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# CORAL AND CORAL REEFS

## by Thomas H. Huxley

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THE subject upon which I wish to address you to-night is the structure and origin of Coral and Coral Reefs. Under the head of "coral" there are included two very different things; one of them is that substance which I imagine a great number of us have champed when we were very much younger than we are now,—the common red coral, which is used so much, as you know, for the edification and the delectation of children of tender years, and is also employed for the purposes of ornament for those who are much older, and as some think might know better. The other kind of coral is a very different substance; it may for distinction's sake be called the white coral; it is a material which most assuredly not the hardest-hearted of baby farmers would give to a baby to chew, and it is a substance which is to be seen only in the cabinets of curious persons, or in museums, or, may be, over the mantelpieces of sea-faring men. But although the red coral, as I have mentioned to you, has access to the very best society; and although the white coral is comparatively a despised product, yet in this, as in many other cases, the humbler thing is in reality the greater; the amount of work which is done in the world by the white coral being absolutely infinite compared with that effected by its delicate and pampered namesake. Each of these substances, the white coral and the red, however, has a relationship to the other. They are, in a zoological sense, cousins, each of them being formed by the same kind of animals in what is substantially the same way. Each of these bodies is, in fact, the hard skeleton of a very curious and a very simple animal, more comparable to the bones of such animals as ourselves than to the shells of oysters or creatures of that kind; for it is the hardening of the internal tissue of the creature, of its internal substance, by the deposit in the body of a material which is exceedingly common, not only in fresh but in sea water, and which is specially abundant in those waters which we know as "hard," those waters, for example, which leave a "fur" upon the bottom of a tea-kettle. This "fur" is carbonate of lime, the same sort of substance as limestone and chalk. That material is contained in solution in sea water, and it is out of the sea water in which these coral creatures live that they get the lime which is needed for the forming of their hard skeleton.

But now what manner of creatures are these which form these hard skeletons? I dare say that in these days of keeping aquaria, of locomotion to the sea-side, most of those whom I am addressing may have seen one of those creatures which used to be known as the "sea anemone," receiving that name on account of its general resemblance, in a rough sort of way, to the flower which is known as the "anemone"; but being a thing which lives in the sea, it was qualified as the "sea anemone." Well, then, you must suppose a body shaped like a short cylinder, the top cut off, and in the top a hole rather oval than round. All round this aperture, which is the mouth, imagine that there are placed a number of feelers forming a circle. The cavity of the mouth leads into a sort of stomach, which is very unlike those of the higher animals, in the circumstance that it opens at

the lower end into a cavity of the body, and all the digested matter, converted into nourishment, is thus distributed through the rest of the body. That is the general structure of one of these sea anemones. If you touch it it contracts immediately into a heap. It looks at first quite like a flower in the sea, but if you touch it you find that it exhibits all the peculiarities of a living animal; and if anything which can serve as its prey comes near its tentacles, it closes them round it and sucks the material into its stomach and there digests it and turns it to the account of its own body.

