Hydrothermal Vents

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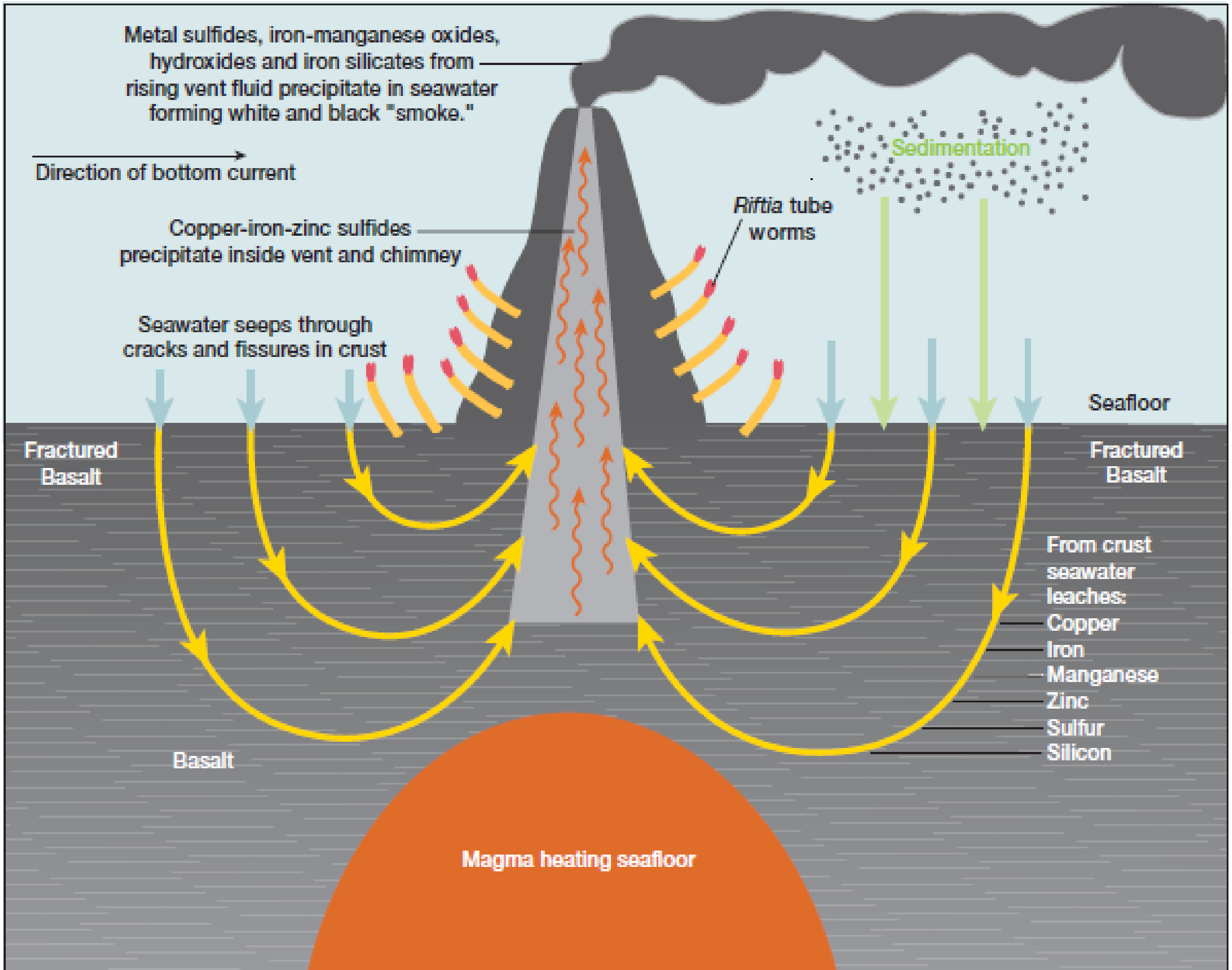
Hydrothermal Vents

- A hydrothermal vent is a fissure on the seafloor from which geothermally heated water issues.
- Hydrothermal vents are commonly found near volcanically active places, areas where tectonic plates are moving apart at spreading centers, ocean basins, and hotspots (mantle plumes).
- Hydrothermal vents are like geysers, or hot springs, on the ocean floor.
- Seawater circulates deep in the ocean's crust and becomes super-heated by hot magma.
- As pressure builds and the seawater warms, it begins to dissolve minerals and rise toward the surface of the crust.
- The hot, mineral-rich waters then exit the oceanic crust and mix with the cool seawater above.
- As the vent minerals cool and solidify into mineral deposits, they form different types of hydrothermal vent structures.

