29 April 2008
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The Senses of the Plants

The way they feel their environment

Plants may not have complex tissues and a nervous system, but they still "feel". If they sprout, develop and flower at the right time and place, that's because they are sensitive to environmental factors. The vegetation boom during each spring shows they obey precise rhythms, which come encoded in their genes. Plants do not have only a touch sensitivity (that has been known for quite some time), but also a chemical one, not to mention their sensitivity to light and temperature variations. This way, plants can appreciate the length of the day and the air temperature, adopting a position fitting their neighborhood. A wound, stress or a disease trigger specific defense mechanisms. Information about their state and environment circulates along signals transmitted from one cell to another, from plant to plant, or even from one plant to other beings. Their sensitivity translates via movements, growth directions and metabolism changes. **Plant touch**Any plant reacts to the slightest touch. In the case of about 1,000 species, this reaction is almost instant: **carnivorous plants** close their trap immediately, the sensitive plants (like Mimosa) retreat their leaves, while nettles break their stinging hairs. In all the other 240,000 species, movements are slower. At the slightest touch, the plant Sparrmannia africana opens up its staminas, making crossed pollination possible. Some plants from the family of the cucumber reduce the length of their stem, increase their diameter and turn stiffer in the next 48 hours after experiencing a rub. Trees exposed repeatedly to the attacks of winds and rains react in the same way, thus creating asymmetry. Legumes have a specific swelling called pulvinus at the base of their leaves. This organ triggers rapid movements (of less than a second), as a reaction to touch or light variations. A sensitive plant requires 30 minutes to return to its initial position, especially if it has been stimulated repeatedly. Darkness causes the folding of the leaves and flowers (in the case of clover and other species) or their opening (in the case of the nightshade). **Plants and light**The photoreceptors of the plants are sensitive not only to the amount of light they receive, but also to its quality. Depending on light, plants orientate in space and time. Some photoreceptors pigments are more sensitive to red, others to blue or ultraviolet. They also distinguish if the light contains more light red or dark red. Both types of light are present in the daylight, but the light red stimulates seed germination and chlorophyll synthesis, inhibiting stem length growth. Under a dense plant cover, there is a relative excess of dark red. In this case, the balance moves towards the inactive form of the phytochrome. The inhibiting process stops and the stems grow longer, a process called "the syndrome of shadow avoiding". The same thing happens when plants grow too dense. In nature, the competition for light is beneficial, but in crops, it determines the plants to use their reserves in order to grow longer, towards the light, instead for the growth of the leaves, seeds or tubers. Based on this phenomenon, specialists engineered plants (like tobacco) that do not naturally react to daylight, increasing the productivity of those crops. The element that detects the intensity and direction of the blue light, the cryptochrome, intervenes in the process of opening the stomas, the pores through which the leaf makes gas exchanges. Due to these photoreceptors, a room plant placed close to a window will bend towards it and will place its leaves perpendicularly on the direction of the sunlight.The first plant receptors of blue light were detected in 1993 in Arabidopsis. They were similar to those found in fruit fly, mice and humans. They represent a kind of universal clock in the living world, ensuring the regularity of a large number of biological functions along 24 hours (the circadian rhythm). The cryptochrome seems to have emerged in bacteria, having a defensive role for their DNA. In plants, it controls growth and flowering. In some plants, like the lily of the valley, flowering depends on the sum of the temperatures experienced by the plants. Like many species (from wheat to olive), this plant must first undergo the cold of the winter in order to flower. This is called vernalization. Spring flowers are extremely sensitive to temperature variations: just one degree more or less makes them open or close back. The same goes for plants adapted to drought that produce proteins that protect them from the harmful effects of the heat. When plants "perceive" the presence of nitrates in the soil, they develop lateral roots. In 1998, the gene controlling this "branching" was detected. **The chemical sense of the plants**After "tasting" the chemical betraying the presence of an aggressor, a plant is able to unleash a chemical war against it. The most sensitive plants create a strong barrier between the