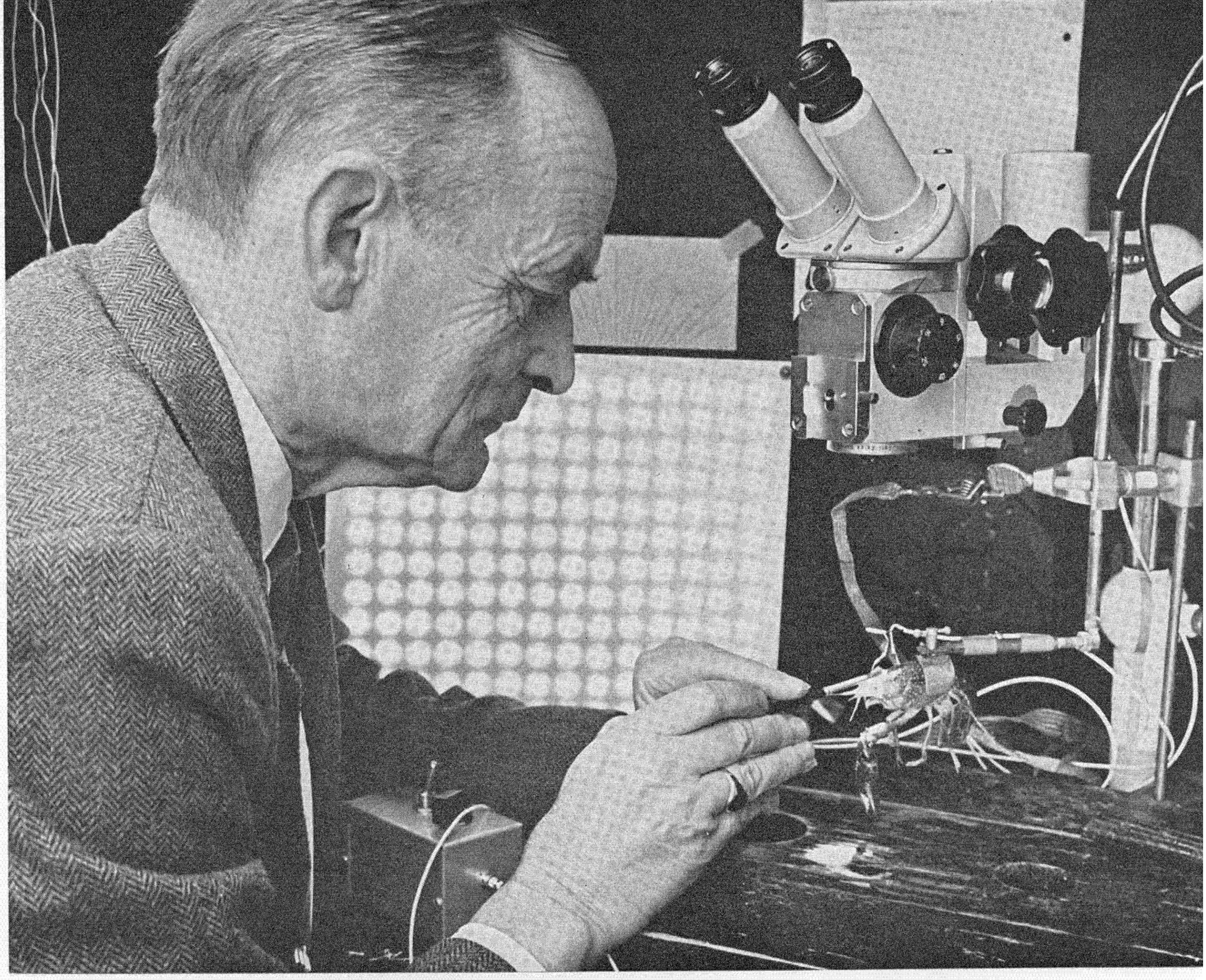

C. A. G. Wiersma measures the electrical impulse responses of the crayfish to touch.

LOOKING INTO SEEING

The freshwater crayfish is making a unique contribution to science at Caltech. C. A. G. Wiersma, professor of biology, who has uncovered valuable information about the central nervous system in past studies of the crayfish, is now in the midst of an investigation of visual integration in the crayfish.

