THE CORAL ISLANDS.---THEIR NATURE, GROWTH, AND GEOGRAPHICAL DISTRIBUTION.

LECTURE DELIVERED AT THE STEVENS INSTITUTE OF TECHNOLOGY BY PROFESSOR A. GUYOT, OF PRINCETON, N. J.

In asking his hearers to accompany him on a sailing excursion, notwithstanding the stormy weather outside, the lecturer assured them that they would be most likely to encounter a calm sea and fair weather on the magnificent waters of the Pacific ocean, with its thousands of islands far away from any coast. Those who are familiar with the glowing narrations of Captain Cook and other navigators will remember that the presence of an island is recognized, long before it becomes visible, by clouds directly above it in the otherwise clear sky. The land absorbs the heat of the sun and accumulates it faster than the water; soon an ascending current of warm air is formed, carrying up moisture into the colder regions of the atmosphere, where it is condensed and forms clouds. A similar phenomenon is observed in our western plains, where the sky is frequently clear early in the morning, but by 10 or 11 o'clock enough heat has been accumulated to cause the formation of clouds.

The islands of the Pacific are of two kinds,called the lower and the higher. The lower rise but 7, 10, and rarely as high as 100, feet above the level of the sea; while the higher islands reach an elevation of 10,000, 12,000, and even 15,000 feet. There is no transition between them. The most remarkable are the lower islands. Their appearance is very peculiar. In the first place, the eye is arrested by a white beach: then comes a line of verdure, due to tropical trees; then a lagoon of quiet water of a whitish or a yellowish color, then another line of verdure, and finally, beyond all, the dark blue waves of the ocean. A picture of Whitsuntide Island illustrated the structure. It is a ring rising 7 or 8 feet above the sea level, enclosing a lagoon, and presenting the characteristics just described. The lagoon inside is but a few fathoms deep; but on the outside of the island, the water is 15,000 feet deep. Here then we evidently have a tower-like structure reaching up from the bottom of the sea, and having a depression in its summit. Some of these lower islands are 50 miles across,but most of them are not so large In some the ring is broken at several points, and these are designated by the Malay word *atoll.*

The island of Tahiti, the principal one of the Society Islands,is a good example of the second class or higher islands. It rises 7,000 to 8,000 feet above the level of the sea, has no lagoon in its center, but a crater, and the water around it is very deep. It may in fact be considered as a mountain rising to a hight of some 18,000 feet from the bottom of the sea Outside of it is a double girdle of low islands, one near, which Darwin calls a fringing reef, and one further out, to which he gives the name of a barrier reef.

On examining these reefs and the lower islands, their structure will be found made up entirely of animal remains, generation after generation having left their homes, consisting of limestone, to accumulate there. On the top we find these animals living and growing, in all colors, shapes, and sizes. The higher islands, on the contrary, except those near the continent, like Borneo, Sumatra, etc., are entirely volcanic,and do not contain sandstone, granite,or gneiss, like the mountains of the continent.

The limestone of the lower islands is not due to sedimentary deposits from the ocean, but is the work of the coral animal, the great architect of the sea. According to Agassiz's description, which is here followed, these animals are but a sac, like the finger of a glove, only more leathery. Around the mouth is a series of tentacles, formed by a prolongation of the skin. They are all skin, in fact, and have no special organs, yet they digest food with tremendous rapidity, absorbing it directly. It makes no difference if you turn them inside out; they will digest just as well as before. You cannot kill them by dividing them: for they live all over, like a plant. For this reason they have been called zoöphytes. If you cut one into eight parts, each part will live and set up in business for itself. Like all other animals,however, they grow out of eggs. The eggs are formed within the skin, which is double,and divided into cells by partitions or septa. When mature, they detach themselves, move about in the water until they find a favorable place, and then establish a new colony. They do not contribute to the growth of their parent colony, which is effected in another way.

On examining a piece of coal, it is seen to be full of little holes, popularly supposed to be the places for the stomachs of the animals, but this is not so at all; the coral animal does not form a secretion around it like the mollusks, but inside, between the two folds of its skin. Coral is, therefore, the bones and not the skull of the animal. As before stated, these animals work in societies or colonies, and their tendency is to repeat the forms peculiar to each species; thus we have corals shaped like a hand,like the branches of trees, like mushrooms, like a brain, with its convolutions. They grow and multiply in these societies by budding or gemmation. The side of the animal begins to bulge out, and the protuberance so formed develops into a new mouth, which soon eats and digests for itself, but does not separate from its parent. This process goes on symmetrically, and produces the variety of regular shapes just described.

