexual organs in flowers. A plant’s class was determined by the number of stamen (male organs) and its order by the number of pistils (female organs). In order to make the controversial issue of what seemed perverse in plant sexuality more acceptable, the perversity being the possibility of sex with more than one partner and with partners of the same sex, Linnaeus adopted traditional wedding and marriage imagery. He suggested that “the flowers’ leaves . . . serve as bridal beds which the Creator has so gloriously arranged, adorned with such noble bed curtains, and perfumed with so many soft scents that the bridegroom with his bride might there celebrate their nuptials with so much the greater solemnity” (quoted in Schiebinger 1996, 113). Despite the conventional conservative vocabulary, Linnaeus’s descriptions exposed the fact that plant sexuality cannot be reduced to heterosexual unions of two partners (organs), because in flowers a female reproductive organ is often accompanied by numerous male reproductive organs or, in Linnaean terms, one wife resides in bed with numerous husbands being either brothers or unrelated to each other. Needless to say, disclosing sexual relations of this kind was received with fierce hostility.

Descriptions of plant sexuality that allegorized human sexuality reveal prevailing gender relations and especially attitudes toward women. During his trip to Lapland in 1732, Linnaeus became particularly interested in a small plant he decided to call *Andromeda*. In his diary, Linnaeus recorded this encounter in the form of a drawing (see figure 1) and a note that demonstrates the long-established association of women with plants: “I noticed that she was blood-red before flowering, but that as soon as she blooms her petals become flesh-coloured. . . . Her beauty is preserved only so long as she remains a virgin (as often happens with women also)—i.e. until she is fertilized, which will not now be so long as she is a bride” (Blunt and Stearn 2001, 51).

The vegetative or nutritive soul, existing in the Western imagination since the time of Aristotle and linked with growth and reproduction, was particularly associated with irrationality and women, resulting in their inferior position in political life. Elaine Miller explains that “western philosophers from Aristotle to Hegel have repeated the analogy of men to



"Andromeda," a sketch by Swedish natural scientist Carl Linnaeus (1707–1778). This sketch comes from a diary Linnaeus kept during his expedition to Lapland in 1732. Andromeda is a name of a plant otherwise known as bog-rosemary, which, like a Greek goddess Andromeda, might occupy a small patch of flooded land surrounded by "evil" creatures. INTERFOTO / ALAMY.

animals and women to plants by virtue of their (perceived) respective characteristics of activity and rationality, on the one hand, and passivity and lack of rationality, on the other" (Miller 2002, 187). This resulted in the association of women with flowers, both as a linguistic convention and an ontological conviction, linking femininity with a decorative status rather than any practical or political force. Hence, passivity, purity, and fragility were praised as female virtues, and, as such, flower-women were treated as objects of male desire. Representing women as flowers ultimately reduced them to their seductive powers and reproductive functions. One of the best visual representations of this perception of women is Italian painter and printmaker Odoardo Fialetti's (1573–1638) *Petal Venus* (1627), which depicts "the dissected pregnant womb as a gorgeously unfurled bloom" (Syme 2010, 8). This concept survived for centuries and was a rather common motif throughout nineteenth-century visual culture. Moreover, historian of science from the University of Cambridge Patricia Fara points out that "legacies of this erotic botanic intensity survive in words such as 'defloration'" (Fara 2004, 11) as well as in the contemporary visual appropriation of flowers in the paintings of American artist Georgia O'Keeffe (1887–1986) and in American artist Judy Chicago's (1939–) installation *The Dinner Party*.

In a feminist context, acclaimed interdisciplinary thinker and Belgian-born feminist philosopher Luce Irigaray (1930–) has inquired into the ontological status of women being figuratively linked with plants and made an effort to positively rework the negative metaphor of woman-flower. In Irigaray's poetic writing, the figure of a flower, similarly to that of lips, refers to the feminine subject and the concept of feminine intimacy. In her book *Elemental Passions* (2013), she refers to the petals of a flower touching each other as lips do in a caress.

