4.7: Driving the evolutionary appearance of multicellular organisms

Now that we have some idea about cooperative behaviors and how evolutionary mechanisms can select and maintain them, we can begin to consider their role in the evolution of multicellular organisms. As we have mentioned there are a number of strategies that organisms take to exploit their environment. Most prokaryotes are unicellular, but some can grow to gigantic sizes. For example, the bacterium *Epulopiscium fishelsoni*, inhabits the gut of brown surgeonfish (*Acanthurus nigrofuscus*); it can grow to more than 600μm in length. As we will see (from an experimental perspective), the cells of the unicellular eukaryotic algae of the genus *Acetabularia* can be more than 10 cm in length. Additionally, a number of multicellular prokaryotes exhibit quite complex behaviors. A particularly interesting one is a species of bacteria that form multicellular colonial organisms that sense and migrate in response to magnetic fields. Within the eukaryotes, there are both unicellular and microscopic species (although most are significantly larger than the unicellular prokaryotes), as well as a range of macroscopic and multicellular species, including those with which we are most likely to be familiar with, namely animals, plants, and fungi.

What drove the appearance of multicellular organisms? Scientists have proposed a number of theoretical and empirically supported models. Researchers have suggested that predation is an important driver, either enabling the organisms to become better (or more specific) predators themselves or to avoid predation. For example, Borass et al. reported that the unicellular algae *Chlorella vulgaris* (5-6μm in diameter) is driven into a multicellular form when grown together with a unicellular predator *Ochromonas vallescia*, which typically engulfs its prey. They observed that over time, *Chlorella* were found in colonies that *Ochromonas* could not ingest.

At this point, however, what we have is more like a colony of organisms rather than a colonial organism or a true multicellular organism. The change from colony to organism appears to involve cellular specialization, so that different types of cells within the organism come to carry out different functions. The most dramatic specialization being that which gives rise to the next generation of organisms, the germ cells, and those that function solely within a particular organism, the somatic cells. At the other extreme, instead of producing distinct types of specialized cells, a number of...
unicellular eukaryotes, known as protists, have highly complex cells that display complex behaviors such as directed motility, predation, osmotic regulation, and digestion. But such specialization can be carried out much further in multicellular organisms, where there is a socially based division of labor. The stinging cells of jellyfish provide a classic example where highly specialized cells deliver poison to any organism that touches them through a harpoon-like mechanism. The structural specialization of these cells makes processes such as cell division impossible and typically a stinging cell dies after it discharges. Such cells are produced by a process known as terminal differentiation, which we will consider later (but only in passing). While we are used to thinking about individual organisms, the same logic can apply to groups of distinct organisms. The presence of cooperation extends beyond a single species, into ecological interactions in which organisms work together to various degrees. Based on the study of a range of organisms and their genetic information, we have begun to clarify the origins of multicellular organisms. Such studies indicate that multicellularity has arisen independently in a number of eukaryotic lineages. This strongly suggests that in a number of contexts, becoming multicellular is a successful way to establish an effective relationship with the environment.

Contributors and Attributions

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