RECORD: Argyll. 1887. [Review of] Journal of researches: A great Lesson. *The Nineteenth Century*, no. CXXII (September), pp. 293-309.

REVISION HISTORY: Transcribed by Christine Chua and edited by John van Wyhe 3.2020. RN1.

NOTE: George John Douglas Campbell (1823 – 1900), 8th Duke of Argyll, KG, KT, P.C, F.R.S, F.R.S.E.

[page] 293

The most delightful of all Mr. Darwin's works is the first he ever wrote. It is his Journal as the Naturalist of H.M.S. 'Beagle' in her exploring voyage round the world from the beginning of 1832 to nearly the end of 1836. It was published in 1842, and a later edition appeared in 1845. Celebrated as this book once was, few probably read it now. Yet in many respects it exhibits Darwin at his best, and if we are ever inclined to rest our opinions upon authority, and to accept without doubt what a remarkable man has taught, I do not know any work better calculated to inspire confidence than Darwin's Journal. It records the observations of a mind singularly candid and unprejudiced–fixing upon nature a gaze keen, penetrating, and curious, but yet cautious, reflective, and almost reverent. The thought of how little we know- of how much there is to be known, and of how hardly we can learn it– is the thought which inspires the narrative as with an abiding presence. There is, too, an intense love of nature and an intense admiration of it, the expression of which is carefully restrained and measured, but which seems often to overflow the limits which are self-imposed. And when Man, the highest work of nature, but, not always its happiest or its best, comes across his path, Darwin's observations are always noble. 'A kindly man moving among his kind' seems to express his spirit. He appreciates every high calling, every good work, however far removed it may be from that to which he was himself devoted. His language about the missionaries of Christianity is a signal example, in striking contrast with the too common language of

[page] 294

lesser men. His indignant denunciation of slavery presents the same high characteristics of a mind eminently gentle and humane. In following him we feel that not merely the intellectual but the moral atmosphere in which we move is high and pure. And then, besides these great recommendations, there is another which must not be overlooked. We have Darwin here before he was a Darwinian. He embarked on that famous voyage with no preconceived theories to maintain. Yet he was the grandson of Dr. Erasmus Darwin– a man very famous in his day, who was the earliest popular exponent of Evolution as explaining the creative work, and who, both in prose and verse, had made it familiar as at least a dream and a poetic speculation. Charles Darwin in his Journal seems as unconscious of that speculation as if he had never heard of it, or was as desirous to forget it as if he concurred in the ridicule of it which had amused the readers of the Anti-Jacobin. Only once in the Journal is there any allusion to such speculations, and then only to the form in which they had been more scientifically clothed by the French naturalist Lamarck. This is all the more curious and interesting, since here and there Charles Darwin records some facts, and enters upon some

reasoning, in which we can now see the undeveloped germs of the theory which ultimately took entire possession of his mind. But that theory was, beyond all question, the later growth of independent observation and of independent thought. He started free– free at least, so far as his own consciousness was concerned. The attitude of his mind was at that time receptive, not constructive. It was gathering material, but it had not begun to build. It was watching, arranging, and classifying facts. But it was not selecting from among them such as would fit a plan. Still less was it setting aside any that did not appear to suit. He might have said with truth that which was said by a greater man before him: 'Hypotheses non fingo.' This is one of the many great charms of the book.

And yet there was one remarkable exception. Like every other voyager who has traversed the vast Southern Ocean, he was struck, impressed, and puzzled by its wonderful coral reefs, its thousands of coral islands, and its still more curious coral 'atolls.' Why is it that so many of the continents and of the great continental islands whose coasts front or are surrounded by the waters of the Pacific, are fringed and protected by barrier reefs of coral? The curious question that arises is not only why the coral should grow at all, or how it grows. All this, no doubt, is full of wonder – wonder all the greater the more we know of its structure and of the nature of its builder. But let the growth of corals in seas of a certain depth and temperature be assumed and passed over, as we do assume and pass over a thousand other things with which we are familiar. The puzzle here is why it should grow in the form of a linear barrier along a coast, and yet not touching it, but at a distance more or less great – sometimes very

great – and always leaving between it and the land an enclosed and protected space of water which, once they have found an entrance through the reef, ships can navigate for hundreds of miles. Why should this same curious phenomenon be repeated on a smaller scale throughout the thousands of islands and islets which dot the immense surfaces of the Pacific? Why should these islands so often be the centre of a double ring- first a ring of calm and as it were inland water, then a ring of coral reef fronting the outer sea, and lastly the ocean depths out of which the coral reef rises like a wall? Why should this curious arrangement repeat itself in every variety of form over thousands of miles until we come to that extreme case when there is no island at all except the outer ring of the coral reef and an inner pool or lake of shallower water which is thus secluded from the ocean, with nothing to break its surface - shining with a calm, splendid, and luminous green, set off against the deep purple blues of the surrounding sea? For effects so uniform or so analogous, repeated and multiplied over an area so immense, there must be some physical cause as peculiar as its effects. Moreover this cause must be one affecting not merely or only the peculiarities of the animal which builds up the coral, but some cause affecting also the solid rocks and crust of the earth. The coral animals must build on some foundation. They must begin by attaching themselves to something solid. Every coral reef, therefore, whatever be its form- every line of barrier-reef however long- every ring however small or however wide, must indicate some corresponding arrangement of subjacent rock. What cause can have arranged the rocky

