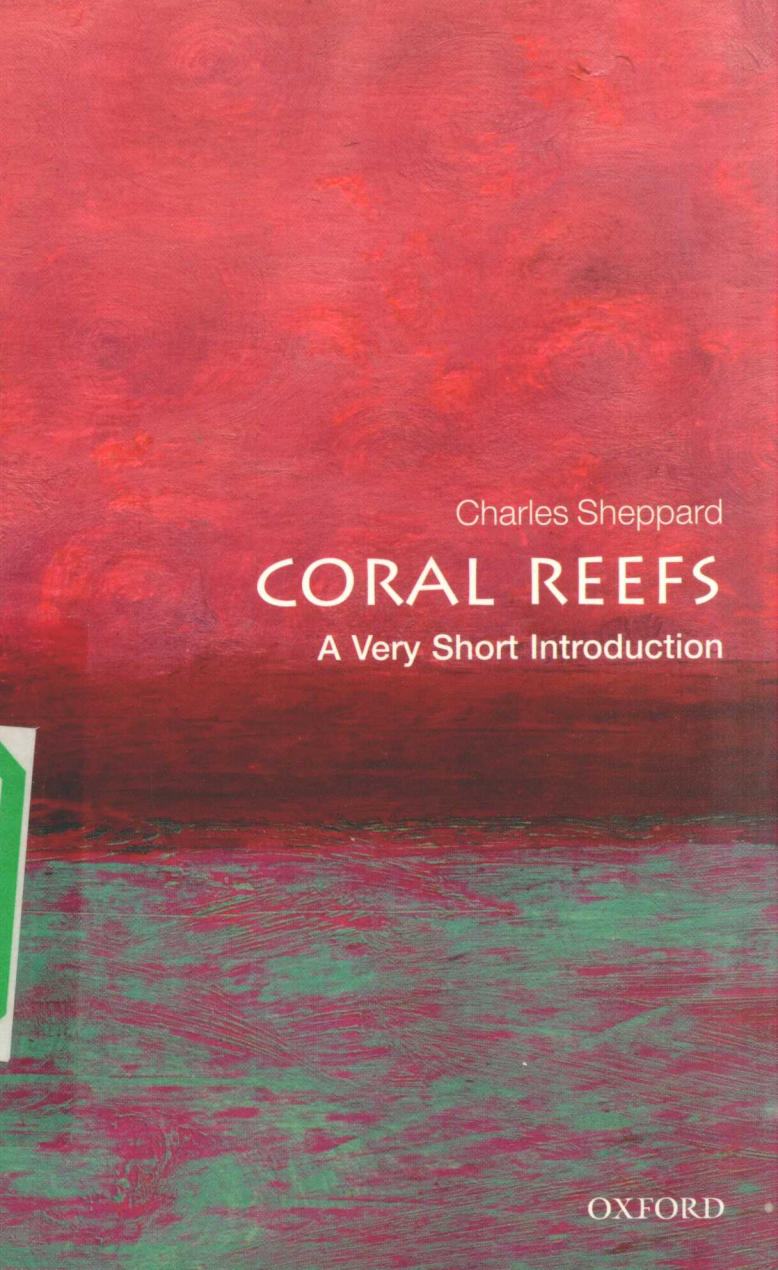
Charles Sheppard
CORAL REEFS
A Very Short Introduction
OXFORD

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Geology or biology?

Discovery and early explorers

Coral reefs have been regarded with awe for centuries. Early seafarers were wary of them, naturalists were confused by them, but many coastal people benefited greatly from these mysterious rocky structures that grew up to the surface of the sea. They have been the source of a rich supply of food for coastal people, and they provide a breakwater from storms and high waves to countless coastal communities that developed in their lee.

Long before scientists started to wonder what coral reefs really were, they had been encountered and used in many ways. Awareness of reefs beyond the local villages that used them for food started, perhaps, amongst pilgrims sailing down the Red Sea to Jeddah, the port serving the holy city of Mecca, for that part of the Red Sea is one area that is gloriously rich—or dangerously strewn, from a seafarer's point of view—with coral reefs. And then, from a European perspective, as trade developed to both the East and West Indies, coral reefs were increasingly encountered. They were a navigational hazard that provided fatal resting places for countless traders because their biology, not understood until much later, leads them to grow up to the surface of the sea at low tide, just where they offer the greatest danger to sailing ships. Perhaps the most famous European explorer to suffer the

consequences was Captain Cook, who nearly came to an early demise on the Great Barrier Reef as he explored the coast of Australia.

Nevertheless, the value of coral reefs has always far exceeded the hazards they pose to navigation. Their scale is enormous; the Indo-Pacific coral reef province, for a start, is the largest ecosystem on Earth, and probably its most diverse, at least at higher taxonomic levels. Ever since mankind spread out from Africa, spreading eastwards through the Indonesian and Philippine archipelagos and onwards to the Pacific Islands, people have inhabited land near reefs or islands on top of them, attracted by the huge quantities of fish and other marine life that were available for food. People living on small islands or beside a coral coast commonly obtained almost all their protein from fishing or gleaning at low tide, and many still do. Even those who lived a little further from the water would obtain a significant proportion of their food from those who caught more from the reef than they needed, in a proportion diminishing with distance from the rich source.

