Sponges can economize on oxygen use

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Sponges lack a signaling pathway that responds to low intracellular oxygen levels in more complex animals. Do they use a different mechanism for this purpose or did their earliest ancestors evolve at a time when less oxygen was available?

Gert Wörheide at Ludwig-Maximilians-Universitaet (LMU) in Munich focuses on the early evolution of animals more than 650 million years ago. He and his colleagues recently demonstrated that the sponges (Porifera), and not the comb jellies (Ctenophora) as some believe, most likely are the sister group to all other animal phyla. In other words, modern sponges are derived from the lineage that first diverged from the last common ancestor of all animals, while all other animal groups emerged from the other branch of the family tree. In their latest study, carried out in collaboration with Professor Donald Canfield's group at the University of Southern Denmark in Odense, Wörheide and his team have now shown that sponges can make do with far less oxygen than most other animals. Moreover, the new work, which appears in the international leading life and biomedical sciences journal *eLife*, reveals that sponges lack the specific biochemical signaling pathway that other animals use to sense the level of the gas present in their cells and tissues.

The vast majority of modern-day animals are dependent on an adequate supply of oxygen for their survival, and they possess a dedicated molecular system that enables them to make the appropriate physiological adjustments when oxygen levels fall below a certain threshold. This so-called HIF signaling pathway is named after the hypoxia-inducible factor, the protein that serves as the oxygen sensor in

the system. However, it was not clear whether or not all contemporary animal lineages have the genes that code for the various protein components of the HIF pathway.

The study grew out of experiments performed in Wörheide's laboratory, in which the team reared specimens of the marine sponge Tethya wilhelma under controlled conditions in aquaria. When the researchers varied the amount of dissolved oxygen available, they found that this species continued to thrive in waters that contained only 0.25 percent of the present saturation level in Earth's atmosphere. "This result was very surprising," Wörheide says, and it immediately prompted the team to ask how the sponges manage to survive on such a small amount of the vital gas. Subsequent molecular genetic investigations on a wider range of sponges, together with several Ctenophoran species, demonstrated that these two lineages lack several essential components of the canonical HIF signaling pathway.

This raises the question of whether or not sponges have evolved the capacity to cope with a relative dearth of the gas in their marine habitats, or have evolved an alternative mechanism for detecting and responding to low levels of oxygen. The answer has considerable implications for the understanding of the evolutionary history of animal life on our planet. It is thought that when the first animals emerged in the Precambrian, the level of oxygen present in the atmosphere was on the order of one-tenth of its current concentration. "But nobody knows precisely what the conditions were like on Earth during that time. However, neither the sponges nor the comb jellies—both most likely the sister groups of all other animals—possess the ability to perceive, and react appropriately to, the level of oxygen in their environment by means of the HIF pathway, as other animals do. And since sponges—as the experiments showed—are able to survive in the presence of very low levels of oxygen, it is tempting to conclude that the last common ancestor of animals evolved and lived in a very oxygen-poor

environment," Wörheide concludes.

More information: Daniel B Mills et al, The last common ancestor of animals lacked the HIF pathway and respired in low-oxygen environments, *eLife* (2018). DOI: 10.7554/eLife.31176

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