Web Supplement 23.6.3

Phaeocystis *Blooms: TEP and DMSP Production*

Because of the importance of TEP in controlling metal availability and the conversion of DOM to marine snow, much effort is being directed at understanding the sources and biological uses of this DOM. Many marine organisms produce TEP including phytoplankton, bacteria, benthic suspension feeders, coral, pteropods, and appendicularians. The latter two use TEP to construct food-trapping nets.

Mucopolysaccharides are a major component of TEP. They serve many biological purposes. In some phytoplankton, these compounds form a mucous sheath that protects against zooplankton grazing and viral infection. They also facilitate the clumping and sinking of cells and, hence, export of POC from the photic zone. Bivalves, gastropods, and tunicates use mucus-covered appendages and gills to trap suspended food particles. Pseudo-feces also tend to be covered in sheaths of mucus as are fecal pellets.

One genus of phytoplankton, *Phaeocystis*, can generate so much TEP when growing under bloom conditions that the resulting DOM can form a thick and smelly foam. This presents a nuisance when it washes up onto beaches. *Phaeocystis* are ubiquitous members of the plankton, dominating the community in coastal regions. Massive blooms of *Phaeocystis* occur annually in European coastal waters and seem to be increasing in frequency and intensity. The TEP is thought to come from two sources: (1) extracellular mucopolysaccharides that hold the cells together into globular colonies and (2) storage polysaccharides (beta-1,3-glucans) that are contained within the cells. The latter are spilled into seawater when cells are ruptured.

The formation of massive gelatinous colonies of *Phaeocystis* likely causes major changes in food web structures, as grazers are deterred and bacteria are supplied with DOM. This in turn alters the vertical and lateral export of organic matter. In some cases, degradation of this organic matter can lead to local anoxia. *Phaeocystis* blooms can come and go in a matter of days. What triggers the beginning and end of a bloom is not known.

Phaeocystis blooms are also of great interest because they are a major source of dimethylsulfoniopropionate (DMSP). (Many other plankton also produce DMSP, using it as an osmolyte, cryoprotectant, and antioxidant.) It is released by the algae in response to physiological and mechanical stress. DMSP is also spilled into seawater as a result of

viral lysis and zooplankton grazing. Bacteria assimilate DMSP, some of which is converted to dimethylsulfide (DMS). Some algae also generate DMS. Being volatile, DMS can degas into the atmosphere where it is photochemically transformed into sulfated aerosols. These aerosols act as cloud condensation nuclei promoting the formation of clouds whose net effect on climate seems to be cooling.

Half of the global flux of sulfur to the atmosphere is contributed by marine DMS, so the plankton responsible for DMSP and DMS cycling, such as *Phaeocystis*, could play a major role in climate control. The production of DMS is very temperature dependent, probably due to the role of bacteria in converting DMSP to DMS. This suggests a negative feedback exists whereby a warming climate leads to an enhanced production of DMS that exerts a cooling effect. This cooling then causes DMS production to decline. Because DMSP seems to act as an antioxidant in plankton, it helps them tolerate stressful conditions, such as high solar radiation and iron-deficient waters. This provides a further linkage between DMSP production and climate-driven environmental conditions. The complicated nature of DMSP and DMS cycling in the upper ocean is illustrated in Figure W23.1.

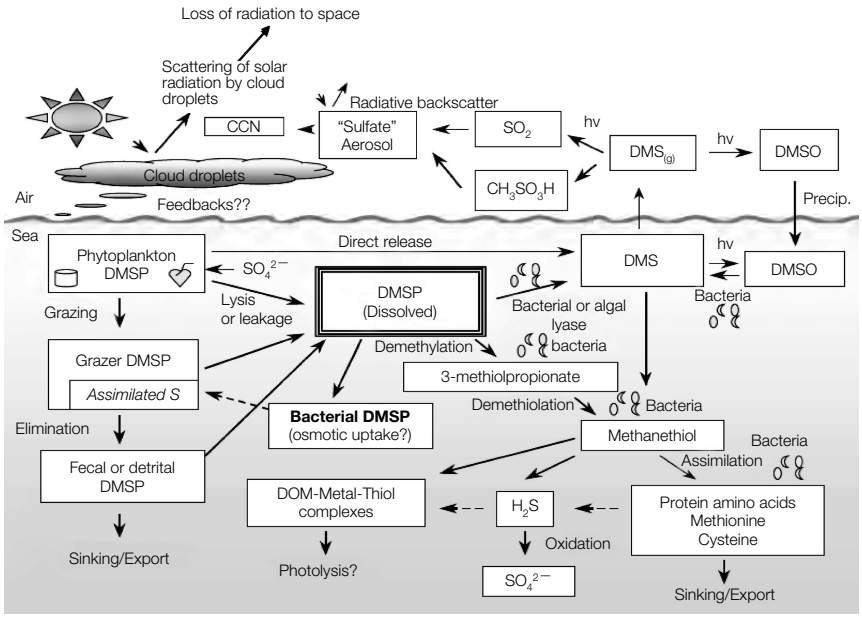

FIGURE W23.1

Conceptual model of the cycling of DMSP and DMS in the upper ocean. A postulated negative feedback involves an enhanced production of DMS by marine phytoplankton when surface temperatures are high, leading to production of CNN (cloud condensation nuclei). CNN increase cloud albedo, which lowers temperatures and solar irradiance at Earth's surface, leading to lower rates of DMS production by marine phytoplankton. *Source*: After Kiene, R. P., *et al*. (2000). *J. Sea Res*. 43, 209–224.

DMS is destroyed by reaction with ozone, making its accumulation in the atmosphere dependent on ozone production rates. Interestingly, marine plankton are also a source of large amounts of CH_3Br. Like DMS, CH_3Br degasses into the atmosphere where it reacts with ozone. Thus, the marine cycling of CH_3Br probably plays a role in the DMS-climate feedback loop. The story of *Phaeocystis* illustrates why a better understanding of global biogeochemical processes requires knowledge of how phytoplankton community dynamics shift over rather short time scales.