

animals living in it, or by coral sand carried into it by wind and waves from the outer edge in the same space of time, and therefore I think the balance of evidence is in favour of Mr. Murray's explanation of lagoon formation.

Could the experiment be made, it would be a matter of extreme interest to know if, and in what proportion, carbonate of lime really exists in lagoon waters, as also the proportion in the waters outside the reef, where new coral formation is actively at work.

It is quite reasonable to suppose that the dead coral so dissolved in the formation of lagoons is carried out as material for fresh coral growths.

Royston, Edinburgh, March 6.

ROBERT IRVINE.

IN reference to the interesting discussion on coral formations which has recently appeared in NATURE, a few words from the chemist's point of view may not be out of place.

For some time past I have been endeavouring to satisfy myself regarding the solubility of calcium carbonate in sea-water, and with this end in view I immersed weighed pieces of dead coral (dried at 212° F. till constant) in sea-water. These were protected by suspending them under glass bells floated in about 18 inches of water, and allowed to remain at rest for a known length of time. The following are the results obtained:—

First Experiment.—*Oculina varicosa*, from St. Thomas, West Indies, weight 16·3164 grammes, with a surface of, roughly, 8 square inches, lost by solution in twenty days, 0·0748 gramme.

Second Experiment.—*Mutropora scabrosa*, from Levuka, Fiji, weight 21·8540 grammes, surface of 16 square inches, lost 0·1497 gramme in thirty days.

Third Experiment.—*Montifora foliosa*, Amboyna, weight 15·3334 grammes, surface of 15 square inches, lost 0·1223 gramme in forty-six days.

Every care was taken that the corals should not be subjected to the action of other than convection currents. The temperature ranged between 30° and 40° F. Specific gravity of the water found less than 1·026.

Mr. W. G. Reid, in a paper communicated to the Royal Society of Edinburgh, showed that the solubility of carbonate of calcium increased with pressure; and when determining the percentage of CaCO₃ in certain soundings I found that the greater the depth the less carbonate derived from surface shells was present, while it is a well-known fact that in the red clay or other deep-sea deposits, CaCO₃ almost completely, if not entirely disappears, as has frequently been pointed out by Mr. Murray.

From the above considerations there can be little doubt that there is considerable action going on in the waters of the ocean.

Take, for instance, a circular lagoon four miles in diameter; this would give a superficial area of 12½ square miles. Taking the results obtained in Experiment 1, and applying them to this imaginary case, then in twenty days, in absolutely still water, there would be dissolved 464 tons of CaCO₃, equal to 3472 tons in a year. If the specific gravity of carbonate of calcium be taken at 2·65, this amount would give a thickness of half an inch covering the whole area of the lagoon. In other words, at the same rate it would require about a century to deepen the lagoon one fathom.

These results must be, however, very much under-stated, as the temperature in the coral regions is about twice what I could obtain; the sea-water is denser; there is the action of carbonic acid gas, CO₂, which is constantly being generated by decomposing organic matters, especially in these warm areas, and all which would increase materially the solubility. Moreover, there are the tides and currents continually replacing, or rather mixing with, the denser waters.

The coral animals in the lagoon are, however, constantly laying down new material in the shape of CaCO₃, assimilated either directly from the sea or through the medium of other organisms upon which they feed, or both combined. Now it depends upon the excess of the one process over the other whether there be an increase or decrease in the depth of the lagoon.

Growth is restricted mainly in reefs to the outer periphery, leaving large spaces of coral sand in the interior to be freely acted upon. In this way the coral formation increases outwards, while there is a deepening of the interior, albeit this deepening is very small.

JAMES G. ROSS.

14 Argyle Place, Edinburgh, March 10.

CAPTAIN WHARTON in his interesting paper satisfactorily explains a condition of reef-growth previously little known and but imperfectly understood. I was pleased to learn that Mr. Bourne's long-expected account of Diego Garcia will soon be published. His remarks concerning the directing influence of currents agree closely with those of Semper ("Animal Life," vol. xxxi. Internat. Sci. Ser. p. 228). Of the importance of this agency there can, I think, be no doubt; but solution is also an important agency within the lagoon, and one more capable of actual demonstration than the directing force of the currents. But amongst the supporters of the *anti-subsidence* theory of Murray there is a difference of opinion as to the relative importance to be attached to solution; and we cannot accept the name of "theory of solution" for the new view if it is intended to exclude the other agencies that previously cause the death of the coral, such as the repressive influence of sand, the diminished food-supply, the tidal scour, &c. With this exclusive meaning, the name "theory of solution" would contradict itself, and we should be regarding the problem in much the same light as if we were solely to contemplate the mystery of our own existence from the point of view of the undertaker.

The development of the new theory should be borne in mind. Chamisso, seventy years ago, advanced the view that an atoll owes its form to the growth of the corals at the margin and to the repressive influence of the reef-debris in the interior; but this view gave no satisfactory explanation of the foundation of such a coral reef, and Darwin was driven to his theory of subsidence. The great defect in the view of Chamisso was, however, removed by Murray, who supplied the foundation of an atoll without employing subsidence; and investigations in the Florida Sea and in the Western Pacific have confirmed his conclusions. The forms of reefs he attributed to well-known physical causes; but Semper and Agassiz have dwelt upon the importance of other agencies, and in our present state of knowledge it will be wisest to combine in one view the several agencies enumerated by these three naturalists as producing the different forms of coral reefs. On the outer side of a reef we have the directing influence of the currents, the increased food-supply, the action of the breakers, &c. In the interior of a reef we have the repressive influence of sand and sediment, the boring of the numerous organisms that find a home on each coral block, the solvent agency of the carbonic acid in the sea-water, and the tidal scour. These are all real agencies, and we only differ as to the relative importance we attach to each. Future investigations will probably add others to the list, besides ascertaining the mode and degree of action of each cause.

March 10.

H. B. GUPPY.

Reason and Language.

THE kindness of Prof. Max Müller's reply I recognize with pleasure but without surprise, since those who know him know him to be as remarkable for his courtesy as his great learning.

In answer to his first question, I must say that I made a point of attending his Royal Institution lecture on the day his "Science and Thought" was published, and was greatly disappointed that illness hindered my attending the others. But I immediately obtained his book, and applied myself to understand what seemed to me its essence, though I have not read it from cover to cover. Should I have to review it, of course I shall conscientiously peruse the whole of it.

Before replying further, it may be well to restate my position as follows.

Man is an intellectual being able to apprehend certain things directly and others indirectly. Normally, his conceptions clothe themselves in vocal sounds, and get so intimately connected therewith, that the "word" becomes practically a single thing composed of a mental and an oral element. But these elements are not *identical*, and the *verbum mentale* is anterior and superior to the *verbum oris* which it should govern and direct. Abnormally, conceptions do not clothe themselves in oral expressions at all, but only in manual or other bodily signs, and this shows that concepts may be expressed (however imperfectly), in the language of gesture without speech. One consequence of these relations is that neither the utterance of sounds (articulate or inarticulate) nor bodily movements could have generated the intellect and reason of man, and Noire's hypothesis falls to the ground. On the other hand, beings essentially intellectual, but as yet without language, would immediately clothe their