Do phytoplankton hold the key to the evolution of marine biodiversity?

Life exploded in our oceans 250 million years ago, leading to the biodiversity that we see today. Before this point, however, the plant and animal life in our seas was considerably less diverse. Several theories have been proffered to explain this – often considering both habitat and climate changes – but very few studies have considered the role of phytoplankton. Dr Ronald Martin from the University of Delaware in the US has shed light on the role phytoplankton played in the diversification of life within our oceans. His works show that changes in the land, nutrient cycling, and phytoplankton communities led to a fundamental increase in biodiversity.

The Paleozoic Era, which began around 542 million years ago, has been characterised by the diversification of life on Earth. The abundance of animals and plants that we see on the planet today can be traced back to the start of this period, known as the Cambrian, by examining the period’s fossilised remains. From these remains, we know that roughly 250 million years after the Cambrian period there was another explosion of life in our oceans and that marine biodiversity has been steadily increasing ever since. The marine fossil record suggests that this explosion was likely powered by the evolution of phytoplankton, microscopic plants that float in the water column. Phytoplankton form the basis of marine food-web pyramids and so the evolution of these minute plants resulted in increased food availability.

The fossil record also shows that the rise of phytoplankton is largely parallel to the evolution of more modern groups of marine animals over this time. Several new types, or taxa, of phytoplankton appeared, including dinoflagellates, coccolithophorids, and diatoms, collectively known as red algae. These replaced the green algae of the previous era, known as acritarchs, offering new food which supported the emergence of new animals. Despite this, the central relationship between phytoplankton and the evolution of marine invertebrates and vertebrates has not been explored in depth.

To shed light on this relationship, Dr Ronald Martin, from the University of Delaware, US, and his colleagues have explored the link between phytoplankton and the evolution of marine animals by examining key changes in several Earth systems over time. Their work has shown that phytoplankton may hold the key to the evolution of the diverse life forms that we find in our oceans today.

**FOSSIL RECORD OF MARINE BIODIVERSITY**

The fossil record of marine biodiversity provides a window into the past and has enabled researchers to delineate between three main phases in the development of marine biodiversity. The first phase occurred during the Cambrian period, at the start of the Paleozoic Era around 542 million to 530 million years ago. During this time, known as the Cambrian explosion, many of the phyla (or major groups of animals) began to appear in the oceans. During the second phase, marine biodiversity seemed to slow and was relatively subdued for the rest of the Paleozoic Era. In the third phase, which occurred during the Mesozoic and Cenozoic eras, a rise in modern marine biodiversity was observed, and this has continued to increase steadily until the present day. Scientists have looked to the fossil records for clues as to why we have seen this increase in biodiversity over the last 250 million years. These records suggest that the modern fauna have higher overall rates of ‘energetics’ as evidenced by the increased rates of locomotion and predation inferred from fossils, and implying greater rates of metabolism and food availability.

Researchers have proposed several explanations to account for these diversity trends, from changes in sea level and habitat area to the changing climate and distribution of animals and plants within ocean ecosystems. All these factors are related, at least in part, to the changing landscape of the Earth which occurred due to collisions between tectonic plates. The continental collisions at this time resulted in the formation of several of the world’s great mountain ranges including the main Alpine orogeny, which produced the Alps and Carpathians in southern Europe, the Himalaya of Asia, the Atlas Mountains in north-western Africa, the Andes of South America, and mountain ranges of western North America.

**NUTRIENT AVAILABILITY AND PRIMARY PRODUCTIVITY**

Another reason for the diversification of marine life that has been importantly overlooked is the increased availability of food within the oceans due to nutrient availability. Several studies by Martin and colleagues have used fossil records to better understand the effects of the influx of nutrients into the oceans on primary productivity or the growth of plant life. They have done this by examining the records of different types of organic compounds such as strontium and carbon, also known as strontium and carbon isotopes.
Behind the Research

Dr. Ronald Martin

Dr. Ronald Martin and his colleagues have explored the link between phytoplankton and marine biodiversity.

Research Objectives

An influx of nutrients into the ocean increased the quality of phytoplankton which was an important factor in marine biodiversification through geologic time.

The diversified marine fauna that has occurred over the last 250 million years or so can be attributed to changes in the quality and quantity of food available. This was due to increased nutrient cycling arising as a result of the building of mountains, volcanic eruptions, and the evolution of plants on land. Further, this suggests that if sufficient habitats, nutrients, and nutrient-rich phytoplankton are available in abundance, then the continued development of marine biodiversity is unlimited, depending on course of the impacts of anthropogenic climate change.

References


Personal Response

Can we use this information from the past to predict what the future of biodiversity in the oceans might look like?

The Earth’s history predicts the future. Continental weathering requires millions of years, so many nutrients are recycled in today’s oceans by the much more rapid upwelling of deep, nutrient-rich waters to the surface. Upwelling today depends on high-latitude glaciers but global warming is melting the ice packs, so surface waters will warm, making them less likely to sink, and upwelling will likely slow. Today, warming is increasingly being reported to lower oxygen levels and stimulate population blooms of dinoflagellates like those which produce red tides. Similar conditions are thought to have occurred during prolonged ‘greenhouse’ conditions in the Earth’s past.