BIOLOGY

A Lady Who Keeps No Secrets

Daphnia's Lack of Reticence, Even About Her Innermost Personal Affairs, Makes Her Very Useful to Scientists

By DR. FRANK THONE

DAPHNE, the mythology books tell us, was a nymph. Like all the lovely creatures of her kind, she never troubled herself over-much about dress. Yet she had her own notions about privacy, her own reticences. One day Apollo saw her, and promptly gave chase, most ardently. When she saw he was about to overtake her, she implored Jupiter to help her. The Lord of Olympus took pity on her and changed her instantly into a laurel bush. And an armful of scratchy branches was all poor Apollo got for his pains.

About Daphnia, the modern zoological namesake of this beautiful unlucky nymph, the story is quite different. Aside from the fact that she also lives in the water, Daphnia is as little like Daphne as can well be imagined. What imp of irony was in the brain of the great Linnaeus when he chose the slim, graceful, modest nymph to be the patroness of a pudgy-figured, jerky little microscopic relative of the crayfish and the lobster, it is hard to guess.

Daphnia is unlike Daphne even in her notions of what to conceal. Even though Daphne did go about undraped, until she finally clothed herself once and for all in bark and leaves, she at least kept her internal affairs to herself. Daphnia has no such reticence as this. She is so completely without secrets that anyone who cares to put her under a microscope can examine in minute detail her heart and nerves and indeed her whole Department of the Interior. Daphnia is a lady completely without secrets.

And therein lies her usefulness to science. Daphnia is a microscopic water-animal, that breeds in millions in summertime ponds and puddles, and is eaten in millions by little fish that in turn are eaten by bigger fish. Daphnia thus performs a very useful work in the food-cycle of the world. She also performs a very useful work in the world's slow process of acquiring knowledge, for Daphnia is a favorite study-creature with zoologists, because her body is so transparent that they can see every organ in it and watch the operation of her life-processes without the toilsome and messy job of dissecting her.

And she doesn't mind being studied, either. She is so tiny that lying in a drop of water under a microscope gives her no discomfort, and a half-pint milk bottle is as spacious a home for her as the Empire State Building would be for a single human being. So in a shelf-full of small bottles a scientist can keep a huge population of Daphnia sisters.

Trying It on Daphnia

One of the things that can be done with Daphnia, to the benefit of the science of physiology and the art of medicine, is the study of the effect of drugs. Having the same essential organs as a human being, but having them on view at all times, she offers an excellent chance to try out numbers of things that we may want to swallow ourselves later on, for the regulation of our own vital machinery.

This does not mean that the effects of drugs on Daphnia will be exactly duplicated in our own insides. After all, the kinship between man and Daphnia is of the remotest. But at least one can drop a little digitalis in the water she swims in, and watch what effect it has on her transparent little heart. Then one can try a little more digitalis, from a second lot to be analyzed, and again watch her heart. The difference between the two records will give some line on the difference between the strengths of the two drug samples. This method of "assay by Daphnia" attracted some notice recently in the public press, where Daphnia was referred to as a "flea." "Water-flea" is one of her common names, given partly because of her round, flea-like shape, partly because of her method of moving about in jumps and jerks, like a flea.

In such studies as this, it would be most desirable to take photographs, and even motion pictures. But here Daphnia baffled research until lately. She did so not by interposing obstacles but by interposing no obstacles. She is so transparent that she casts next to no shadows at all on a photographic plate; and where there is no contrast of light and shade there can be no photograph. It is as though Daphnia were showing her mythical namesake Daphne that there is more than one way of defeating the searching fingers of the sun-god. By interposing no obstacles at all, Daphnia lets him slip by, baffled.

But Daphnia's photographic elusiveness has met its countercheck in the ingenuity of a German scientist in Prague, Dr. Josef Gicklhorn, of the Zoological Institute. He was interested, too, in the question of reactions to drugs, but to drugs of a particular kind: the so-called vital stains.

There are certain dyes that will color particular tissues or organs of plants or animals, and leave others uncolored or at most very faintly stained. Some of these, like salvarsan, are of great medical importance; others are of less direct use, but serve a purpose in revealing the relationships and origins of various parts of the body. This paves the way for later practical advances by laying a solider theoretical foundation.

Dr. Gicklhorn was interested in both

DAPHNIA'S INVESTIGATOR

Dr. A. M. Banta, Carnegie Institution researcher into the life story of Daphnia. The bottles are community dwellings that house colonies of the little animals.

these aspects of vital stain technique, and he chose Daphnia for his principal research animal because of her beautiful transparency, checking up his results on such creatures as frogs and guinea pigs, which are more nearly related to man but which are larger, more expensive to obtain, house and feed, and must be killed and dissected to see how a stain is working inside them.

Interior Decorations

He found, among other things, that his stains could pick out not only special organs in the body, but special cells or groups of cells in an organ, according to their chemical affinity for these tissues, leaving closely neighboring regions quite unstained. He found also that the same stain that "takes" in a given organ in Daphnia "takes" also in the analogous organ in a "higher" animal: a stain that colors her kidneys, for example, colors also the kidneys of snails, insect larvae and frogs.

