Vegetal Roots

A Philosophy of Plants and Humans

Author:

Priscilla van den Berg

Supervisor:

Prof.dr. J. de Mul

Erasmus University Rotterdam

Faculty of Philosophy

Advisor: Prof.dr. J.J. Vromen

15 ECTS, 27 June, 2017

Word Count: 23415

Contents

Preface

In this thesis, I aim to give attention to the fascinating world of plants, by making a philosophical analysis of the relations between plants and human beings from the perspective of their common root: organic life. Appreciating plants is not a naturally thing to do, especially for philosophers. In the history of Western philosophy is it hard to find a philosopher who takes plants seriously. Academic philosophers are often occupied with traditional subjects such as epistemology and metaphysics. Obviously, words and ideas are interesting subjects, but what drives me is the question why it is that plants are seen as inferior to animals, despite the fact that we are utterly dependent on them. To deepen our understanding of the interrelations between humans and plants is the main concern of this thesis.

Naturally, I could not have written a philosophy of plants and humans without the teachers who inspired and supported me. The intellectual enthusiasm, engagement and active participation in public debates of many philosophers of the Faculty of Philosophy of the Erasmus University Rotterdam inspired me profoundly as a student in philosophy. Every person who wants to learn to think rigorously and to question thoroughly should start a study in philosophy, especially in the warm environment of the Faculty of Philosophy at Rotterdam, which offers such a wide range of philosophical disciplines. At this place, I would like to thank my supervisor Prof.dr. J. de Mul, for his active, critical and stimulating supervision. His contributions in the area of philosophical anthropology provided me a solid basis for writing this thesis. And a special word to thank Prof.dr. J.J. Vromen, for his critical reading and useful comments on the research plan.

Priscilla van den Berg

Wassenaar, June 2017

Introduction

Plants form the basis of all life on earth. While humans evolved in two-legged species, plants evolved to inhabit two distinct environments: soil and air. Plants use water from the soil and tap carbon dioxide from the air. By capturing energy from sunlight, they turn water and carbon dioxide into sugars that provide food for all types of animals. Every animal is in a direct or in an indirect way dependent on plants. Furthermore, plants are one of the sources that give us the oxygen that we breathe. Their roots anchor soils, slow down erosion and they remove carbon dioxide from the atmosphere. However, even if we do acknowledge that plants play this important role, we still find it very difficult to appreciate them. Plants are so unlike us, that we tend to see them as inferior to animals and especially humans. Despite the fact that we are entirely dependent on plants. We use trees to build our houses, we buy flowers to surprise our loved ones, we eat vegetables and sweet fruits to stay healthy and drink tea from tea plants grown in India. We use plants, or chemicals extracted from them to treat diseases and smoke marihuana to change our awareness.

Since plants are everywhere around us, it is remarkable that humans pay so little attention to them. When it comes to the botanical world, many of us still live in the world of Aristotle. The Greek philosopher thought that plants are one of the lowest forms of development of life, because plants lack movements and cannot experience or desire anything. Animals can, and humans are on top of that capable of rational thought. Fortunately, science and research never stand still. The world of plants is completely different than we have ever thought. Research that has been carried out in plant biology reveals for instance, that plants have perceptions, desires and are able to communicate in their own way. This means that the concepts of ‘nature’, ‘life’ and ‘the human’ and their interrelationships should be reconsidered. Humans are more vegetal than previously understood and plants are more like us than presupposed.

The aim of this thesis is to open up new ways of thinking about plants that are everywhere around us. I outline the elements of a ‘philosophy of plants’ and reflect on what seeing plants in relationship with us, means for human life. In order to do so adequately, I first point out which problems in philosophy this ‘vegetal turn’ is meant to overcome. In the first part - Plant Blindness - I will explore the following question: why is it, that so many people tend to overlook plants in their environment? I start with a discussion of the concept ‘plant blindness’. This concept means that humans are often unable to notice plants in the environment. Two botanists, James Wandersee (1946-2014) and Elisabeth Schussler (1970), introduced the term ‘plant blindness’ for this phenomenon. They use the word ‘blind’ in the same way as ‘blind spot’ or ‘blind date’. To be clear, by the term ‘blind’ they don’t mean a total lack of vision, but rather missing crucial information. Plant blindness leads to “the inability to recognize the importance of plants in the biosphere and in human affairs; the inability to appreciate the aesthetic and unique biological features of plants; and the misguided, anthropocentric ranking of plants as inferior to animals, leading to the erroneous conclusion that they are unworthy of human consideration” (Wandersee & Schussler, 2001, p. 3).

This last symptom of plant blindness was not only defended by Aristotle, but his hierarchical order of life influenced Western thinking for centuries. The German botanist Julius von Sachs (1832-1879) describes the implications of this view on plants: “In Unzähligen Wiederholungen zieht sich dieser Gedanke durch die Geschichte der Botanik hin und zumal die Anatomen und Physiologen des 18. Jahrhunderts wurden nicht müde, die Einfachheit des Pflanzenbaues und vegetabilichen functionen hervorzuheben” (Sachs, 1875, p. 47). The philosophical anthropology of Helmuth Plessner (1892-1985) can also be seen in the light of this idea of a system of life, which he calls *Stufen des Organischen*. His ideas will be discussed, because in the biophilosophy of Plessner, we already witness an opening to understand and appreciate other forms of life by humans.

The idea that plants are distinct from animals and humans was shaken up by the botanical work of Charles Darwin (1809-1882). We all know that Darwin published his momentous theory of evolution in *On the Origin of Species* (1859), but some of his most important findings were actually in plant biology. In his work plants are no longer seen as passive organisms as opposed to animals and humans, but rather described as complex systems that respond to their environment. The last chapter of part I is therefore devoted to the botanical work of Darwin. The ignorance of Darwin’s botanical work, is a good example of our plant blindness.

In the second part of the thesis - The World of Plants - I continue a philosophical reflection on plants via a discussion of work of contemporary biologists like Daniel Chamovitz (1963). In the second part, the central question is: what can research in plant biology tell us about the life of plants? Plants are unmoving organisms, and because of this they evolved complex sensory systems that allow them to respond to ever-changing circumstances. I discuss some recent biological research that is carried out on plants. Research in this field reveals for instance that plants have the power of perception: plants can sense and respond to their environment, for example to light, touch, gravity, and chemicals and can modify their physiology accordingly. Plants communicate too. They have an internal communication system and plants communicate to each other and to other organisms as well. Plants are able to form memories and recall the memory at a later moment in order to respond to it. By no means this thesis can give a complete review of what the latest science has discovered about plants, but it will give a good impression of the topic in order to reflect philosophically on it.

In the third and last part of the thesis - Reconsidering the Relationship between Plant and Human - I show that the biological discoveries about plants have an effect on the way we see ourselves too. The central question of part three is: what are the implications of a ‘philosophy of plants’ regarding the relationship between plants and humans? A first philosopher and biologist who discussed the connection between plants and humans that I analyze is in the work of Nicole Karafyllis (1970). She investigates the work of J.O. de la Mettrie, *L’homme plante*, to open up a new perspective on the life of humans and plants. She also discusses the anthropology of plants in the context of movies, which is an attempt to bring movement into the vegetal. Then, I shall analyze the biophilosophy of Plessner and Martin Heidegger (1889-1976). Their thinking will offer me a possibility to deepen our understandings of other forms of life.

I shall further discuss the work of Michael Pollan (1955), who takes in his book *The Botany of Desire* the plant’s point of view seriously. In order to do so, he states that humans are prone to overestimate their agency in nature. Another author that discusses the entanglement of plants and humans is the Dutch philosopher Wouter Oudemans (1951) in his book *Plantaardig: vegatatieve filosofie*. This book makes an important contribution to a ‘philosophy of plants’, because it allows us to escape some problematic divisions, such as humans-animals-plants, nature-culture and object-subject. In the last chapter, I shall sketch two poles of the philosophical anthropology tradition and illustrate how it is possible to formulate an alternative approach to humans and plants which is related to the term ‘emergence’.

In the thesis, I use terminology that is usually reserved for humans. It is important to be aware that we can’t equate human experiences to the ways in which plants function in their worlds (Chamovitz, 2012, p. 5). The intelligence of plants and humans are for example mutually incomparable. However, there is no other terminology available and our understanding has always been embedded in a human context. This means we always run the risk of anthropomorphic projection on other forms of life. On the other hand, this terminology will help to open up new ways of thinking about plants and in the end, about what we are.

A ‘philosophy of plants’ teaches us that our anthropocentrism should be reconsidered. Philosophical reflections on plants can make an important contribution to this. If we realize that we share on a broad level biology with plants, this helps to create an opening to actually coexist in a nonviolent relationship with the green world. A nonviolent attitude means that we give up on sharp divisions, and start to realize that everything is entangled. We then become aware that we are part of nature.

Part I Plant Blindness

Introduction

Plants are essential in our ecosystem, but most people tend to be more interested in animals than in plants. Why is it that so many people tend to overlook plants in their environment? The human population is continuously growing, but one in eight plant species is currently threatened by extinction (Wandersee & Schussler, 2001). This is a problem, because if most people don't pay attention to plants around them, it is less likely that people will contribute to plant conservation, or that society will support science research in the botanical field. In order to examine this problem, I shall first review what contributes to our plant blindness, then discuss the anthropocentric ranking that started with the ideas of Aristotle and continued for centuries. This will put me in a position to describe some of the most important botanical findings of Darwin, because his perspective changed this classical anthropocentric thinking.

1. Seeing green

Scholars and philosophers believed for centuries that human beings are the most significant creatures of the entire universe. We therefore see nature mostly in terms of the value for humans. When it comes to other forms of life, such as animals, this belief holds. On the one hand, humans tend to see animals as inferior to humans, because animals are not exactly like us. On the other hand, animals do appeal to our imagination. Lots of people have very close relationships with their pets and in the top ten of popular day-trips are many zoos mentioned. Especially in the last two centuries, research in biology demonstrated several parallels between humans and animals. The growing interest in evolutionary theories also made an important contribution to this research area, that focused on heritable characteristics and processes of natural selection. Darwin emphasizes this in the nineteenth century: "Nevertheless the difference in mind between man and the higher animals, great as it is, certainly is one of degree and not of kind" (Darwin, 1871, p. 104).

However, some of the most significant discoveries in all of biology came from research executed on the vegetal kingdom. In 1665 Robert Hooke discovered cells, the building blocks of all life, by studying cork through a microscope. Darwin's contemporary Gregor Mendel (1822-1884) discovered the principles of modern genetics and heredity by doing experiments with pea plants. In the mid-twentieth century Barbara McClintock (1902-1992), a botanical scientist, discovered 'genetic transposition' (jumping genes). She discovered the mechanisms of genetic change and genetic regulation in maize plants, from one generation to the next. Later research showed that these mobile genetic elements are characteristic of all DNA and connected to cancer in humans (Chamovitz, 2012).

In the Netherlands, the primatologist Frans de Waal (1948) tried to close the gap between animals and human, by emphasizing the intelligent behavior and cognition of primates. De Waal focuses in his work on the similarities between mammals, vertebrates and humans and takes as a point of departure, evolutionary continuity. De Waal states that, roughly in the last twenty years, science demonstrated time after time that many animals, including dogs, dolphins and crows have capacities that we thought that only humans were capable of, such as cognitive, emotional and moral capacities[1] (De Waal, 2016). There are several stories to tell about the intelligence and social behavior of animals. Nowadays the thought that humans are unique in every possible way is therefore outdated. Humans and animals are both the product of evolutionary processes of variation and natural selection. Nevertheless, evolutionary processes can lead to distinct species, such as the hominids having unique human capacities.

However, there still remains a gap between animals/humans on the one side and plants on the other side. Plants are seen as inferior to animals and are seen as a less interesting biology subject by students in the United States (Wandersee & Schussler, 2001). The viewpoint that focuses on animals and its preference above plants and other life forms is called ‘zoocentrism’ or ‘zoochauvinism’. Peeters (2016) explains in his book *Botanische revolutie* that the zoocentric view can be seen again in our education, public information and nature protection. To illustrate zoocentrism, he gives the example of a nature documentary *Natuur in de Delta* (2015). The makers of this documentary tell the story of the Dutch nature from an animal viewpoint. Sea eagles, beavers and hares play leading roles in the movie, but the perspective of plants is not being touched. This happens often in documentaries and movies, because plants are so unlike us that it is very difficult to imagine what life is like for them. Another example of our zoocentric view is the ignorance of the importance of research in the botanical field. One of the reasons that McClintock’s research was not taken seriously in the 1940s and 1950s, was that she discovered mobile genetic elements on maize plants, while most research was based on zoological findings. In 1983, she finally received a Nobel Prize for her discovery of genetic transposition. Further, it is important to be aware of the fact that zoocentrism is a misleading term, because to neglect the world of plants is often not an

[1] De Waal has been criticized for anthropomorphism: the unfairly ascription to animals of human psychological characteristics.

intentional act. It is rather a deep-rooted condition. Wandersee (2001, p. 6) states that plant blindness is the human “default condition”.

In 1998, Wandersee and Schussler introduced the term plant blindness after years of research studies and investigation, in order to cry for an appreciation for and understanding of plants, not just in biology but in society in general as well. They acknowledge that inattention to plants could be due to zoochauvinistic biology, but they conclude through their findings that that kind of sources are actually secondary. The primary factor why people tend to pay little attention to plants is because of our “visual information processing systems” (p. 2). It is obviously not the case that when we open our eyes and look around us, we see everything of what we look at. Moreover, what we see is usually affected by our assumptions. In the philosophy of science this problem is known as ‘the theory-ladenness’ of our perception. Observations are ‘theory-laden’ if the researcher is affected by his theoretical presuppositions. A famous illustration of this problem is the duck-rabbit drawing, that can be perceived as a duck or a rabbit without the object of perception changing. Scientific research showed that during visual perception only a very small amount of the data our eyes produce is actually considered consciously (Wandersee & Schussler, 2001, p. 4).

In order to give an explanation of why plant blindness occurs the botanists give a long list of principles of human visual perception and cognition. Let me name a few. It is often the case that we only see what we expect to see, and not what is actually in front of us. Once an object acquires meaning for the observer, the more likely it is that it will be consciously noticed. This affect is familiar to most of us. Let me give an example. When I started studying ornithology I began to see all these different types of birds in the park that must have been there all the time during my former walks, but I never fully perceived them, let alone noticed their different colors, distinct bird songs and behavior patterns.