foundations of the coral in such curious shapes? Extreme cases of any peculiar phenomenon are always there which most attract attention, and sometimes they are the cases which most readily suggest an explanation. Ring-shaped islands of such moderate dimensions that the whole of them can be taken in by the eye, supply such cases. There are atoll islands where ships can enter, through some break in the ring, into the inner circle. They find themselves in a perfect harbour, in a sheltered lake which no wave can ever enter, yet deep enough and wide enough to hold all the navies of the world. Round about on every side there are the dazzling beaches which are composed of coral sand, and crowning these there is the peaceful cocoanut palm, and a lower jungle of dense tropical vegetation. On landing and exploring the woods and shores nothing can be seen but coral. The whole island is a ring of this purely marine product; with the exception of an occasional fragment of pumice stone, which having been floated over the sea from some distant volcanic eruption, like that of Krakatoa, here disintegrates and furnishes clay, the most essential element of a soil. But reason tells us that there must be something else underground, however deeply buried. When the corals first, began to grow, they must have found some rock to build upon, and the shape of these walls

[page] 296

must be the shape which was thus determined. One suggestion is obvious. Elsewhere all over the globe there is only one physical cause which determines rooky matter into such ring-like forms as these, and which determines also an included space of depth more or less profound. This physical cause is the eruptive action of volcanic force. When anchored in the central lagoon of a coral atoll, are we not simply anchored in the crater of an extinct volcano- its walls represented by the corals which have grown upon it, its crater represented by the harbour in which our ship is lying? The vegetation is not difficult to account for. The coral grows until it reaches the surface. It is known to flourish best in the foaming breakers. These, although confronted and in the main resisted by the wondrous tubes and cells, are able here and there in violent storms to break off the weaker or overhanging portions of the coral and dash them in fragments upon the top of the reef. Often the waves are loaded with battering rams in the shape of immense quantities of drift timber. These bring with them innumerable seeds and hard nuts able to retain their vitality whilst traversing leagues of ocean. Such seeds again find lodgment among the broken corals, and among the decaying pumice. Under tropical heat and moisture, they soon spring to life. The moment a palm-tree rears its fronds, it is visited by birds- especially by fruit-eating pigeons bringing with them other seeds, which are deposited with convenient guano. These in turn take root and live. Each new accession to the incipient forest attracts more and more numerous winged messengers from interminable archipelagoes until the result is attained which so excites our admiration and our wonder in the atoll islands of the Pacific. All this is simple. But here as elsewhere it is the first step that costs. Are all atolls nothing more than the cup-like rings of volcanic vents? And if they are, can a like explanation be given for the barrier reefs which lie

off continental coasts, and where the crater-like lagoon of an atoll is represented only by a vast linear expanse of included and protected sea?

Here were problems eminently attractive to such a mind as that of Darwin. Vast in the regions they affect, complicated in the results which are presented, most beautiful and most valuable to Man in the products which are concerned, the facts do nevertheless suggest some physical cause which would be simple if only it could be discovered. All his faculties were set to work. Analysis must begin every work of reason. Its function is to destroy- to pull to pieces. Darwin had to deal with some theories already formed. With some of these he had no difficulty. 'The earlier voyagers fancied that the coral building-animals instinctively built up these great circles to afford themselves protection in the inner parts.' To this Darwin's answer was complete. So far is this explanation from being true, that it is founded on an assumption which is the reverse of the truth. These massive kinds of coral which build np reefs, so far from wanting the

[page] 297

shelter of a lagoon, are unable to live within it, They can only live and thrive fronting the open ocean, and in the highly aerated foam of its resisted billows. Moreover, on this view, many species of distinct genera and families are supposed instinctively to combine for one end; and of such a combination Darwin declares 'not a single instance can be found in the whole of nature.' This is rather a sweeping assertion. In the sense in which Darwin meant it, and in the case to which he applied it, the assertion is probably, if not certainly, true. The weapon of analysis, however, if employed upon it, would limit and curtail it much. We cannot indeed suppose that any of the lower animals, even those much higher than the coral-builders, have any consciousness of the ends or purposes which they or their work subserve in the great plan of nature. But Darwin has himself shown us, in later years, how all their toil is co-operant to ends, and how not only different species and families, but creatures belonging to different kingdoms, work together most directly, however unconsciously, to results on which their common life and propagation absolutely depend. In the case before us, however, this second objection -of Darwin is superfluous. The first was in itself conclusive. If the reef-building corals cannot live in a lagoon, or in a protected sea, it is needless to argue further against a theory which credits them with working on a plan to insure not their own life and well-being, but their own destruction.

