STEVENS INSTITUTE LECTURES.—MOONLIGHT AND ITS SOURCE.

BY PRESIDENT HENRY MORTON.

The moon shines, as is well known, by reflected light; and a consideration of the nature of reflected light will therefore be a profitable introduction to the study of the moon itself. When a pebble is dropped in the smooth water surface of a pond, circular ripples or waves will be formed, constantly expanding as they recede from the center of disturbance. In like manner, a source of light produces a disturbance in the ether pervading all space, thereby throwing it into ripples or waves, which differ from the former only in being spherical instead of being confined to a flat surface. When one of these advancing waves of light strikes against an obstacle, it will be thrown back as an india rubber ball would be when thrown against a wall, returning with the same force with which it struck, because the impinging ether is perfectly elastic.

FIG. 1.

In the accompanying figure are seen a series of waves proceeding from the center, C. One of them has arrived at an obstacle, D, but for which it would have reached E, as shown by the dotted lines, F, H, G; as it is, however, the wave is thrown back with the force with which it struck, evidently describing the curve, F, H, G, just as far above the obstacle as the unobstructed wave would have gone below it. The other waves would be reflected in the same manner and give rise to a series of curves having a center at C', as far below D as C is above it. When speaking of reflection, it has been customary to explain the phenomena by using the term "rays;" but it must be remembered that these only represent the direction in which waves proceed, and not the manner of their propagation. If a line joining C and G represent the direction of the wave striking at the latter point, the direction of the reflected ray will be indicated by a line joining C' and G, thus furnishing an easy proof of the law that the "angle of reflection is equal to the angle of incidence."

After the above new explanation of the familiar law, the lecturer exhibited the reflection of waves upon the screen, by means of a beautiful piece of apparatus. The light of an oxycalcium burner was reflected by means of an inclined mirror through a flat horizontal glass tank filled with water. By means of puffs of air, waves were produced upon the center of the water surface, and these were reflected upon the screen by a large inclined mirror above the tank. The sides of the latter were made to slope considerably outward, so as to avoid reflection from them; and the audience was thus enabled to verify what had been stated about the propagation of waves. A glass plate held in the water on the side of the tank reflected back the waves of water, in circles having very much the appearance of those in Fig. 1.

After dwelling briefly upon the well known laws of reflection, and exhibiting in illustration some of those beautiful Yo Semite views where the eye strives in vain to discover which is the landscape and which the reflection in the river, the lecturer described how objects thus reflecting light become of themselves secondary sources of illumination. A number of objects, lighted up by the lime light and thrown upon the screen by means of a lens, appeared in bold relief and startling proportions. The engraving herewith, representing the professor's hand, will give some idea of the effect.

It is in this manner that the moon receives its light from the sun and becomes in turn a source of illumination to us.

Passing thence to the consideration of the moon itself, photographs representing its different phases were exhibited. These, the lecturer stated, made by Mr. Rutherford and Dr. Draper, were productions of which America might be justly proud, as nothing had ever been produced in other countries that would bear comparison with them. The topography of the moon has been accurately studied and the different portions of her surface have received names, some of them poetical. Thus we have the Sea of Nectar, the Sea of Storms, the Frozen Sea, the Lake of Sleep, the Lake of Death, the Misty Marsh, the Meadow of Dreams; the mountains have been named after distinguished men. Some of the most important are Tycho Brahe, Ptolemy, Herschel, Archimedes, Copernicus, etc. The different regions containing these various parts were separately discussed. It seems that the moon is composed of burnt out craters of immense volcanoes, some of them a hundred miles across the top, and that there is no vestige of water or atmosphere about it. Consequently the stars will be visible thence, even when the full blaze of the sun is upon it, during its day of fourteen terrestrial days, because there is no diffusion of light. It is the presence of our atmosphere that prevents us from seeing the stars in daytime. The manner of measuring the height of lunar mountains is by observing their shadows at differ-