Some distance below the surface, we no longer find these beautiful shapes, but a dense, solid, coral rock. Take for instance the coral reefs of Florida. Beginning 120 feet below the surface, we first find about 30 feet of massive rock, then the astræa, then the meandrina, and about ten feet below the surface the palmata or hand-shaped coral. In the shallow mud between the reefs and the continent, there are multitudes of branching corals of the most beautiful forms, colors, and delicacy of structure. The production of coral rock is explained partly by the mechanical action of the waves, and partly by the destruction of the coral insect by the sea urchin and other animals that feed on it. The waves disintegrate the structure formed by the animal,and then roll back the coral sand thus produced upon it, where it undergoes a process of induration in the course of time.

It is an interesting question how the structure ever rises above the water level, seeing that the animal which makes it cannot live out of the water. The little architects retain enough sea water to last them over until the next tide and are so enabled to work up to the highest watermark. Actinia have been observed all closed up on the rock at low water, and then suddenly opened like magnificent flowers, 5 and 6 inches in diameter, when the tide rose.

The ring form of the Pacific islands is due to the shape of the foundation upon which the coral animals built. On the Florida coast the reefs run parallel to the land for the same reason. Now take this, together with the fact that all the high islands are volcanoes, with the regular conical shape, and you will be prepared to understand the explanation, given simultaneously by Darwin and Dana, that the low islands were originally reefs around the high islands or volcanoes, and that the latter, by the gradual subsidence of the ocean bed, sank and left the reefs appear as low islands, with a lagoon where the crater of the volcano was. The reefs, of course, were gradually carried down along with the mountain upon the sides of which they rested, but the coral insects kept on building towards the surface; the mountain appeared as a smaller and smaller cone in the center; what was left a fringing reef now became a barrier reef, and the mountain finally disappeared altogether. This theory is supported by the fact that barrier reefs are found extending 1,700 feet down, while the coral insect cannot live at a depth greater than 120 feet. These facts were illustrated by fine pictures of the island of Bolabola and others, in different stages of the process of subsidence.

The vegetation on the islands is due partly to seeds floating in the sea, and partly to seeds dropped by birds. Hence there are very few species of trees and plants; but being in the tropics, they flourish luxuriantly.

At present, the coral formations are confined to the tropics, because the coral animal cannot exist where the temperature falls below 60°. Dana states that the central axis of the Pacific Ocean is subsiding altogether; it has already gone down more than any other part of the ocean. There are now no islands at all above the water along its line.

In old geological times, the temperature of the earth must have been much more uniform; for we find coral formations very abundantly in nearly all parts of the world. Other limestone formations are formed by a yet lower form of animal, a protozoön, which works at the bottom of the sea and thus covers nearly three quarters of the whole surface of the globe. A diagram was exhibited, showing what the microscope revealed to Ehrenberg in a piece of chalk.

Surely then, concluded the lecturer, if so great a portion of the earth's crust is the product of animal life, we must correct our notions of matter and force, and admire the beauty and simplicity of the economy of God, who makes the most insignificant of creatures subservient to his great works. C. H. K

THE NATIONAL ACADEMY OF SCIENCES.

The spring meeting of the National Academy of Sciences opened at the Smithsonian Institute, in Washington, on April 17. There is a strong attendance of the most eminent of our scientists; and judging from the papers which have been read up to the time this issue goes to press, the session is likely to prove an interesting and instructive one. Copious abstracts of the various communications will be found in the SCIENTIFIC AMERICAN SUPPLEMENT, No. 20; and therefore we give in this place put a brief *resumé* of the more important ones presented. That indefatigable investigator, Professor A. M. Mayer, of the Stevens Institute, opened the proceedings with a paper on tuning forks, which instruments are now largely used for determining short periods of time by means of apparatus involving their vibrations. These researches are vitiated by errors, regarding which little is known; and although instruments have been constructed to indicate the exact measure of time taken by the forks for their vibration, such apparatus has not been accurate. Professor Mayer's new instrument involves a clock pendulum which, at the lowest point of its path, touches a mercury globule, and so completes an electric current to a fork which describes a wave line on a revolving cylinder, covered with smoked paper. When the electric spark passes, it goes through the paper. Thus the length of time between the beats of the pendulum is measured on the waved line, and the number of waves is the number of tuning fork vibrations. Hence, by counting the number of waves between each spark hole, the number of vibrations in a given time may be accurately determined. It is found that the effect of a change of temperature of 1° is $\frac{1}{22000}$ of the length of a vibration; and the effect, therefore, of temperature on any fork may be ascertained by multiplying its number of vibrations per second by the decimal 0 00004545. A difference of 10° in temperature, during the use of a tuning fork to measure the velocity of a projectile, would obviously make a serious difference in the record.

General H. L Abbott read a paper on the simultaneous ignition of large numbers of fuses, in mining operations. The essay dealt with mathematical points, and involved many formulæ, but resulted in a rule which has been reduced to practice, so that 2,500 fuses can be fired at a single instant. The speaker said, incidentally, that more than 8,000 fuses would be simultaneously exploded to blow up the Hell Gate excavations.