She distinguishes between becoming a flower on one's own and being forced to become a flower as a mode of masculine appropriation of femininity; as she writes, "You want to make me into a flower?" to become "your flower" (34). But a woman has her own ways to become herself; she has her own roots to grow into herself—a message that Irigaray conveys by saying, "Before I knew you, already I was a flower. Must I forget that, to become your flower? The one which is your destiny for me" (34). The sexual connotation of a flower is clear, but the model of female sexuality tailored to men clouds what is actually hidden somewhere deeper—in the ground, all the way down the roots: "My petals swell with your vigor, itself nourished by my blood, but thus separated from their life's source . . . they are held open in an ideal permanence so that, eternally fixed, I guarantee the concept of the flower for you" (34). The flower, however, touches the earth with its roots and exposes only the "petals spreading and coming together" (32). Pointing out another layer of this writing on the flower-woman, Miller suggests that as a result of Irigaray's strategy "the plant moves from an analogy to woman to a metonym for woman" (Miller 2002, 192). In other words, this strategy opens up space for a critique of the perception of woman as flower and enables an empowering new concept of woman-flower. The latter represents femininity self-aware of its potential, agency, and erotic powers.

The interest in botanical queerness nowadays is focused mainly on plants themselves, and inquiries into their sex life provide refreshing inspiration in feminists' thinking about the materiality of sexual relations in human and nonhuman contexts. "Like critical plant studies in general, then, a queer way of thinking about reproducing plant bodies," writes Aubrey Streit Krug, "calls attention to how plants and humans exist in trans-corporeal relationships. Trans-corporeality can be dangerous, but it can also be sustaining, and in any case, it is unavoidable" (Streit Krug 2013, 262). Canadian environmental scholar Catriona Sandilands celebrates the notion of "botanical queerness," which, as she believes, may be helpful in thinking through the terms and concepts of queer theory. Rejecting efforts to see plants reduced to the interests of humans who instrumentalize them, she suggests inquiring into the intriguing sexual strategies of plants. The latter involve not just other plant species but also wind, water, gravity, and animals. Plants developed pollinating strategies that involve insects lured to them most commonly by color, smell, and rewards such as nectar and pollen, but some use the peculiar strategy of sexual mimicry, leading to copulation with the deceived wasps and bees. Hundreds of orchid species produce flowers that attract insect pollinators by imitating the actual look of the sexual organs and sex pheromones of their potential mates.

An international group of artists and designers, including Pei-Ying Lin, Dimitris Stamatis, Jasmina Weiss, and Špela Petrič, working together on a project called Plant Sex Consultancy (PSX Consultancy), have declared an interest to "design methodologies to create augmentations for [their] vegetal clients, which supplement and enhance their natural reproductive strategies." They chose a number of plants for whom they intended to design body extensions and augmentations in an attempt to solve their sex-related problems. In a strategic anthropomorphic gesture, the artists gave their plant clients voices, to allow them to describe their problems. The most important aspect of this work, however, is certainly its directing viewers' attention not only to the various reproductive strategies employed by flowering plants but also to the fact that plants' reproductive functions are highly dependent on environmental conditions, including anthropogenic pressures linked to domestication. One of the clients, the commonly known potted plant cyclamen, coevolved with specific large bees that performed buzz-pollination; this species, however, has gone extinct for unknown reasons. The cyclamen flower requires a specific, large insect to shake it with

a specific frequency, and scientific research suggests that although other insects visit the flower, they may not be successful in pollinating it. Therefore, the artists developed “a vibrating pod with a sensor [which] is designed to gently grasp the cyclamen flower. When triggered by a visiting insect, the pod shakes with the exact frequency needed to release the pollen onto the insect” (PSX Consultancy). The actual objects are something between a sex toy and a prosthesis compensating for a lost function. In this inquiry into plants’ desires, we learn about adaptation, coevolution and transspecies relations as well as humans’ impact on the environment.