These creatures are very voracious, and not at all particular what they seize; and sometimes it may be that they lay hold of a shellfish which is far too big to be packed into that interior cavity, and, of course, in any ordinary animal a proceeding of this kind would give rise to a very severe fit of indigestion. But this is by no means the case in the sea anemone, because when digestive difficulties of this kind arise he gets out of them by splitting himself in two; and then each half builds itself up into a fresh creature, and you have two polypes where there was previously one, and the bone which stuck in the way lying between them! Not only can these creatures multiply in this fashion, but they can multiply by buds. A bud will grow out of the side of the body (I am not speaking of the common sea anemone, but of allied creatures) just like the bud of a plant, and that will fashion itself into a creature just like the parent. There are some of them in which these buds remain connected together, and you will soon see what would be the result of that. If I make a bud grow out here, and another on the opposite side, and each fashions itself into a new polype, the practical effect will be that before long you will see a single polype converted into a sort of tree or bush of polypes. And these will all remain associated together, like a kind of co-operative store, which is a thing I believe you understand very well here,—each mouth will help to feed the body and each part of the body help to support the multifarious mouths. I think that is as good an example of a zoological co-operative store as you can well have. Such are these wonderful creatures. But they are capable not only of multiplying in this way, but in other ways, by having a more ordinary and regular kind of offspring. Little eggs are hatched and the young are passed out by the way of the mouth, and they go swimming about as little oval bodies covered with a very curious kind of hairlike processes. Each of these processes is capable of striking water like an oar; and the consequence is that the young creature is propelled through the water. So that you have the young polype floating about in this fashion, covered by its 'vibratile cilia', as these long filaments, which are capable of vibration are termed. And thus, although the polype itself may be a fixed creature unable to move about, it is able to spread its offspring over great areas. For these creatures not only propel themselves, but while swimming about in the sea for many hours, or perhaps days, it will be obvious that they must be carried hither and thither by the currents of the sea, which not unfrequently move at the rate of one or two miles an hour. Thus, in the course of a few days, the offspring of this stationary creature may be carried to a very great distance from its parent; and having been so carried it loses these organs by which it is propelled, and settles down upon the bottom of the sea and grows up again into the form and condition of its parents. So that if you suppose a single polype of this kind settled upon the bottom of the sea, it may by these various methods—that is to say, by cutting itself in two, which we call "fission," or by budding; or by sending out these swimming embryos,—multiply itself to an enormous extent, and give rise to thousands, or millions, of progeny in a comparatively short time; and these thousands, or millions, of progeny may cover a very large surface of the sea bottom; in fact, you will readily perceive that, give them time, and there is no limit to the surface which they may cover.

Having understood thus far the general nature of these polypes, which are the fabricators both of the red and white coral, let us consider a little more particularly how the skeletons of the red coral and of the white coral are formed. The red coral polype perches upon the sea bottom, it then grows up into a sort of stem, and out of that stem there grow branches, each of which has its own polypes; and thus you have a kind of tree formed, every branch of the tree terminated by its polype. It is a tree, but at the end of the branches there are open mouths of polypes instead of flowers. Thus there is a common soft body connecting the whole, and as it grows up the soft body deposits in its interior a quantity of carbonate of lime, which acquires a beautiful red or flesh colour, and forms a kind of stem running through the whole, and it is that stem which is the red coral. The red coral grows principally at the bottom of the Mediterranean Sea, at very great depths, and the coral fishers, who are very adventurous seamen, take their drag nets, of a peculiar kind, roughly made, but efficient for their purpose, and drag them along the bottom of the sea to catch the branches of the red coral, which become entangled and are thus brought up to the surface. They are then allowed to putrefy, in order to get rid of the animal matter, and the red coral is the skeleton that is left.

In the case of the white coral, the skeleton is more complete. In the red coral, the skeleton belongs to the whole; in the white coral there is a special skeleton for every one of these polypes in addition to that for the whole body. There is a skeleton formed in the body of each of them, like a cup divided by a number of radiating partitions towards the outside; and that cup is formed of carbonate of lime, only not stained red, as in the case of the red coral. And all these cups are joined together into a common branch, the result of which is the formation of a beautiful coral tree. This is a great mass of madrepore, and in the living state every one of the ends of these branches was terminated by a beautiful little polype, like a sea anemone, and all the skeleton was covered by a soft body which united the polypes together. You must understand that all this skeleton has been formed in the interior of the body, to suit the branched body of the polype mass, and that it is as much its skeleton as our own bones are our skeleton. In this next coral the creature which has formed the skeleton has divided itself as it grew, and consequently has formed a great expansion; but scattered all over this surface there were polype bodies like those I previously described. Again, when this great cup was alive, the whole surface was covered with a beautiful body upon which were set innumerable small polype flowers, if we may so call them, often brilliantly coloured; and the whole cup was built up in the same fashion by the deposit of carbonate of lime in the interior of the combined polype body, formed by budding and by fission in the way I described. You will perceive that there is no necessary limit to this process. There is no reason why we should not have coral three or four times as big; and there are certain creatures of this kind that do fabricate very large masses, or half spheres several feet in diameter. Thus the activity of these animals in separating carbonate of lime from the sea and building it up into definite shapes is very considerable indeed.