But next, Darwin had to encounter the theory that atoll islands were built upon extinct volcanoes, and represented nothing but the walls and craters of these well-known structures. This he encountered not with a sweeping assertion, but with a sweeping survey of the vast Pacific. Had those who believed in this theory ever considered how vast that island-bearing ocean was, and how enormous its supposed craters must have been? It was all very well to apply some known cause to effects comparable in magnitude to its effects elsewhere. The smaller atolls might possibly represent volcanic craters. But what of the larger? And what of the grouping? Could any volcanic region of the terrestrial globe show such and so many craters as could correspond at all to the coral islands? One group of them occupies an

irregular square 500 miles long by 240 broad. Another group is 840 miles in one direction, and 420 miles in another. Between these two groups there are other smaller groups, making a linear space of more than 4000 miles of ocean in which not a single island rises above the level of true atolls- that is to say, the level up to which the surf can break and heap up the coral masses, and to which the winds can drift the resulting sands. Some atolls seem to have been again partially submerged-'half-drowned atolls' as they were called by Captain Moresby. One of these is of enormous size- ninety nautical miles along one axis, and seventy miles along another. No such volcanic craters or mountains east anywhere else in our world, We

should have to go to the airless and waterless Moon, with its vast vents and cinder-heaps, to meet with anything to be compared either in size or in distribution. And then, the linear barrier reefs lying off continental coasts and the coasts of the great islands are essentially the same in character as the encircling reefs round the smaller islands. They cannot possibly represent the walls of craters, nor can the long and broad sheltered seas inside them represent by any possibility the cup-like hollows of volcanic vents.

These theories being disposed of, the work of synthesis began in Darwin's mind. He sorted and arranged all the facts, such as he knew them to be in some cases, such as he assumed them to be in other cases. Above all, like 'stout Cortez and his men,' from their peak in Darien, 'he stared at the Pacific.' The actual seeing of any great natural phenomenon is often fruitful. It may not be true in a literal sense that, as Wordsworth tells us, 'Nature never did betray the heart that loved her.' But it is true that sometimes she discloses her secrets to an earnest and inquiring gaze. Sometimes things actually are what they look to be. Outwardly they are what their image on the retina directly paints them; and in their history and causes they may be what that image suggests not less directly to the intellect and the imagination. So Darwin, one day, standing on a mountain from which he commanded a wide space of sea, looked down upon an atoll with its curious ring of walled-in water, calm, green, and gleaming in the middle of the oceanic depths of blue. Did it not look as if there had once been an island in the middle? Did it not look as if the coral ring had been built up upon the rocky foundation of its former shores? Did it not look as if, somehow, this island bad been removed, and the encircling reef had been left alone? Somehow!

This could not satisfy Darwin. How could such an island be removed? Its once fringing and encircling reef would have protected it from the devouring sea. Did it not look as if it had simply sunk? Subsidence! Was not this the whole secret? The idea took firm hold upon his mind. The more he thought of it, the more closely it seemed to fit into all the facts. The coral fringing reef of the island would not subside along with its supporting rocks, if that subsidence took place slowly, because the coral animals would build their wall upwards as fast as their original foundation was sinking downwards. And was there not a perfect series of islands in every stage of the suggested operation? There were islands with coral reefs atoll attached to their original foundations, islands with fringing reefs adhering to them all round, and leaving no lagoons. There were others where the foundations had sunk a little, but not

very much, leaving only shallow and narrow spaces of lagoon water between the island and the barrier reef. Others there were again where the same process had gone further, and wide and deep lagoons had been established between the reef and the subsiding island.

[page] 299

Then, there was every variety and degree of the results which must follow from such a process, until we come to the last stage of all, when the island had wholly sunk, and nothing remained but the surviving reef - a true atoll - with its simple ring of coral and its central pool of protected water. Then further it could not but occur to Darwin that the objection which was fatal to the volcano theory was no difficulty in the way of his new conception; on the contrary, it was in strict accordance with that conception. The vast linear reefs lying off straight and continental coasts, which could not possibly represent volcanoes, were completely explained by a vast area of subsiding lands. The reefs were linear because the shores on which they had begun to grow had been linear also. The immense areas of sheltered sea, from twenty to seventy miles in breadth, which often lie between the barrier reefs and the existing shores, for example, of Australia and New Guinea, were explained by the comparatively shallow contours of land which had gradually subsided and had left these great spaces between the original fringing reef and the existing shores. The more Darwin pondered, the more satisfied he became that he had found the clue. The cardinal facts were carefully collated and compared.