TECHNOLOGICALLY AUGMENTED PLANTS: CHIMERAS, CYBORG PLANTS, AND PLANTOIDS

Humans have always looked for ways to transform plants for their own needs, instrumentalizing human-plant relations, yet the domestication of plants may also be viewed as an exchange of benefits. The agricultural revolution around 12,500 years ago marked the beginning of social history, civilization, and biotechnology, which leads to creating new forms of life. The first domesticated plants, also called the Neolithic founder crops, include three cereals, four pulses, and flax, which were cultivated by the farming communities of the early Holocene in the Fertile Crescent, comprising western Asia, the Nile valley, and the Nile delta. A scientific lab equipped with bioengineering tools has become the contemporary stage for the domestication of plants. Some of the results of plant-technology entanglements include direct intervention on the molecular level (DNA), plant-computer interfaces, and inspiration drawn from plant body constructions resulting in chimeras, cyborg plants, and plantoids.

For centuries the separation of what grows by itself and what requires human intervention to grow was considered one of the fundamental divisions informing Western ontologies. In *Physics*, Aristotle, the founder of natural history, explains:

If you planted a bed and the rotting wood acquired the power of sending up a shoot, it would not be a bed that would come up, but wood which shows that the arrangement in accordance with the rules of the art is merely an accidental attribute, whereas the substance is the other, which, further, persists continuously through the process. (1984, book II, chapter 1, 192b9–11)

With the help of bioengineering tools and methods, we are already capable of reprogramming biological systems to some degree, either for one generation or permanently, so that the change is carried on to future generations. Genetically modified plants, including transgenic plants, are developed with specific features beneficial in agriculture and to perform specific tasks, such as functioning as chemical factories. By specific modification, they can produce vitamins, enzymes, proteins, pharmaceuticals, and other desired chemicals. This complies with the more general observation that biotechnology alters what is known as biological, and it is, as American Hannah Landecker claims, “the specificity of ‘life’ after biotechnology” (2005).

Transgenic plants, or plant-related chimeras, are products of bioengineering capable of creating new plant species, unattainable by traditional techniques of horticulture, such as a deliberate cross-pollination, selective breeding, or grafting and budding. With genetic engineering enabling a transfer of genetic material of one species to another, distant species can meet on the molecular level, which allows for transgenic organisms, such as plant-animal chimeras, to come into existence. Plants with animal genes have been successfully produced in commercial and academic biological laboratories, often to serve as bioreactors in the



Eduardo Kac's Edunia, a plantimal from his Natural History of the Enigma series. *Edunia was developed in a professional laboratory setting by introducing Eduardo's genetic material to a plant petunia. Its chimerical nature is revealed in its very name Edunia but not visible to the naked eye; the human gene, however, is expressed in the veins of the flower petals.* © EDUARDO KAC.

production of biomolecules for pharmaceutical purposes. Such organisms are not usually available for public viewing in natural history museums or science museums, and they do not in any way resemble mythological chimeras, whose bodies easily gave away their mixed-species origins. Art, however, can provide the public with a glimpse into the current potential of bioengineering and encourage debate on the ontological and ethical aspects of such practices as well as their future consequences. The Brazilian-born and US-based artist Eduardo Kac's flowering plant called *Edunia*—belonging to *The Natural History of Enigma* series (2003–2008)—is undoubtedly the most recognized contemporary living plant artwork (see figure 2). This genetically engineered *plantimal*, as Kac proposed to name it, is a chimera of a petunia plant and the artist's genes. It explores, in an art context, the technological potential for creating new species contributing to the postnatural rather than natural history of plants and humans meeting on the molecular level. On the one hand, this ambivalent art project demonstrates that plants and humans, though they are so very different, are related and share a basic biology that enables creation of chimeras; the project therefore alerts its viewers that the newly created species requires ethical consideration and hospitality. On the other hand, the work points out that humans, with their anthropocentric convictions and with the aid of technology, are ready to influence or even “infect” any other living being on the molecular level with their own genes in order to pursue their own goals.

