EVOLUTIONARY PERSPECTIVE

Symbiotic Bacteria—the Essential Guests

Some bacteria have evolved to live in close, or **symbiotic,** associations with other marine organisms. Some symbiotic bacteria are **parasites** that may cause a disease. Others, on the other hand, benefit their hosts. These symbiotic bacteria began their association by increasing the chances of survival of the host and evolved to become essential—hosts could not survive without them. In many cases the symbiotic bacteria are even sheltered in special tissues or organs that evolved in the host, an example of **coevolution,** in which two species evolve in response to each other.

All eukaryotic organisms, including humans, shelter bacteria without which they could not live. The chloroplasts and mitochondria of eukaryotic cells evolved from symbiotic bacteria (see "From Snack to Servant: How Complex Cells Arose," p. 73). These bacteria have become an integral part of all complex cells.

There are many cases of symbiotic bacteria among marine organisms. Symbiotic bacteria, for example, are involved in digesting the wood that is ingested by shipworms (*Teredo*), which happen to be bivalve molluscs, not worms. Like all wood-eating animals, shipworms lack cellulase, the enzyme needed to digest cellulose, the main component of wood. Wood is a surprisingly common habitat in many marine environments, so everything from driftwood to boat bottoms is exploited by shipworms, thanks to their symbiotic bacteria.

Symbiotic bacteria are also responsible for the light, or **bioluminescence,** that is produced by some fishes, squids, octopuses, and other animals of the deep (see "Bioluminescence," p. 369). The bacteria are usually sheltered in special light-producing organs, or **photophores.** These deep-sea animals, which live in darkness, use light to communicate with other members of their species, lure prey, blend with the light that filters from the surface, and perform other functions. Flashlight fishes (*Anomalops*), which live in shallow tropical waters, lodge their symbiotic bacteria in an organ beneath each eye. A shutter mechanism controls the emission of light, so that the fish can "blink" at night. Groups of fish blink in synchrony, a behavior that is involved in attracting prey.

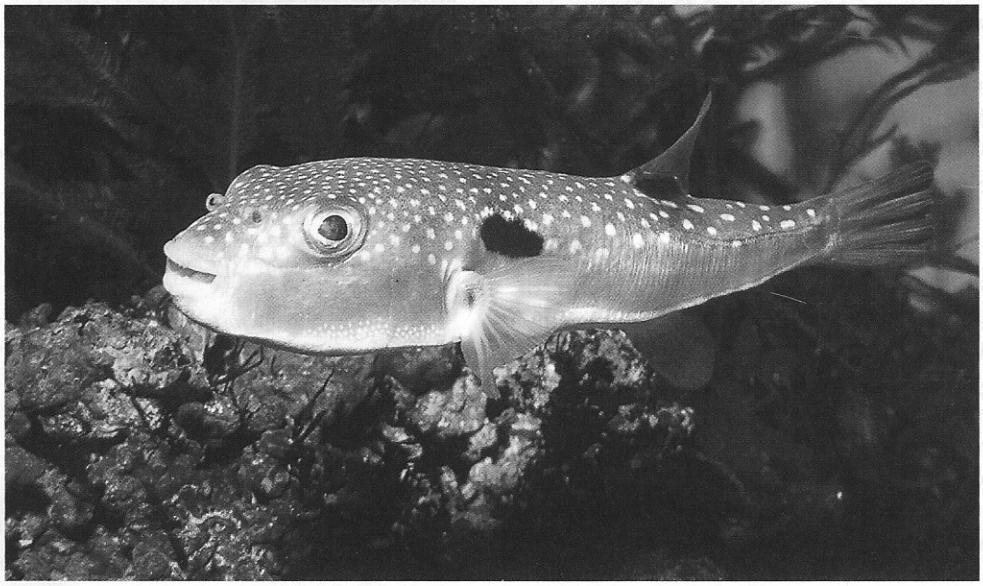
Chemosynthetic bacteria symbiotic with mussels, clams, and tubeworms that live around deep-sea hydrothermal vents have a very particular role: manufacturing organic matter from CO_2 and the abundant hydrogen sulfide (H_2S) from the vents. The symbiotic bacteria live in a special organ, the feeding body, of the giant hydrothermal-vent tubeworm *Riftia* (see Fig. 16.29).

Marine symbiotic bacteria can also affect human health. Pufferfishes store a toxin that is deadly to any predators (including humans) that eat them. The fish, or *fugu,* is a delicacy in Japan. Licensed chefs must prepare the fish; otherwise, the toxin **(tetrodotoxin)** will kill anyone feasting on fish that has been improperly prepared. Tetrodotoxin is a deadly neurotoxin (that is, it affects the nervous system). In fact, it is one of the most powerful poisons known, and there is no antidote. The deadly toxin is stored mostly in the liver and gonads of the fish, so the internal organs must be expertly removed. Mistakes do happen and numerous deaths (including the suicides of disgraced cooks) take place every year in Japan. Cooks may still be guilty, but not the puffers: the toxin is not produced by puffers but apparently by symbiotic bacteria. The fish are actually resistant to tetrodotoxin as a result of a genetic mutation that changes the site where the toxin binds to nerve cells.

Tetrodotoxin and very similar toxins have also been found in a variety of marine organisms, including flatworms, snails, crabs, sea stars, and several species of fishes. It has also been found in the blue-ringed octopuses, notoriously toxic animals. Tetrodotoxin of an unknown source has also been found in dead sea urchins and is suspected as their cause of death. We are not yet sure if in all of these animals the toxin is produced by symbiotic bacteria or if it is accumulated from their food. In arrow worms, however, symbiotic bacteria in the mouth do produce tetrodotoxin that is used to paralyze prey.

Being a neurotoxin, tetrodotoxin may block pain signals in humans. A derivative being tested as a pain reliever for cancer and other diseases would have the advantage of not being addictive, as are morphine and similar drugs.

The production of powerful toxins that are used by other organisms is just one example of the amazing abilities of bacteria—invisible to the eye but powerful giants when it comes to their role in the environment.



A Japanese pufferfish, or *fugu* (*Takifugu niphobles*).