Now I think I have said sufficient—as much as I can without taking you into technical details, of the general nature of these creatures which form coral. The animals which form coral are scattered over the seas of all

countries in the world. The red coral is comparatively limited, but the polypes which form the white coral are widely scattered. There are some of them which remain single, or which give rise to only small accumulations; and the skeletons of these, as they die, accumulate upon the bottom of the sea, but they do not come to much; they are washed about and do not adhere together, but become mixed up with the mud of the sea. But there are certain parts of the world in which the coral polypes which live and grow are of a kind which remain, adhere together, and form great masses. They differ from the ordinary polypes just in the same way as those plants which form a peat-bog or meadow-turf differ from ordinary plants. They have a habit of growing together in masses in the same place; they are what we call "gregarious" things; and the consequence of this is, that as they die and leave their skeletons, those skeletons form a considerable solid aggregation at the bottom of the sea, and other polypes perch upon them, and begin building upon them, and so by degrees a great mass is formed. And just as we know there are some ancient cities in which you have a British city, and over that the foundations of a Roman city; and over that a Saxon city, and over that again a modern city, so in these localities of which I am speaking, you have the accumulations of the foundations of the houses, if I may use the term, of nation after nation of these coral polypes; and these accumulations may cover a very considerable space, and may rise in the course of time from the bottom to the surface of the sea.

Mariners have a name which they apply to all sorts of obstacles consisting of hard and rocky matter which comes in their way in the course of their navigation; they call such obstacles "reefs," and they have long been in the habit of calling the particular kind of reef, which is formed by the accumulation of the skeletons of dead corals, by the name of "coral reefs," therefore, those parts of the world in which these accumulations occur have been termed by them "coral reef areas," or regions in which coral reefs are found. There is a very notable example of a simple coral reef about the island of Mauritius, which I dare say you all know, lies in the middle of the Indian Ocean. It is a very considerable and beautiful island, and is surrounded on all sides by a mass of coral, which has been formed in the way I have described; so that if you could get upon the top of one of the peaks of the island, and look down upon the Indian Ocean, you would see that the beach round the Island was continued outward by a kind of shallow terrace, which is covered by the sea, and where the sea is quite shallow; and at a distance varying from three-quarters of a mile to a mile and a half from the proper beach, you would see a line of foam or surf which looks most beautiful in contrast with the bright green water in the inside, and the deep blue of the sea beyond. That line of surf indicates the point at which the waters of the ocean are breaking upon the coral reef which surrounds the island. You see it sweep round the island upon all sides, except where a river may chance to come down, and that always makes a gap in the shore.

There are two or three points which I wish to bring clearly before your notice about such a reef as this. In the first place, you perceive it forms a kind of fringe round the island, and is therefore called a "fringing reef." In the next place, if you go out in a boat, and take soundings at the edge of the reef, you find that the depth of the water is not more than from 20 to 25 fathoms—that is about 120 to 150 feet. Outside that point you come to the natural sea bottom; but all inside that depth is coral, built up from the bottom by the accumulation of the skeletons of innumerable generations of coral polypes. So that you see the coral forms a very considerable rampart round the island. What the exact circumference may be I do not remember, but it cannot be less than 100 miles, and the outward height of this wall of coral rock nowhere amounts to less than about 100 or 150 feet.