First there was the fact that the reef-building corals could not live at any greater depth than from twenty to thirty fathoms. Secondly there was the fact that they cannot live in water charged with sediment, or in any water protected from the free currents, the free winds, and the dashing waves of the open and uncontaminated sea- that vast covering of water which in the southern hemisphere is world-wide and world-embracing. Thirdly there was the fact that the coral reefs rise suddenly like a wall out of oceanic depths, soundings of a thousand fathoms and more being constantly found close up to the barrier reefs. Fourthly there is the fact that on the inner side, next the island or the continent which they enclose or protect, the lagoon or the sheltered area is often very deep close to the reef, not indeed affording oceanic soundings, but nevertheless soundings of twenty to thirty fathoms. All these facts are indisputably true. Taking them together, the conclusions or inferences to which they point may well seem inevitable. Let us hear bow Darwin himself puts them in the short summary of his theory which is given in the latest edition of his Journal:-

From the fact of the reef-building corals not living at great depths, it is absolutely certain that throughout these vast areas, wherever there is now an atoll, a foundation must have originally existed within a depth of from twenty to thirty fathoms from the surface. It is improbable in the highest degree that broad, lofty, isolated, steep-sided banks of sediment, arranged in groups and lines hundreds of leagues in length, could have been deposited in the central and profoundest parts of the Pacific and Indian Oceans, at an immense distance from any continent, and where the water is perfectly limpid. It is equally improbable that the elevatory forces should have uplifted throughout the above vast areas, innumerable great

rocky banks within twenty to thirty fathoms, or 120 to 180 feet, of the surface of the sea, and not one single point above that level; for where on the whole face of the globe can we find a single chain of mountains, even a few hundred miles in length, with their many summits rising within a few feet of a given level, and not one pinnacle above it? If then the foundations, whence the atoll-building corals sprang, were not formed of sediment, and if they were not lifted up to the required level, they must of necessity have subsided into it; and this at once solves the difficulty. For as mountain after mountain, and island after island, slowly sank beneath the water, fresh bases would be successively afforded for the growth of the corals.

So certain was Darwin of these conclusions that he adds, in a most unwonted tone of confidence:-

I venture to defy any one to explain in any other manner, how it is possible that numerous islands should be distributed throughout vast areas—all the islands being low—all being built of corals, absolutely requiring a foundation within a limited depth from the surface. (1)

The voyage of the 'Beagle' ended in the autumn of 1836, and Darwin landed in England on the 2nd of October. He proceeded to put into shape his views on the coral islands of the Pacific, and in May 1837 they were communicated to the public in a paper read before the Geological Society of London. His theory took the scientific world by storm. It was well calculated so to do. There was an attractive grandeur in the conception or some great continent sinking slowly, slowly, into the vast bed of the Southern Ocean, having all its hills and pinnacles gradually covered by coral reefs as in succession they sank down to the proper depth, until at last only its pinnacles remained as the basis of atolls, and these remained, like buoys upon a wreck, only to mark where some mountain peak had been finally submerged. Besides the grandeur and simplicity of this conception, it fitted well into the Lyellian doctrine of the ' bit by bit' operation of all geological causes-a doctrine which had then already begun to establish its later wide popularity. Lyell had published the first edition of his famous Principles in January 1830- that is to say, almost two years before the 'Beagle' sailed. He had adopted the volcanic theory of the origin of the coral islands; and it is remarkable that he had nevertheless suggested the idea, although in a wholly different connection, that the Pacific presented in all probability an area of subsidence. Darwin most probably had this suggestion in his mind when he used it and adopted it for an argument which its author had never entertained (2). However this may be, it must have prepared the greatest living teacher of geology to adopt the new explanation
which turned his own hint to such wonderful account. And adopt it he did, accordingly. The theory of the young naturalist was hailed with acclamation. It was a magnificent generalisation. It was soon almost universally accepted with admiration and delight. It passed

(1) Journal, p. 468

(2) Lyell's Principles, 11th edition, p. 595.

[page] 301

into all popular treatises, and ever since for the space of nearly half a century it has maintained its unquestioned place as one of the great triumphs of reasoning and research. Although its illustrious author has since eclipsed this earliest performance by theories and generalisations still more attractive and much further reaching, I have heard eminent men declare that, if he had done nothing else, his solution of the great problem of the coral islands of the Pacific would have sufficed to place him on the unsubmergeable peaks of science, crowned with an immortal name.