aggressor (virus, bacterium or fungus) and the backward intact cells, killing the attacked cells. The emitted chemical signals often spread far away from the attacked point, stimulating prolonged defense reactions. When defoliated by the caterpillars of moth, Zeiraphera diniana, the larches produce smaller and less nutritious leaves, a fact that diminishes the number of predators for 4-5 years. The beech attacked by the aphid Phyllaphis fagi synthesizes chemicals that inhibit the digestion of the insects. The pine invaded by insects digging galleries in its bark responds through an increased release of resin. The oak opposes to the growth of the mistletoes by producing increased amounts of toxic tannins. At the moment, over 10,000 plant secondary metabolites, with toxic or rejecting actions against the plant-eating insects are known, like alkaloids, tannins, peptides and terpens. When in danger, plants also emit SOS signals. The phenomenon was first signaled in the bean attacked by mites. The plant emits an array of chemicals that attract other mites, predators of the first. The presence of the Spodoptera caterpillars on the corn leaves triggers the release of a chemical cocktail that attracts the parasitoid wasps of these larvae. Just one molecule from the saliva of the caterpillar is enough to cause the SOS signal. The tobacco chemically attracts the wasp Cardiochilles nigriceps, when attacked by the caterpillars of the moth Heliothis virescens, but it remains inert to the presence of the caterpillars of Helicoverpa zea (that attacks the corn). Some corn varieties defend themselves against the root worm (Diabrotica virgifera), emitting chemicals that attract minute nematode worms that kill the root worms, which are in fact the larvae of a beetle. One chemist made an experiment: he investigated how willows react when attacked by a caterpillar, so he assigned them to two lots: one which he invaded with caterpillars and another as a witness, leaving it "untouched". After 14 days, he picked up leaves from the two plots to feed other caterpillars, this time in the lab. He found that the larvae that ate small amounts of leaves were growing very slowly. But what was more puzzling is that leaves from both plots were equally "unpleasant" for the caterpillars. What had happened? Both willow groups filled their leaves with a chemical that proved to be repulsive for the insects. The message had been transported by ethylene, a gas normally produced during the reaping of the fruits but also released by harmed or irritated tissues. In other trees, the reception of the message induces the synthesis of the tannins, lignin and other defensive chemicals. Another potential message may be the acetylsalicylic acid (or aspirin), extracted from the willow bark ("salix" means "willow" in Latin). Poplars react similarly to willows to insect attack. When informed about an occurring attack, up to 50 % of the compounds synthesized by a tree can be used as defense products, stored mostly in leaves, their most vulnerable organ. However, trees were found to communicate not only for defense, but also in order to time their blooming. In fact, blooming at the same time can also be a defense mechanism, as the consumers will not have enough time to eat too many flowers, as it would happen if trees bloomed one after another. Parasite plants were even found to sniff their host-plants, selecting only the preferred ones! The dodder (Cuscuta) attacks tomatoes, carrots, onions, citrus trees, cranberries, alfalfa and even flowers. It blankets and kills its host. Scientists thought the dodder simply grew at random, with the discovery of a plant to attack being just a chance encounter. A 2006 research showed dodder can sense chemicals released by host plants and then head for that direction. It can even identify favorite plant hosts over less desirable ones. When the shoot finds a victim, it begins growing in a coil around the host plant, injecting needles into stems and leaves to suck out water and nutrients. As dodder seedlings have only a limited amount of food in their seeds, they must find a host plant quickly or else they die. Scientists found in a lab experiment that 80 % of the dodders grew towards a tomato plant. When they tried to trick the dodder seedlings with artificial tomato plants, it turned out didn't take the bait: 77 % grew towards the real plants. Moreover, the dodders could distinguish between a favorite host plant, such as the tomato, and a poor one such as wheat. When placed in the middle of wheat and tomato plants, the dodders swayed aboveground in circular movements in the direction of the tomato plants. Scientists suspect the dodder is equipped with sense receptors that can smell their hosts. **Plant hearing** What about the hearing of the plants? Many plant lovers are convinced the sensitivity of their indoor plants to music is real. Some farmers believe that sounds louder than the human voice stimulate the germination and rapid growth of some vegetables. Researches made so far did not confirm or infirm the auditory skills of the plants.