ent times of day. They are carefully measured by means of the micrometer; and from their length and the accurately determined relative position of sun and moon at the time, the astronomer is enabled to calculate the height of the mountains. Different views taken from paintings by Mr. James Hamilton, an artist of note, of what must be the appearance of portions of the moon by earth-light and by day-light were then exhibited. They gave an excellent idea of what is believed to be the condition of the moon's surface. All we know of the moon is of one side only; for she never turns the other towards us. Professor Janssen accounts for this fact by supposing that the greater part of the mass of the moon lies on the side away from us, and that our side is comparatively light and frothy, thus giving it an eccentricity which would prevent the other side from ever turning towards us. If there existed any water or air on the moon, it would, according to this hypothesis, be drawn away from our side towards the opposite one.

It has been advanced as a theory that the moon has passed through the different stages which geology teaches us took place on the earth; that finally, by cooling off, all the air and water have been absorbed and that she is now a dead planet, devoid alike of animal and vegetable life, burnt out and frozen. This is represented to be the ultimate destiny of our earth and of all the planets, though millions and millions of years may be required to accomplish it. The earth, we suppose, has partially cooled from a liquid, molten mass, and the greater part of her interior is still in that state. Afterwards she was covered by immense glaciers, which have left their imprints upon the rocks all over her surface. These stages of development can be seen now going on simultaneously in the other planets. Jupiter being greatest in bulk and consequently requiring a longer time to cool, according to the hypothesis, has not yet arrived at our stage. Observations by Professor Mayer and others demonstrate that it has for some time been undergoing changes and sending out more light than it received from the sun; while Mars has passed our stage and exhibits the phenomena of huge snowstorms and evidences of an Arctic period. Maps of the two planets, showing their characteristics, were produced upon the screen in this connection. According to this bold hypothesis, the moon represents the very remote future of the planet on which we live, a time when it will be no longer a fit habitation for man.

THE WONDERS OF THE EGG.—SECOND LECTURE.

The following lecture was recently delivered by Professor Agassiz, before the Museum of Comparative Zoölogy, at Cambridge, Mass.:

I closed my last lecture with the remark that before approaching the question of origin it was indispensable to be familiar with the conditions under which organized beings were multiplied. It is a feature which is too frequently neglected in any discussion of this kind. I propose to bring before you, as plainly and methodically as I can, the conditions accompanying the maintenance of animal life upon the earth. Do you realize that all the living beings which surround us, however great their diversity, have a short time since been eggs; that there is not a human being, nor a quadruped, nor a bird, nor a reptile, nor a fish, which has not been an ovarian egg; that generation after generation these ovarian eggs bring forth new beings like those from which they were produced, and that this is an indispensable condition for the very existence of all the life with which we are familiar? But this is not all. Besides the individuals capable of producing eggs, there must be a corres-

ponding set of individuals from whom the egg receives an impulse, leading to the formation of the new being within it; in other words, the egg must be started by an influence from without, that is, by contact with sperm cells, into those successive changes or transformations by which the new being is produced. This is true of all beings not provided with the power of reproduction by budding or self-division; although, as I said in my last lecture, there are occasional exceptions to the rule, as among bees and certain moths and butterflies, known to produce living beings by means of non-fecundated eggs. We have many animals among the lower organisms, and especially in the class of radiates, that combine the three modes of reproduction: multiply by eggs, buds, and self division at various times. Others propagate by the two first processes alone, without the last. Among the higher animals propagation by eggs is the only method known. Neither mammal, bird, reptile, nor fish multiplies its kind in any other way. All eggs arise in what are called ovaries. These are clusters of cells, forming bunches of a somewhat glandular character in appearance. Between these cells the eggs are formed and in such a way as at first to be hardly distinguished from the cells themselves. The same is true of sperm cells, which arise in organs of the same character as the ovary, and are formed in a manner perfectly similar to that of the formation of the egg. So we have these two spheres of growth which characterize sex in the animal kingdom, arising in conditions so very similar that the essence of the two is hardly to be determined by observation. It is only by the process of growth, by the influences produced by the one upon the other, and by the consequences of these influences, that we recognize the essential difference which distinguishes them.