Dr. Wiersma is finding out how and what the crayfish "sees" by registering the information it sends from its eyes to the brain via the optic nerves. These messages are sent in the form of electrical impulses along one or more of the 17,000 separate fibers that make up each optic nerve. Some of the fibers carry impulses from the eye to the brain, some from the brain to the eye, some in both directions.

In his investigations into the nerve circuitry of seeing, Dr. Wiersma has been able to identify several specialized kinds of fibers, to map their locations, and to describe their function .

The space-constant fibers, one of these kinds, report to the brain only what is seen by the part of

A Caltech biologist investigates the nerve circuitry of seeing by studying the complex optic nerve system of the simple crayfish.

the eye looking toward the sky—no matter which way the crayfish is turned. Apparently these fibers are linked with the crustacean's organs of balance—two small, hollow bowls called statocysts—located at the base of the smaller of the two pair of feelers. These bowls are lined with tiny hairs, each connected to a separate nerve ending. A small amount of granular dirt, congealed into a statolith and attached to the hairs, bends them in accordance with the pull of gravity. As the crayfish turns in any direction except horizontally, this pull shifts to affect different hairs. The nerve fibers in the hairs keep the brain informed about the position of the crayfish in its relation to the stream bed.

This information, transmitted to the space-constant fibers, is probably what causes the field of vision to change so that the fibers continue to report only what is seen by the crayfish in its area of sight pointed toward the sun.

The sustaining fibers are another fiber type identified by Dr. Wiersma. There are 14 of these in each optic nerve, and they react to light with a continual discharge of electrical impulses as long as light is seen. Each fiber relays information from a different part of the eye by indicating how much light that part is receiving.

The dimming fibers are still another type found in the crayfish. These fibers convert the amount of darkness into impulses, and they function especially when the crayfish is in dim light. The more the light decreases, the more active these fibers become. When light increases, the fibers stop firing electrical impulses, at least temporarily.

The jittery movement fibers, a fourth kind, are evidence for the presence of a biological computer mechanism in back of each eye. This mechanism can predict the rate and direction of any object that passes in front of it. As the eye sends the necessary messages to the brain, the tiny computers intercept them and use them to calculate, in a fraction of a second, the rate and direction of the object's movement. As soon as this information is available, the computer switches off the impulses in the movement fibers. But if the moving object changes its speed or direction in any manner not predicted by the computers, the switch is thrown on again, and the fibers' discharges resume.

Of the total of 17,000 nerve fibers in the crayfish, some 7,000 are sensory fibers leading to the eye from the fine hairs that cover much of the creature's front parts. Although the investigators do not know why these hairs are linked with the eyes, they may have some function similar to that of the hairs in the statocysts.

Dr. Wiersma has gathered information about only 150 of the remaining 10,000 fibers. He believes that a large number of those yet unidentified are used for purposes other than vision—for example, a large number may be involved in the secretion of hormones.

The way in which individual fibers of the optic nerve are studied involves injecting a needle into the optic nerve and shifting its tip cautiously until a good response is picked up from only one or two fibers. This needle electrode, which measures about 1/25,000 of an inch in diameter at the tip, is coated so that electrical contact is limited to the tip. It then picks up the impulses moving along the fiber. These impulses are amplified and transmitted to an oscilloscope, a loudspeaker, and a digital counter. The information is then computed and used to map the location and function of the fibers.

The crayfish can be induced to respond to outside stimuli by having an object or light source passed in front of its eyes. Other responses can be evoked by lightly touching a part of its body. The number of electrical impulses recorded is related to the effectiveness of the stimuli.

Dr. Wiersma began working with the crayfish when he was a graduate student in Holland in 1928. These crustaceans are particularly well suited to his present visual integration research. They are plentiful in southern California; they maintain their optic reactivity after months of captivity and experimentation; and the fact that their eyes are located on stalks that contain the optic nerve fibers makes it comparatively easy to tap them.

What Dr. Wiersma is learning about the crayfish brings science nearer to an understanding of the basic principles of sight in other creatures, including humans.

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