And now comes the great lesson. After an interval of more than five-and-thirty years the voyage of the 'Beagle' has been followed by the voyage of the 'Challenger,' furnished with all the newest appliances of science, and manned by a scientific staff more than competent to turn them to the best account. And what is one of the many results which have been added to our knowledge of nature – to our estimate of the true character and history of the globe we live on? It is that Darwin's theory is a dream. It is not only unsound, but it is in many respects directly the reverse of truth. With all his conscientiousness, with all his caution, with all his powers of observation, Darwin in this matter fell into errors as profound as the abysses of the Pacific. All the acclamations with which it was received were as the shouts of an ignorant mob. It is well to know that the plebiscites of science may be as dangerous and as hollow as those of politics. The overthrow of Darwin's speculation is only beginning to be known. It has been whispered for some time. The cherished dogma has been dropping very slowly out of sight. Can it be possible that Darwin was wrong? Must we indeed give up all that we have been accepting and teaching for more than a generation? Reluctantly, almost sulkily, and with a grudging silence as far as public discussion is concerned, the ugly possibility has been contemplated as too disagreeable to be much talked about. The evidence, old and new, has been weighed and weighed again, and the obviously inclining balance has been looked at askance many times. But despite all averted looks I apprehend that it has settled to its place for ever, and Darwin's theory of the coral islands must be relegated to the category of those many hypotheses which have indeed helped science for a time by promoting and provoking further investigation, but which in themselves have now finally 'kicked the beam.'

But this great lesson will be poorly learnt unless we read and study it in detail. What was the flaw in Darwin's reasoning, apparently so close and cogent? Was it in the facts, or was it in the inferences? His facts in the main were right; only it has been found that they fitted into another explanation better than into his. It was true that the corals could only grow in a shallow sea, not deeper than from twenty to thirty fathoms. It was true that they needed some foundation provided for them at the required depth.

[page] 302

It was true that this foundation must be in the pure and open sea with its limpid water, its free currents, and its dashing waves. It was true that they could not flourish or live in lagoons or in channels, however wide, if they were secluded and protected from oceanic

waves. One error, apparently a small one, crept into Darwin's array of facts. The basis or foundation on which corals can grow, if it satisfied other conditions, need not be solid rock. It might be deep sea deposits if these were raised or elevated near enough the surface. Darwin did not know this for it is one of his assumptions that coral 'cannot adhere to a loose bottom. (3) The 'Challenger' observations show that thousands of deep-sea corals and of other lime-secreting animals flourish on deep-sea deposits at depths much greater than those at which true reef-building species are found. The dead remains of these deeper-living animals, as well as the dead shells of pelagic species that fall from the surface waters, build up submarine elevations towards the sea level. Again, the reef-building coral will grow upon its own debris–rising, as men, morally and spiritually, are said by the poet to do, 'on stepping-stones of their dead selves to higher things.' This small error told for much; for if coral could grow on deep-sea deposits when lifted up, and if it could also grow seaward, when once established, upon its own dead and sunken masses, then submarine elevations and not submarine subsidences might be the true explanation of all the facts. But what of the lagoons and the immense areas of sea behind the fringing reefs? How could these be accounted for? It was these which first impressed Darwin with the idea of subsidence. They looked as if the land had sunk behind the reef, leaving a space into which the sea had entered, but in which no fresh reefs could grow. And here we learn the important lesson that an hypothesis may adequately account for actual facts, and yet nevertheless may not be true. A given agency may be competent to produce some given effect, and yet that effect may not be due to it, but to some other. Subsidence would or might account for the lagoons and for the protected seas, and yet it may not be subsidence which has actually produced them.

Darwin's theory took into full account two of the great forces which prevail in nature, but it took no account of another, which is comparatively inconspicuous in its operations, and yet is not less powerful than the vital energies, and the mechanical energies, which move and build up material. Darwin had thought much and deeply on both of these. He called on both to solve his problem. To the vital energy of the coral animals he rightly ascribed the power of separating the lime from sea-water, and of laying it down again in the marvellous structures of their calcareous homes. In an eloquent and powerful passage he describes the wonderful results which this energy achieves in constructing breakwaters which repel and resist

(3) Journal, ed. 1852, p. 477.

