and right, though it may take millions of years to prove that right is right. I have the same faith in Nature; and, taking my stand on this scientific faith, I believe that natural selection must in the end prove rational selection, and that what has vaguely been called the survival of the fittest will have to be interpreted in the end as the triumph of reason, not as the mere play of chance. F. MAX MÜLLER.

Oxford, February 21.

"Coral Formations."

CAPTAIN WHARTON'S paper on coral formations in last week's NATURE (p. 393) will have been read with great interest by all who have examined and studied coral reefs. It is unlikely that any objections will be raised to the illustrations he has brought forward of how the coral plantations may be built up from deeply submerged banks, and eventually formed into complete atolls and barrier reefs at a great distance from continental and other shores. The mode of formation has been dwelt upon by Le Conte and Guppy in the case of barrier reefs, and I have pointed out the same thing in my remarks about the Maldive and similar atoll groups. The instances cited by Captain Wharton are of great value, especially as he has been able to consult large manuscript plans.

Captain Wharton apparently considers that the solution of carbonate of lime by sea-water plays no important part in deepening, widening, and modifying the form of such atolls and barrier reefs; in this I cannot agree with him.

By reference to what is now taking place in Nature, as well as to experiments conducted in the laboratory, it has been shown that the solution of the carbonate of lime of dead shells and skeletons by the sea is as constant and universal as its secretion by the living organisms. From some considerations which I recently laid before the Royal Society of Edinburgh, it is probable that there is more secretion and deposition of carbonate of lime in the ocean, as a whole, than removal by solution, and it is almost certain that at the present time there is a vast accumulation of carbonate of lime going on within the coral-reef regions of the ocean. The amount of secretion becomes less with increasing depth beyond one hundred fathoms, and laboratory experiments under great pressures have shown that the rate of solution becomes greater with increasing depth; but both processes are always in action wherever there are life and growth, death and decay. In some regions secretion is in excess, and there is a formation of calcareous deposits; in others solution is equal to secretion, as over the red clay areas of the ocean. Again, solution may be in excess of secretion, as in the larger and more perfect coral lagoons. The *rôle* of carbonate of lime in the ocean may not inaptly be compared to that of aqueous vapour in the atmosphere over land surfaces. Where precipitation is in excess of evaporation, fresh-water lakes are formed, and rivers carry the surplus water down to the ocean; where evaporation is in excess, there is a formation of inland drainage areas, deserts, and salt lakes.

In small coral atolls the periphery is large relatively to the size of the lagoon, and the secretion of lime and formation of coral sand are greatly in excess of the solution that takes place, hence the lagoon becomes filled up; in it are frequently found deposits of sulphate of lime, guano, magnesian and phosphatic rocks. On the other hand, when a comparatively large atoll reaches the surface, the periphery being small relatively to the size of the lagoon, there is less secretion and formation of coral sand by the living outer surface than is removed in solution from the lagoon; it is in consequence widened, deepened, and reduced to a more or less uniform appearance, while the islands on such reefs never, so far as I know, contain deposits of sulphate of lime, guano, magnesian or phosphatic rocks. On open banks, such as the Macclesfield and Tizard Banks, the coral sand is generally largely made up of bottom-living Foraminifera, Polyzoa, Serpulæ, and Calcareous Algæ, and the bank may be rising from the secretions of these organisms; but when the peripheral reefs reach the surface the conditions become more or less inimical to vigorous growth, and in a perfect atoll the fine calcareous mud is removed at a relatively rapid rate.

My answer to Captain Wharton's question is that in all normal conditions the extent of surface in the shell, coral, or fragment of coral sand exposed to the action of sea-water compared with the mass determines the rate at which these organisms will disappear in solution. It is improbable that this action is extremely slow at the bottom of the deep lagoons. Independently of the mixing by convection currents, even a very slight wind over the surface of the lagoon will set the whole water in motion. This is clearly shown by my observations in the western lochs of Scotland, which are much deeper than any lagoon; a moderate breeze produces motion at a depth of sixty fathoms in a very short space of time. The water mixed up with the mud at the bottom is thus changed long before the point of saturation is reached.

I have never seen any wide extent of fringing reef but what was very deeply cut up with channels, and from Captain Wharton's own description this appears to be the case at Rodriguez. That a ship channel has not there been formed is probably due to the shallow water surrounding the island and the probably rapid growth outward of the reef; the average depth outside the reef is usually less than ten fathoms, and at a distance of two miles seaward it is only from twenty to thirty fathoms. In some instances the large proportion of Calcareous Algæ on the reefs appears to compensate for the removal in solution, and thus to retard the formation of ship channels.

I doubt if any recent writer has attempted to give an "explanation which will fully account for the almost infinite variety of coral formations." It is unnecessary to state that each reef must have peculiarities depending on the nature and form of its foundation, and the meteorological and other conditions of the seas in which the reef is situated; it is only by a careful and detailed study of all these conditions that the peculiarities of any individual reef can be fully explained. At the same time it appears to me beyond doubt that the general and well-known characteristic features and form of coral reefs can be accounted for by reference to certain general considerations, chief among these being the vigorous growth of reef-forming species in positions and at depths where the supply of pelagic oceanic organisms, which form their food, are most abundant, and the removal of dead coral and coral debris wherever this is exposed to the action of sea-water.

Captain Wharton calls attention to our imperfect knowledge of the coral groups of the Pacific, but he understates the case in saying "that the waters of the Fiji and the Society Islands are the only ones which can be said to be in any sense surveyed." Cook, Kotzebue, Duperrey, Beechy, and Wilkes have given running surveys of many of the Paumotus, and we know something about the depths inside and outside of a good many of them. We know much about the islands containing guano. The French have made some excellent charts of the New Caledonia reefs, and the Americans have done the same for some of the Hawaiian Islands. Captain Wharton will acknowledge that we have a splendid survey of the Maldives, the most extensive group of atolls in the world; the islands marked with names in this British Survey number 602. Other groups in the Indian Ocean are well surveyed, and nearly all the Atlantic reefs have been correctly laid down on charts.

I feel sure that all who take an interest in this subject will hope for many more contributions from Captain Wharton's pen on coral formations. JOHN MURRAY.

I HAVE read with great interest the article on coral formations in your last number (p. 393), by Capt. Wharton. It is not because I wish to claim to have anticipitated the views which he gives as to the formation of atoll lagoons and barrier reef lagoons that I am writing to state that at the very date of the publication of Capt. Wharton's article I was engaged in writing a paper on coral formations, based upon a study of living corals at Diego Garcia, and on a consideration of the great submerged atolls known as the Great Chagos Bank and the Pitt and Centurion Banks, situated north and west of that island, in which I arrive at conclusions nearly identical with his. It has seemed to me, as it has to him, that the solution of dead coral rock in the interior of a reef does not sufficiently account for the formation of lagoons, and that the true cause of the atoll and barrier lagoons surrounded either by a reef which is awash, or by a strip of low land, lies in the peculiarly favourable conditions for coral growth present on the steep external slopes of the reef. In Diego Garcia I observed that although the shore reefs are for the most part covered with 1 or 2 feet of water, even at the lowest spring tides, yet their flat surfaces are nearly invariably barren of growing coral. Just at their edges, however, and on the steep external slopes beyond the edges, reef-building corals grow luxuriantly. According to Capt. Moresby, quoted by Mr. Darwin in his book on "Coral Reefs," the flat surface of the rim of the Great Chagos Bank is barren of living corals,