Hydrothermal Vents

Deep in the oceans of the world, around 2000-3,500 m down, there is no sunlight. Nevertheless, along the continental plates mid-oceanic ridge abundant life is observed. Since the plates emerge from a molten state, the vents are hyper-thermal. Some are 400 C at their exits, where they meet surrounding waters at 2-4 C, nearly freezing. Yet they spew hot water that does not boil at the high pressures that deep. The water has seeped in from the oceans above. The mineral mounds that are produced by precipitation are called chimneys and are either black smokers (400 C, 2500 m, Fe, S) or white smokers (250 C, 1500 m, Ba, Ca, S), depending on temperature, depth and dissolved elements.

Today's oceans contain about 3.41×10^{20} gals. At 1.1×10^{12} gal per cubic mile, this is equivalent to 310,000,000 cubic miles. There is of order 40,000 miles of mid-oceanic ridge in the oceans. Each year it is estimated that 3.7×10^{14} gals of fluid is expelled through the vents. If there were perfect mixing, it would take 1 million years (10^6 yr) for the all of the oceans to cycle through the vents once. Of course there is not perfect mixing, very far from it.

Phenomenal film footage was used in the 2005 TV documentary *Aliens of the Deep*, produced by James Cameron who worked on a Russian research vessel with a number of Russian and NASA scientists. These are really beautiful images. At one point, after marveling at how abundant the life is without sunlight, Cameron muses that if the Sun were to go out the life in the depths wouldn't notice or care. Its energetics is not coupled to the Sun, so he alleged. In 2010, The Discovery Channel aired *Planet Earth Extremes: Summit and Abyss*. While lingering briefly at a vent, using poorer footage than was seen in *Aliens*, the narrator flatly asserts that the abundant life does not depend on sunlight or oxygen. The reason for this view is based on the presence of hydrogen sulfide bacteria that use H_2S for energy. These bacteria are in the Achaea domain of life. So a putatively primitive representative of modern life is the basis of an intricate and prolific food chain that is based on H_2S, and not on sunlight or O_2.

When there is a lot of H_2S there is an odor :-). Something doesn't smell right about the TV accounts! That rotten egg smell is characteristic of hydrogen sulfide and not of sulfur *per se*. But something does smell funny about the preceding claims. The hydrothermal vent life is strongly dependent on dissolved oxygen in the cold water! This oxygen comes from the atmosphere in which it arises by photosynthesis. The H_2S is oxidized by O_2 and the Achaea are aerobes as are all the other attendant life forms. It should have been a big clue that all the multitudes of clams, shrimp, crabs, tubeworms, fish and even octopi are aerobic, and only thrive because they live in oxygen-rich waters. Deep currents keep the oxygen rich water flowing past the vents.

Most striking of all the animals are the giant tubeworms (1-4.5 m). They have a chitinous outer tube from which a vermillion red head emerges. The red color is simply caused by a type of hemoglobin that can bind both H_2S and O_2. It is red because hemoglobin is red, but in the total darkness of the deep most creatures are albino. Under the bright lights used in filming the red really stands out. It is a signal that O_2 is essential. The tubeworms and the bacteria live in obligate symbiosis.

Now that we have cleared the air, let us summarize. The hydrothermal vent food chain starts with an Achaean bacteria that oxidizes H_2S using O_2 that is dissolved in the cold deep ocean currents and is trapped by giant tubeworms. The oxygen in turn has its origin in Sun driven photosynthesis.

One site that gets this right is http://en.wikipedia.org/wiki/Giant_tube_worm It is a shame that popularized presentations made for TV can't get it right too. Why didn't the scientists with James Cameron insist that he too gets it right?

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