The problem with green plants is that they tend to blend-in in their surroundings. Green leaves tend to overlap each other and that makes it hard for someone to actually see them. When flowering plants are in bloom, we tend to label them and this makes it easier to consciously perceive them. If we see a *Rhododendron* in the winter, we perceive it (if we are lucky) as an ordinary bush. But when the plant is covered with all its beautiful blossoms in springtime, we usually do pay attention.

Plants typically grow in close proximity to each other and they are static as well. Static proximity is a visual cue that humans use to group objects into bulk visual categories

(Wandersee & Schussler, 2001, p. 5). This also explains why humans tend to overlook plants in their environment. It is easier to focus our attention to moving objects, like animals. Humans tend to get bored if they look too long at a constant scene. Another reason why people do perceive a lion in the field without noticing the plants in the background is obvious. Animals can be potentially dangerous. Plants are non-threatening elements in our environment and we can ignore them without any (direct) consequences. Have you ever heard of a human-eating plant? Nevertheless, if we are warned that some mushrooms in the forests are toxic, we become very careful of which types of mushrooms to pick.

Thus, Wandersee argues that it is not just our zoocentrism that causes plant blindness, but rather our visual and cognitive system that is responsible for our ignorance and inattention to plants in general. What affects our visual attention has to do with the degree of attention we pay to it and the importance we assign to it. Therefore, Wandersee argues that botanical education and plant-growing experiences may enhance our plant awareness in order to overcome plant blindness.

2. Hierarchical system of life

In the previous chapter, we have seen that an important symptom of plant blindness is the misguided, anthropocentric ranking of plants as inferior to animals and that this leads to the erroneous conclusion that plants are unworthy of human consideration. This symptom was in fact defended by Aristotle. The Greek philosopher was one of the first philosophers who described a strict hierarchical system of life. He divided non-living things from living things. In the natural order, Aristotle sees a hierarchical system that starts with non-living things, such as rocks, minerals and metals. One step further are living things, starting with the kingdom of plants, then animals and humans on the highest level. This so-called ladder of being (*Scala Naturae*) contains hierarchical levels, whereby each level upwards possesses the positive attributes of the previous levels and at least one more. In *The Anima* Aristotle divides plants from non-living things, because plants are able to nourish themselves and reproduce others of the same kind. Plants have a vegetative soul (*psyche threptike*). Animals have in addition to a vegetative soul, a sensitive soul (*psyche aisthetike*). Animals have the ability of sense-perception, and they also have desires and the power of self-motion. Human beings have a rational soul (*psyche dianoetike*) on top of that; humans are capable of rational thought.

René Descartes (1596-1650) is often seen as 'the father of modern philosophy', because he broke with some important insights of Aristotelian philosophy. He criticized for example empiricism, but held on to the belief that humans are the centre of everything. The thought that humans can reason was very important for Descartes. According to him, only humans have a soul, because the other functions (reproduction, sense-perception, motion etc.) can be explained physically, apart from the functioning of the soul. Thinking or rationality is the ultimate difference between animals and humans. The sign of rationality for humans is the use of language. In the fifth part of the *Discours* Descartes states: "For it is highly deserving of remark, that there are no men so dull and stupid, not even idiots, as to be incapable of joining together different words, and thereby constructing a declaration by which to make their thoughts understood; and that on the other hand, there is no other animal, however perfect or happily circumstanced which can do the like" (Descartes, 2011, p. 118). Animals cannot reason. They can move, but more like an automate. In the Cartesian view, animals are seen as machines.

Julien Offray de la Mettrie (1709-1751) published in 1748 a provoking work named *L'homme machine*, in which he claims, contrary to Descartes and other philosophers, that *the human* is also nothing more than a machine, too. He starts his argumentation with an attack on the soul: the soul does not exist independent of the body. To think is nothing but the functioning of the body machine. In other words, thinking is a function of matter. De la Mettrie wrecks the distinction between animals and humans: he does not exclude that apes can learn a language.

However, the idea of a hierarchical classification of the natural world was still alive in the eighteenth century. The Swedish botanist and physician Carl Linnaeus (1707-1778) divided the world into three kingdoms of nature: minerals, plants and animals. Minerals are able to grow. Plants can grow, bloom and fade. Animals are the most developed ones, because they have perception, desires and self-movement as well. In the work *Systema Naturae* Linnaeus outlines his system and describes more than ten thousand species of organisms that he classifies in classes, orders, genera and species. Linnaeus' system developed and eventually laid the basis of our modern taxonomy.

The idea of one hierarchical order came eventually into question in the eighteenth century, with the ideas of controversial thinkers like Jean-Baptiste de Lamarck (1744-1829). Peeters (2016) describes his ideas as controversial. In de Lamarck's view there is no such thing as one ladder of being, but rather there are side-branches. Organisms have a build-in tendency to climb the ladder of complexity. This drive enables organisms to turn from simple to more complex forms. Organisms develop because they adapt their behavior to their constant-changing environment, in order to survive. Lamarck gives the example of giraffes. Giraffes stretched their necks, in order to reach the leaves of high trees. Their necks became longer by stretching it. Their offspring would inherit the longer necks and continued stretching it, so their necks became longer and longer. But, Peeters notes, if the surrounding of organisms would never change, there would still be one ladder in de Lamarck's view. The only reason that there are side-branches, is because of the isolation of species in different habitats. His view corresponds therefore with an escalator: every organism stands on an escalator that is moving upward to greater complexity.

The philosophical anthropology of Helmuth Plessner (1892-1985) can also be seen in the light of the idea of a ladder of life, which he calls *Stufen des Organischen* (stages of the organic). He distinguishes living things from inanimate objects, because living things can realize their own boundaries, contrary to inanimate objects. Living things are characterized by a 'double aspectivity' (*Doppelaspektivität*): they have an inside as well as an outside. Plessner divides three different types of boundary realization, by using the concept 'positionality' (*Positionalität*). Positionality is the position that living things take in relative to their surroundings, while at the same time being limited by them. Plessner uses this concept to explain the differences between plants, animals and humans. Plants *are* their boundary realization. Animals can control their boundary realization, thus the life of animals is centric. Animals are able to interact with their surroundings from their center. The positionality of human beings is excentric, because humans are able to relate to themselves from outside their centre as well. This means for example that humans can experience their experiences. Excentricity leads to a great variety of cultural and technological inventions.

3. Darwin's experiments

The clear hierarchical system of life was shaken up by the work of Charles Darwin. In his view plants are no longer seen as simple organisms opposed to animals and humans. Darwin showed that plants are complex in their own ways. I will devote this last chapter of part I to the botanical findings of Darwin. His experiments still influence research in plant biology to this day (Chamovitz, 2012, p. 12). Peeters (2016) discovered that despite the immense amount of literature about the scientific, societal and personal life of Darwin, most of us are unfamiliar with Darwin’s botanical work. He notes that this is a good example of our plant blindness.

Darwin makes in his autobiography very clear that plants are not inferior to humans and animals. Plants can reproduce themselves while still being anchored in the soil, they work together with all sorts of organisms, they capture and consume preys without having a mouth or stomach. They can move without muscles, perceive the world around them without senses and show an intelligence without having a nervous system (Peeters, 2016, p. 13).

The most famous work of Darwin is without any doubt: *On the Origin of Species* (1859). However, there are lots of myths about Darwin’s ideas in this work. The origin of the expression ‘survival of the fittest’ comes for instance from a philosopher named Herbert Spencer, instead of Darwin. And Darwin himself does not even speak of ‘evolution’ but of ‘descent by modification’. Another popular misunderstanding about *On the Origin of Species* is that Darwin states that humans descended from apes. But Darwin never mentions in this work the relationships with apes. Only twelve years later in *The Descent of Man, and Selection in Relation to Sex* he writes about human evolution. Acorn-shells are used to form the basis of Darwin’s evolutionary theory, not humans. But the most common misunderstanding is that Darwin’s main interest lied in animals and the development of the hominid *Homo sapiens.* When you investigate the works of Darwin, it actually are not humans or the famous Darwinfinches that stand out. After the publication of his masterwork - a fact not widely known- Darwin studied especially the kingdom of plants. He investigates plants for more than twenty years and writes eight books and more than seventy articles about the green world. Nevertheless, the animals and the finches became the famous examples of the theory of evolution (Peeters, 2016, p. 23).

Less familiar are the series of experiments that Darwin conceived to investigate plants. Darwin was for example fascinated what the effects of light were on plants. In his book *The Power of Movement in Plants* (1880) he describes that most plants bend toward light. Most us of know this effect as well: our houseplants grow toward the sunlight coming through the window. To test the hypothesis Darwin and his son invented a simple experiment. They grew pots of canary grass in a totally dark room. Then they turned on a small gas lamp, but kept is so dim that they were not able to see the contours of the pots themselves. After only three hours the plants curved toward the light. They noticed that is was always the same part of the plant, a little below the tip that was curving. That is why they hypothesized that the “eyes” of the plant were found at the seedling tip. To test this, they carried the experiment out in five different seedlings: a) the seedling is untreated and is part of the control group; b) the seedling its tip is cut off; c) the tip is covered with a lightproof cap; d) the tip is covered with a clear cap; e) the seedling is covered in its middle by a lightproof tube.

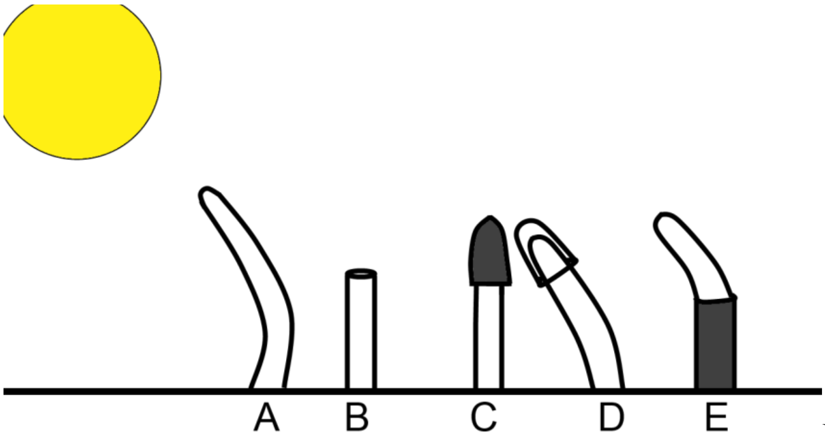


Image of Darwin's experiment

The first (a) and the last (e) seedling bended toward the light. But if they cut off the tip of the seedling or covered it with a lightproof cap, the seedling didn't bend toward the light. However, with a clear cap the tip did bend (d). Darwin proved in this simple experiment the process of 'phototropism': when light hits the tip of a plant it transfers the information to the middle of the plant to inform it to bend in that direction. The Darwins proved that plants have rudimentary sight (Chamovitz, 2012, p. 15).

Another experiment Darwin conducted was to test if the bladders of the *Utricularia vulgaris* (greater bladderwort) are partly filled with air to make it float freely in the water. Darwin's teacher, John Stevens Henslow was convinced that the bladders served to let the water plant float, so that its yellow flowers stayed above the surface of the water. Forty years later Darwin tested Henslow's hypothesis by cutting off all of the bladders of the plant. Then he put the plant back into the water. Without its bladders, the plant was still floating freely. What is the function of the bladders then, Darwin asked himself? He found out that the bladders function as botanical boobytraps for small insects and crayfishes. He demonstrated that when the larva of a crayfish swims against a bladder, it activates the trap and absorbs the poor larva. Darwin published, after doing fifteen years of research, his results in the book *Insectivorous Plants* (1875). Darwin was one of the first scientists that published a book about carnivorous plants. The example of the experiment on *Utricularia vulgaris* illustrates how naïve curiosity can lead to important discoveries, such as flesh-eating plants. Darwin became an expert on carnivorous plants, including the Venus flytrap (*Dionaea muscipula*) (Chamovitz, 2012).

The Venus flytrap grows in the wetlands of Carolinas, where the soil is nutritionally poor. This plant had to develop other abilities, next to photosynthesis to supplement its nutrition. The leaf blade of the Venus flytrap is divided in two main lobes that are connected by a midrib, forming the trap. The internal sides of the lobes contain pink and purple hues and its edges nectar that attracts all kinds of insects. When a small insect, like a fly flies across the leaves, it activates its trap and the two leaves snap shut with amazing force. The prey can't escape, because the edges are fringed by "jail bars of interlocking cilia[2]" (Chamovitz, 2012, p. 55). Once activated, the trap starts to digest its prey. The amazing thing about the Venus flytrap is that it is specialized to sense if the prey is the right size to consume. It can distinguish if the prey is worth the energy to open the trap for, or if it is just a falling raindrop for instance. The hairs on the inside of the lobes act as triggers: if two hairs are touched within twenty seconds of each other, the two leaves spring together. Darwin tested all types of proteins and substances on the leaf, but could not come up with the mechanism of the signal that caused the ability of differentiation between rain and insects (Chamovitz, 2012, p. 56). His contemporary John Burdon-Sanderson revealed that pressure on two hairs leads to an electrical signal that is followed by the trap closing. He showed that electrical activity regulates plant development. More than hundred years later, it was proved that electric stimulation itself activates the movement of the trap. Only recently is discovered how the Venus flytrap remembers the amount of hairs that have been touched, which I'll explore in the next part of the thesis when I discuss recent plant biology.

Peeters (2016, p. 151) describes that the discovery of the Venus flytrap wasn't without a fight. When in 1768 Linnaeus received an image and description of this plant, he grabbed his Bible. We can read in Genesis 1:30: "And to every beast of the earth and to every bird of the heavens and to everything that creeps on the earth, everything that has the breath of life, I have given every green plant for food." Animals use plants for food, and not the other way around. If the Venus flytrap is indeed carnivorous, then it is not a real plant Linnaeus argued. Thanks to Darwin the strict borders between animals and plants slowly began to blur. His botanical discoveries on insectivorous plants shed a new light on the perspective of plants. Linnaeus stated that plants grow, bloom and fade. But if you look at the behavior of the Venus flytrap you can ask if its reaction on stimulation is fundamentally different than the reflexes of certain animals.