the oceans along thousands of miles of coast. On the subterranean forces which raise and depress the earth's crust he dwelt–at least enough. But he did not know, because the science of his day had not then fully grasped, the great work performed by the mysterious power of chemical affinity, acting through the cognate conditions of aqueous solution. Just as it did not occur to him that a coral reef might advance steadily seaward by building ever fresh foundations on its own fragments when broken and submerged, or that the vigorous growth of the reefs to windward was due to the more abundant supply of food brought to the reef-building animals from that direction by oceanic currents, so did it never occur to him that it

might melt away to the rear like salt or sugar, as the vital energy of the coral animals failed in the sheltered and comparatively stagnant water. It was that vital energy alone which not only built up the living tubes and cells, but which filled them with living organic matter capable of resisting the chemical affinities of the inorganic world. But when that energy became feeble, and when at last it ceased, the once powerful structure descended again to that lower level of the Inorganic, and subject to all its laws. Then, what the ocean could not do by the violence of its waves, it was all-potent to do by the corroding and dissolving power of its calmer lagoons. Ever eating, corroding, and dissolving, the back waters of the original fringing reef– the mere pools and channels left by the outrageous sea as it dashed upon the shore– were ceaselessly at work, aided by the high temperature of exposure to blazing suns, and by the gases evolved from decaying organisms. Thus the enlarging area of these pools and channels spread out into wide lagoons, and into still wider protected seas. They needed no theory of subsidence to account for their origin or for their growth. They would present the same appearance in a slowly rising, a stationary, or a slowly sinking area. Their outside boundary was ever marching further outward on submarine shoals and banks, and ever as it advanced in that direction its rear ranks were melted and dissolved away. Their inner boundary– the shores of some island or of some continent- might be steady and unmoved, or it might be even rather rising instead of sinking. Still, unless this rising were such as to overtake the advancing reef, the lagoon would grow, and if the shores were steady, it would widen as fast as the face of the coral barrier could advance. Perhaps, even if such a wonderful process had ever occurred to Darwin–even if he had grasped this extraordinary example of the 'give and take' of nature– of the balance of opposing forces and agencies which is of the very essence of its system, he would have been startled by the vast magnitude of the operations which such an explanation demanded. In its incipient stages this process is not only easily conceivable, but it may be seen in a thousand places and in a thousand stages of advancement. There are islands without number in which the fringing

reef is still attached to the shore, but in which it is being 'pitted,' holed, and worn into numberless pools on the inner surfaces, where the coral is in large patches dead or dying, and where its less soluble ingredients are being deposited in the form of coral sand. There are thousands of other cases where the lagoon interval between the front of the reef and the shores has been so far widened that it is taking the form of a barrier, as distinguished from a fringing reef, and where the lagoon can be navigated by small boats. But when we come to the larger atolls, and the great seas included between a barrier reef and its related shores, the mind may well be staggered by the enormous quantity of matter which it is suggested has been dissolved, removed, and washed away. The breadth of the sheltered seas between barrier reefs and the shore is measured in some cases not by yards or hundreds of yards, not by miles but by tens of miles, and this breadth is carried on in linear directions, not for hundreds of miles, but for thousands. And yet there is one familiar idea in geology which might have helped Darwin, as it is much needed to help us even now, to conceive it. It is the

old doctrine of the science, long ago formulated by Hutton, that the work of erosion and of denudation must be equal to the work of deposition. Rocks have been formed out of the ruins of older rocks, and those older rocks must have been worn down and carried off to an equivalent amount. So it is here, with another kind of erosion and another kind of deposition. The coral-building animals can only get their materials from the sea, and the sea can only get its materials by dissolving it from calcareous rocks of some kind. The dead corals are among its greatest quarries. The inconceivable and immeasurable quantities which have been dissolved out of the lagoons and sheltered seas of the Pacific and of the Indian Ocean, are not greater than the immeasurable quantities which are again used up in the vast new reefs of growing coral, and in the calcareous covering of an inconceivable number of other marine animals.

Here then was a generalisation as magnificent as that of Darwin's theory. It might not present a conception so imposing as that of a whole continent gradually subsiding, of its long coasts marked by barrier reefs, of its various hills and irregularities of surface marked by islands of corresponding size, and finally of the atolls which are the buoys indicating where its highest peaks finally disappeared beneath the sea. But, on the other hand, the new explanation was more like the analogies of nature– more closely correlated with the wealth of her resources, with those curious reciprocities of service which all her agencies render to each other, and which indicate so strongly the ultimate unity of her designs. This grand explanation we owe to Mr. John Murray, one of the naturalists of the ‘Challenger’ expedition, a man whose enthusiasm for science, whose sagacity and candour of mind, are not inferior to those of Darwin, and whose

[page] 305

literary ability is testified by the splendid volumes of Reports now in course of publication under his editorial care. Mr. Murray's new explanation of the structure and origin of coral reefs and islands was communicated to the Royal Society of Edinburgh in 1880 (4) and supported with such a weight of facts and such a close texture of reasoning that no serious reply has ever been attempted. At the same time the reluctance to admit such an error in the great Idol of the scientific world, the necessity of suddenly disbelieving all that had been believed and repeated in every form, for upwards of forty years of cancelling what had been taught to the young of more than a whole generation– has led to a slow and sulky acquiescence, rather than to that joy which every true votary of science ought to feel in the discovery of a new truth and– not less– in the exposure of a long-accepted error. Darwin himself had lived to hear of the new solution, and with that splendid candour which was eminent in him, his mind, though now grown old in his own early convictions, was at least ready to entertain it, and to confess that serious doubts had been awakened as to the truth of his famous theory.

