Tube worm nourished with help from within

Giant worms with no eyes, mouths or guts are the most puzzling of the rich collection of unusual creatures found clustered around hot-water vents on the ocean floor. At first these strange worms were thought to absorb nutrients from the surrounding sea (SN: 4/7/79, p. 231). But now a variety of evidence indicates that they are largely independent of external food sources. With the help of internal bacteria, the worms seem to be "autotrophic animals," capable of synthesizing their own food from inorganic materials.

Because little light reaches the deep-living vent community, the most obvious food chain has at its base bacteria that derive the energy to make organic molecules from chemical reactions of the hydrogen sulfide concentrated in the hot vent waters. Clams, mussels and other filter-feeders consume these bacteria. But the worms, which have no mouths, must be nourished by a different means.

The feathery plumes these worms extend from their opaque, white tubes seemed a likely site for taking up organic molecules dissolved in the ocean water. But recent studies indicate that the uptake rates for related worms, which are only millimeters to centimeters long, are too low to account for their metabolism. Nourishing the giant tube worms, which can be as long as 3 meters and which have a far greater ratio of body mass to surface, would be even more difficult.

A series of papers by a dozen scientists in the July 17 SCIENCE describes current information on the giant tube worms, named *Riftia pachyptila* Jones, and suggests an alternate means of nourishment. The source of organic molecules for the worms is quite different from that of neighboring clams and mussels, reports Greg H. Rau of the University of California at Los Angeles. He has compared ratios of stable carbon isotopes ($^{13}C/^{12}C$), which are characteristic of food source, and has found a striking difference between vent animals and other marine animals that use food derived from photosynthesis. In addition, Rau has found three-fold differences between the isotope ratios of the vent community filter feeders and the puzzling tube worms. He concludes that the worms rely on organic molecules produced within their bodies by chemical pathways different from those that supply organic molecules to the other animals.

The third segment of the worm body appears to be the source of its organic molecules. The trunk (TR) region, which includes more than half the length of adult *Riftia,* contains a well-vascularized structure called the trophosome. Crystals of elemental sulfur have been found in this area in most specimens. Horst Felbeck of the Scripps Institution of Oceanography in San Diego has found high levels of several enzymes in the trophosome that could be used to generate organic molecules. Two of the enzymes catalyze synthesis of the energy-storing molecules, ATP, by using energy contained in sulfur compounds. Two other enzymes are part of the pathway used by plants to convert carbon dioxide into useful organic molecules.

Closely packed bacteria make up much of the "tissue" in the trophosome and are the favored candidate for supplier of organic molecules. Colleen M. Cavanaugh of Harvard University and colleagues at the Smithsonian Institution and at Woods Hole Oceanographic Institution report approximately 4 billion bacteria per gram in the lobes of the trophosome. They suggest the enzymes that oxidize sulfide and reduce carbon dioxide to organic matter are contained in the bacteria. The bacteria have not been found in eggs removed from the tube worm ovary, so how the microorganisms come to colonize a worm is still unknown. But Meredith L. Jones says, "There's no doubt it gets a blue ribbon for a neat symbiotic relationship."

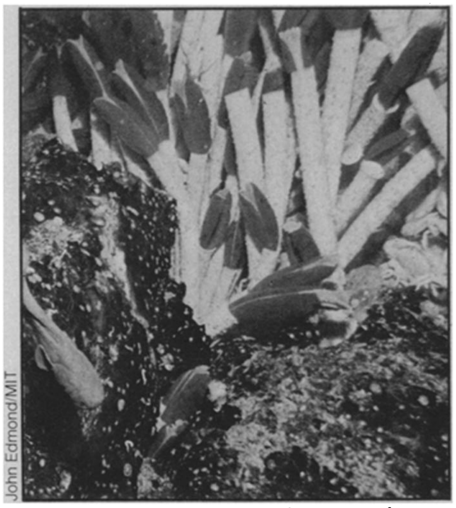
Jones examined 63 specimens of *Riftia* before describing it as a new species and a new genus. He told SCIENCE NEWS in an interview that specimens collected at three locations appear to differ in the proportions of the four body regions. He plans to obtain more specimens this fall to determine whether there is more than one *Riftia* species.

Among the interesting anatomical characteristics of the giant tube worms are the 228,000 tentacles that give the first body region its feathered appearance. The animal's brain is in the second region, called the vestimentum (VE) because two flaps overlap to make an external chamber. The genital apparatus opens into this chamber, and on the outer vestimental surface pear-shaped glands secrete the protein and chitin that make the tube.

The third body region (TR) contains the gonads, as well as the packages of bacteria. The short final, or opisthosomal (OP), region has many segments each encircled with toothed bristles. Jones says the worm uses the bristles to secure itself to the inside of its tube.

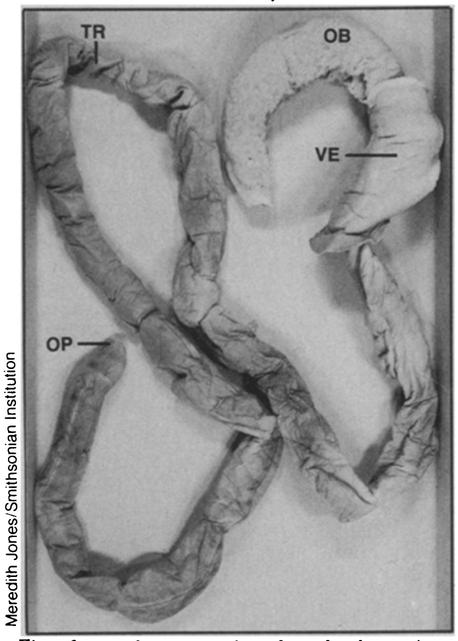
The blood of the worm is being analyzed by two teams. Jonathan R. Wittenberg at Albert Einstein College of Medicine and collaborators are examining reactions of hemoglobin with oxygen. Alissa J. Arp and James J. Childress of the University of California at Santa Barbara report that the high oxygen-carrying capacity they have found might provide the animal with a small oxygen reserve. They say the blood characteristics that would be supportive of a chemoautotrophic animal in an unusually variable environment.

Four years of investigation have provided extensive data, but much remains to be learned about how the strange giant tube worm fits into its dark, deep sea, hot water, sulfurous environment. □



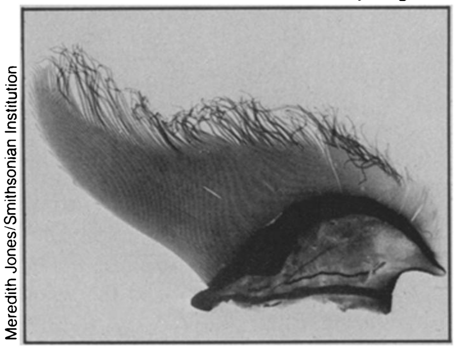
John Edmond/MIT

Tube worms extend red plumes undersea.



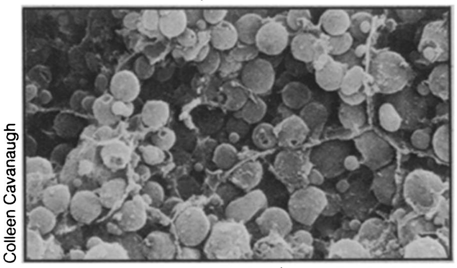
Meredith Jones/Smithsonian Institution

Five-foot tube worm has four body regions.



Meredith Jones/Smithsonian Institution

Rows of tentacles ring the first body region (OB) to form the plume.



Colleen Cavanaugh

Spherical bacteria, 3 to 5 microns, are packed in lobes in the trunk region (TR).