Cyborg plants, or plant-borgs, are no longer solely the inhabitants of science fiction. As hybrids of machines and organisms, to recall Haraway's 1985 definition, cyborgs are brought to life (assembled) in labs and invested with a hope that they might help in the fight against

environmental pollution and climate change. Cyborg plants are a focus in a scientific project called PLEASED (Plants Employed as Sensing Devices), which aims to use communities of plants, such as forests and meadows, as “sensing and decision-making devices” (PLEASED). In the future, because they are much more sensitive and sophisticated and operate as networks, plants are expected to replace the artificial devices used now to monitor chosen environmental parameters; so far the project focuses on humidity and temperature. Both measuring the electrical signals emitted by plants in response to environmental changes and actually decoding these signals are the greatest challenges to scientists currently. One day, we may be able to understand how and what the forest is communicating.

A plantoid, analogically to android, is a plant-inspired self-growing robot. With the ability to absorb materials from the surrounding environment, it can build its own structure as a mode of self-movement. The plantoid resembles plant roots but, at least at this point, cannot be mistaken for them. Vegetal bodies have come under the scrutiny of engineers because “the architecture of their body and their physiological attitudes make plants an unlimited source of inspiration for robotic scientists” and especially because the “modularity, reiteration and evolved sensing systems are among the most important problems of today’s robotics” (Mazzolai 2010, 90). Although plantoids are still a rare artificial species to encounter (only prototypes have been constructed at the Instituto Italiano di Tecnologia in Genoa), they mimic plant roots in their ability to sense and exercise a distributed intelligence. They are meant to operate underground, performing tasks such as soil penetration (soil monitoring), and perhaps one day will be used in medical procedures as flexible surgical tools.

Whereas plant cyborgs together with plantoids are rare and evoke curiosity rather than controversy, genetically modified plants, which are much more common, are viewed by activists as products of biopiracy (i.e., as an act of dominating nature for commercial purposes) and are met with criticism and resistance. Indian ecofeminist and activist Vandana Shiva, writing in *Biopiracy: The Plunder of Nature and Knowledge* (1997), suggests that biopiracy is actually a continuation of the colonizing practices of invasion and exploitation, designed to support the further accumulation of capital in the West. In her view, the new colonies are “the interior spaces of the bodies of women, plants, and animals. Resistance to biopiracy is a resistance to the ultimate colonization of life itself—of the future of evolution as well as the future of non-Western traditions of relating to and knowing nature” (5). As plants can be designed to be sterile, which is common in genetically altered crops that are engineered to produce dead seeds, the biotechnological revolution, by depriving seeds of their self-regenerative powers, is viewed by Shiva as another unfolding of the colonization of seeds, both through the use of technologies and through property rights (Shiva 1997, 49). Selling seeds producing sterile plants ensures farmers’ need to purchase new seeds every year.

PLANTS IN FUTURE ENVIRONMENTS: EARTH AND BEYOND

Plants do not need animals, including human-animals, to survive, whereas animals cannot survive without plants. They directly or indirectly produce all the food consumed by animals and link heterotrophs with the sun, the planet’s main source of energy. Food, energy, and the environment have been pronounced as three domains posing major challenges for humans in the twenty-first century (Erhardt and Frommer 2012) vis-à-vis growing human population, climate change, and environmental devastation. Donna Haraway, for whom the current geological period of the Anthropocene is an event after which nothing will be the same, warns

that “the edge of extinction is not just a metaphor; system collapse is not a thriller” (2015, 161). However, recent studies suggest that plants are more resilient to events leading to extinction than animals. This is also of interest to Canadian artist Oliver Kellhammer, whose project *Neo-Eocene* (started in the 1990s) refers to climate change, especially global warming, and focuses on those plant species that lived through several geological periods and are still around (called *living fossils* by Darwin). Kellhammer’s goal is to recreate forests of the distant geological epoch Eocene, connecting the deep past with the future, by planting trees such as metasequoia, sequoia, and ginko in what is now Canada, an area these species are known from fossil records to have populated in the past. The Eocene here provides a point of reference, as it was a geological epoch that started with a dramatic warming of the climate about 55.8 million years ago, when even the polar regions were inhabited by warm weather species of plants and animals.