If, however, Mr. John Murray has not been cheered by the acclamations which greeted his illustrious predecessor, if the weight of a great accepted authority and of preconceived impressions has kept down the admiration which ought ever to reward the happy suggestions

of laborious research, he has had at least the great satisfaction of observing the silence of any effective criticism. But more than this- he is now having the still greater satisfaction of receiving corroborative support from the observations of others.

His own series of facts as ascertained during the voyage of the 'Challenger' constituted an array of evidence tolerably conclusive. But since he read his paper in Edinburgh, no island has been discovered in the Solomon group by another naturalist, Dr. Guppy (5), which lifts into the light and air a complete record of the series of operations beneath the waters of the Pacific to which Mr. Murray ascribes the origin of countless other island, islets, and atolls. Here the barrier reef and the atoll have been elevated from their bed, and all their foundations have been shown. Those foundations are not solid rock, but are just what Darwin assumed they could never be, deep-sea deposits. These had been originally, of course, laid down in more or less oceanic depths. But elevation, not depression, had begun the work. The deep deposit had ceased to be deep because the crust of the earth, on which it lay, had been bulged upwards by subterranean force. The deep bottom had become a shoal, rising to the required distance from the surface level of the sea. The moment it reached the thirty or the twenty fathom depth, the reef-building corals seized upon it as their resting-place, and began to

(4) Proc. Roy. Soc. Edin. vol. x. pp: 503-18.

(5) Surgeon of H.M.S, 'Lark.' Trans. Roy. Soc. Edin. June 1885.

grow. Possibly some process of induration may have affected the deposit before it reached this point. Probably it was consolidated or indurated by the luxuriant growth of myriads of deep-sea creatures at depths greater than thirty fathoms.

It has recently been discovered by another naturalist of the 'Challenger' school (6) that there may be a special explanation of this part of the operation. It is found that shoals have the immediate effect of converting the tidal wave of deeper water into a current. This current sweeps off the looser deposits covering the shoal. Deep sea corals then settle upon it. There may, and often do, build up their walls to a great height, and if this height reaches the zone of the true reef-building species, a firm basis is at once provided for their operations. Shoots have lately been discovered off the African coasts of the Atlantic, which in tropical seas would probably have become coral islands. This may or may not have been often the case in the Pacific. But it does not affect the question, except in so far as it may justify Darwin's conception that reef corals cannot grow on 'loose deposits.' They may have ceased to be so soft and loose as they are when resting in the quiet depths of the thousand fathoms sea. This induration may be part or an accompaniment of the process of elevation, but whether it be so or not the process is equally one of elevation and not of subsidence. In the island described by Dr. Guppy the foundations of the reef-building corals are seen resting directly on the remains of the pelagic fauna, and both theories equally assume and assert the uncontested fact that these foundations when the coral wall began to grow must have been

previously elevated to the requisite level, that, namely, of from 180 to 120 feet below the surface of the ocean. Mr. John Murray's explanation is fully confirmed that the coral reefs often begin on shoals; that these shoals are due to elevations of the sea bottom; that the reef when once established can and does grow seaward upon its own fragments broken and submerged; that these form a 'talus' capable of indefinite advance until the furthest limit of the shoot is reached; that the rearward ranks of the coral animals die as they are left behind 'in the hot and shallow waters of the lagoon; that their calcareous skeletons are then attacked by the solvent action of the water, are eaten away and carried off to form the materials of new reefs and the shells of countless other creatures. These have likewise been confirmed by the investigations of Mr. Alexander Agassiz in the West , Indies. Often in the Pacific, as in all other regions of the earth, the elevating force rest for ages, having done all the work which on some particular area they have got to do. The shoals remain shoals only covered with the walls and battlements of coral. This is the case which accounts for countless islands never

(6) On Oceanic Shoals discovered by the S.S. "Dacia,", by J. Y. Buchanan, F.R.S.E. Proc. Roy. Soc. Edin. Oct. 1883.

exceeding a certain height. On the other hand, and 'otherwhere,' the elevating forces, after a rest, resume their operation, life up these coral walls and battlements wholly out of the sea, and make other islands by the thousand which become the delight of man; whilst in yet another class of cases the elevation open out into volcanoes, and constitute great areas of land which are among the most fertile regions of the habitable globe. But everywhere cycle of operations in which they are a subordinate but a powerful agent.