When the outward face of the reef is examined, you find that the upper edge, which is exposed to the wash of the sea, and all the seaward face, is covered with those living plant-like flowers which I have described to you. They are the coral polypes which grow, flourish, and add to the mass of calcareous matter which already forms the reef. But towards the lower part of the reef, at a depth of about 120 feet, these creatures are less active, and fewer of them at work; and at greater depths than that you find no living coral polype at all; and it may be laid down as a rule, derived from very extensive observation, that these reef-building corals cannot live in a greater depth of water than about 120 to 150 feet. I beg you to recollect that fact, because it is one I shall have to come back to by and by, and to show to what very curious consequences that rule leads. Well then, coming back to the margin of the reef, you find that part of it which lies just within the surf to be coated by a very curious plant, a sort of seaweed, which contains in its substance a very great deal of carbonate of lime, and looks almost like rock; this is what is called the nulli pore. More towards the land, we come to the shallow water upon the inside of the reef, which has a particular name, derived from the Spanish or the Portuguese—it is called a "lagoon," or lake. In this lagoon there is comparatively little living coral; the bottom of it is formed of coral mud. If we pounded this coral in water, it would be converted into calcareous mud, and the waves during storms do for the coral skeletons exactly what we might do for this coral in a mortar; the waves tear off great fragments and crush them with prodigious force, until they are ground into the merest powder, and that powder is washed into the interior of the lagoon, and forms a muddy coating at the bottom. Beside that there are a great many animals that prey upon the coral—fishes, worms, and creatures of that kind, and all these, by their digestive processes, reduce the coral to the same state, and contribute a very important element to this fine mud. The living coral found in the lagoon, is not the reef building coral; it does not give rise to the same massive skeletons. As you go in a boat over these shallow pools, you see these beautiful things, coloured red, blue, green, and all colours, building their houses; but these are mere tenements, and not to be compared in magnitude and importance to the masses which are built by the reef-builders themselves. Now such a structure as this is what is termed a "fringing reef." You meet with fringing reefs of this kind not only in the Mauritius, but in a number of other parts of the world. If these were the only reefs to be seen anywhere, the problem of the formation of coral reefs would never have been a difficult one. Nothing can be easier than to understand how there must have been a time when the coral polypes came and settled on the shores of this island, everywhere within the 20 to 25 fathom line, and how, having perched there, they gradually grew until they built up the reef.

But these are by no means the only sort of coral reefs in the world; on the contrary, there are very large areas, not only of the Indian ocean, but of the Pacific, in which many many thousands of square miles are covered either with a peculiar kind of reef, which is called the "encircling reef," or by a still more curious reef which goes by the name of the "atoll." There is a very good picture, which Professor Roscoe has been kind enough to prepare for me, of one of these atolls, which will enable you to form a notion of it as a landscape. You have in the foreground the waters of the Pacific. You must fancy yourself in the middle of the great

ocean, and you will perceive that there is an almost circular island, with a low beach, which is formed entirely of coral sand; growing upon that beach you have vegetation, which takes, of course, the shape of the circular land; and then, in the interior of the circle, there is a pool of water, which is not very deep—probably in this case not more than eight or nine fathoms—and which forms a strange and beautiful contrast to the deep blue water outside. This circular island, or atoll, with a lagoon in the middle, is not a complete circle; upon one side of it there is a break, exactly like the entrance into a dock; and, as a matter of course, these circular islets, or atolls, form most efficient break-waters, for if you can only get inside your ship is in perfect safety, with admirable anchorage in the interior. If the ship were lying within a mile of that beach, the water would be one or two thousand feet deep; therefore, a section of that atoll, with the soundings as deep as this all round, would give you the notion of a great cone, cut off at the top, and with a shallow cup in the middle of it. Now, what a very singular fact this is, that we should have rising from the bottom of the deep ocean a great pyramid, beside which all human pyramids sink into the most utter insignificance! These singular coral limestone structures are very beautiful, especially when crowned with cocoa-nut trees. There you see the long line of land, covered with vegetation—cocoa-nut trees—and you have the sea upon the inner and outer sides, with a vessel very comfortably riding at anchor. That is one of the remarkable forms of reef in the Pacific. Another is a sort of half-way house, between the atoll and the fringing reef; it is what is called an "encircling reef." In this case you see an Island rising out of the sea, and at two or three miles distance, or more, and separated by a deep channel, which may be eight to twelve fathoms deep, there is a reef, which encircles it like a great girdle; and outside that again the water is one or two thousand feet deep. I spent three or four years of my life in cruising about a modification of one of these encircling reefs, called a "barrier reef," upon the east coast of Australia—one of the most wonderful accumulations of coral rock in the world. It is about 1,100 miles long, and varies in width from one or two to many miles. It is separated from the coast of Australia by a channel of about 25 fathoms deep; while outside, looking toward America, the water is two or three thousand feet deep at a mile from the edge of the reef. This is an accumulation of limestone rock, built up by corals, to which we have no parallel anywhere else. Imagine to yourself a heap of this material more than one thousand miles long, and several miles wide. That is a barrier reef; but a barrier reef is merely as it were a fragment of an encircling reef running parallel to the coast of a great continent.