---

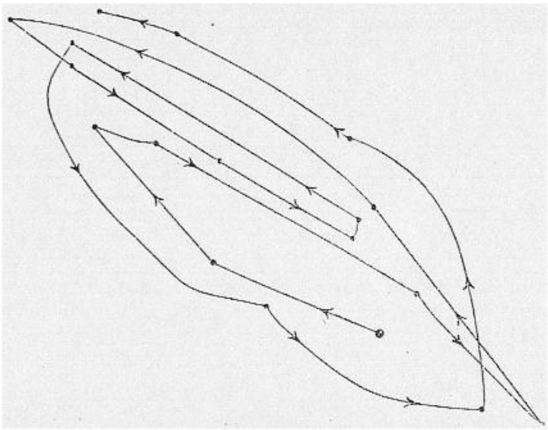
[2] For the Venus flytrap in action, see: www.youtube.com/watch?v=ymnLpQNyI6g

Darwin was fascinated about climbing plants as well. He writes his findings in *On the Movements and Habits of Climbing Plants* (1865). Darwin discusses five categories of climbing plants: twining plants, leaf climbers, tendril bearers, hook- and root climbers. First of all Darwin describes his observations of the largest category of twining plants, by taking the case of the Hop (*Humulus lupulus*). When the shoot of a Hop rises from the ground, it first grows straight upwards, but the next formed shoot, bends to one side and travels slowly rounds towards all points of the compass, moving like the hands of a watch, with the sun (Darwin, 1875, p. 3). Then Darwin observes and measures precisely the turning cycle and the amount of time the cycles take. While the plant is growing slowly the turning cycles become bigger and bigger. It seems that the plant searches for an object around which to twine. Darwin wonders therefore, if the twining plants move spontaneous in circles, or if the movements are just signs of growth. Most contemporary botanists of Darwin, such as Hugo von Mohl (1805-1872), explain the circle movement of climbing plants by their spiral growth processes (Peeters, 2016). However, Darwin thinks that the moving habits of twining plants are autonomous.

He concludes that "the capacity of revolving is inherent in almost every plant in the vegetal kingdom". And "it has often been vaguely asserted that plants are distinguished from animals by not having the power of movement" (Darwin, 1875, p. 206). We have seen that Aristotle divided animals from plants, because animals have, contrary to plants, desires and the ability of self-movement. However, climbing plants are a good example of plants that use movements in order to survive, Darwin argues. Moreover, he states that climbing plants move spontaneous. Peeters (2016, p. 194) notes still another important fact: Darwin connects in the title of his work the words 'movement' and 'habit'. A habit is normally associated with 'instinct' or 'custom' or 'manner'. But Darwin uses the word to illustrate the different climbing patterns of plants. These patterns are more like developed forms of behavior, similar to the instincts of animals.

In *The Power of Movement in Plants* (1880) Darwin further described his ideas about the independent, autonomous movements of plants, which he terms "circumnutation" (*circum* is Latin for "circle" and *nutatio* for "sway"). He derives the term from Sachs, who uses circumnutation for the movement of individual shoots and stems during their growth upward or to the side. Sachs holds the view that the movement of a plant is the result of a plant's action of environmental stimuli, such as gravity and growth processes. However, Darwin uses circumnutation differently, meaning the plant moves autonomous, without apparent stimuli.

Darwin observed that all plants move in a recurring spiral oscillation. To see the process of circumnutation, you have to study the movements of plants extensively, during a long time span. Nowadays, we would use time-lapse photography to document this, but Darwin came up with an inventive experiment. He suspended a glass plate above a plant and marked the seedling of the tip of the plant with black beeswax. He marked on the glass the position of the tip of the plant every few minutes for several hours. Then he connected the dots. This simple experiment enabled Darwin to document the exact movements of the plant, as one of the first scientists. He found out that plants move in ellipses, just as the images of a Spirograph (Chamovitz, 2012, p. 107).


Circumnutation of a wild cabbage (*Brassica*) seedling

Darwin monitored more than three hundred kind of plants, like the wild cabbage above. He concluded that circumnutation is the driving force of almost all the movements of plants. The spiral pattern varies between species: some plants have large movements, others small and the speed varies as well. The Polish scientist Maria Stolarz points out that the amplitude, period, shape and direction of circumnutation differs in various plant species. Both environmental and individual factors influence circumnutation in plants. It turns out to be a very complex phenomenon, “a compilation of growth processes and intercellular communication involving the biological clock” (Stolarz, 2009, p. 386).

Back to Darwin. He hypothesized that circumnutation is a build-in behavior of plants, but other scientists like Sachs thought that gravity and growth processes are the driving power of circumnutation. If Darwin’s theory is correct, circumnutation would continue unimpeded in the absence of gravity; if Sachs theory is correct, circumnutation would not occur in space. The plant physiologist Allan Brown (1917-2004) develops an experiment with Arabidopsis in space, as part of the Biosatellite III program, to test if the plant would move in the absence of gravity. Unfortunately because of budget problems, his experiments were canceled. But in

1983, on board of the Columbia space shuttle, a new experiment was carried out with the seedlings of sunflowers. Because of their robust movements on earth, this flower is the perfect test plant to see what happens in the absence of gravity. Almost all the seedlings exhibited circumnutation. However, there remained doubts about the outcome, because the experiments were carried out on seeds germinated on earth and this may have influenced the circumnutation in space. To test the second hypothesis, the seedlings had to germinate in space. This finally happened in the International Space Station in 2007, where astronauts germinated Arabidopsis plants on board of the space station. The seedlings were monitored and photographed every few minutes. The Arabidopsis plants did move in spiral patterns, demonstrating the hypothesis of Darwin. The only difference is that in space the circular movements are smaller than on earth, but Darwin was correct to state that circumnutation is a build-in behavior of plants; it just needs gravity to amplify the movements (Chamovitz, 2012, p. 111).

Darwin’s botanical works reveal that plants are far more complex than supposed. I discussed some experiments Darwin conceived, in order to show that his curiosity shed a new light on the world of plants. The idea of a hierarchical order of life began thereby to shake to its foundations. The discoveries of processes like phototropism, demonstrate that plants have rudimentary sight. Darwin was one of the first scientists to discover that carnivorous plants react on stimuli in the same way as animals have reflexes. Darwin found out that climbing plants use movements in order to survive. In animals, movements are seen as behavior patterns. Circumnutation can be regarded as its analogue and, thus, as a manifestation of plant behavior (Stolarz, 2009, p. 386). The early experiments by Darwin therefore can provide the foundations for a philosophy of plants that takes plants seriously. In the next part of the thesis I shall investigate what the latest research in plant biology can tell us more about the fascinating green world.

Part II The World of Plants

Introduction

Before Darwin it was clear: human beings are the superior creatures with rationality and unique capabilities such as language. But with the ideas of Darwin this anthropocentric ranking started to change. Darwin emphasizes the interrelatedness of all living beings. Since then, research that has been carried out on plants revealed a lot more about the science behind them. I will explore in the second part the question: what can research in plant biology tell us about the life of plants? In order to find out what scientists have revealed about plants, I have selected three aspects of plant abilities: the power of sense-perception in plants, the way plants communicate and their abilities to store and recall biological information.

4. Plant senses

Most animals can choose their environment. When the weather gets extreme, for example when it storms, they seek shelter. When winter is coming, they migrate to warmer areas. When they can't find anything to eat, they move to a more nutritious place to stay in. Plants, by contrast, are rooted at one place. This means they must withstand their environment and adapt to it. The sessile lifestyle of plants made them develop complex sensory systems that allow them to respond to dynamic surroundings. Let's see what science has found out about plant senses.

We know from Darwin's studies that almost all plants bend toward light, and this process is called phototropism. Another phenomenon is the ability of plants to measure how much light comes in, in order to know when to flower. This concept is known as photoperiodism. When farmers discovered this phenomenon, they started to manipulate when plants are flowering by controlling the amount of light a plant gets. Short-day plants are plants that normally require a long period of darkness, but they can be manipulated by turning on the lights in the middle of the night, in order to keep them from making flowers. This technique is especially important for flower farmers, who need to control when plants are flowering, such as before and during special days like Mother's Day when they sell the most blooming plants (Chamovitz, 2012).

Scientists also revealed that plants can differentiate between colors. Humans have four kinds of photoreceptors: these are the cells in the retina that respond to light. We have rhodopsin that is extremely sensitive to light and three photopsins that form the basis of color vision, for red, blue and green light. Another receptor for blue light is called cryptochrome and this receptor is involved in the circadian clock. To discover how many photoreceptors plants possess, experiments were carried out on *Arabidopsis thaliana*, a small flowering plant similar to wild mustard. They varied with different colors of light and measured if plants grew taller. Scientists found out that Arabidopsis has at least eleven different photoreceptors. These photoreceptors give the plant important information about when it is time to germinate, when it should bend to light, when it needs to flower and when the night falls in. Light is a basic element of photosynthesis and a plant literally grows toward its food. In order to survive, a plant needs to know where the light is, how much light there is, for how long and what the color of light is. Environmentally, this makes much sense. When the night falls, the light is far-red and this tells a plant it should "turn itself off". In the morning, when there is red light, the plant wakes up and adjusts its growth accordingly. When the days are getting longer, they start growing. A plant needs to know when to set its seeds, because in wintertime the seeds cannot survive. So, the best time to set its seeds is in autumn when the nights are getting longer (Chamovitz, 2012, pp. 21-23).

Plants are thus more complex organisms than humans at the level of perception. Obviously, plants don't have eyes, as we don't have roots, but sight has to do with the ability to detect electromagnetic waves and respond to it. The human retina has rods and cones that detect light signals and transfers this information to the brain, and we can respond to this information. Plants get visual signals from multiple photoreceptors and respond to this as well: by bending toward the light for example. Plants and animals developed their visual systems independently from each other, but despite independent evolutionary roads, they have things in common such as an internal clock. Plants have, just like animals, circadian clocks that regulate their leaf movements and photosynthesis. So, at a basic level plants and humans do have similar photoreceptors: "they all consist of a protein connected to a chemical dye that absorbs the light" (Chamovitz, 2012, p. 24).

Another plant sense I would like to discuss is "touch". *Mimosa pudica*, or the "touch me not plant" is a beautiful example of a plant that is hypersensitive to touch. The name *Pudica* is Latin and means "shy". If a leaf is touched, the plant responds by folding the compound leaflets inward and droop. This response is generally believed to function as a defense mechanism against harm, reducing the appearance of the leaves, or enhancing the display of defensive thorns (Mescher & De Moraes, 2015, p. 427).

Only a few minutes later, the leaflets reopen again. Recent studies showed that closed leaves reopen sooner when there is less light available. This suggests that the plant accepts the risk of harm and the costs of reduced photosynthesis by closed leaves, as in a trade-off (Mescher & De Moraes, 2015). In order to understand how the leaves can move in the absence of muscles, Chamovitz (2012, p. 59) describes plant cells. Next to the protoplast, similar to cells in animals, a plant cell is enclosed by a cell wall, which gives a plant its strength. The protoplast resembles a water balloon, and normally there is so much water in it that is presses on the cell wall which allows plants to be erect. But when there is not enough water, there is little pressure on the cell walls and the plant wilts. The *Mimosa* has pulvinus cells on its leaflets and these cells act as hydraulic pumps, that pump water in and out the cells. When the pulvinus cells contain enough water, the leaflets are open; when they lack water, the pressure drops and the leaves fold inward.

After this short description of basic plant cell biology, I turn back to the plant *Arabidopsis thaliana*. Janet Braam, Professor of biosciences at Rice University demonstrated that when an Arabidopsis plant is touched a few times, the whole genetic makeup of the plant changes. She named these touch-activated genes “TCH genes”. These genes are powerful molecular tools for studying how plants perceive environmental changes and respond to it. Braam showed that THC genes encode calmodulin: a calcium modulated protein. Calmodulin is a very important protein that can bind with calcium and modulates the activity of proteins involved in processes, like memory and nerve growth. Calcium is important for health in humans as well: almost every cell in our body uses it. In plants, calcium helps maintain cell turgor and is part of the plant cell wall (Chamovitz, 2012, p. 65). Braam demonstrated that when an Arabidopsis is touched, it makes more calmodulin. Since then, scientists revealed that over two percent of Arabidopsis genes are activated when touched[3]. This discovery is very important, because it shows how far-reaching a plant’s response is in order to survive.

What is sense of touch for humans? The human skin contains millions of nerve endings that are able to detect different physical sensations, such as temperature or pressure. When these specialized mechano-sensory receptors are stimulated, it transfers these signals through the nervous system to the brain, which translates the signals into sensations, such as pain. Plants obviously don’t have a brain or a nervous system. Plants lack therefore subjective and

[3] Chamovitz notes the DNA found in the nucleus of each cell of the Arabidopsis plant contains about twenty-five thousand genes.

emotional feelings, such as pain. But they do feel mechanical stimulation and they can respond to certain kinds of stimulation, in their own unique ways. Plants are not able to escape from their environment, but they developed ways to adapt to it: they changed their metabolism. So, when it comes to touch, there are differences between plants and animals, but at a cellular level these differences start to disappear. Plant and animal cells share 'neural' similarities, such as glutamate, dopamine and serotonin, to name a few (discussed in chapter six) (Calvo, 2016). In the words of Chamovitz (2012):

> Mechanical stimulation of a plant cell, like mechanical stimulation of a nerve, initiates a cellular change in ionic conditions that results in an electric signal. And just like animals, this signal can propagate from cell to cell, and it involves the coordinated function of ion channels including potassium, calcium, calmodulin, and other plant components. (pp. 68-69)

Plants also respond to olfactory cues. Most of us know that many animals use their olfactory sense to gather information at some distance from other organisms via the detection of chemical cues present in the air or water. Until recently, there was controversy about the question if plants exhibit a similar response to odor cues in the air (Mescher & De Moraes, 2015). To explore this question, scientists have been studying wild lima beans (*Phaseolus lunatus*) for the past couple of years in Mexico. Lima beans emit volatile chemicals into the air when attacked by insects and scientists wondered why is was that this plant released these chemicals (Chamovitz, 2012, p. 39). Experiments were carried out to investigate this question. Scientists monitored the air around damaged and undamaged leaves and between different plants. They demonstrated the damaged leaves (damage is caused for example when an insect or bacteria attacks a leaf) release chemicals that warn the other leaves from future damage. Not only does the same plant warn its own leaves to protect itself, but they also revealed that when the neighboring plant is close enough (at least a few feet) to the attacked plant, it benefits as well by protecting itself. They further compared the chemicals emitted by the plants following bacterial infection with those emitted following an insect attack. The leaves under bacterial attack emitted methyl salicylate and those under insect attack produced methyl jasmonate. Methyl salicylate is very similar to salicylic acid, that we know best as the chemical precursor for aspirin. For plants this chemical is used to stop the infection, just like we use salicylic acid when we are infected. Methyl jasmonate is a volatile form of jasmonic acid. This functions as a defense hormone that plants emit upon leaf damage inflicted by insects (Chamovitz, 2012, p. 45).

