Biochemistry IN PERSPECTIVE

Photosynthesis in the Deep

How can light-dependent photosynthesis occur at the bottom of the ocean, where there is no sunlight?

Sunlight penetrates ocean water to a depth of 200 m (about 660 ft). Accordingly, it has long been assumed that photosynthetic organisms do not exist below this depth. It came as a surprise, therefore, when in 2003 an intriguing exception was discovered more than a mile below the surface of the Pacific Ocean off the coast of Mexico. Investigators isolated a new species of green sulfur bacteria (referred to as *Chlorobium bathomarium*, or GSB1) in close proximity to the extremely hot water (measured at 350°C) of hydrothermal vents. In this nearly pitch-black environment, GSB1, an obligate anaerobic, photosynthesizing organism, apparently harnesses blackbody radiation emitted by the hot water (Figure 13A). A *blackbody* is a substance that absorbs radiant energy, in this case geothermal energy, and emits light energy. The hotter the substance becomes, the shorter the wavelength of light that it emits. The elements in an electric stove, for example, begin to appear dull red as the oven temperature reaches a certain level. It should be noted that some researchers believe that chemical reactions may also contribute to the dim light emitted from hydrothermal vents.

GSB1 is an autotroph that requires only elemental sulfur (S°), H_2S, CO_2, and light energy to maintain its existence. It can absorb sufficient amounts of low-energy light because it possesses an extremely efficient light-harvesting antenna called a chlorosome. *Chlorosomes* are membrane-bound vesicles attached to the plasma membrane that collect low-energy photons of light, no matter how rare, and transfer them to the photosynthetic reaction centers in the plasma membrane.

In addition to aggregates of bacteriochlorophyll c (a molecule similar to chlorophyll, but with an absorption maxima near the infrared), chlorosomes contain smaller amounts of bacteriochlorophyll a, carotenoids, and quinones. They also contain small amounts of lipid and protein molecules. However amazing GSB1 is, it is instructive to put its lifestyle in context. It survives in a very hostile and low-light environment, but its growth (as measured by cell division time) is measured in years instead of the minutes or hours that are characteristic of photosynthetic bacteria in more temperate environments.

FIGURE 13A
Light Emitted at a Hydrothermal Vent Heated by Geothermal Energy.

SUMMARY: Dim light, sufficient for a slow-growing type of photosynthetic green sulfur bacterium, is used to fix carbon near hydrothermal vents. This light is emitted by hydrothermal vents, which are hot enough to cause "blackbody" radiation.