Hydrothermal Vent



Types of hydrothermal vents

Hydrothermal vent structures are characterized by different physical and chemical factors, including the minerals, temperatures, and flow levels of their plumes:

- **Black smokers:** emit the hottest water (between 300-400 °C), darkest plumes, which are high in sulfur content and form chimneys up to 18 stories tall, or 55 meters (180 feet).
- **White smokers:** The plumes of white smokers are comparatively cooler (~200-330 °C) form smaller chimneys, lightly colored and rich in barium, calcium, and silicon.
- **Snowblower vents (Diffuse vents/Seeps):** develop around low-temperature diffuse flows, often around lava from underwater volcanoes. Snowblowers earn their nickname by ejecting columns of white, fluffy particles.
- Vents with even cooler, weaker flows are often called seeps release clear water typically up to 30 °C. They appear to shimmer because of differences in water temperatures or bubble because of the presence of gases, like CO_2.

Types of hydrothermal vents

Black smokers

White smokers

Snowblower vent

Hydrothermal vent ecosystem

- Despite the extreme temperatures and pressures, toxic minerals, and lack of sunlight that characterized the deep-sea vent ecosystem, the species living there were thriving.
- The conversion of mineral-rich hydrothermal fluid into energy is a key aspect of these unique ecosystems.
- Through the process of chemosynthesis, bacteria and archaea provide energy and nutrients to vent species without the need for sunlight.
- The organisms such as *Riftia pachyptila* and *Alvinella pompejana* utilize this symbiotic relationship in order to utilize and obtain the chemical energy that is released at these hydrothermal vent areas.

Hyperthermophiles

- Microbes that live here are known to be hyperthermophiles, microorganisms that grow at temperatures above 90 °C.
- These microbes are thought to contain proteins that have extended stability at higher temperatures due to intramolecular interactions but the exact mechanisms are not clear yet.
- The denaturation of DNA are thought to be minimized through high salt concentrations, more specifically Mg, K, and PO_4 which are highly concentrated in hyperthermophiles.
- Along with this, many of the microbes have proteins similar to histones that are bound to the DNA and can offer protection against the high temperatures.

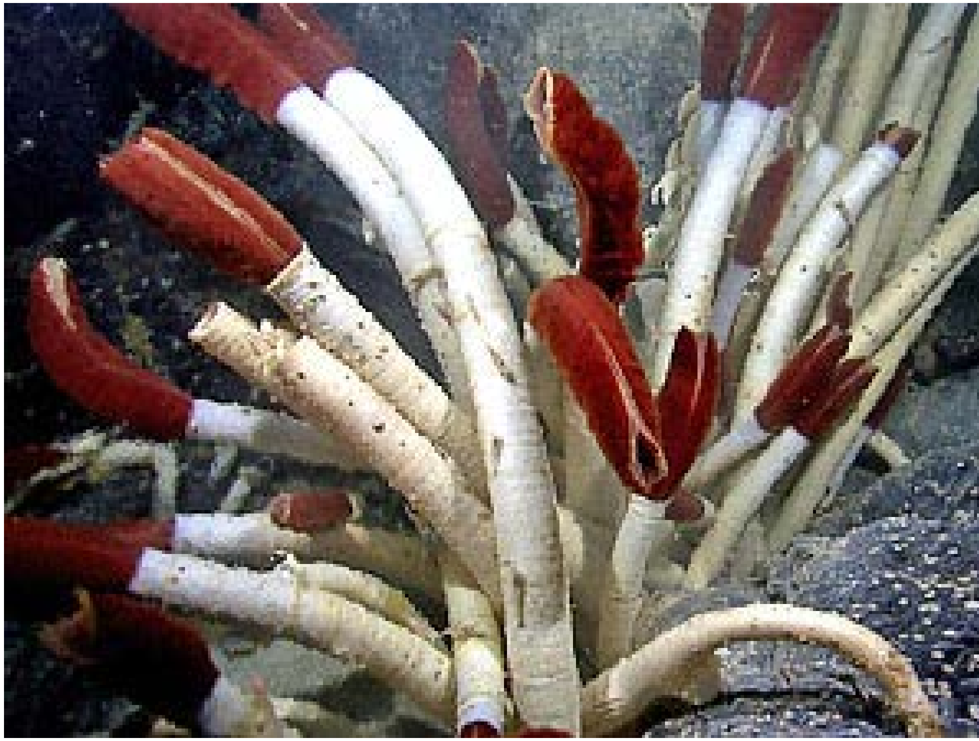
Microbial community

- Hydrothermal vent plumes contain high concentrations of methane and carbon monoxide.
- Deep sea water is also a large reservoir of carbon and concentration of carbon dioxide species such as dissolved CO_2 and HCO_3^- around 2.2mM.
- The bountiful carbon and electron acceptors produced by geological activity support an oasis of chemoautotrophic microbial communities (gammaproteobacteria, epsilonproteobacteria, alphaproteobacteria, and members of archaea) that fix inorganic carbon, such as $CO_{2,}$ using energy from sources such as oxidation of sulfur, iron, manganese, hydrogen and methane.
- Methanotrophs utilize the high concentrations of methane as an energy source and a source of carbon.
- These bacteria supply a large portion of organic carbon that support heterotrophic life at hydrothermal vents.