For us it is very clear: plants smell. We are definitely attracted by their rich smell, for instance one of my favorites is the smell of a pine forest. For humans smell is defined as the ability "to perceive the odor or scent through the nose by means of the olfactory nerves". We sense airborne volatile chemicals and our brain processes this information, so we can respond to it. Moreover, smells are often connected to memories and emotions for us. Plants are nose- and brainless organisms and don't interpret signals like us. Humans have a large number of different odor receptors, each specified for sensing unique volatile chemicals. However, so far (only) the ethylene receptor has been identified in plants (Chamovitz, 2012). But plants do detect volatile chemicals in the air and scientists demonstrated that plants respond to odor cues emanating from other plants. Recent studies indicate that some plants can also perceive olfactory cues emanating from insect herbivores themselves (Mescher & De Moraes, 2015, p. 431). These studies all indicate plants have an olfactory sense.

Plant responses to light, touch, olfactory and chemical cues discussed above do not exhaust the sensory perception exhibited by plants; that would necessitate a biological textbook. Instead, I highlighted some important senses and by presenting this, it became clear that plants actively monitor sensory information from their environment and respond in ways that profoundly influences their surroundings. Plants are active participants in interaction with other organisms and the natural world, which can be further elaborated by focusing on the ways plants communicate.

5. Plant interaction

In 1973, *The Secret Life of Plants*, a *New York Times* bestseller was published, which addressed all kinds of plants' perceptual, psychological and emotional capacities. The book received considerable public attention and popular press headlines, but lacked scientific evidence. As a consequence many scientists became wary of studies that hinted at parallels between animals and plant senses and even worse, the topic sometimes hindered scientific advances in this area (Mescher & De Moraes, 2015, p. 426).

Ten years later, scientists published amazing findings about plant communication. They claimed that trees warn each other of insect attacks. They discovered that caterpillars were less likely to forage on willow trees, if there were already infested trees in the neighborhood. The healthy trees that were nearby contained phenolic and tannic chemicals that made them unpalatable to the insects, but only the trees that were not isolated from the infested trees contained these chemicals (Chamovitz, 2012, p. 35). The scientists concluded that there must be an airborne message system between the trees. Three months later, the experiments were repeated under controlled conditions, instead of monitoring trees in the open air. The result supported the earlier experiment: the damaged trees communicate, by emitting a gaseous signal to the undamaged ones to defend themselves against harm. However, these early reports of plants signaling were often received with skepticism by the scientific community, as lacking the correct controls, while others urged caution against overreaching implications. But over the past decade, plant communication has been demonstrated for as large number of plants, including barley, sagebrush and tomato plants. Plants communicate aerially (through airborne chemical signals) with members of their own group and with other species as well. To review plant communication, I focus first on the interaction between plants and their fungal partners.

Of all known land plant species, around 65% are in a symbiotic relationship with the arbuscular mycorrhizal (AM) fungi and around 90% of the land plants with fungi in general. The nineteenth century German biologist Albert Bernard Frank (1839-1900) coined the term "myrcorrhiza" to describe the symbiosis, wherein plants provide fungi with carbon supply and in exchange, the fungi provide plants nutrients like phosphorus and nitrogen, via their mycelia. Many fungi also provide non-nutritional benefits to plants, including protection against pathogens, or resistance against drought and salinity (Bücking, Mensah & Fellbaum, 2015). But that is not all. AM fungi and plants form underground complex networks (called "common mycorrhizal networks"), wherein many interactions take place between multiple fungal species and multiple plant hosts. The plant species interact and communicate via these networks with the fungi. Both partners can choose between multiple trading partners for their resources. This connection ensures the fungus a continuous carbon supply; even when the plant is attacked above the ground by herbivores and loses its ability to transfer carbon. Plant species can differ their carbon investment into the fungi network in order to receive more nutrients from the fungal partner than the competing plants. This plant behavior follows the dynamics of a biological market system: carbon to nutrient exchange ratios at the mycorrhizal interface are controlled by resource supply (Bücking et al., 2015).

The mycorrhizal networks also play an important role in the communication between different plants by transferring infochemicals and warning signals (Bücking et al., 2015). In the previous chapter, we have seen that if plants are attacked by insects, they produce volatile organic compounds. Biologists revealed that these volatiles are produced by undamaged plants when they are connected underground via mycorrhizal networks with damaged plants.

The volatiles act for example as a repellent for aphids, but attract aphids-eating arthropods. This indicates plants use warning signals to protect each other, shortly after being attacked by herbivores in partnership with mycorrhizal networks. For us, it is difficult to think about these kinds of interaction, because most plant responses are relatively imperceptible to humans. This can easily lead us to overlook underlying similarities between humans and other organisms. Or we do imagine things like the interrelatedness of organisms, at moments when we watch science fiction movies. Maybe the epic film *Avatar,* directed by James Cameron comes to mind. The film is set up in the mid-22nd century and takes place on the habitual forest moon Pandora, where everything is interconnected and all organisms live in harmony with nature. Dr. Grace Augustine, a character in the film explains: "What we think we know, is that there's some kind of electrochemical communication between the roots of the trees. Like the synapses between neurons". Recent plant studies show that there is some truth in this remark. Research of interaction patterns like those between plants and fungal species uncover the interrelatedness of all living beings again and again.

Around 200,000 species of insects communicate by vibrations, to locate partners, attract mates, or exploit plant resources. Even more insects use vibrations to locate prey or avoid predators (Appel & Cocroft, 2014). Chewing insects produce characteristic, high-amplitude vibrations that may travel rapidly to other parts of the plant. Researchers wondered if plants can detect the vibrations produced by chewing herbivores and respond to the thread of insects. They argued that a vibration signaling pathway could complement other signaling pathways, such as airborne volatiles and electric signals.

To test the hypothesis that plants respond to the vibrations of chewing caterpillars, by inducing chemical defenses, scientists carried out experiments with *Arabidopsis thaliana*. They measured the amount of chemical defenses[4] in response to chewing vibrations from caterpillars, and two additional vibration controls: wind-induced vibrations and the vibrations of the song of leaf-hoppers. Wind is a common source of vibration in the field and the song of leaf hoppers was chosen because it has a similar frequency spectrum as chewing insects, but a contrasting temporal pattern (Appel & Cocroft, 2014, p. 1266). In this set of experiments, Appel and Cocroft showed that the vibrations caused by chewing caterpillars lead to higher levels of chemical defenses in Arabidopsis than did the untreated plants that had experienced

[4] Arabidopsis produces three kinds of chemical defenses when attacked by insects: glucosinolates, polyphenol anthocyanins and a suite of volatile compounds.

no vibrations. They also revealed that the plants discriminate between the vibrations caused by insect herbivore chewing and those caused by wind or leafhopper song.

Since insects are among the most important consumers of plants in terrestrial ecosystems, plants evolved the abilities to detect insects and respond to damage from herbivores. In order to survive, plants must distinguish the vibrations of predators from the many environmental vibrations that are not damaging to plants, such as wind or insect chirping. Plants thus need to communicate for survival.

Gagliano, Mancuso and Robert (2012) discovered that plants can even communicate bioacoustically. Recent evidence illustrates that the young roots of corn respond to sound sources by bending towards it. Moreover, they discovered that the roots generate acoustic emissions in the form of loud and frequent clicks. They therefore propose “that some form of sensitivity to sound and vibrations also play an important role in the life of plants” (p. 325). Evolutionarily, to perceive sounds is advantageous for most animals, because sounds give us information about our environments, close by or more distant. Sounds can warn us of potentially dangerous situations. Most terrestrial mammals have evolved external morphology, like ears or eardrums, to collect these vibrations. However, some auditory animals lack such external auditory structures. Snakes, for example lack outer ears, but they can pick up ground-borne vibrations via their jawbones. Plants are sessile organisms that cannot flee when attacked. But we have seen that they can respond to leaf vibrations caused by insect herbivore chewing. Could it not also be advantageous for them to hear other sounds as well? Chamovitz (2012) states that there is little, credible evidence when it comes to plant responses to sound. Further research is clearly required to investigate the capacity of plants to detect and use sounds.

In this chapter, we have seen that plants communicate aerially, that plants communicate via fungal networks and that some plants respond to vibrations caused by chewing insects, eliciting chemical defenses. Plants can even communicate bioacoustically, by making and responding to clicking noises. Plants actively acquire information from their environment, but can they also store and recall biological information?

6. Plant memory

One of the first scientists who studied how plants store sensory information was M. J. Jaffe, a plant physiologist. In 1977, Jaffe studied how the sense of touch affects the curling of pea tendrils. A pea tendril is a specialized stem with a threadlike shape that grows in a straight line until it finds a host that is suitable to coil around. The scientist found out that when he rubbed the tendril in a well-lit environment, it rapidly coiled. But when he touched it in a dark environment, the tendrils didn’t coil, which indicated that the tendrils need light for their curling behavior. Moreover, Jaffe discovered that if he placed the tendril for as long as two hours after stimulation in the dark environment in a light environment, it coiled without having to touch it again. Did the pea tendril that somehow stored this information and later recollected it show plant “memory?” (Chamovitz, 2012).

In order to investigate this question, we must be aware that, for humans there are different types of memory. The psychologist Endel Tulving (1927) made a distinction between three types: procedural, semantic and episodic memory. Semantic memory is the ability to remember general knowledge, like the memory of concepts, whereas episodic memory refers to consciously recollect memories from the past, such as recalling a great holiday. Plants clearly do not meet the standards of semantic and episodic memory. Procedural memories are automatically retrieved without the need of being aware of it, such as when we tie our shoes. Procedural memory is the lowest level of memory. It depends on the ability to sense external stimulation (Chamovitz, 2012, p. 115). The question remains if plants are capable of this type of memory. Chamovitz (2012) mentions still other types of memories such as sensory memory, muscle-motor memory and immune memory. He concludes that all forms of memory include processes of encoding information, storage of information and retrieving information and that these are thus the processes we need to look for when it comes to plant memory.

Ever since experiments on the Venus flytrap revealed that electrical stimulation activates the trap, as we have seen in chapter three, scientists puzzled how the plant encodes the information that something touched its hairs and recalls this memory once the second hair is touched. To recap, the Venus flytrap only comes into action if two hairs are touched within about twenty seconds. By the end of the twentieth century scientists discovered that when a trigger hair on the inside of the lobe is touched, this causes an action potential that induces calcium channels to open in the trap. They hypothesized that the trap needs enough calcium concentration and therefore that just one trigger hair does not reach the right concentration of calcium. A second hair needs to be stimulated to push the concentration of calcium over the threshold (Chamovitz, 2012, p. 118). This idea is supported by subsequent research. To make a long story short, I will explain what is discovered about the memory of the Venus flytrap.

When the first hair is touched, it causes an action potential that radiates form cell to cell. This electric charge is stored for about twenty seconds, as an increase in ion concentrates. Only if a second action potential reaches the inside of the lobe, the cumulative charge and ion concentrates will be high enough to close the trap. If it takes too long to trigger the second hair , the plant "forgets" the first trigger and stays open. The Venus flytrap thus meets the standard of procedural memory. Philosophically interesting, is the fact that the electric signal in the Venus flytrap is similar to the electric signals in neurons in animals, including humans (Chamovitz, 2012).

But that is not all. Scientists also revealed that some plants have a long-term memory of trauma. Experiments were carried out on Spanish needle (*Bidens pilosa*). They noticed that once the main bud is decapitated, both lateral buds started to grow more or less evenly. But if one of the cotyledons was wounded, then the lateral buds grew asymmetrical. Then they experimented with the amount of time between wounding the leaf and decapitating the main bud and extended the time up to a couple of weeks. It turned out that the lateral bud farthest from the wounded cotyledon grew out. Somehow this plant stored the information of the trauma and had a mechanism for recalling it, even up to two weeks later. It is still not entirely clear how this information is stored in the central bud, but it could be that the hormone auxin plays a role of importance here[5] (Chamovitz, 2012).

Let me give one more example of plant memory. Cherry trees in Washington, D.C. bloom in the early spring, when there are about twelve hours of daylight. However, in mid-September there are also twelve hours of daylight, nevertheless the cherry trees never bloom in the fall. If they did, their fruit would freeze in the approaching winter. The trees are able to differentiate between the two periods. This indicates they know it's April, because they remember the preceding winter (Chamovitz, 2012, p. 126).

In order to understand how a plant can remember the winter is only the past decade or so discovered through research involving the genes of the Arabidopsis. Chamovitz (2012) describes this research process. First of all, we need to know that there are different ecotypes of Arabidopsis: some grow in northern climates and need vernalization to flower, while those in warmer climates don't need vernalization. This need for vernalization is encoded in the genes. The specific gene involved is called *FLC: flowering locus C.* The northern plants have the *FLC* genes that need winter in order to flower. "In its dominant version, *FLC* inhibits

[5] Auxin is one of the first discovered plant hormones and is involved in many processes, such as plant growth.

flowering until the plant has undergone a vernalization" (p. 127). Once the plant undergoes the winter, the *FLC* gene is no longer transcribed and is thus turned off. This means the plant could potentially start to flower if the environmental conditions are ideal (light, temperature etc.). Somehow, the plant must remember the cold climate to keep *FLC* turned off.

Researchers have discovered that epigenetics plays a significant role in a plant's memory of winter. Epigenetics refers to potentially heritable changes in gene activity that does not involve changes in DNA sequence. The discovery of epigenetics was highly important in biology, because beforehand scientists thought that only changes in the DNA sequence could be passed on from cell to cell. Through epigenetics, scientists were able to discover that cold treatment triggers a change in the structure of the histones (a process called methylation) around the *FLC* gene, which turns off the gene and makes the plant able to flower. This epigenetic change is passed down via cells over successive generations. The *FLC* gene remains inactive in the cells even after the cold winter is over (Chamovitz, 2012, p. 128). Through the discovery of epigenetics, plant memory could not only be explained from season to season, but from generation to generation as well.