I told you that the polypes which built these reefs were not able to live at a greater depth than 20 to 25 fathoms of water; and that is the reason why the fringing reef goes no farther from the land than it does. And for the same reason, if the Pacific could be laid bare we should have a most singular spectacle. There would be a number of mountains with truncated tops scattered over it, and those mountains would have an appearance just the very reverse of that presented by the mountains we see on shore. You know that the mountains on shore are covered with vegetation at their bases, while their tops are barren or covered with snow; but these mountains would be perfectly bare at their bases, and all round their tops they would be covered with a beautiful vegetation of coral polypes. And not only would this be the case, but we should find that for a considerable distance down, all the material of these atoll and encircling reefs was built up of precisely the same coral rock as the fringing reef. That is to say, you have an enormous mass of coral rock at a depth below the surface of the water where we know perfectly well that the coral animals could not have lived to form it. When those two facts were first put together, naturalists were quite as much puzzled as I daresay you are, at present, to understand how these two seeming contradictions could be reconciled; and all sorts of odd hypotheses were resorted to. It was supposed that the coral did not extend so far down, but that there was a great chain of submarine mountains stretching through the Pacific, and that the coral had grown upon them. But only fancy what supposition that was, for you would have to imagine that there was a chain of mountains a thousand miles or more long, and that the top of every mountain came within 20 fathoms of the surface of the sea, and neither rose above nor sunk beneath that level. That is highly improbable: such a chain of mountains was never known. Then how can you possibly account for the curious circular form of the atolls by any supposition of this kind? I believe there was some one who imagined that all these mountains were volcanoes, and that the reefs had grown round the tops of the craters, so we all stuck fast. I may say "we," though it was rather before my time. And when we all stick fast, it is just the use of a man of genius that he comes and shows us the meaning of the thing. He generally gives an explanation which is so ridiculously simple that everybody is ashamed that he did not find it out before; and the way such a discoverer is often rewarded is by finding out that some one had made the discovery before him! I do not mean to say that it was so in this particular instance, because the great man who played the part of Columbus and the egg on this occasion had, I believe, always had the full credit which he so well deserves. The discoverer of the key to these problems was a man whose name you know very well in connection with other matters, and I should not wonder if some of you have heard it said that he was a superficial kind of person who did not know much about the subject on which he writes. He was Mr. Darwin, and this brilliant discovery of his was made public thirty years ago, long before he became the celebrated man he now is; and it was one of the most singular instances of that astonishing sagacity which he possesses of drawing consequences by way of deduction from simple principles of natural science—a power which has served him in good stead on other occasions. Well, Mr. Darwin, looking at these curious difficulties and having that sort of knowledge of natural phenomena in general, without which he could not have made a step towards the solution of the problem, said to himself —"It is perfectly clear that the coral which forms the base of the atolls and fringing reefs could not possibly have been formed there if the level of the sea has always been exactly where it is now, for we know for certain that these polypes cannot build at a greater depth than 20 to 25 fathoms, and here we find them at 50 to 100 fathoms."

That was the first point to make clear. The second point to deal with was—if the polypes cannot have built there while the level of the sea has remained stationary, then one of two things must have happened—either the sea has gone up, or the land has gone down.

