Decentralized Life Processes of Plants and a Comparison with Animals

By Claudia Martin

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Language and music have been the focal points of her professional life. She worked as a translator and has written essays and fiction. Her most recent book of whimsical fantasy stories is titled *Imagine That!*

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First, some statistics. There are 300,000 to perhaps 500,000 vascular plant species and 2,800,000 non-vascular plant species, like mosses and lichens. The earliest plants on the planet are algae, which still supply 70% of the oxygen to our atmosphere. There are 72,500 species of algae, and they have existed for seven billion years. Among vertebrate animals, there are 30,000 fish species, 9,200 bird species, and 6,200 mammal species alive now. Of invertebrate animals there are 1,300,000 species. Insects alone have one million species.

This paper's origins lie in a book recommendation from *Scientific American. What a Plant Knows: A Field Guide to the Senses* by Daniel Chamovitz, Director of the Center for Plant Biosciences, Tel Aviv University, opened new vistas on plant life for me, a non-scientist, with its 140 notes about research done by other scientists and twelve pages of notes concerning scientific terms, concepts, and substance and process names.

Another book about plant life, *Brilliant Green* by Stefano Mancuso and Alessandra Viola, prompted me to do further extensive studies. Using Greek and Latin roots, researchers constantly form new scientific terms, creating a lingua franca that can be used by botanists all over the globe. An amusing example is the term "thigmomorphogenesis," which means response of plants to mechanical stimulation. Why not say so in the first place! Charles Darwin was a great inventor of botanical terms. He created the word "circumnutation" for the internal movement of plant parts in spirals or circles. So, if you ever had too much to drink and are weaving a bit, you could simply say you are circumnutating.

In the seventies, a pseudo-scientific book called *The Secret Life of Plants* created a great sensation by combining some scientific discoveries about plants with esoteric, spiritual wishful thinking. A plant has no central nervous system, no emotions, and no sense of hearing, so playing Mozart does not make it grow; neither does praying over it. The most recent successor to *The Secret Life of Plants* is *The Hidden Life of Trees*, by Peter Wohlleben, which mixes science with human emotional terms. A plant does not intentionally communicate with its neighboring plants. Humans may have emotional bonds to plants, and human attention may influence plant growth, but the emotion is coming strictly from the human side, and to use concepts formulated to describe human communication to describe what plans do is misleading. These books and others like them may be amusing, but they can be dismissed as not totally factual.

The better-grounded books discuss what a plant sees, smells, feels by touch, how it uses electro-chemical signals, how it sleeps and hibernates, how it knows where it is, what it remembers, how it senses gravity in the root system and overcomes gravity with upward and sideward growth, how its immune system and defense mechanisms work, the ways in which it is aware, how it knows time and seasons.

The words for sensory input and reaction to it are often taken, admittedly,

from animal concepts. A plant does not "see" or "smell" as animals with a central nervous system do; nor do plants have brains. Plant intelligence is based on distributive, decentralized information systems and metabolic systems. A plant receives input from the environment through many distributed cell systems and reacts to this input electro-chemically through a pathway comparable (but not identical) to animal nervous systems. Input is directly sent to those specific cell complexes, mainly in the root systems, which can react to it. By decentralizing the metabolic functions, a plant assures continued survival, should a section of it be destroyed. Since plants are stationary, they cannot flee from predators or natural events. A distributive information system is essential for plant life.

Plant intelligence works differently from animal intelligence; nonetheless, it is intelligence, and calling it intelligence is not merely a romanticized fantasy. Human hubris had long assumed that humans are the only intelligent life forms on earth, but in the past sixty years, thanks to numerous academic researchers and field studies occurring all over the globe, science established that animals and plants operate with a form of intelligence. Nor is language a prerequisite for intelligenceThere are manifold non-linguistic communication methods in other life forms: sounds, body language, colors, chemical and electrical messages.

Intelligence is a universal necessity. We may define universal intelligence as the ability to evaluate sensory input from the environment and to respond to it with appropriate actions, including communication, learning, decision-making, and memory. Since the multi-dimensional network of causes and effects in our universe create an ever-changing environment, fixed instinctual programs alone cannot succeed in that environment. An array of different forms of unifying intelligence is essential for the existence of both plants and animals.

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There are similarities and differences between the intelligence of animals and that of plants. This paper is a very brief glimpse into that vast topic.

Plant life has existed on our planet for almost two billion years, a long time in which to develop complicated reactions to environmental challenges. Animals have existed for about 450 million years. The basic elements of genetic code are the same in plants and animals—we are all related. Animals, however, mainly use light and sound waves for information gathering and communication, while plants more often use electro-chemical messages.