A growing number of recent studies indicate that plants possess the ability to remember environmental or physical stress exposure, that affects their genetics and can even be passed down from one generation to the next. The phenomenon of the acquired memory of exposure to stress is called "transgenerational memory". Features of transgenerational memory include elevated genome instability, a higher tolerance to stress experienced by parents, and a cross-tolerance (Bilichak & Kovalchuk, 2016). The concept of the possibility of the inheritance of acquired traits caused by environmental conditions, dates back to the theories of de Lamarck. Recent reports have proved that stress exposure of Arabidopsis plants induced an epigenetic change, which were passed on to their progeny. In other words, scientists showed that the plants of the next generations responded better to various stresses, such as heat stress and treatments with salt solutions, compared with plants of the control group. Moreover, transgenerational effects have been reported in many different plants, and not only in plants but in animals as well.

Surely, plants have the ability to store and recall biological information. By presenting a short overview of recent reports of the behavior of different plants, I have shown that plants are able to form memories, retain this memory for a certain period and recall the memory at a later moment in order to respond to it. Chamovitz (2012, p. 131) concludes that "many of the mechanisms involved in plant memory are also involved in human memory, including epigenetics and electrochemical gradients".

By now it should be clear: plants are very active organisms. Plants have the ability to sense and respond to their environment; they differentiate between colors and respond to many different parameters, such as light, temperature, gravity and humidity. Plants respond to touch and are able to differentiate between certain kinds of stimulation. They also respond to olfactory cues. Furthermore, plants have an internal communication system, and communicate via mycorrhizal networks. They warn each other by releasing chemicals in the air. Plants discriminate between vibrations caused by insect chewing and harmless vibrations, such as those caused by wind. Plants can even learn from their past and modify their physiology accordingly to protect themselves from future damage. In a sense, plants can be viewed as intelligent as well. In fact, in the last decade many scientific reports and books about plant intelligence were published, so speaking about plant intelligence is no longer taboo.

Anthony Trewavas (1939), a Professor in plant physiology and molecular biology, points out that although as species humans are more intelligent than other animals, it is unlikely that intelligence as a biological characteristic originated only with *Homo sapiens.* In his view, intelligence is a biological characteristic which evolved through the natural selection of properties in earlier organisms (Chamovitz, 2012). Trewavas has done significant research on plant behavior and intelligence. He argues that it is the degree of flexibility that can be observed in the behavioral repertoire of plants, against contingencies in their environment, that grants the ascription of intelligence to plants (Calvo, 2016, p. 1324). In general, "intelligence" is a debated term. It can be defined in many different ways and can be applied to humans, animals and plants. All kinds of capacities mark intelligence, such as perceptual capacities, understanding, logic, problem solving, decision making, goal-oriented behavior, planning and self-awareness. The study of plant intelligence, is therefore a challenging discipline.

In the 21st century a new field of inquiry in the study of plant intelligence arises: "plant neurobiology". It emerged as a multidisciplinary endeavor, which included a number of disciplines within the plant sciences, such as plant cell and molecular biology, physiology, biochemistry, evolutionary biology and plant ecology. Plant neurobiology focuses on plant signaling and adaptive behavior with an eye to providing an account of plant intelligence that escapes the limits of particular plant science areas (Calvo, 2016, p. 1326). It aims to account for the ways plant perceive and act in a purposeful manner. The idea behind it is that plants show flexibility in their behaviors: this calls for the integration of information signaling across the diverse plant structures. However, plant neurobiology is a controversial discipline. Critical biologists claim for instance, that its theoretical basis is flawed and the similarities between plant physiology and neural networks in animals were exaggerated.

In my view, plant neurobiology is a useful discipline, because highlighting similarities between different organisms, opens up the debate about the parallels between the manners animals process information and the ways plants function. This can help to overcome anthropocentric and zoocentric tendencies that dominated human thinking for centuries. It can also challenge people to make connections that we normally tend to overlook. Moreover, the multidisciplinary endeavor transcends the individual scope of the disciplines and makes it possible to integrate different areas of expertise and gain synergy. The term "plant neurobiology" may not be the best choice however. Animal neurobiology covers the functioning of nervous systems and brains of animals and employs genetic and molecular approaches. It investigates their morphology, physiology and biochemistry. Obviously, plants lack a nervous system or a brain. They even lack their building blocks, like neurons and synapses. And yet, plant and animal cells and tissues share 'neural' similarities. Calvo (2016) considers all kinds of similarities, for instance between the signaling systems of plants and animals.

To illustrate such a similarity: plant biologists discovered plants contain proteins, that we know best as neuroreceptors in humans. Chamovitz (2012, p. 132) gives the example of the glutamate receptor. Glutamate is the most prominent neurotransmitter in our body. In the brain it is important for neural communication, memory formation, learning and a number of neuroactive drugs target glutamate receptors. Scientists discovered that Arabidopsis plants are sensitive to neuroactive drugs that alter glutamate receptor activity. How glutamate receptors exactly work in plants is still not fully known, but recent studies indicate that glutamate receptors in plants function in cell-to cell signaling in a way that's very similar to how human neurons communicate with each other.

On the other hand, it is a good thing to be aware of the use of anthropomorphic language, especially when similarities between animals and plants are exaggerated. Instead, I would like to argue for "critical anthropomorphic" language. The biologist Gordon Burghardt (1941) introduced this term, in order to use our sentience to generate hypotheses in light of scientific knowledge of the species, its perceptual world, and evolutionary history (De Waal, 2016, p. 34). Burghardt used this kind of language in the study of animal behavior, but it could also be applied in the study of other species, such as plants. Critical anthropomorphism of plant behavior could be useful as a means, not as an end in itself.

What we need to be aware of is that plants and animals do share a genetic past, but that fact does not negate separate evolutionary paths. We share 15% of our genes with mustard grass for example. But, we branched off from our common ancestor 1,6 billion years ago. This means that the abilities of plants are to be situated in their particular evolutionary contexts. Plants are aware, but not in the same way as humans are aware. As Chamovitz (2012, p. 138) points out, plants are not aware of us as individuals. We are just one of the external pressures that influence a plant's chances for survival and reproductive success. Some biologists use anthropomorphic language to make others understand better the complexity and sophistication that plants manifest in their behavior patterns, and in my case I make use of it in order to open up new ways of thinking about plants and in the end about what we are. But that does not mean that we are able to equate human experiences with plant experiences. While it is possible for us to imagine what it is like to be plant, although this is already really challenging, this will never be the perspective of a plant.

All the similarities between humans and other animals and plants in particular I have been discussing so far, lead me to a very intriguing philosophical question: what are the implications of a 'philosophy of plants' for us regarding our relationships with plants?

Part III Reconsidering the Relationship between Plant and Human

Introduction

In the previous chapters, I have used a critical anthropomorphic vocabulary for analyzing the world of plants. With the help of this vocabulary, it is possible to describe plants as active participants in interactions with other organisms, while at the same time keeping in mind that the experiences for plants and human beings are qualitatively different. This approach helps to see ourselves in a different light as well. Focusing on the world of plants teaches us that plants and humans maintain parallel abilities, thereby creating a new perspective on the life of humans and plants. In the third and last part of this thesis, I shall focus on the implications of a ‘philosophy of plants’ regarding the relationship between plants and humans. In order to do so, I continue to elaborate a ‘philosophy of plants’ via a critical discussion of the work of contemporary philosophers including Karafyllis, Pollan, and Oudemans. A deepened understanding of the relationship between plants and humans is my primary goal of the third part, which will take me to express some preference for an emergentist middle position in the tradition of philosophical anthropology.

7. Man as plant

In Aristotle’s early view, plants are seen as living things instead of living beings. For him, it was clear that only animals and humans have the ability of sense-perception and the power of self-motion. Currently, as we have discussed in the second part, plants are viewed without any doubt, as active participants in interaction with their environment and as having perceptual abilities. At a phenomenological level, plants are the perceivable foundation for biota, but on the ontological, anthropological and ethical level there remains a huge division between plants on the one side and animals/humans on the other side. Plants lack for instance, a body, a brain, a heart and blood. This is one of the reasons why plants on the ontic level, are rather classified with the abiotic and lifeless things. It leads to a philosophical problem: on a biological perspective, plants are the first living beings and humans share genes with them. But, on an anthropological perspective, we work with animal and machine models in which the focus on the nature of human beings and animals is dualistic, meaning mind and body are viewed as two separate entities (Karafyllis, 2012, p. 26).

Traditionally, the central idea in natural philosophy is that something that is vegetable, is not physical. The vegetable is associated with processes of growth and reproduction. The two most powerful models in anthropology are animal and machine models, in which plants are viewed as completely different from animals/humans. However, in the eighteenth century de la Mettrie, a philosopher we have met before in the second chapter when I referred to his more famous work *L'homme machine*, writes a satirical essay *L'homme plante*[6], in which he discusses the commonality between plants and humans. De la Mettrie argues that the human soul only consists of needs (*Bedürfnisse*): "Von der bedürfnislosen Pflanzenseele (die daher bei La Mettrie gar keine ist) über die Tierseele zur Menschenseele steigern sich Bedürfnisse und die zugehörigen Fähigkeiten zu deren Befriedigung" (Karafyllis, 2012, p. 29). He thereby equates processes of growth and development in the human soul[7].

Karafyllis (2012) analyses the relationship between humans and plants in the early works of de la Mettrie. For Karafyllis (and I agree), the achievement of de la Mettrie is that he relates the vegetal with the material in animals/humans. In another work (*Histoire naturelle de l'âme)*, de la Mettrie rejects the classification system of the kind of souls as possessed by different kinds of living things from Aristotle. In this work, de la Mettrie only recognizes the vegetative soul, that according to him, could be different for plants than for animals/humans, but that does not mean at a lower level in the hierarchy. In *L'homme plante* he denies the existence of a vegetative soul, because plants would not need a soul; they lack needs or longings.

Karafyllis continues by discussing plant anthropomorphism and "*Plantamorphisierung des Menschen*", in which plants often function as a symbol for a kind of passivity. She points out that sometimes, plants are used in a symbolic sense to refer to human beings. It often happens when we refer to the beginning or the end of human lives. Think of the following expressions that are familiar in German: "In der Blüte seiner Jahre", or "Grün hinter den Ohren". The English language uses plant metaphors as well: "Going back to your roots", "He is in a vegetative state", and "I heard he is kind of a vegetable now". These plant metaphors are examples in which plants are used to contrast them with the active life of human beings.

The idea of plants as passive, unconscious beings can also take a monstrous appearance. In the context of cinema or literature it happens when writers accentuate quite the opposite: roots that normally prevent a plant from moving transform into moveable legs, or shoots, stems or

[6] We could consider the ignorance of this essay as another example of our plant blindness.

[7] The idea of man as a deficient being, a poor being, marked by birth with a lack is in the twentieth century expressed in the anthropological tradition by Arnold Gehlen (1904-1976).

leafs suddenly grow rapidly and become very active (Karafyllis, 2007). In a cinematic context, the connection between plants and humans becomes apparent. Take for example 'The Ents' in *The lord of the rings* by J.J.R. Tolkien, that appear as ancient, big, walking tree-like species, which are something in-between plant- and animal creatures. Or, imagine the following scenario: You are at work in Amsterdam. The company you are working for is located next to the Vondelpark. While you are sending an e-mail, you hear a loud noise. You look out your window and see a car just crashed into a tree. When you look further up the street you see a police officer coming. He walks over to the car. The next moment, he pulls a gun from his trousers and shoots himself in the forehead. As the blood drains from the officer's head, a woman steps off the sidewalk, picks up the gun and shoots herself as well. You feel scared. Meanwhile, you notice a building worker who falls off the roof of a building. Confused, you notice another person falling down. People outside seem completely calm. Some are standing still, others are walking backwards. At this point, you feel extremely frightened and turn on the radio. You hear the news that these mass suicides are caused by a bio-terrorist attack, in which terrorist have apparently released an airborne neurotoxin in the Vondelpark. Fortunately, the outbreak is over, just as quickly as it began. Several months later, scientist reveal that plants and trees were responsible for the attack, by releasing chemicals, they started to defend themselves from human threads. This scenario is based on the thriller film *The Happening,* written and directed by M. Night Shyamalan, in 2008. Scenarios like this make us aware of the reciprocal relationship between people and plants. By bringing movement into the vegetal, it becomes easier to identify ourselves with plants. On the one hand, humans and plants share a remarkable number of similarities, but on the other hand we should not forget that our experiences are qualitatively different. So perhaps scripts like these, represent our own subjective judgment of a tree's unemotional physiological make-up. How plants appear to us, is deeply intertwined with what we are.

In *L'homme plante* de la Mettrie anthropomorphizes plants as well, when he compares our lungs with leafs. In his words: "Den Lungen entsprechen bei uns Blätter. Diese wiederum ersetzen dieses Organ bei den Pflanzen, so wie dieses bei uns die uns fehlenden Blätter ersetzt" (Karafyllis, 2012, p. 40). In the eighteenth century, the ability to breathe is seen as common principal for all living beings. By anthropomorphizing plants, de la Mettrie is able to view "humans as plants". This way he is bridging the divide between humans and plants. In this new perspective, the plant becomes a material animal. Plants are no longer things which can nourish themselves and reproduce others of the same kind, but, by contrast, plants become self-regulating beings that grow and die while at the same time being rooted. By anthropomorphizing plants and at the same time viewing human beings as plants, his essay results in a critic against the exceptional position of humans on the one hand, as defended in the Christian tradition, in which it is believed that man is created in the image of God. On the other hand, he criticizes the mechanical view of animals, as defended by Descartes (Karafyllis, 2012, p. 27). In de la Mettrie's view, man and animal consist of the same primordial matter. However, he also asserts that there is a difference in quality between humans and animals, because only humans have morals and laws. He connects the concepts of matter and soul with growth; on a physiological level are humans as plants which have to develop and grow. De la Mettrie opens up a new way of thinking about plants and humans by his analogue of a vegetative animal, which is *de l'homme à la plante*.

Even today, the idea of a "man as plant" teaches us that a hierarchical order of life is not as clear as it seems. Humans do not stand outside, or 'on top of' the natural environment, but are part of it. As we saw in the second chapter, Plessner developed a philosophy of nature in his work *Die Stufen des Organischen und der Mensch*. He distinguished living things from inanimate things, because living things can realize their own boundaries. This idea is especially relevant for a 'philosophy of plants', because Plessner understands biological processes such as reproduction, as expressive realizations of life. For that reason, expressivity is no longer a category restricted to humans (as it was before), but plants are viewed as expressive life forms as well. To recap, because living things have a boundary, living things are characterized by a 'double aspectivity', they have an inside and an outside. Plessner uses the concept of 'positionality' to describe the different types of boundary realization between plants, animals and humans. Plants *are* their boundary realization, whereas animals are able to interact with their environment from their center. The life of animals is thus centric. The human type of positionality is excentric, because humans are able to keep a certain distance to their center as well. In Plessner's biophilosophy, we see further that humans have a threefold existence: we are physical and at the same time *in* our body and *outside* our body. In Plessner's words: "Das Lebendige ist Körper, im Körper (als Innenleben oder Seele) und auβer dem Körper als Blickpunkt, von dem aus es beides ist" (Plessner, 1928, p. 365). Plessner continues by discussing the human world, which is threefold as well. We are situated in an outer world (*Auβenwelt)*, an inner world (*Innenwelt)* and a socio-cultural world (*Mitwelt*). Humans are thus not enclosed in their environment (*Umwelt*) but are characterized by a certain openness to their world (*Welt*) (De Mul, 2013, p. 475).