The metasequoia (or dawn redwood), one of Kellhammer’s botanical choices, is among the greatest botanical finds of the twentieth century. It was believed to be extinct until the 1940s and until then had been known only from fossils. Similar to ginko trees, which persisted in another part of China, a small population of metasequoia trees survived in the forests of central China and were revived by Buddhist monks, who cultivated them in their gardens. In anticipation of significant global warming, the artist wants to reintroduce these trees back into Northern Hemisphere environments on the premise that, because these species were prevalent during the Eocene Thermal Maximum, they may be best suited for the hot climate to come. Not only may they prove to be very adaptable, but they may also be the ones that will take over the territories vacated by species that will go extinct. Yet the future climate and its impact on Kellhammer’s young deep-time forest, consisting in part of living fossils, is impossible to predict; the Neo-Eocene is unknown, but as recent research suggests, mass extinction events affecting plants create opportunities for renewal of biodiversity. Owing to global warming, the future may belong to those species that have already proved able to deal with similar conditions.

The future environment of plants may also be elsewhere than the earth. So far the only nonterrestrial environment where plants have been grown has been within space stations. This is a highly technologically controlled environment, in which plants grow without soil. While this may not seem like a difficult obstacle to overcome, as we already have hydroponic (plants growing in mineral nutrient solution) and aeroponic (plants growing in air/mist environment) farms operating on the planet’s surface, for earth-bound life-forms being away from the earth posits the problem of orientation. Gravitropism—a plant’s response to gravity—is positive in roots, which grow down, and negative in shoots, which grow up. Plants, however, can cope even with microgravity, a condition of weightlessness they have never encountered in their evolutionary development. The first plant to bloom away from the earth was *Arabidopsis thaliana* (thale cress, the most common lab plant) on board the Soviet space station Salyut-7 in 1982, which paved the way for further successful experiments with edible plants in space (Meggas 2010).

Selecting or even modifying plants, and eventually taking them on a longer cosmic journey, may also be seen as giving them a territorial advantage. They already inhabit the International Space Station, and their presence will certainly increase in the future, both physically and mentally benefiting the human crew. The first benefit concerns the need to produce food on long journeys; the second is for psychological comfort and relaxation, aspects that should not be underestimated.

Settling on Mars or other planets requires the availability of sustainable food sources. Cultivating plants in native soils seems to be, so far, the best option. The results of experiments investigating the possibility of growing plants in Martian and lunar soils show that plants can adapt, given the assumption “that plant cultivation will be carried out in close surroundings with Earth-like light and atmospheric conditions” (Wamelink et al. 2014). For humans, then, taking plants into space is a necessity that is intentionally implemented, while the plants are just taking a ride and perhaps a great evolutionary chance at the same time.

HUMAN-PLANT ETHICS

Plants have been excluded from moral consideration as insensitive and inanimate beings. This exclusion is a result of a zoocentric perspective that wrongly maintains a hierarchy of living beings in which plants occupy the lowest position. Matthew Hall, arguing for a change in attitudes toward plants, explains that “perceiving and relating to them as passive resources is outdated and rests ultimately on inadequate observations” (2011, 160). Only recently, following scientific evidence of plants’ sophisticated responses to changing environmental conditions and an acknowledgment of their basic cognitive abilities, has a plant ethics been put forth by plant biologists, philosophers, and environmental activists. And yet, as mentioned previously, a better understanding of plants as biological systems has led to further instrumentalization of them. In other words, while there has been little respect for plants and limited knowledge of their sophisticated lifestyles, new knowledge is merely opening up new ways to utilize plants’ bodies.