In order fully to appreciate what eggs are, we must remember—what has been known for about a half a century only—that all organized bodies are composed of little bags which are called cells, and which are formed and multiplied in various ways. Most of these cells are so small that they can only be perceived by the aid of high magnifying powers. There are, it is true, a few cell structures large enough to be seen with the naked eye, as for instance, the cells of common elder pith, or the coarse cells of the orange. It is one of the great problems of modern research to ascertain how these cells are formed and what is their mode of reproduction. For it does not seem that cells are formed in the same way under all circumstances. Some naturalists assume that in the animal substance secreted by a living body, such as milk, which is secreted by the mammary glands or similar substances secreted by other organs, certain particles become centers of action, around which other particles crowd; and when a little collection of this kind, microscopically small, has been formed, an envelope arises around it, and we have the utricle or cell. Others believe that minute, imperceptible particles of animal substance swell and enlarge, and become hollow, so that a little bag is formed, a cell envelope in short, which fills as it enlarges into a fluid substance.

As yet we know but imperfectly what cells are; still more imperfectly do we know how they are formed, and still less do we understand their function. Yet the amount of facts already ascertained respecting them is truly overwhelming. This much, however, may be positively stated: between ovarian eggs in their earliest condition and cells in their elementary state, such as constitute the substance of all animal bodies, there is no essential difference.

THE EGG OF THE MAMMALIA.

Let us now consider the ovarian egg as we know it in mammalia, and then proceed to compare it with the ovarian egg as far as is known in other classes of vertebrates. When it has acquired its ultimate growth, prior to the formation of the germ, the egg of the mammalia presents a bag the walls of which are exceedingly transparent. This bag is filled with a substance which is itself transparent, and yet which appears, under a very high magnifying power, to be granular, as if dotted with particles floating in the fluid. In that outer bag is another diminutive bag containing also a transparent fluid. This inner bag occupies an eccentric position with reference to the periphery of the outer bag, and in it are contained one or several dots. These parts of the mature egg have received names.

The outer envelope is called the vitelline membrane, because it has been ascertained by comparison that it corresponds exactly to the exceedingly thin skin inclosing the yolk in the hen's egg. A yolk is called the vitellus, and hence the name. The bag contains the yolk; and however transparent this fluid may be, it retains the name of yolk. To the naturalist the word yolk no longer designates that peculiar substance contained in the bird's egg of a yellowish color. The yolk may be any substance which is contained in the outer envelope of the egg. The inner bag is called the germinative vesicle. That name was given to it under the impression that from it the germ arises. The name has been retained, though I wish at the outset that you should free yourself from the idea that it has any special connection with the formation of the new being. The dot or dots within the germinative vesicle are ordinarily called the germinative dots. From their discoverers these parts have also had some other name applied to them. It was Professor Purkinje, of Breslau, who discovered the germinative vesicle, and in his honor some physiologists call it the Purkinjen membrane or vesicle. Professor Wagner of Göttingen discovered the presence of the dot in the germinative vesicle, and in his honor it is occasionally called the Wagnerian dot or dots.

The dimensions of such a mammalian egg are very small. It comes just within the range of the power of the human eye. Practiced embryologists may detect, without the use of the lens, an ovarian egg in its organ when it has reached

FIG. 2.—ILLUMINATION BY RADIATION.

ponding set of individuals from whom the egg receives an impulse, leading to the formation of the new being within it; in other words, the egg must be started by an influence from without, that is, by contact with sperm cells, into those successive changes or transformations by which the new being is produced. This is true of all beings not provided with the power of reproduction by budding or self-division; although, as I said in my last lecture, there are occasional exceptions to the rule, as among bees and certain moths and butterflies, known to produce living beings by means of non-fecundated eggs. We have many animals among the lower