Plants exhale oxygen during daytime and thus have made oxygen available for animals to breathe in for their metabolic processes.

Sensory perception in plants and animals frequently uses the same cell structures. For instance, the three sight sensory components that enable animal eyes to transform electro-magnetic light waves into sight are similar to the light sensitive cells in plants. However, plants have *eleven* facilitators, being able to interpret ultra violet and infrared light and other gradients. Plants do not use the green component of the spectrum for photosynthesis; it is reflected back. That is why the plant world appears green to those of us animals who see color.

Plants are the only life forms that can use the sun's energy to transform carbon dioxide (which they breathe in) into food and body energy. This process is achieved with the plant enzyme chlorophyll, contained in cells called chloroplasts. Nutrients obtained from the root systems are also needed. Plants exhale oxygen during daytime and thus have made oxygen available for animals to breathe in for their metabolic processes.

The difference between plants and animals that we likely think of first is that plants are stationary and animals are mobile. Mobility is the reason why only animals developed the sense of hearing, so as to hear predators and prey, to communicate with each other, to warn of danger, and to find mates over a distance. Despite being stationary due to their dependence on their root systems, however, plants have developed many means to move their seeds over distance. First, there was only wind, rain, and gravity. Plant pollen can be transported by wind, as many human allergy sufferers can confirm. Consider the bird feather-like appendages of dandelion seeds, which have developed a method of flight comparable to feathered flying animals at later periods. Maple seeds, with one flying wing and a heavy seed at the other end, use gravity to circle in the air and finally penetrate into the soil. Plants have also developed countless ways of using the mobility of animals to spread plant seeds by providing carbohydrates, proteins, and sugars in their seeds as animal food in addition to feeding the plant seedling. Plant colors and fragrances aid in animal attraction.

Stationary plants are not devoid of internal movements. They move a lot

within their bodies, changing positions in a daily rhythm, moving up and downwards, in spirals and circles adjusting to external information.

Flowering plants with sperm and ovaries developed after animals appeared on the planet. Ferns already propagated with haploid cells, namely ovaries and a huge amount of sperm cells. The fern sperm cells are mobile in rainwater with the help of flagella, the same as animal sperm. Mixing of hereditary factors is essential for plant and animal reproductive variations. Both plants and animals produce a huge surplus of possible progeny. From millions of sperm cells, maybe only one new organism will develop.

Plants are the producers of food and animals the consumers of that food. Animal life would not have come into existence without already-existing plant life. However, the essential role of animals to spread plant seeds creates a symbiotic relationship between plants and animals, including humans. Animal waste and decaying bodies also add nutrients for plants to the soil, as do dead plant components. Billions of beneficial bacteria work for the life processes in plants and animals alike. Some also are unsuited and cause infections.

When infections occur, both plants and animals have immune systems to fight them. The white spots one can sometimes observe on plant leaves are a sign of immune cells surrounding and shutting off harmful bacteria or fungi. Fungi are not as generally deleterious for plants as they are for animals, however. Plants live in symbiosis with billions of fungi in the plant root system. These fungi help to hold moisture, break down food, and stimulate electric activity, but also consume some of the plant-created food sources. Fungi transmit chemical reactions of plants infested by parasites or insects to the root systems of neighboring plants, enabling these to produce chemical counter measures to avoid infestation. This is a form of communication between plants, helped by fungi, but it is an anthropomorphizing stretch of the imagination to say plants "message" to each other or "help" each other intentionally.

Plants produce over 800 different chemicals, with many more perhaps still to be discovered. Animals use plant chemicals for medicinal purposes just as plants themselves do. For instance, salicylic acid from willow bark is the essential ingredient of the human wonder drug aspirin. Quinine, very effective against malaria, is another important plant medicine from the tropical Cinchova tree bark. Medicinal plant chemicals are often very bitter, which discourages insect larvae or aphids from eating leaves. People may need the proverbial "spoonful of sugar" to tolerate plant medications.

Plants have two vascular systems to transport liquids and nutrients, like blood and lymph vessels in animals.

Both animals and plants have sensory abilities to assess environmental input. Animals have a more or less centralized nervous system and an organ called the brain, built on electro-chemical processes in networks of billions of neurons. Special brain centers are devoted to specialized tasks. In plants, the root systems contain millions of tiny root tips, which can sense and direct environmental input, which together with other environmental sensory input is sent to the appropriate cell complexes, which can take action for or against it. These cell complexes work on the same electro-chemical principles as in animal neurons, with similar chemical elements and their salts creating the ion flow (mainly potassium, sodium and calcium). Together they form a network of information and action similar to that of a human computer internet, which likewise has no controlling central authority.