There is no escape from one of these two alternatives. Now the objections to the notion of the sea having gone up are very considerable indeed; for you will readily perceive that the sea could not possibly have risen a thousand feet in the Pacific without rising pretty much the same distance everywhere else; and if it had risen that height everywhere else since the reefs began to be formed, the geography of the world in general must have been very different indeed, at that time, from what it is now. And we have very good means of

knowing that any such rise as this certainly has not taken place in the level of the sea since the time that the corals have been building their houses. And so the only other alternative was to suppose that the land had gone down, and at so slow a rate that the corals were able to grow upward as fast as it went downward. You will see at once that this is the solution of the mystery, and nothing can be simpler or more obvious when you come to think about it. Suppose we start with a coral sea and put in the middle of it an island such as the Mauritius. Now let the coral polypes come and perch on the shore and build a fringing reef, which will stop when they come to 20 or 25 fathoms, and you will have a fringing reef like that round the island in the illustration. So long as the land remains stationary, so long as it does not descend so long will that reef be unable to get any further out, because the moment the polype embryos try to get below they die. But now suppose that the land sinks very gradually indeed. Let it subside by slow degrees, until the mountain peak, which we have in the middle of it, alone projects beyond the sea level. The fringing reef would be carried down also; but we suppose that the sinking is so slow that the coral polypes are able to grow up as fast as the land is carried down; consequently they will add layer upon layer until they form a deep cup, because the inner part of the reef grows much more slowly than the outer part. Thus you have the reef forming a bed thicker upon the flanks of the island; but the edge of the reef will be very much further out from the land, and the lagoon will be many times deeper; in short, your fringing reef will be converted into an encircling reef. And if, instead of this being an island, it were a great continent like Australia, then you will have the phenomenon of a barrier reef which I have described. The barrier reef of Australia was originally a fringing reef; the land has gone slowly down; the consequence is the lagoon has deepened until its depth is now 25 fathoms and the corals have grown up at the outer edge until you have that prodigious accumulation which forms the barrier reef at present. Now let this process go on further still; let us take the land a further step down, so as to submerge even the peak. The coral, still growing up, will cover the surface of the land, and you will have an atoll reef; that is to say, a more or less circular or oval ring of coral rock with a lagoon in the middle. Thus you see that every peculiarity and phenomenon of these different forms of coral reef was explained at once by the simplest of all possible suppositions, namely, by supposing that the land has gone down at a rate not greater than that at which the coral polypes have grown up. You explain a Fringing Reef as a reef which is formed round land comparatively stationary; an Encircling Reef as one which is formed round land going down; and an Atoll as a reef formed upon land gone down; and the thing is so simple that a child may understand it when it is once explained.

But this would by no means satisfy the conditions of a scientific hypothesis. No man who is cautious would dream of trusting to an explanation of this kind simply because it explained one particular set of facts. Before you can possibly be safe in dealing with Nature—who is very properly made of the feminine gender, on account of the astonishing tricks which she plays upon her admirers!—I say before you can be safe in dealing with Nature, you must get two or three kinds of cross proofs, so as to make sure not only that your hypothesis fits that particular set of facts, but that it is not contradicted by some other set of facts which is just as clear and certain. And it so happens, that in this case Mr. Darwin supplied the cross proofs as well as the immediate evidence. You have all heard of volcanoes, those wonderful vents in the surface of the earth out of which pour masses of lava, cinders and ashes, and the like. Now, it is a matter of observation and experience that all volcanoes are placed in areas in which the surface of the earth is undergoing elevation, or at any rate is stationary; they are not placed in parts of the world in which the level of the land is being lowered. They are all indications of a great subterranean activity, of a something being pushed up, and therefore naturally the land either gives way and lets it come through, or else is raised up by its violence. And so Mr. Darwin, being desirous not to merely put out a flashy hypothesis, but to get at the truth of the matter, said to himself, "If my notion of this matter is right, then atolls and encircling reefs, inasmuch as they are dependent upon subsidence, ought not to be found in company with volcanoes; and, 'vice versa', volcanoes ought not to be found in company with atolls, but they ought to be found in company with fringing reefs." And if you turn to Mr. Darwin's great work upon the coral reefs, you will see a very beautiful chart of the world, which he prepared with great pains and labour, showing the distribution on the one hand of the reefs, and on the other of the volcanoes; you will find that in no case does the atoll accompany the volcano, or the volcano burst up among the atolls. It is most instructive to look at the great area of the Pacific on the map, and see the great masses of atolls forming in one region of it a most enormous belt, running from north-west to south-east; while the volcanoes, which are very numerous in that region, go round the margin, so that we can picture the Pacific to ourselves a section of a kind of very shallow basin—shallow in proportion to its width, with the atolls rising from the bottom of it, and at the margins the volcanoes. It is exactly as if you had taken a flat mass and lifted up the edges of it; the subterranean force which lifted up the edges shows itself in volcanoes, and as the edges have been raised, the middle part of the mass has gone down. In other words, the facts of physical geography precisely and exactly correspond with the hypothesis which accounts for the infinite varieties of coral reefs.