President F. A. P. Barnard gave a learned exposition of the theory of magic squares, which are arithmetical puzzles, extremely abstruse and of no immediate practical value.

Professor Henry, President of the Academy, in reviewing scientific progress, said that it was contemplated to conduct a series of new experiments, under the auspices of the Smithsonian Institution, to determine accurately the rate of increase of the earth's temperature at progressive depths—also new investigations on the velocity of light. The work of weighing the earth accurately will also, probably, be undertaken anew.

Professor Mayer also read a second paper, showing how certain sounds would extinguish the sensation of other sounds; and adduced the rule that, while low sounds cannot extinguish high ones, the high sounds may obliterate low ones. This fact is of great importance in the conduct of an orchestra. The conductor regulates the players according to the impression, on his ear, of the different sounds at the place where he stands. But what may be perfect there is necessarily imperfect elsewhere; and therefore, at greater distances the high sounds may be killing the lower ones. To provide the best music, the conductor should locate himself in the middle of the room.

ASTRONOMICAL NOTES.

OBSERVATORY OF VASSAR COLLEGE.

The computations and some of the observations in the following notes are from students in the astronomical department. The times of risings and settings of planets are approximate, but sufficiently accurate to enable an ordinary observer to find the objects mentioned. M. M.

Position of the Planets for May, 1876.

Mercury.

Mercury rises on May 1 at 5h. 25m. A. M., and sets at 7h. 51m. P. M. On the 31st, Mercury rises at 5h. 47m. A. M., and sets at 8h. 52m. P. M.

Mercury should be looked for after sunset, some degrees north of the point where the sun disappears. On May 21 it will be at its greatest elongation east of the sun, and can easily be found, as it makes very nearly the diurnal path of Venus, and is about 24° nearer the horizon. The new moon is very near Mercury on May 25.

Venus.

On May 1, Venus rises at 7h. 20m. A. M., and sets at 10h. 53m. P. M. On the 31st, Venus rises at 7h. 26m. A. M.,and sets at 10h. 35m. P. M.

Venus is at its greatest elongation on May 4. A glass of low power will show that Venus presents phases like the moon. Venus is not at its greatest brilliancy until June, but it can be seen now to cast a shadow when a pencil is held in its light.

Mars.

Mars rises on May 1 at 6h. 38m. A. M., and sets at 9h. 39m. P. M. On the 31st, Mars rises at 6h. 1m. A. M., and sets at 9h. 12m. P. M.

Although Mars is now apparently very small, it is easily found, as it makes nearly the same diurnal path with Venus and shines with a ruddy light. If Mars is seen on the 21st, Mercury can be found nearer the horizon, and nearly in the continuation of the curve which passes through Venus and Mars.

Jupiter.

Jupiter is becoming visible in the evening. It rises on May 1 at 8h. 17m. P. M , and sets at 5h. 55m. the next morning. On May 31, Jupiter rises at 6h. 1m. P. M , and sets at 3h. 46m. A. M. of the next day. Jupiter is still near the star *β Scorpii,* and its daily motions can be watched with reference to this star.

Saturn.

Saturn is seen only in the morning hours. It rises at 2h. 34m. A. M. on the 1st, and on the 31st at 12.40 A. M. It comes to the meridian on the 31st at 6 A. M., and should be looked for in the southeast, before sunrise, at an altitude somewhat less than 31½°.

Uranus.

On May 1, Uranus rises at 11h. 31m. A. M., and sets at 1h. 36m. the next morning. On the 31st Uranus rises at 9h. 36m. A. M., and sets at 11h. 39m. P. M. The position of Uranus is still among the small stars of *Leo.*

Neptune.

Neptune is not only very remote, but at present its path is so nearly that of the sun that it cannot be seen.

Sun Spots.

The report is from March 19 to April 20 inclusive. During this period, photographing has been rendered almost impossible by clouds. In a few cases, very small spots have been seen upon the sun's disk, but at present, with a telescope of 2½ inches aperture, no spot can be found.

The Proposed Aquarium in Central Park.

The subject of an aquarium in Central Park, New York city, is again being agitated, and a bill is before the New State Legislature allowing of the establishment, the same to be under control of the Park Commissioners. We have frequently pointed out the usefulness of such an exhibition, and the benefits which the people would derive from so excellent a means of education and recreation. New York is so situated as to allow of the stocking of a fine aquarium with ocean fishes with but little trouble, and we trust that the appropriation may be granted.

MESSRS. JONES & LAUGHLIN, American Iron Works, Pittsburgh, Pa., employ in one department 62 men,61 of whom are subscribers to the SCIENTIFIC AMERICAN.