Confronted with this predicament, in 2008 the Swiss Federal Ethics Committee on Nonhuman Biotechnology published a document entitled “The Dignity of Living Beings with Regard to Plants: Moral Consideration of Plants for Their Own Sake.” The committee explained that dignity is understood as “inherent worth, good of its own and own interests”; therefore, “if something has inherent worth, this means it has something, which we also call ‘dignity.’ A being that has inherent worth therefore counts morally for its own sake. A being has a ‘good of its own’ if one can do good or bad things to it, i.e. if the being can be injured” (Swiss Federal Ethics Committee 2008, 7).

Rather predictably, the Swiss report caused a major controversy among scientists, humanities scholars, and the general public. The responses from scientists were contradictory, with strong voices against awarding rights to plants, which could supposedly halt scientific developments well as enthusiasm and hope. “The discussion of their rights is only beginning,” Stefano Mancuso and Alessandra Viola state, “but it can’t be put off any longer” (2015, 160). Hall assumes a more moderate position, arguing for relationships of care and responsibility; rather than opting for legal standing, he considers it to be more important to build awareness that “like other living beings, plants actively live and seek to flourish” (Hall 2011, 13).

Within the humanities, conservative voices see in plant rights an act of diminishing of human superior status. Posthumanist thinkers are also reluctant to grant rights to plants, as this gesture is seen as another paternalistic move that merely preserves the anthropocentric tradition of inclusions and exclusions based on presupposed hierarchies. Netherlands-based feminist philosopher Rosi Braidotti, writing in *The Posthuman* (2013), identifies such attitudes as *compensatory humanism* and calls for a more critical approach to humanism, noting that “in this cross-species embrace, Humanism is actually being reinstated uncritically

under the aegis of species egalitarianism” (79). In other words, granting rights to nonhumans is a manifestation of post-anthropocentric neo-humanism, which has come about as compensatory efforts in environmental crisis and taken the form of solidarity between human and nonhuman others. It does not offer any re-imagining of human-nonhuman ontological positions and relations.

Is any activism or politics concerning plants possible at all? Perhaps Plumwood, for whom the extension of no-harm principles to sentient animals only, as proposed by Australian philosopher and bioethicist Peter Singer (1946–) in 1973, was not radical enough, offers such a possibility. She has called for moral consideration of all non-humans. Plumwood believes that “the ability to apply ethical concepts (for example, respect) to earth others is largely a matter of concept formation and of individuating in appropriate ways, in terms of discerning others as autonomous intentional systems, rather than in terms of instrumental and mechanistic system of individuation” (2002, 138). She calls for a less arrogant, and therefore less anthropocentric, attitude toward nonhuman others, which is possible by adopting an “intentional stance” in which we do not deal with them strictly on our own terms. “Earth others can be seen not as objects for manipulation but as ‘other nations’ of roots or wings or legs, nations we must meet on their own terms as well as ours” (Plumwood 2002, 137). This opens up the possibility of ethics and politics shaped in terms of a “response to other’s needs, ends, directions and meanings” (138). Plumwood, however, does not argue for giving plants the status of subjects, as nonhumans interact with each other without any recognition of status, as could be expected in a fully intersubjective relation.

FOLLOWING THE PLANTS

Few feminists have said anything about plants, although there are exceptions, including those who, in one way or another, have suggested following plants. But in what way could we actually follow plants? Is following plants possible, and is it at all desirable? In other words, and more precisely, what is the image of plants we want to follow, which employed metaphors are desirable? Throughout the history of Western philosophy plants with their specific modes of existence were figuratively associated with specific modes of being in the world and modes of knowledge production. “We’re tired of trees. We should stop believing in trees, roots, and radicles,” French philosophers Gilles Deleuze and Félix Guattari declared in *A Thousand Plateaus* (1987, 15), exposing that both the verticality of a tree trunk and its root represent not only traditional Western affinity for genealogy, continuity, and accumulation but also traditional hierarchies and binary logic. Instead, the philosophers have proposed the figure of the rhizome—a “subterranean stem” that stands for multiplicity, grows horizontally, has no center, and is neither limited nor predictable. Feminist theories in the 1990s picked up the figure of the rhizome as critical toward “phallogocentric culture and patriarchal representational models” (Grosz 1994, 161), praising its openness to interconnectivity and heterogeneity, as this would better suit inquiries into sexual identity, subjectivity, and corporeal becomings.