However, the positionality of humans is not only excentric, but we remain centric as well. Our openness is at the same time restricted, because we remain, beyond our control, physical beings. The vegetable is a shared component of all life forms. It is important to note, that the categories Plessner describes are not fixed. He speaks of concrete categories of life (*Lebenskategorien*). It is because of this threefold existence that humans have a unique capacity that plants don't have: the ability to understand each other and – up to a certain level- to understand other forms of life.

De Mul (2013, p. 469) illustrates our ability of interspecies understanding by telling a story about his playful dog. The point of the story is, as shall be confirmed by most dog owners, that we think we have a clear understanding of the dog's desire to play, as described in the following game: the dog runs away to collect a stick, after which it returns and puts the stick in front of me. Then, the dog takes a few steps back and keeps switching eye contact between me and the stick, while wagging its tail throughout the process. I am supposed then, to throw the stick away, after which the dog retrieves it and this process repeats itself a couple of times. Obviously, our understanding of the dog's play is not a psychological understanding of an intention, or that I know perfectly what is going on in the dog's mind. On an ontological level we could say that this is a discontinuity between me and the dog. But on the other hand, there is also a continuity: the dog and I participate in the same life, though – due the distinct type of positionality - in a different way. There is an understanding 'in embodied interaction'. I interpret the behavior of the dog *in* the bodily enactment.

Humans have three kinds of perspectives. The first-person perspective refers to the viewpoint of ourselves. In this example, in a first-person perspective I could experience my playing with the dog as an act of intentionality, or project my playful mood to the dog. The third-person perspective belongs to the person, or in this case, the dog being talked about. The second-person perspective on the other hand, belongs (in linguistic communication) to the one's being addressed. This is the "you" perspective, but this perspective could, as de Mul (2013, p. 470) points out be extended to "include all elements of non-linguistic behavior in human communication and interaction which address the other". What characterizes this interactive play between the dog and I is that is unfolds itself in the course of bodily interaction. I could experience this interaction thus from a 'second-animal' perspective. Clearly, it is much easier to imagine what it is like to be a dog, than an octopus, much less a begonia; due to the degree of kinship. And, we should not forget that we always run the risk of anthropomorphic projection when we try to understand other forms of life. However, especially relevant for my topic is that this second-person perspective has important implications for our understanding of other forms of life, plants included.

Our understanding depends on the extent to which we can go along with other species. In *Die Grundbegriffe der Metaphysik* (1929/1930) Martin Heidegger speaks about the differences between living things and human beings. He explores the question how to understand animals. He understands the difference between the way things are open for humans and for animals, not as a gradual difference, nor as a qualitative difference, nor as a quantitative difference:

> Es handelt sich *nicht* einfach nur um eine *qualitatieve Andersheit* der tierischen Welt gegenüber der Welt des Menschen und erst recht nicht um quantitative Unterschiede der Weite, Tiefe und Breite - nicht darum, ob und wie das Tier das Gegebene anders nimmt, sondern ob das Tier überhaupt etwas als etwas, etwas *als* Seiendes vernehmen kann oder nicht. (Heidegger, 29/30, p. 383)

According to Heidegger, animals are related to their environment, but humans do not have access to the nature of that relation. What we tend to see as "food", or "nest", appears to the animal incomparable different. An animal does not view something *as* something. The experience of the world for a caterpillar, is something entirely else for a human being. A caterpillar does not see a grass halm *as* a grass halm. The caterpillar experiences only caterpillar-things or something 'caterpillar-like'. Heidegger continues to speak of the way we have access to other living beings, which he calls *ein Sichversetzen,* meaning 'a going along with' (*Mitgehen*). This going along, is at the same time 'a splitting up' (*Auseinandergehen*), an 'against each other' (*Gegeneinandergehen*) and most of all, a 'side by side' (*Nebeneinandergehen*) (Van Kampen, 2005, p. 198). On the one hand, we can go along with other species (continuity), on the other hand we cannot (discontinuity). This 'going along' seems to be close to the interactive second-animal perspective, as we have discussed in the last section.

Plessner's ideas could be relevant for a 'philosophy of plants', because through his philosophy of nature we also come to the realization that *because* we share characteristics with plants and animals, we are able to analyze these other types of living beings. However, we should keep in mind that plants do not have brains. This means that any subjective terms do not fit plants. Take the example "happiness". If you search for the word "happiness" in a standard dictionary, you will find out that it is defined as "a mental or emotional state of positive or pleasant feelings". Philosophers often define happiness in terms of well-being.

Perhaps “happiness” for a plant could be defined in terms of “an optimal physiological state”. But we all know a human can be in perfect health, but still feel miserable. A plant can sense chewing vibrations from caterpillars, or when its leaves are drought. But they cannot, to our current knowledge, experience a mental or emotional state. The latest research that has been carried out in neuroscience, show that there is a physical correlation between underlying neural mechanisms in the brain and forms of happiness. This means that happiness is related to highly complex neural structures and connections in the brain, which is only present in higher vertebrates. And, the idea that a plant is brainless makes it hard to apply cognitive concepts as understanding, communication and intelligence to organic life. Many critics would state that any anthropomorphic description of a plant is therefore at its base severely limited (Chamovitz, 2012). An argument like this, hits the nail on the head in case of emotional, or spiritual ascriptions of human characteristics to plants (as happened, for instance, with *The secret life of plants*) or when anthropomorphism of plant behavior is used to make overreaching or sensational claims and thus not for the sake of literary clarity. Moreover, anthropomorphizing plants, left unchecked, can easily lead to unfortunate consequences. Chamovitz (2012) gives the example of the Swiss government who established an ethics committee to further define dignity in terms of plants. Or take the example of someone, who projects his own psychological state to a houseplant, as describing the plant that looks wilted as “not looking happy”.

However, as biological research carried out on plants shows, plants respond to environmental variability in many, active ways and they maintain many parallel abilities to detect, or anticipate changing conditions in the physical world. Maybe, we could try, together with Heidegger, to go along *with* plants, because partly, our life form overlaps with many other organic forms of life.

8. Who’s in charge?

At first glance, the sessile lifestyle of plants seem to be utterly different from our own. Their sedentary lifestyle obscures the fact that plants actively perceive and respond to ever-changing environments, as the responses frequently entail changes in their internal physiology. Further, plants act on a different timescale than humans, which makes it difficult to observe their behavior patterns. Aristotle, one of the first philosophers who argued for a strict hierarchical system of life, set plants apart from animals and humans because plants did not have the ability of sense-perception, desires or self-movement. In fact, plants, *despite* being rooted, have evolved all kinds of abilities for survival. The list of plant strategies has been growing continuously in recent years. So, to state that humans are for instance more “advanced”, really depends on how you define that term and on what “advances” you value (Pollan, 2001). We tend to value human capacities, like language, rationality and being conscious as unique, but are mostly unaware of the fact that plants developed, by the same process of natural selection, photosynthesis and, for instance chemical defenses.

While many of the chemicals plants produce are designed to defend themselves against harm, many other chemicals plants make have the opposite effect: attracting other species. Many flowers have evolved to be attractive to animals, as the sweet scents attract animals to cause them to transfer their pollen. But, long ago there were no flowers. Around four hundred sixty million years ago, plants started to inhabit the earth’s surface. The first plants (sea algae) were very small and most of them were more or less leafless. Ferns and mosses appeared during the Carboniferous period, around three hundred million years ago. Then, during the age of Dinosaurs, in the Mesozoic era, gymnosperms, like conifers and cycads, took over the environments. Gymnosperms are vascular plants whose seeds are not enclosed in an ovary. The angiosperms, the first flowering plants with enclosed seeds, appeared during the Cretaceous period, and they became over forty million years, the most dominant world’s plant. Famous is how Darwin described the sudden appearance and great success of angiosperms: he called it “an abominable mystery”. Darwin could not understand how this sudden appearance of a new class happened, because in his view natural selection can’t produce sudden or great modifications. Nature makes no jumps and natural selection is a gradual process, according to him.

The coming of the class angiosperms changed a lot: flowering plants attract insects, birds, animals and humans with their scents, colors, forms and fruits for transportation and pollination. In the evolution of plants, desires became important. By working together with other species, plants became more successful in reproduction and more varieties of flowers and seeds developed. Now natural selection favored blooms to manipulate pollinators and fruits that appealed to foragers. By the coming of angiosperms, the desires of other organisms became important, because plants that succeeded at satisfying those longings would produce more offspring. This way beauty had emerged as a survival strategy for plants (Pollan, 2001, p. 119).

Michael Pollan (2001) tells in *The botany of desire* the story of four of our most ordinary plants: the tulip, the apple, cannabis and the potato. Pollan chooses these plants because the plants are known as “domesticated species”. However, he immediately points out that it is *not* the case that humans domesticated the species as in a one direction side view. Instead, he argues that plants are in charge of us as well: plant species use all kinds of strategies for advancing their own interests. Think of the tulip: a flowering plant with an amazing strategy to make itself beautiful in the eye of its greatest admirers, namely us. The tulip, by satisfying our desire for a certain kind of beauty, led to one of the first economic investment bubbles. This episode in the Dutch Golden Age in the period between 1634 and 1637 became known as: “tulip mania”. At its peak, tulips were sold for extraordinarily high prizes. The tulip bubble burst in 1637, and the prices collapsed suddenly. The tulip has gotten us, to travel it from Central Asia, to Turkey and eventually to distribute it to the rest of the world. The apple, by our desire for sweetness, brought us from the ancient forests in Kazakhstan, where the story of the apple begins, to produce and sell it all over the world. The apple as we know it today, became one of the most eaten fruits worldwide. And cannabis, by its ability to alter human consciousness, has gotten us to risk arrest and our lives for it. Cannabis made us grow a great deal indoors where the plant could be taken care of under controlled conditions. These indoor growers pamper the plants so passionately, and are taking so good care of all their needs, Pollan calls the cultivators of cannabis “the best gardeners of my generation”. (p. 135) Finally, Pollan uses the potato as an example of our desire to exert control over our environment. Potatoes give an immense amount of food per acre. So, to nourish themselves the Inca’s cultivated the potato and eventually, the potato has gotten itself out of Peru to Europe and is grown to the world’s fourth largest food crop.

According to Pollan (2001), it makes thus as much sense to state that plants domesticate humans, as the other way around. To illustrate his view even better, he compares the role human beings play with the role bumblebees play in nature. A bumblebee probably regards himself, as he flies in a garden, as a subject and the bloom he is plundering for its drop of nectar, as an object. But in fact, this is really just a lack of the bee’s power of imagination. The flower has manipulated the bee into spreading its pollen from blossom to blossom. Humans think of themselves as subjects, but what if this is a failure of our imagination too? Are we humans the subjects, apart from the objects? Pollan notes the failure of our language, that divides the world into active subjects and passive objects, but shows how co-evolution (discussed in the next section) teaches us that every subject is also an object and every object a subject.

By describing the reciprocal relationship between the bumblebee and the flower that we are all familiar with, Pollan makes us aware that humans and domesticated plants have formed a similarly reciprocal relationship. Thus, did humans make the tulip a hotly desired plant, or was it in fact an evolutionary strategy of the tulip to attract humans instead of bees by their beautiful flowers? By discussing the reciprocal relationship between humans and plants, Pollan explains what is known as “co-evolution”. In biology, co-evolution occurs when two species act on each other to advance their individual interests, thereby affecting each other’s evolution. A beautiful example of co-evolution is the relationship between hummingbirds and plants. Some plant species rely on hummingbirds for pollination instead of the insects their ancestors did, and they have developed some spectacular traits to attract these birds: brightly colorful flowers that are relatively odorless, sucrose rich nectar and trumpet-shaped flowers for easy access for the birds that have long thin beaks. These birds have a poor sense of smell, but have good color vision. Hummingbirds are famous for their ability to hover while feeding from plants, and they need lots of sugar to sustain this behavior. In a co-evolutionary bargain, the plant gets transportation for its pollen and the hummingbird gets nectar (Foote, 2015). Co-evolution can also lead to the exhibition of sophisticated forms of behavior, like sexual deception. Take for example the tongue orchid (*Cryptostylis subulata*). The smell this orchid produces exactly mimics the pheromone of a female wasp. Male wasps think the orchid’s flowers are female wasps and starts to copulate with the petals; even to the point of ejaculation. In doing so, pollen sticks to the wasp (Oudemans, 2014).

Not only humans walked an evolutionary road, but plants did as well. It is a good thing Pollan emphasizes humanity’s simultaneous evolution with plants. He shows us that human desires and a plant’s needs often go hand in hand. Thereby, Pollan calls attention that it is not only us who are in charge of plants, but plants are modeling us as well. This reminder is extremely important, concerning our “default condition” for plant blindness, and our long history of our misguided, anthropocentric ranking of plants as inferior to animals. Moreover, Pollan is very clear about his aims. His hope is that his book will change our perspective a little, so that plants won’t appear so alien, so “Other” anymore. Seeing plants “in an intimate and reciprocal relationship with us means looking at ourselves a little differently, too: as the objects of other species’ designs and desires, as (…) remarkably unself-consious”. (Pollan, 2001, p. 21) His book reveals that humans are prone to overestimate their agency in nature. The moment we realize this self-overestimation, nature unexpectedly looks very different. What we must see is that we are not the ones who exert control over nature, just as the fact that we don't stand outside, or apart from nature, but we are part of nature's web.