One other point, before I conclude, about this matter. These reefs, as you have just perceived, are in a most singular and unexpected manner indications of physical changes of elevations and depressions going on upon the surface of the globe. I dare say it may have surprised you to hear me talk in this familiar sort of way of land going up and down; but it is one of the universal lessons of geology that the land is going down and going up, and has been going up and down, in all sorts of places and to all sorts of distances, through all recorded time. Geologists would be quite right in maintaining the seeming paradox that the stable thing in the world is the fluid sea and the shifting thing is the solid land. That may sound a very hard saying at first, but the more you look into geology, the more you will see ground for believing that it is not a mere paradox.

In an unexpected manner, again, these reefs afford us not only an indication of change of place, but they afford an indication of lapse of time. The reef is a timekeeper of a very curious character; and you can easily understand why. The coral polype, like everything else, takes a certain time to grow to its full size; it does not do it in a minute; just as a child takes a certain time to grow into a man so does the embryo polype take time to grow into a perfect polype and form its skeleton. Consequently every particle of coral limestone is an expression of time. It must have taken a certain time to separate the lime from the sea water. It is not possible to arrive at an accurate computation of the time it must have taken to form these coral islands, because we lack the necessary data; but we can form a rough calculation, which leads to very curious and

striking results. The computations of the rate at which corals grow are so exceedingly variable, that we must allow the widest possible margin for error; and it is better in this case to make the allowance upon the side of excess. I think that anybody who knows anything about the matter will tell you that I am making a computation far in excess of what is probable, if I say that an inch of coral limestone may be added to one of these reefs in the course of a year. I think most naturalists would be inclined to laugh at me for making such an assumption, and would put the growth at certainly not more than half that amount. But supposing it is so, what a very curious notion of the antiquity of some of these great living pyramids comes out by a very simple calculation. There is no doubt whatever that the sea faces of some of them are fully a thousand feet high, and if you take the reckoning of an inch a year, that will give you 12,000 years for the age of that particular pyramid or cone of coral limestone; 12,000 long years have these creatures been labouring in conditions which must have been substantially the same as they are now, otherwise the polypes could not have continued their work. But I believe I very much understate both the height of some of these masses, and overstate the amount which these animals can form in the course of a year; so that you might very safely double the period as the time during which the Pacific Ocean, the general state of the climate, and the sea, and the temperature has been substantially what it is now; and yet that state of things which now obtains in the Pacific Ocean is the yesterday of the history of the life of the globe. Those pyramids of coral rock are built upon a foundation which is itself formed by the deposits which the geologist has to deal with. If we go back in time and search through the series of the rocks, we find at every age of the world's history which has yet been examined, accumulations of limestone, many of which have certainly been built up in just the same way as those coral reefs which are now forming the bottom of the Pacific Ocean. And even if we turn to the oldest periods of geologic history, although the nature of the materials is changed, although we cannot apply to them the same reasonings that we can to the existing corals, yet still there are vast masses of limestone formed of nothing else than the accumulations of the skeletons of similar animals, and testifying that even in those remote periods of the world's history, as now, the order of things implies that the earth had already endured for a period of which our ordinary standards of chronology give us not the slightest conception. In other words, the history of these coral reefs, traced out honestly and carefully, and with the same sort of reasoning that you would use in the ordinary affairs of life, testifies, like every fact that I know of, to the prodigious antiquity of the earth since it existed in a condition in the main similar to that in which it now is.

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1 (return)
[ A Lecture delivered in Manchester, November 4th, 1870.]

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