CARNIVOROUS PLANT EVOLUTION

Family Lentibulariacea

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Carnivorous plant evolution has been a mystery for a long time. This is because it is difficult to see how such complex structures could arise on a plant, when it seems there is nothing on a plant that could possibly become a trap. How could a leaf grow tentacles, or become a pitcher, or a flytrap? How could a root become a bladder trap when it seems anything in between a root and a bladder trap would be disastrous for the plant? The answer is that this is misleading. There are intermediate steps that can be advantageous for certain purposes, and structures have not developed from something that was not already there. Even noncarnivorous plants contain within their genetic blueprints the traits needed for traps. Modification and recombination of already existing genes brought about their carnivorous habit.

The butterworts evolved from a noncarnivorous plant that favored wet ground and had sticky, gland-tipped hairs covering its leaves to discourage plant-eating animals. This plant first became carnivorous when a mutation occurred which relocated a gene that controlled the manufacture of protein-dissolving enzyme to the glandular hairs. This gene was originally expressed in the seed, where the embryonic plant used the enzyme to break down food sources stored in the endosperm. With this mutation the plant became able to digest small insects that would sometimes be ensnared by the sticky glands on the leaves. The insect's soft tissues would be digested by the enzymes in the glandular secretions and absorbed through the leaves. Proteins that make up the insect's body contain nutrients which the butterwort needs and which are low in the type of environment that the plant lives. With these made more available, survival is easier. Offspring carried on this trait, and following generations improved the insect capturing and devouring ability. They did this by evolving separate glands that produce enzyme only. These glands developed from modified mucilage glands that lost their stalks to rest on the leaf surface. The enzyme glands produce enzyme when excited by the capture of insects and are responsible for absorption. Another ability acquired by the butterwort is the capability of bending its leaves around digesting prey. This was better for holding and assimilating the resultant fluid. This capacity was adapted from the plants ability to bend toward light. The phototropic response became modified so that the leaf bent in reaction to protein instead of light.

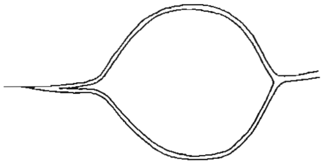
It is evident from the study of floral anatomy that general *Pinguicula, Genlisea, Polypompholyx* and *Utricularia* are closely related. They have all been grouped together in a single family: Lentibulariaceae. The butterwort, genus *Pinguicula,* has the least complex trapping method of its family. This plant, I believe, gave rise to all its more complicated carnivorous relatives.

Butterworts grow on wet ground, often near bodies of water, also around springs on rocks. At one time, long ago, a genetic accident produced air spaces in a butterwort's roots. These cavities became very advantageous when they enlarged into floats, like those seen on some seaweeds. The float bladders kept the plant more buoyant when it was washed into the water. The butterwort could then grow on the water surface where there was less competition for growing space.

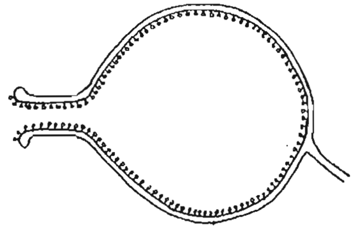
A butterwort of this kind was later affected by another mutation that relocated glandular hairs and enzyme glands to the inner surface of the float bladders. Plants that acquired this trait benefited when small aquatic animals found their way into the bladders and became digested and absorbed in the same manner as if they had been trapped by the butterwort leaf.

