Evolution of Carnivorous Plants

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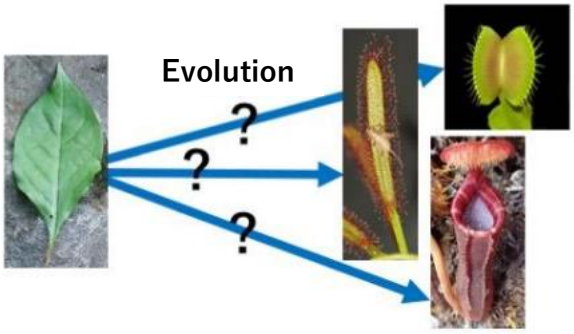
The hallmark of living organisms is that they evolve. However, when I was a student, many elitist professors said that evolution was not a science but "evolutionarism" because it could not be reproduced by experiments. However, with advances in biology, it became possible to decode various organisms' genomes (entire genes), that contain traces of evolution. Evolutionary biologists achieve their dream to infer the evolutionary process with statistical significance. Furthermore, advances in genetic recombination technology have made it possible to carry out experiments to make extant living organisms evolve. Today, biologists do not say "evolutionarism" but keep the phrase by Theodosius Dobzhanski in their mind "Nothing in biology makes sense except in the light of evolution".

Two major principles in evolution, Charles Darwin's "natural selection" and Motoo Kimura's "neutral evolution" can explain most evolutionary processes, and there are many empirical examples. However, even with such principles, there still remain unexplained phenomena, one of which is the evolution of complexity. It is difficult to explain the mechanisms needed to evolve complex adaptive traits, because such traits comprise plural components and become adaptive only when all components are gathered together. However, based on the evolutionary principles, each component evolves one by one according to the accumulation of mutations. For example, how did carnivorous plants evolve? Plants usually produce flat leaves for the most efficient photosynthesis. On the other hand, carnivorous plants have modified leaves to attract, capture, digest, and absorb their prey. Once plants acquire the four traits necessary for carnivory, they are advantageous because they can obtain nutrients from prey. However, if each trait evolves step by step, or independently, the intermediate plants with one or some of the four traits are not adaptive and difficult to survive because of the modified leaves with less photosynthetic ability as well as loss of energy to produce digestive enzymes or absorption systems.

How did carnivorous plants evolve?



Over the past few years, the genomes of carnivorous plants, such as the Albany pitcher plant Cephalotus follicularis, the sundew Drosera rotundifolia, the Venus flytrap Dionaea muscipula, and the bladderwort Utricularia gibba, have been decoded. Furthermore, it becomes possible to artificially modify the genomes with genome editing techniques. We are ready to study what genes have evolved to form the carnivorous traits. Japan is leading the world in these studies.

Some carnivorous plants rapidly move to capture prey within a second. How do plants without muscle move? Water movement manages the movement. When water moves into and out of cells, cells expand and shrink, respectively. The change of volumes of multiple cells results in the movement. What genes manage the movement mechanisms and how did they evolve. It is still a big challenge.

Rapid plant movement is not limited to carnivorous plants. You might have seen the sensitive plant Mimosa pudica. The leaves close, when you touch them. They do not move to make you enjoy it. For what? Several hypotheses have been proposed but not yet proved. If we can make non movable sensitive plants with genome editing technology and compare them to movable regular sensitive plants, we will be able to examine what hypothesis is most plausible.

Why does the sensitive plant move?

The Venus flytrap can move rapidly and more. They have a memory system, even without brains. When one of six sensory hairs on a leaf surface is touched once, the leaf does not move. When a hair is touched one more time within 30 seconds, the leaf closes. After more than 30 seconds, no movement. It means that the flytrap memorizes the first stimulus for 30 seconds. How can a plant with no brain and no nerves remember it? This mystery will be solved with experimental techniques developed in Japan.

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