Europeans mostly travelled west across the Atlantic at first, where they encountered the coral fringed islands of the Caribbean. Columbus's first New World landfall was made tricky by the coral reefs of San Salvador island in the Bahamas (some say), which the intrepid navigator thought was Cathay on the other side of the world. Following the early days of exploration to the West Indies came the age of naturalists. At this time, the coral island of Bermuda, which lies to the north of the main Caribbean region, became important in providing these early exploring naturalists with a half-way stop on their journey. This period of exploration promoted the beginnings of modern scientific understanding, because many of the ships of discovery also carried a naturalist as a passenger, possibly appointed by a king or an archduke on whose patronages so much early discovery depended. Slightly

later, ships bearing these naturalists headed eastwards too, sometimes on journeys of exploration, but more commonly as appointed passengers. One naturalist, Carsten Niebuhr, wrote of coral reefs as he travelled east:

> I have already had occasion to speak, in the course of my travels, of the astonishing mats of works formed by the marine insects; namely the immense banks of coral bordering, and almost filling up [the sea]. The reader may therefore conceive with himself what a variety of madrepores and millepores are to be met with in these seas.

He wrote this in 1792. There was in those days, and for a long time to come, an almost complete inability to see or understand what went on beneath the surface of the water. Sea monsters still decorated nautical charts, and the monsters were only slightly less useful than the positions marked of many of the reefs. Fifty years later, in 1840, also travelling eastwards, J. Raymond Wellstead was still mystified by it all and wrote:

> there are secrets on the surface as well as within the bosom of the ocean, which lie shrouded from human observation and research ... where there is mystery there will always be interest, and to the greater the one, the more intense the other.

Another naturalist of that time, C. G. Ehrenberg, who became very well known in coral science circles, wrote in 1832:

> hummingbirds sport around the plants of the tropics, so also small fishes, scarcely an inch in length and never growing larger, but resplendent with gold, silver, purple and azure, sport around the flower-like corals.

These naturalists were clearly fascinated by coral reefs and probably were equally frustrated by not being able to see them

properly. But some were starting to get closer to them; another half century later, in 1878, C. B. Klunzinger wrote:

> Nowhere can one contemplate the life of the corals, and what belongs to it, more quietly and comfortably than here, although he has to lie on his belly—a trifling matter for the naturalist—and hold his magnifying glass at the point of his nose above a coral bush.

Meanwhile Alfred Russel Wallace, the co-discoverer of evolution, wrote of Indonesian reefs in 1869:

> The clearness of the water afforded me one of the most astonishing and beautiful sites I have ever beheld. The bottom was absolutely hidden by a continuous series of corals, sponges, actinae, and other marine productions, of magnificent dimensions, varied forms and brilliant colours... it was a sight to gaze at for hours, and no description can do justice to its surprising beauty and interest.

And this amazement came after he had explored such exotic parts of the world as the Amazon, not to mention Indonesia's islands.

Explanation of how reefs grow—the 'Coral Reef Question'

In the 19th century geologists were the leaders in research on coral reefs, developing an understanding of how these remarkable structures developed. Considerable controversy and impassioned arguments developed around how reef structures grew upwards to sea level and then stopped. In one sense this was easy: they were somehow produced by marine life and everybody knew that marine life would not grow out of the water. But what were they? What were the animals—or were they plants as was thought for quite a while—and how did they make the rock? The term 'animacule' was coined at one stage to describe the baffling small bunches of waving tentacles that were attached to the top of the rocks they sat upon, some a few inches long, but mostly very tiny. It was clearly very confusing at the

biological level, though at the geological level the early scientists were starting at least to see what had actually happened.

Scientists knew by then that this rock was limestone, calcium carbonate, and a very pure form of it. They knew too that the shells of many animals were also made of limestone. But although it was well known that marine organisms produce limestone, these reef structures were immense. Inland, many miles from the sea, were other limestone hills and mountains, clearly very ancient. Could marine organisms have built these too? They certainly contained marine fossils, which suggested that indeed they had—that is, unless the naturalist had a biblical view of time spans, which certainly posed an unsolvable problem to quite a number of these naturalists. Before the full recognition of an ancient Earth, the implied vast timescales served to baffle as much as to enlighten.

Charles Darwin's famous voyage on the *Beagle* was one of the turning points in coral reef science. Although better known for his ideas on evolution, I think his 1842 book on coral reef formation and large-scale movements of parts of the Earth's surface were more innovative and original. His theory depended on the massive subsidence of volcanoes (and other parts of the Earth's surface). Darwin proposed that coral animals could grow only in the surface regions, and as the land against which they grew subsided, the corals kept growing upwards, on top of each other, to maintain their position in shallow and warm waters. It had already been observed, in sections taken from fossil reefs, that corals were embedded in the limestone matrix, so this was not the shock; what surprised and was contested by some was the huge scale of space and time needed, if Darwin's explanation was correct. His theory had a simple but powerful elegance along with its explanatory power, and it eventually became accepted and then proved long after his own lifetime, as we shall see.

But in Darwin's time this was still only a partial theory, and it did not displace all the earlier theories for many years. For example, in