On the other hand, we must be clear. Pollan presumes to take seriously the plant's point of view. Although it is appealing to look at the relationship between us and domesticated plants from the angle of the plants' perspective, to deepen our understanding of the reciprocal relationship, we must realize that we necessarily view plants through the lens of our human' perspective. This is an unavoidable conceptual bias and has been a frequent source of confusion in the study of plants (Mescher & De Moraes, 2014). Maybe the attempt to take seriously the plant's point of view is a form of anthropocentrism[8]. A form that mirrors our own attempt at defining our relationship with other species. Humans often compare themselves to others. And we often project our emotions to animals as we think to see a lot of human characteristics in them. I know some cat owners who claim their cats understand them when they talk to them, but really don't care. So, maybe the attempt to take 'the plant's point of view' is just a projection of our own human experience and an attempt to seek our own place in nature.

Another philosopher who shares the desire to think about the reciprocal relationship between humans and plants is Oudemans (2014). He illustrates his view by telling the story of a plant collector, named David Douglas. In 1825, David Douglas arrived at the west coast of North-America. He was looking for some unknown trees that could be meaningful for the European culture of gardening and the forestry. He collected the seedlings of some of the biggest pine trees of the world, which he called the "American pines" and send these seeds back to London. Thanks to David, the pine tree arrived in Europe. Since then, European gardens and landscapes transformed dramatically. After the introduction of the douglas in Europe, English estates were not the same anymore. Nowadays, the pine 'douglas' is the biggest supplier of construction timber and paper worldwide. However, David never realized his actions would have had such a great impact on the European landscape and market. He could not have foreseen that Europe would be covered with the offspring of these pine trees. And especially not, that the douglas would be seen, years and years later, as a real threat of native tree species. What this example shows is that humans are not the self-thinking creatures that we

[8] As we have seen in the previous chapter, Plessner and Heidegger point out that human understanding of other life forms is possible due to the fact that we share certain characteristics of life with them. On the other hand, our understanding of other species is always limited, due to the fact that all types of living beings are qualitatively different.

think we are, as opposed to passive plants. Human' intentions are interwoven with the natural environment, which is incalculable. We are part of and intertwined with the history of life, including plants and trees.

According to Oudemans (2014), humans need sharp divisions, such as the nature-culture dichotomy, in order to think we are able to control nature. The evolution theory already demonstrated that the categorical division between humans and the natural world is no longer tenable. In the nineteenth century, Darwin contemplates about life as a tangled bank, clothed with many species, plants and animals, all dependent upon each other in a complex manner. Currently, despite this insight, humans still tend to think they are in charge and like to see themselves as subjects in their own world. Maybe this is an inevitable tendency of regarding ourselves as subjects; due to our excentric positionality we can relate to ourselves from outside our center, as Plessner reminds us. A good illustration of our 'need to control' is given by the Dutch nature policy. Take the policy of Staatsbosbeheer (Dutch Forest Service) in my home-town Wassenaar. For several years people from the town and Staatsbosbeheer have been arguing over a small patch of pine forest, called the Ganzenhoekbos. Staatsbosbeheer wants to return the forest to a more natural and diverse state, by cutting down around eighty percent of several exotic pine trees, such as the Corsican Pine. Their main argument for cutting down these trees is that the trees are not "natural" species. According to them, pine trees do not belong in a landscape with sand dunes. But, what are "natural" species really? In fact, Holland consists of one big cultural environment. The natural heritage of the Netherlands is managed and decorated by humans. Furthermore, even if Staatsbosbeheer wants to control this patch of forest by protecting its natural course, or by recovering the biodiversity, this controlling is a form of managing too: the soil and vegetation needs to be changed, trees have to be cut down, machines have to enter the area, etc. But that is not all. Wassenaarse citizens protested against the radical plans Staatsbosbeheer made. They created a foundation with the purpose to preserve the current Ganzenhoekbos. The foundation stands for keeping the forest as it is: a pleasant green pine forest. However, the will to preserve this pine forest is perverse as well. Nature constantly adapts itself to ever-changing circumstances. So, it is not that "natural" to save a small patch of pine forest. Oudemans calls the nature policy of Staatsbosbeheer "botanic racism". Staatsbosbeheer wants to make the Dutch forests more "natural", by planting indigenous species and eradicating the exotic plants, but ignores the nomadic character of plants worldwide. The division between nature and culture is, as the Dutch landscape shows, problematic. Oudemans emphasizes that plants and trees are part of the natural world, which is constantly changing, just like humans are part of nature's web - even when they discuss or think about nature. We can try to control or categorize plants, but in the end, plants have their own agenda.

One of the ways humans try to manage plants is by cultivating them. We modify plants into crops and cultivated plants and in this process, we tend to think we are the ones who are in charge. Moreover, we see cultivation as an expression of our intelligent management of nature: the introduction of agriculture is often viewed as a step forward for human development. Is that really the case? Oudemans (2014, p. 115) argues that it is not. In the first place, managing nature is not even possible, because our cultivating has unpredictable consequences. The opposition between nature and culture is a very ambivalent view: if we bring culture into nature, something gets lost, namely the natural. Culture seems artificial, something that destroys the original. Further, Darwin demonstrated that the artificial selection itself is a variety of the natural, and is part of it. Are we the only ones that are cultivating? Or is it rather the case that animals, plants and humans cultivate each other, in a back and forth interactive play[9]? We cannot answer the question where nature stops and culture begins. Nature is, according to Aristotle, the bringing forth of something out of itself. On the other hand, cultural and technical objects are artificial: they are generated by an external force. If we follow this definition, a wasp nest or an anthill are not that natural anymore. And what to think of our national parks, are they natural or artificial? We would like to see ourselves as cultural beings, and thus as masters of our natural environment, but we are artificial by nature. A worker using a hydraulic excavator that removes trees, is just as natural as a beaver that cuts down an oak tree with its teeth, 'designed by' the process of natural selection (De Mul, 2015, p. 6). We tend to associate plants with nature, and as something completely different than the artificial, which is associated with culture and humans. But, as I have showed by now, the division between nature (plants) and culture (humans) is not clear. This makes the opposition between nature and culture highly problematic and if we look at the relationship between plants and humans, this antithesis could definitely not be maintained. We are all part of a complex ecosystem. Therefore, the interrelations between human and plant should be reconsidered.

[9] Hans-Georg Gadamer discusses in *Wahrheit und Methode* the relation between art and play. In the play, the subjectivity of the participants disappear; the play itself becomes 'the subject'. The participants got caught up in the play. Every playing is thus at the same time a 'being played'. The play is characterized by a reciprocal movement.

Nowadays there are many consumers protesting against the use of chemicals, known as E-numbers in our food. Consumers want to eat natural products: food that is unprocessed and preferably organic or raw. The last century, there is a tendency that consumers want their food to be made up of ingredients they recognize. Marketers are eager to substitute artificial dyes with natural ones to keep up with consumers' needs. A few years ago, Starbucks was in the news, because consumers found out that the red dyes in their strawberry drinks contained cochineal, which is produced from crushed beetles. The discussion was not so much about cochineal being synthetic, because it actually is a natural dye, but they protested against the idea of killing insects for their shakes. Starbucks started using a tomato-based dye instead. Consumers were relieved. But, this tomato-dye may sound to customers natural, in fact it is not really that 'natural' to color food. In fact, many food is artificial colored and consumers on the other hand, expect their food to be a certain color. Many of the food that we tend to see as 'natural', is very poisonous if not domesticated by humans. The stems and leaves of the tomato plant (like potatoes) contain the chemical glycoalkaloid. If you eat a high concentration of this poison, you will die. And wild almonds, are full of cyanide. The almonds that we consume are carefully processed to remove traces of poison and bacteria. On the other hand, food additives and E-numbers are only permitted in certain foods and in specific limits: these are regulated by the European Food Safety Authority. We have to realize that our ideas about what is natural and what is not, are shaped by marketers as well.

The examples of the Dutch nature policy, cultivating plants, managing national parks and natural food that I have discussed so far, all reveal our desire to control nature. Oudemans calls them "ritual gestures" that have to hide the fact, that what we call 'nature' cannot be managed (Oudemans, 2014, p. 120). In the end, the vegetative philosophy of Oudemans leads to the assertion that humans and birches are varieties of each other. Birches have to adapt themselves continuously, in their struggle for survival. And humans are more vegetative than previously understood. We can see birches and humans as varieties of each other, due to the fact that both species are complex organisms that constantly absorb energy, remodel this to labor in order to survive and reject the useless leftover (Oudemans, 2014, p. 152). In a sense, birches and humans are self-undermining, because they are only maintained, when they reproduce themselves and in the end, die. Dying contributes, just as sexual reproduction, to genetic variation. In this way, plants, animals and humans are all related living beings in the game of nature.

9. Philosophical anthropology and emergentism

A characteristic feature of philosophical anthropology is the discussion of the concepts of 'nature', 'life' and 'human beings', both singly and in their relation to each other. Max Scheler (1874-1928) and Plessner were among the first philosophers who founded the tradition that we know today as 'philosophical anthropology' (Honenberger, 2015). But long before the beginning of the twentieth century, philosophers were dealing with questions of living things and nature, as we have seen in the hierarchical system of life, as defended in the Aristotelian tradition. Descartes' ideas mark the beginning of modern philosophy, because he revolutionized the world view. Before him the world was approached and explained from a divine perspective. In the Christian tradition for example, it is believed that mankind is created in the image and likeness of God. Accordingly, humans are viewed as unique creatures and are set apart from the animal world and the plant kingdom. Human beings are a reflection of God's intellect and are 'the crown of creation'. But since modern times *the human* became the point of departure. This is the reason why we speak of 'an anthropological turn' since the modern philosophy of Descartes. A characteristic of modernity was the Cartesian doubt, and the doubt presupposed human thinking and 'the subject'. In a sense, man starts to take a special and unique position, instead of God. Man became the centre of everything. Naturally, this anthropological turn was a gradual process. We should not forget that Descartes could not develop his philosophical system without making use of a completely perfect God, because God had to guarantee our clear and distinct ideas are true and reliable. A perfect God would not deceive us, Descartes argued.

As we have seen, rationality is the ultimate difference between animals and humans for Descartes. Animals can't think, but they are capable of self-motion, just like automatons. Descartes associated animals with complex organic machines, which he called '*bête machine'* (animal-machine). In the seventeenth century, machines came to the foreground as models for living beings, especially animals. We can see a parallel with the computers of our time and the automatons of the seventeenth century. Were animals compared to machines in the seventeenth century; human brains were compared to computers in the twentieth century.

However, in Descartes' time, the machine model could not explain human thinking and for that reason Descartes argued only humans have a rational soul independent of the body. Thinking cannot be reduced to the mechanics of our bodies. Thus, Descartes continued that humans must be composed of two substances: the body (*res extensa*) which could be compared to animal bodies and the mind (*res cogitans*) which is connected to the body, but separated as well (think of dreaming and separated in the end, when we die). By contrast, de la Mettrie continued the discussion of machines, by positing a radical material point of view: the human is a machine as well. The human body is, according to de la Mettrie: "…a machine which winds its own springs. It is the living image of perpetual movement" (de la Mettrie, 1748, p. 21). He concludes his essay with the words: "Let us then conclude boldly that man is a machine, and that in the whole universe there is but a single substance differently modified" (p. 80). With the philosophy of de la Mettrie, everything became material, human thinking (the rational soul, or consciousness) became nothing more than a epiphenomenon. De la Mettrie is often seen as a herald of a materialistic philosophy of nature. In the mechanistic model there is only one substance: matter. In this reductionist tradition is the human mind a epiphenomenon of the mechanical movement of a collection of fundamental parts from which all else is put together. In exploring this tradition, it is helpful to distinguish between weak and strong versions of reductionism. Weak reductionism is using reductionism as a methodology. Physics use this (fruitful) methodology when they explain the behavior of gases by molecules, the properties of molecules by atoms, which in turn are explained by nuclei and electrons. It is a form of downward explaining, which can be extended as far as the most fundamental entities (Clayton & Davies, 2006, p. 11). On the other hand, many physicists are strong reductionists. This position is also known as 'ontological reductionism'. Most physicists believe that all of nature, including consciousness, can be explained once the final building blocks of matter are identified and the rules that govern them. In short, they believe that the whole is nothing but the sum of the parts. A reductionist and mechanical model of the evolution of life is for example defended by Richard Dawkins, in his popular and well-known book *The Selfish Gene* (1976). In Dawkins view, humans and other living beings are nothing more than the "survival machines" of genes.

Thus far, I have distinguished roughly two models or approaches to the question of 'the human' in philosophical anthropology. An example of the first is the Christian anthropological view, wherein humans are mainly compared to God. In the modern time a mechanistic model appears, in which humans are mere complicated machines. The mind is viewed as a epiphenomenon of fundamental, primitive objects. In my concluding remarks, I will sketch the elements of an alternative approach which is related to the term 'emergence'. In describing this view, I will make clear that this resonates with the anthropological philosophy of Plessner.

Emergentists assert that new qualities arise at each level of complexity, that cannot be explained (at least not in a straightforward manner) by known properties of the parts (Clayton & Davies, 2006). The whole is thus often more than the sum of the parts. These scientists challenge the account of nature of reductionists. Weak emergentists insist that in order to explain complex behavior like human behavior, we need to make use of other methods, such as introspection or simulation. But the fundamental causal processes remain, ultimately, physical in their view. It is due to the limited state of our knowledge that we can't recognize the underlying fundamental processes. Strong emergence is more contentious, because it holds that the bottom-level entities are inadequate to account for the system's behavior as a whole (Davies, 2006, p. 12). Strong emergentists believe that new qualities come into existence over the course of evolutionary history.

Emergence has a long history in philosophy, but its position within physics is more tentative. The last couple of decades strong emergence is re-emerging within science. This is due to the rise of the sciences of complexity, such as chaos theory, network theory and self-organizing systems. Moreover, recent empirical studies (think of epigenetic research) encouraged the view that many features of organisms could not be 'explained away' in terms of the mechanics of the elements[10]. We could say that emergentists take a middle position between strong reductionists, who define consciousness in terms of the brain, and dualists who assert that consciousness arises from additional mental (or vital) essences. Emergentists insist that brains can be conscious, while neurons of the brain are not (Davies, 2006, p. 10). I would like to express some preference for a middle position in the tradition of philosophical anthropology. Adapting an emergentist position to my own purpose, I could say that not all properties of living beings could be completely reduced to the fundamental structure of matter. In each new level of complexity something new emerges; in a way that does not conflict with the laws of physics. If we look at the notion of boundaries of Plessner again, from a emergentist' perspective we could say that all boundaries of living things are negotiable and subject to qualification. Each stage of the organic life can be viewed as a transition point, in which living beings transform and new (often more complex) qualities arise. In the emergentist anthropological view, the human is not vegetative or an *animal rationale*; a plant or an animal with something extra added to physical processes. What we should see is that all living beings, plants and animals share a genetic past (we all share the

[10] See the epilogue of the Dutch translation of Denis Noble's *The Music of Life* in which Jos de Mul notes several empirical studies that encouraged the view that an *integrated* approach of life is needed (De Mul, 2016, p. 195).

property of ‘being alive’), but in a qualitatively different manner. Thus, every living being acts on the natural world in a different manner from the efforts from which it emerged.