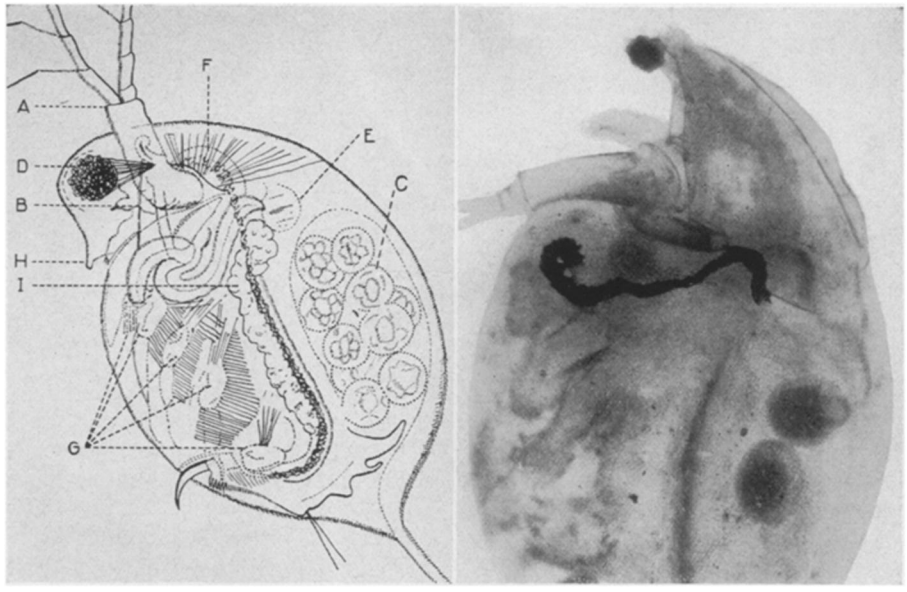
Another thing that Daphnia showed the German physiologist was that the intensity and speed with which a vital stain takes hold depends mainly on the intensity of function of the organ concerned. Thus healthy parts stain more quickly than sick ones; young animals react more strongly and more quickly than old.

Normal, healthy organisms always give a typical picture with vital stains, he discovered. And when an animal is beginning to get sick, it shows it in the stain-reaction more quickly than it does in its general behavior and appearance.

And the beauty of all Dr. Gicklhorn's chemical researches on Daphnia was that they automatically made her photographable. He has been able to obtain a considerable number of good pictures of her secrets hitherto quite beyond the reach of the camera and only faintly readable to the searching eye of the scientist himself.

Daphnia has been questioned for other biological secrets than those of physiological reactions to drugs and dyes. Dr. A. M. Banta, a research worker at the station for experimental evolution which the Carnegie Institution of Washington maintains at Cold Spring Harbor, Long Island, has learned from her a number of interesting and potentially important facts about heredity, evolution and sex.

Daphnia is especially useful from Dr. Banta's point of view because she seldom bothers with a male mate, being able to bring forth numerous progeny all summer long by her unaided self. This ability of unmated females to produce young is not uncommon among the lower animals; it is known to biologists as "parthenogenesis," which is Greek for "virgin birth." It is, for example, the regular method of propagation during warm weather among aphids, or "plant lice."



THE LADY HERSELF, SKETCHED AND PHOTOGRAPHED

Study of Daphnia through the microscope has enabled scientists to sketch the lady's internal arrangements in detail. The letter A indicates her antenna; B, the brain with optic ganglion; C, brood case with developing ova; D, eye; E, heart; F, intestine; G, legs; H, beak; and I, ovary. On the right is a microscopic photograph taken after Daphnia had put on sufficient make-up, by swallowing dyes, to stain her internal organs and make them visible through her transparent body.

"Just Like Her Mother"

An animal that propagates in this way is valuable to the student of heredity because the young inherit from only one parent, and thus the troublesome questions of possible hybrid origins of new traits, that plague geneticists dealing with biparental animals or plants, do not enter in. One of the things Dr. Banta has observed in his swarms of Daphnias is the sudden appearance of quite new forms, that thereafter breed true.

Another very interesting thing Dr. Banta has learned from Daphnia is a way to control the sex ratio among offspring. For though Daphnia disdains the company of a mate during the summer, she does become the mother of sons as well as daughters as autumn advances, and the eggs that carry the species through the winter are the result of their mating. Dr. Banta learned that the number of males in the progeny of a female is directly dependent on the slowing-down of her physiological processes. Daphnias that live "fast" have few or no sons; only daughters. Those that live "slow" will have from 35 to 100 per cent. male offspring.

This was discovered first as a result of a "crowding" experiment. Dr. Banta took two bottles of equal size. In one he put ten females, in the other only one. The solitary Daphnia produced no males at all; the crowded ones produced many. Then he tried the effects of chemicals that would slow down the metabolism, or body processes. Under the effects of these chemicals even uncrowded females produced male offspring. As a check on this, he took two "crowded" bottles, left one untreated, added a stimulant to the second. The females in the untreated bottles reacted normally, producing males. Those in the "stimulated" bottles, despite their crowding, gave birth to daughters almost exclusively.

Possible applications of this principle to sex-ratio control in higher animals and man are not yet in order. But at least Daphnia must be credited with an assist in the difficult game which scientists have long been trying to win: determining in advance whether it will be boy or girl.

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