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Animal multicellularity induced by the snowball Earth

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Late Neoproterozoic is a period of climatic changes and animal evolution. It is still unknown whether there is a strong crucial link between the two events. However, one can believe the presence of the linkage if any biological evolution has progressed with biological effort to overcome the environmental tribulation. Recent advance in Neoproterozoic earth sciences permits discussion on this subject.

Currently well-accepted idea is that increased oxygen concentration induced the animal evolution. Here, the accumulated nutrients induced explosive photosynthesis immediately after the Marinoan snowball (635 Ma), and the raised oxygen supported collagen formation and animal respiration. In fact, this hypothesis fits well with the evolution of bilaterians (~550 Ma). However, the distinct ocean oxygenation was far much later (~585 Ma), and more primitive animals have already appeared before.

Primitive animals, sponges and cnidarians, also have evolved during a period of the Neoproterozoic climatic change. In order to understand their evolution, the stratified ocean can be taken into account. Nutrient source for the high productivity of the post-snowball ocean was unlikely from hydrothermal but rather from continental weathering because of the high Sr isotopic ratios. Thus, weak upwelling could not homogenize the water column, and the low-density and ice-molten water sealed the ocean. Huge amount of organic matter was at least partly suspended at the density gradient and provided food for animals. Similar circumstances can be seen in habitat of the modern deep-sea coral reefs. In addition, this hypothesis fits the fact that the primitive multicellular animals are all filter feeders (Kano et al., in press). Keyword for the evolution existed in food rather than oxygen.

The most primitive multicellular animal, a sponge, was likely originated from choanoflagellate. This filter-feeding protozoa is morphologically similar to the choanocytes of sponges, and genetically encoded for cell adhesion as preadaptation for multicellularity. Further interesting characteristics is symbiotic microbes in the sponge body. Microbes extracted from the cell-adhering matrix are sponge specific, and appear similar association independently with species and geographic distribution. Thus, Hentschel et al. (2002) hypnotized that they have own evolution since the appearance of the sponges. The sponge specific microbes include Chloroflexi group and delta-proteobacteria, for which a suitable habitat is redox interface. They were probably captured when choanoflagellates gather the suspended organic matter, stopped swimming in oxygen-poor water, and became multicellular.

Hentschel, U. et al. (2002) Molecular evidence for a uniform microbial community in sponges from different oceans. Applied and Environmental Microbiology, 68, 4431?4440.

King, N. et al. (2008) The genome of the choanoflagellate Monosiga brevicollis and the origin of metazoans. Nature, 451, 783-783.

Kano, A. et al. (in press) The evolution of animal multicellularity stimulated by dissolved organic carbon in early Ediacaran ocean: DOXAM hypothesis. Island Arc.

Keywords: Neoproterozoic, Sponges, Ocean stratification