In a recent article in this Review I had occasion to refer to the curious power which is sometimes exercised on behalf of certain accepted opinions, or of some reputed Prophet, in establishing a sort of Reign of Terror in their own behalf, sometimes in philosophy, sometimes in science. This observation was received I expected it to be– by those who being themselves subject to this kind of terror are wholly unconscious of the subjection. It is a remarkable illustration of this phenomenon that Mr. John Murray was strongly advised against the publication of his views in derogation of Darwin's long-accepted theory of the coral islands, and was actually induced to delay it for two years. Yet the late Sir Wyville Thomson, who was at the head of the naturalists of the 'Challenger' expedition, was himself convinced by Mr. Murray's reasoning, and the short but clear abstract of it in the second volume of the Narrative of the Voyage has since had the assent of all his colleagues (7).

Nor is this the only case, though it is the most important, in which Mr. Murray has had strength to be a great iconoclast. Along with the earlier specimens of deep-sea deposits sent home by naturalists during the first soundings in connection with the Atlantic telegraph cable, there was very often a sort of enveloping slimy mucus in the containing bottles which arrested the attention and excited the curiosity of the specialists to whom they were consigned. It was structureless to all microscopic examination. But so is all the protoplasmic

matter of which the lowest animals are formed. Could it be a widely diffused medium of this protoplasmic material, not yet specialised or individualised into organic forms, nor itself yet in a condition to build up inorganic skeletons for a habitation? Here was a grand idea. It would be well to find missing links; but it would be better to find the primordial pabulum out of which all living things had come. The ultra-Darwinian enthusiasts were enchanted. Haeckel clapped his bands and shouted out Eureka loudly. Even the cautious and discriminating mind of Professor Huxley was caught by this new and grand generalisation of the ‘physical basis of life.' It 'was announced by him to the British
(7) Narr. ‘Chall.’ Exp. vol. i. p. 781.

[page] 308
Association in 1868. Dr. Will. Carpenter took up the chorus. He spoke of ‘a living expanse of protoplasmic substance,’ penetrating with its living substance the ‘whole mass’ of the oceanic ‘mud.’ (8) A fine new Greek name was devised for this mother slime, and it was christened ‘Bathybius,’ from the consecrated deeps in which it lay. The conception ran like wildfire through the popular literature of science, and here again there was something like a coming Plebiscite in its favour. Expectant imagination soon played its part. Wonderful movements were seen in this mysterious slime. It became an ‘irregular network,’ and it could be seen gradually ‘altering its form,’ so that ‘entangled granules gradually changed their relative positions.’ The naturalists of the ‘Challenger’ began their voyage in the full Bathybian faith. But the sturdy mind of Mr. John Murray kept its balance– all the more easily since he never could himself find or see any trace of this pelagic protoplasm when the dredges of the ‘Challenger’ came fresh from bathysmal bottoms. Again and again he looked for it, but never could he discover it. It always hailed from home. The bottles sent there were reported to yield it in abundance, but somehow it seemed to be hatched in them. The laboratory in Jermyn Street was its unfailing source, and the great observer there was its only sponsor. The ocean never yielded it until it had been bottled. At last, one day on board the ‘Challenger’ an accident revealed the mystery. One of Mr. Murray's assistants poured a large quantity of spirits of wine into a bottle containing some pure sea-water, when lo! the wonderful protoplasm Bathybius appeared. It was the chemical precipitate of sulphate of lime produced by the mixture of alcohol and sea-water. This was bathos indeed. On this announcement 'Bathybius' disappeared from science, reading us, in more senses than one, a great lesson on ‘precipitation.’ (10)
This is a case in which a ridiculous error and a ridiculous credulity were the direct results of theoretical preconceptions. Bathybius was accepted because of its supposed harmony with Darwin’s speculations. It is needless to say that Darwin's own theory of the coral islands has no special connection with his later hypotheses of Evolution. Both his theory and the theory of Mr. Murray equally involve the development of changes through the action and interaction of the old agencies of vital, chemical, and mechanical change. Nevertheless the disproof of a theory which was so imposing and had been so long accepted, does read to us the most important lessons. It teaches us that neither the beauty– nor the imposing character– nor

the apparent sufficiency of an explanation may be any proof whatever of its truth. And if this he taught us even of explanations which concern results purely physical, comparatively simple, and compara

(8) Proc. Roy. Soc. No. 107, 1868, pp. 190-1.

(9) The Depths of the Sea, 2nd ed. London, 1874, pp. 410-15.

(10) Narr. 'Chall.' Exp. vol. 1, p. 939.

tively definite, how much more is this lesson impressed upon us when, concerning far deeper and more complicated things, explanations are offered which are in themselves obscure, full of metaphor, full of the pitfalls and traps due to the ambiguities of language–explanations which are incapable of being reduced to proof, and concern both agencies and results of which we are profoundly ignorant.

ARGYLL.