Both plants and animals have supporting physical structures, but of different kinds. Vertebrate animals have interior skeletons built of minerals like calcium; invertebrate animals may have a supporting system of collagen. Insects have an outer shell built by organic chitin. Mollusks and other animals without a skeleton may build outer protective layers using minerals. 97 percent of all animals are invertebrates. Plant structures are supported by organic fibers, which can obtain great strength and thickness, as in the trunks of trees. Plants have two vascular systems to transport liquids and nutrients, like blood and lymph vessels in animals. Plants do not have a central pumping system like a heart, but rely instead on hydraulic pressures and gravity, somewhat similar to animal lymphatic systems.

Both plants and animals need to sleep. Plants go into a sleep state prompted by the absence of light, as many animals do. Animals can be awakened by touch or by sound, plants only by light. Flower growers take advantage of this trait by shining red light on sleeping flower plants, waking the plant's metabolism, and thus the growers can coax chrysanthemums to bloom for Mothers' Day instead of in the fall. Flowers often close their petals for sleep, and other plants often change their positions, leaves drooping or

folding into the fetal position of their budding stage. Many animals also curl up for sleep in fetal position. In contrast to animals, plants change their breathing during sleep, inhaling oxygen for internal purposes and exhaling carbon dioxide to get rid of waste products.

In cold climates, plants may live only for one season, reproducing every year by their seeds, but other plants, like some animals, go into a state of hibernation. Deciduous plants shed their leaves and cut off photosynthesis and supply of liquids. Energy supplies are stored in roots, tubers, or bulbs, just as animals prepare for winter with body fat or stashed food. Animals have the advantage of being able to migrate and may also grow thick furs. Plants do not migrate, obviously, but a few have invented fur-like covers of plant material for their early spring buds. Just consider the fur-like outside of pussy willow buds. A good idea is likely to be achieved by evolution several times, a phenomenon for which the scientific term is "convergence".

Coniferous trees do not hibernate. Their many narrow needles do not contain much liquid for freezing. Needle-bearing plants have also developed a chemical antifreeze to add to liquids in wintertime. Some slower photosynthesis is sustained by spreading branches into available sunlight.

A plant has the ability to recognize volatile particles in the air it breathes, which in animals we would call a sense of smell. This ability often leads to the formation of cells that counteract harmful invasions of pests. A plant's defense and immune system is also informed about injuries and remembers attacks for several weeks. It then produces repair material—for instance, resins to heal tree bark. Similarly, in animals a protective scab of coagulated blood platelets forms over skin injuries.

Plants have a sense of touch and react to contact with animals and other plants. An extreme example is the Mimosa Sensitiva, which recoils its leaves at the lightest touch, thus reducing edible surface and also squashing small insects. Flowers react to the touch or the buzzing vibration of sound waves of insects by releasing nectar.

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By measuring the differing lengths of light waves, a plant obtains a sense of time and the passage of the seasons. Morning light contains more blue, evening light more red fractions. Plants notice seasonal changes in length of daylight as animals do.

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What is a plant? With the exception of algae, a plant is a multi-cellular, stationary living organism with the ability to sense environmental stimuli and to process them for all its needs, including propagation and defense. A plant can sense different electromagnetic light wavelengths. Thanks to this ability, a plant knows light and darkness, time and seasons. A plant can sense the chemical molecules of smells, can feel touch and gravity, heat and cold. It is aware of place and space. It notices inflicted injuries and takes action for repair.

In short, a plant is a living organism with decentralized metabolism and decentralized intelligence.

Plants are very ancient ancestors of animals. Although animals share the same basic genetic code with plants, a plant's functioning is alien to us humans, as plants do not have emotions, nor empathy with neighboring plants of the same species, nor intentional communication. Yes, plants can assess special electrochemical messages from neighboring plants and intertwining root systems. But plants do not intentionally help each other; they are strictly self-oriented. Yes, they establish symbiotic or dependent relationships with other life forms, but only on a utilitarian basis. Aggressive forms of plant defense with thorns and poisons are not a sign of intrinsic emotional hate or lust to kill.

Although we need to be wary of romanticizing claims made about plants by this or that bestselling book, the fact remains that plants are the basis of all life on this planet. It behooves us as super-intelligent organisms to treat and preserve plants with awe and respect. We utterly depend on them.

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