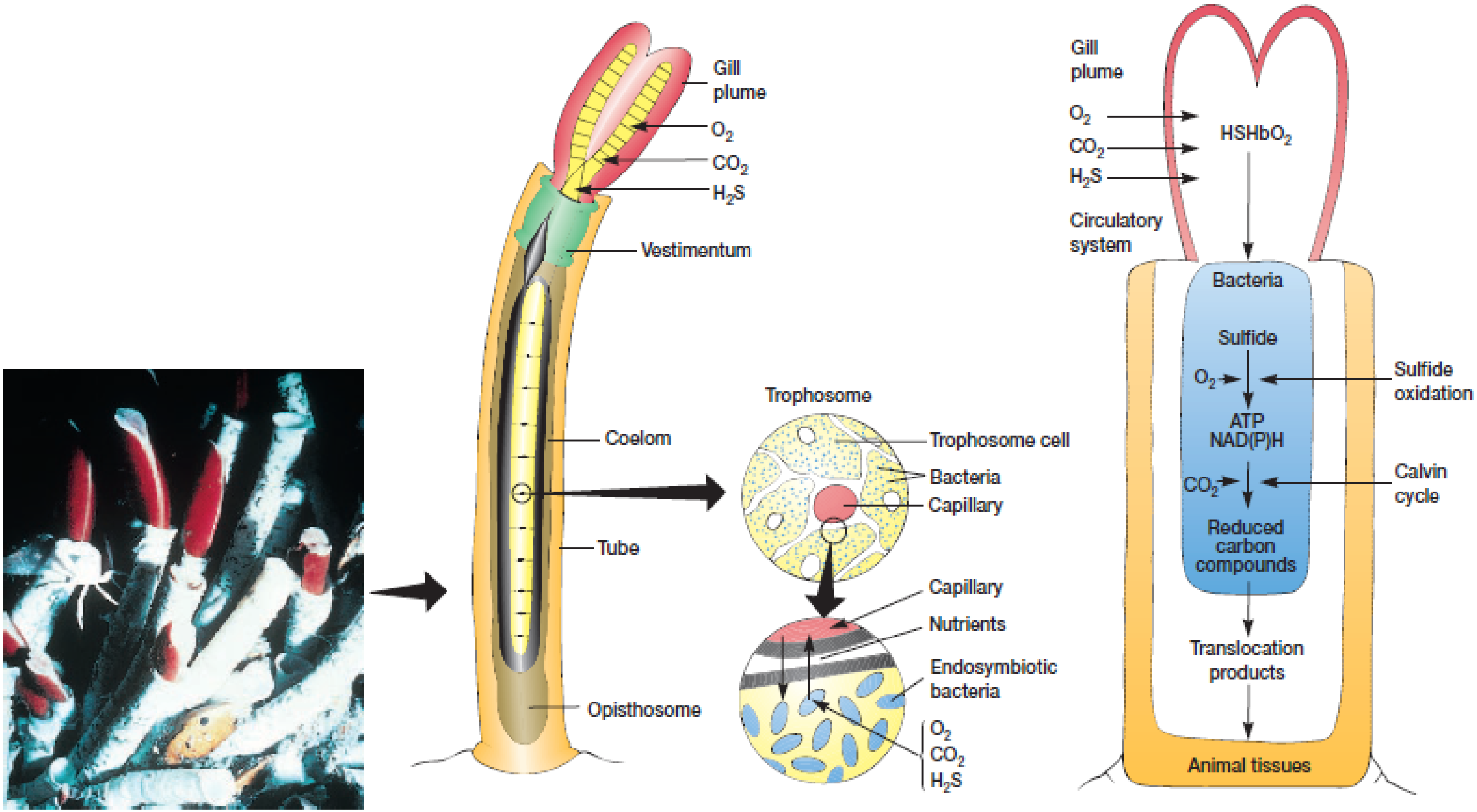
Tube worms (*Riftia pachyptila*)

- The giant (1 m in length), red, gutless tube worms (*Riftia* spp.) near these hydrothermal vents provide an example of a unique form of mutualism.
- To date all attempts to culture the endosymbiotic microorganisms have been unsuccessful.
- Oxygen, carbon dioxide, and hydrogen sulfide are absorbed through the gill plume and transported to the blood cells of the trophosome.
- The CO_2 can also be transported to the bacteria as freely dissolved in the blood or in the form of organic acids such as malate and succinate.
- These acids are decarboxylated to release CO_2 in the trophosome, the tissue containing bacterial symbionts.
- Hydrogen sulfide is bound to the worm's hemoglobin ($HSHbO_2$) and carried to the endosymbiont bacteria.
- The bacteria oxidize the hydrogen sulfide and use some of the released energy to fix CO_2 in the Calvin cycle.
- Some fraction of the reduced carbon compounds synthesized by the endosymbiont is translocated to the animal's tissues.

Life in Deep-Sea Hydrothermal Vents



The Tube Worm—Bacterial Relationship



(a) (b) (c) (d)

Questions

- What is hydrothermal vent? Discuss ecosystem of hydrothermal vent in detail.
- Write short note on:
  - Hydrothermal vent
  - Microbial community of hydrothermal vent
  - Symbiotic association of microorganisms at hydrothermal vents