According to Plessner, the paths of evolution have led to a uniquely human quality that plants don’t have: excentric positionality. The excentric position deepens human life; we can take distance from our own physical existence. That is, we can take a position *about* our position. We are tempted to locate ourselves at the top of the hierarchical system of life, but what we must see is that every living organism considers itself to be the supreme subject in their world. Perhaps anthropocentrism is ‘natural’ and unavoidable. And it helps to explain our plant blindness as well. Human beings are living beings who are constantly trying to adapt themselves to the environment, by trying to control ‘nature’ in order to reproduce themselves. It is unlikely that we will be able to overcome anthropocentrism, so perhaps the best we can do is being reflective about it. Being reflective means to think carefully about the concepts of ‘nature’, ‘organic life’ and our part in it, learn from our experiences and engage in conversations. All species are part of a system of interrelatedness. We are not the superior ones. The natural world is more complex, dynamic and creative than we previously understood. Being a reflective being can help us better understand the multitude of ways in which plants that are everywhere around us make us human.

Conclusion

The aim of this thesis was to open up new ways of thinking about plants, because plants are up until now mainly understood to be significantly different from animals and humans. Besides, plants are seen as unworthy of human consideration. In order to overcome the division between plants and humans, I outlined the elements of a 'philosophy of plants' and reflected on what seeing plants in relationship with us means for human life. What insights have we obtained?

First of all, it has become clear that our anthropocentric ranking of plants as inferior to us is misguided. We are all part of nature and the differences between plants and animals are not as significant as once believed. However, most people still tend to think we should not pay much attention to plants. This led me to question why it is that so many people tend to overlook plants in their environment. A detailed analysis of our plant blindness revealed that this blindness is a deep-rooted human condition. Our education, public programs and even nature protection highlights the life of animals instead of the life of plants. Researchers concluded that the primary factor for explaining why people tend to overlook plants, is because of limitations on human visual perception. Our visual and cognitive system turned out to be responsible for the ignorance and inattention to plants.

This led me to realize that philosophers also have been underestimating plants. For centuries philosophers have ranked plants as inferior to animals, because plants lack sense-perception, desires, self-motion and rationality. This line of reasoning started with Aristotle, who was one of the first philosophers who defended a strict hierarchical system of life. Later, in modern philosophy, Descartes held on to the belief that humans are the most significant creatures, because of the idea that only humans are rational and capable of language. In the eighteenth century, the idea of a hierarchical classification of the natural world was still alive, as Linnaeus' system showed. However, we could also notice that the idea of one hierarchical order came into question in this century, when de Lamarck argued that organisms have a build-in tendency to climb the ladder of complexity. Finally, we could see the idea of stages in the organic life back in the philosophical anthropology of Plessner. Especially important for a 'philosophy of plants' is that Plessner created an opening to appreciate other forms of life as well.

However, the one that really shook up the idea of a clear and hierarchical system of life was Charles Darwin. By discussing some of his botanical works, I showed that his experiments shed a new light on the plant kingdom. By revealing the complex ways plants respond to ever-varying conditions of life, Darwin showed that plants are not the passive, automatic organisms as opposed to humans and animals. Instead, plants are active and sophisticated organisms. He created a new perspective on the life of plants: plant responses to stimuli could be viewed as a form of plant behavior, similar to the instincts of animals. Perhaps the following words written by Darwin (1880) show his perspective the best:

> It is hardly an exaggeration to say that the tip of the radicle thus endowed [with sensitivity] and having the power of directing the movements of the adjoining parts, acts like the brain of one of the lower animals; the brain being seated within the anterior end of the body, receiving impressions from the sense-organs, and directing the several movements. (p. 573)

Thanks to Darwin the strict borders between animals and plants slowly began to blur.

In part II of the thesis, I investigated what the latest research in plant biology could tell us about the world of plants. In this part, I formulated a critical anthropomorphic vocabulary with which to analyze the life of plants. This vocabulary is used as a means to open up new ways of thinking about plants and in the end about what we are. In the first section, I discussed recent research to question plant sensory perception. Plants have evolved sophisticated perceptual abilities that allow them to respond to ever-changing environments. Plants differentiate between (far-)red, UV-light and blue light and can distinguish different touches. They also respond to olfactory and chemical cues. Plants appear to be active participants in interaction with each other and other organisms, which I further elaborated by focusing on the diverse ways plants communicate. Plants communicate aerially by releasing airborne chemical signals and plants interact via underground complex fungal networks. Plants can also detect vibrations produced by chewing insects and respond to damage from herbivores. Researchers found out plants can even communicate bio-acoustically, by making and responding to clicking noises. In the final chapter of part II, I made it clear that plants are able to form memories, retain this memory for a certain period and recall the memory in order to respond to it. Plants can even learn from their past, for example when they are exposed to environmental or physical stress, they modify their physiology accordingly to protect the next generation from future damage. In a sense, plants can be viewed as intelligent as well. A very recent discipline in the study of plant intelligence is plant neurobiology. I discussed this discipline, because highlighting similarities between different organisms, opens up the debate about the parallels between the manners animals process information and the ways plants function. This can help to overcome anthropocentric tendencies that dominated human thinking for centuries. To be sure, the term “plant neurobiology” is not the best choice, because plants obviously lack a brain and a nervous system. But animal and plant cells do share all kinds of similarities; a connection which we easily tend to overlook.

Exploring what recent research could teach us about the amazing competencies of plants, brought me to the question if there are any implications of a ‘philosophy of plants’ for us, regarding the relationship between human and plant. Traditionally, in natural philosophy the vegetable was viewed as something completely different than the physical. However, it became clear that de la Mettrie related the two. He showed a new perspective on the exceptional position of humans, which he strongly criticized. He did so by highlighting the plant as a material animal and the vegetable part of humans. Even today, the idea of a “man as plant” teaches us that a hierarchical system of life is not as clear as it seems. On the one hand, we could see that Plessner held on to a certain typology of the organic. On the other hand, he made us realize that *because* we share characteristics with plants and animals, we are able to analyze these other types of living beings. Or, as Heidegger pointed out, we can come to a better understanding of other species, to the extent to which we can go along *with* them.

Thanks to Pollan and Oudemans, we came to the realization that humans and plants have formed a similarly reciprocal relationship. By telling the stories of four domesticated plants, Pollan called attention that it is not only humans who are in charge of the natural world, but plants are modeling us as well. He reminded us that we often overestimate our agency in nature. By discussing his ideas, it became clear that we don’t stand outside, or apart from nature. In fact, we are part of nature’s web. Oudemans made an important contribution to a ‘philosophy of plants’ as well, because his vegetative philosophy allows us to escape the object-subject dichotomy and problematic divisions humans have been created, such as the division between nature and culture. By referring to the Dutch landscape and by discussing the current tendency to eat more ‘natural’ products it has become clear that the opposition between natural and unnatural is highly problematic and ambivalent.

In the final chapter of the thesis I expressed some preference for an emergentist middle position in the tradition of philosophical anthropology. An emergentist perspective provides a more accurate account of the complexity and dynamics of the natural world and ‘the human’ than was possible within the two most powerful models of anthropology, in which humans are mainly compared to God, animals or machines. In describing such a view, I made it clear that emergentism resonates with the biophilosophy of Plessner. In an emergentist perspective, each stage of the organic life can be viewed as a transition point, in which living beings transform and new qualities arise. This means boundaries between plants and humans are subject to questioning. The organic life cannot be completely understood or ‘placed’ within a closed and hierarchical system.

Throughout the thesis I mainly focused on the similarities between humans and plants, because of the long history of our misguided anthropocentric ranking of plants as inferior to animals. Moreover, we all suffer from plant blindness. And focusing on the lives of plants in relationship with us, affects the way we see ourselves too. Increased knowledge of the complexity and sophistication plants manifest in the way they adapt themselves to changing circumstances, led us to realize that the differences between humans and plants are not as important as once believed. In fact, humans and plants are more closely related than we previously understood. As a consequence, the relations between plants, animals and humans need to be rewritten. Sharp divisions, such as humans-animals-plants, nature-culture and object-subject will not do justice to the complexity of the natural world, in which everything is interrelated. Plants are like reflectors, in which we can see ourselves in a different way: we emerged from vegetal roots.

Bibliography

- Appel, H.M. & Cocroft, R.B. (2014). Plants respond to leaf vibrations caused by insect herbivore chewing. *Oecologia, 175* (4), 1257-1266.
- Bilichak, A. & Kovalchuk, I. (2016). Transgenerational response to stress in plants and its application for breeding. *Journal of Experimental Botany, 67* (7), 2081-2092.
- Bücking, H., Mensah, J. A., & Fellbaum, C. R. (2016). Common mycorrhizal networks and their effect on the bargaining power of the fungal partner in the arbuscular mycorrhizal symbiosis. *Communicative & Integrative Biology, 9* (1), 1-4.
- Calvo, P. (2016). The philosophy of plant neurobiology: a manifesto. *Neuroscience and its philosophy, 193* (5), 1323-1343.
- Chamovitz, D. (2012). *What a plant knows: A field guide to the senses.* New York: Scientific American/ Farrar, Straus and Giroux.
- Darwin, C.R. (1865). On the movements and habits of climbing plants. *Journal of the Linnean Society of London, 9* (33-34), 1-118.
- Darwin, C.R. (1871). *The descent of man, and selection in relation to sex.* (Vol. 1). London: John Murray. Retrieved from http://darwin-online.org.uk/content/frameset?pageseq=117&itemID=F937.1&viewtype=text
- Darwin, C.R. & Darwin, F. (1880). *The power of movement in plants.* London: John Murray. Retrieved from http://darwin-online.org.uk/content/frameset?viewtype=text&itemID=F1325&pageseq=1
- Clayton, P. & Davies, P.C.W. (2006). *The re-emergence of emergence: the emergentist hypothesis from science to religion*. Oxford/New York: Oxford University Press.
- Descartes, R. & Verbeek, T. (2011). *Bibliotheek Descartes. Band 3. Over de methode: Essays.* Amsterdam: Uitgeverij Boom.
- Foote, C. (2015, June 16). Hummingbirds and plants: an evolutionary love affair? Retrieved from https://blogs.biomedcentral.com/bmcseriesblog/2015/06/16/hummingbirds-plants-evolutionary-love-affair/
- Gagliano, M., Mancuso, S. & Robert, D. (2012). Towards understanding plant bioacoustics. *Trends in Plant Science, 17* (6), 1-3.
- Heidegger, M. (1983). Die Grundbegriffe der Metaphysik. Welt- Endlichkeit - Einsamkeit, in *Gesamtausgabe*, Band 29/30. Frankfurt am Main: Klostermann.

- Honenberger, P. (Ed.). (2015). *Naturalism and philosophical anthropology: Nature, life and the human between transcendental and empirical perspectives.* New York: Palgrave & Macmillan.
- Kampen, H. van. (2005). *Heideggers Dasein en de mechanica van de levende natuur* (Doctoral dissertation). Leiden: Universiteit Leiden. Retrieved from http://www.filosofie.info/wp-content/VanKampen.pdf
- Karafyllis, N.C. (2007). Pflanzenmonster im Film. Kultur- und naturwissenschaftliche Versuche, Bewegung ins Vegetative zu bringen. In Ed. S. Scholz/F. Holtschoppen, *MenschenFormen. Visualisierungen des Humanen in der Neuzeit* (pp. 204-224). Königstein/Ts.: Ulrike Helmer.
- Karafyllis, N. C. (2012). Julien Offray de La Mettrie: *L'Homme-Plante* (1748) - Zum Versuch einer Anthropologie jenseits von Tier- und Maschinenmodell. In: Mariacarla Gadebusch Bondio/Hania Siebenpfeiffer (Ed.): *Konzepte des Humanen*. Ethische und kulturelle Herausforderungen. *Lebenswissenschaften im Dialog*14 (pp. 25-54). Freiburg: Alber.
- Mescher, M.C. & De Moraes, C.M. (2014). Role of plant sensory perception in plant-animal interactions. *Journal of Experimental Botany*, *66* (2), 425-433.
- Mettrie, J.O. de. la. (2016). *Man a machine.* (G.C. Bussey, Trans.). Chicago: The Open Court Publishing co. (Original work published 1748) Retrieved from http://www.gutenberg.org/files/52090/52090-h/52090-h.htm
- Mul, J. de. (2013). Dilthey, understanding nature. Dilthey, Plessner and biohermeneutics. In G. D'Anna, H. Johach, E.S. Nelson, *Dilthey, Anthropologie und Geschichte* (pp. 459-478). Würzburg: Königshausen & Neumann.
- Mul, J. de. (3 mei 2015). Terug naar de natuur? Nee, bedankt. Retrieved from https://www.trouw.nl/groen/terug-naar-de-natuur-nee-bedankt~ae11ff43/
- Noble, D. (2016). *De muziek van het leven: Biologie voorbij de genen.* (T. Roozenboom, Trans.). Amsterdam: University Press B.V. (Original work published 2006)
- Oudemans, Th.C.W. (2014). *Plantaardig: Vegetatieve filosofie.* Zeist: KNNV Uitgeverij.
- Peeters, N. (2016). *Botanische revolutie: De plantenleer van Charles Darwin.* Zeist: KNNV Uitgeverij.
- Pollan, M. (2001). *The botany of desire: A plant's-eye view of the world.* New York: Random House.

- Sachs, F.G.J. (1875). *Geschichte der Botanik vom 16. Jahrhundert bis 1860.* München: R. Oldenbourg.
- Stolarz, M. (2009). Circumnutation as a visible plant action and reaction. Physiological, cellular and molecular basis for circumnutations. *Plant Signaling & Behavior, 4* (5), 380-387.
- Waal, F.B.M. de. (2016). *Zijn we slim genoeg om te weten hoe slim dieren zijn?* Zutphen: Drukkerij Wöhrmann.
- Wandersee, J.H. & Schussler, E.E. (2001). Toward a theory of plant blindness. *Plant Science Bulletin, 47* (1), 2-9.