Now, in times of environmental crisis, it is more urgent, challenging, and exciting to invest in the transformative powers of “plant-thinking” and possibly turn to real plants. Michael Marder, in his book *Plant Thinking: A Philosophy of Vegetal Life* (2013), asks what “plant-thinking” can do for living beings, including plants, and American cultural theorist Jeffrey T. Nealon, in *Plant Theory: Biopower and Vegetable Life* (2015), wants to know “what (if anything) changes in our present humanities debates about animal studies and biopower if

we take vegetable life into account or if we take plants to be a linchpin for thinking about biopolitics” (xv). Biopolitics—the inclusion of biological life in the mechanisms of power as well as the control apparatus exerted over biological lives—usually concerns humans and more recently also animals. The introduction of a biopolitics of vegetable life would not only extend the territory of life into a vegetal realm and call for rethinking the question of life itself but also point to a different mode of operation of plant life based on interconnectivity and distributiveness. Plant-thinking, similarly, has the potential to transform the realm of politics but, more important, that of ethics.

Yet how can the principle of dense interconnectivity be extended by feminist theories into plant bodies, behaviors, and sexualities? Irigaray, in *Elemental Passions* (2013), doubts that she, as a woman, could ever abandon her “love of the vegetal” (33) and wonders if a man would become a plant. As a female practice of “becoming flower,” for herself and for a man, actually concerns humans only, “becoming with plants,” not only on human terms, is now the real challenge. This is because, as Haraway suggests, “when species meet, the question of how to inherit histories is pressing, and how to get on together is at stake” (2008, 35). We then urgently need to reinvent human-plant relations through the materialities of animal and plant bodies, metabolic systems, energy, and time (including the geological past and future) as well as through technologies fusing, appropriating, and mirroring our bodies with those of plants. Coevolution has never finished and, on the contrary, might even be accelerating, allowing interconnectivity far beyond what has ever been imagined and researched. Plants energizing the earth connect us, terrestrial animals, to the source of cosmic energy and offer us sensitivity and communication beyond individuality. With the growing body of knowledge on plants’ lives, “we are only beginning to understand what it means to be a plant,” as Swiss biologist and environmental activist Florianne Koechlin points out (2005, 6). Perhaps this trope of efflorescence may be yet another way of explaining being together in naturecultures.

Summary

Plants’ being in the world has rarely been addressed by feminist theories, but topics such as the vegetative soul’s association with femininity, plant bodies’ radical otherness as a cause for their exclusion from ethics and biopolitics, the peculiar sex life of plants as inspiration for human non-heteronormative practices, becoming plant/flower, and becoming with plants are among those that have been considered. Humans’ instrumental relationship with plants, based on a traditional hierarchy between the human and the nonhuman, is giving way to possibilities for activism and ecojustice, especially vis-à-vis technoscientific developments such as molecular interventions into plant bodies (genetically modified organisms) and patenting.

Contemporary transdisciplinary plant research (critical plant studies) acknowledges the most recent empirical evidence from plant biology of plants’ sophisticated ways of going about their lives, which challenges traditional zoocentric perceptions of plants as passive objects. An awareness of plants’ specific sensitivity and intelligence, which enables them to realize their own survival strategies, can no longer be ignored in feminist theories. Both learning about plants and learning from plants open up territories and perspectives as yet unknown and hardly even imagined.

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