Stages of Bladder Elaboration

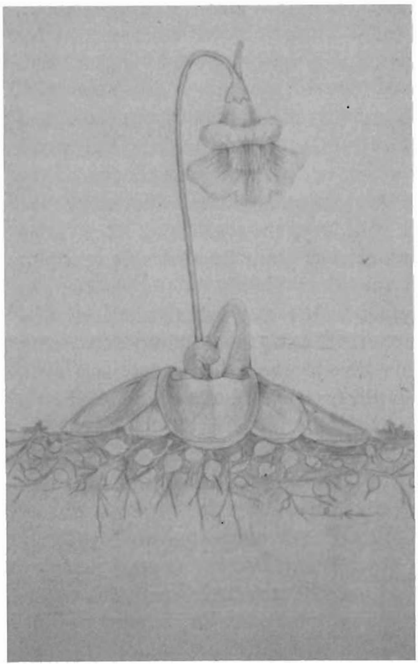
Drawings by Ivan Snyder



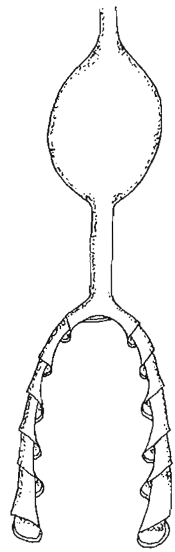
A. Float bladder



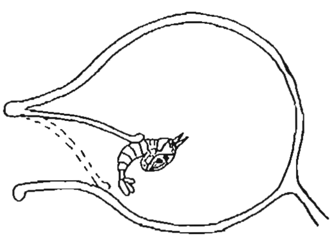
B. Float bladder with translocated glands



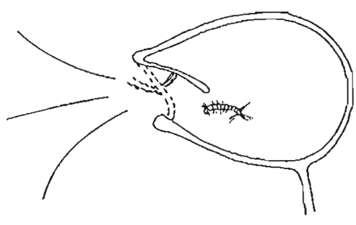
(see description bottom p. 19)



C. Genlisea



D. Trap bladder with oneway door



E. Vacuum trap bladder with trigger hairs on door

CARNIVOROUS PLANT EVOLTUION (Cont'd.)
This new trapping device developed a good passageway into itself and proved to be very efficient. Aquatic animals are much more available than flying insects. Bladder traps were so much better that butterwort leaves were no longer necessary, in fact were a burden. Primitive bladderworts lost the gluey trap on their leaves and developed smaller leaves, more easily kept above water. Some plants in the proper area found it suitable to grow beneath the water, with only the flower above. A plant such as this, advanced in its trap mechanism, came to be *Genlisea.*

Among the primordial bladderworts evolving, some formed oneway doors on their bladders. These doors easily pushed open to let animals enter, but prevented the animal's escape. Natural selection favored bladders with doors, which allowed animals to pass with least difficulty. Mutations caused recombination of genetic material and gave the bladders the ability to alter turgor pressure in some of its cells when touched. Cellular turgor is controlled in the plants phototropic response to make possible the ability to bend toward light. When this became relocated to the walls of the bladders, the bladders could warp and produce a vacuum in the trap. The vacuum would suck animals through the door and into the trap. With time, specialized cells developed into the trigger hairs on the bladder door to signal when they received tactile stimulation.

The bladderworts are a very diverse group. They have evolvd as aquatic, terrestrial and epiphytic plants. Their great success in nature reflects the effectiveness of their trapping mechanism. The bladder traps are the most complex of all the carnivorous plants. Their evolution is difficult to explain without easily recognized steps in increase of complexity leading up to them. To write this article I compared the most advanced, and most simple, features shared by the carnivors to hypothesize the most logical evolutionary scheme. A few of the facts that have led me to believe the ideas expressed in this article are: *Utricularia pubescens* has mucilage glands on its leaf surface. This suggests it may have once had butterwort leaves. Bladderworts have mucilage glands on their bladders. This shows they may have become relocated from the leaves. Aquatic bladderworts use their bladders not only for trapping, but also in floatation. *U. inflata* even has inflated structures for floatation other than its bladders. It is reasonable a butterwort could benefit having air bladders on its roots because of the plant's proximity to water. Perhaps such a plant still exists and awaits discovery.

Literature Cited

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Ching, T.M., Metabolism of Germinating Seeds, chap. 2 pp. 103-218. In: Seed Biology. T.T. Kozlowski, ed. Vol. 2. New York, Academic Press. 1972

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Illustration page 18: Butterwort with float bladders. Depiction of possible evolutionary intermediate linking butterworts to bladderworts.

Illustration by Ivan Snyder. Photo by Bob Mailloux