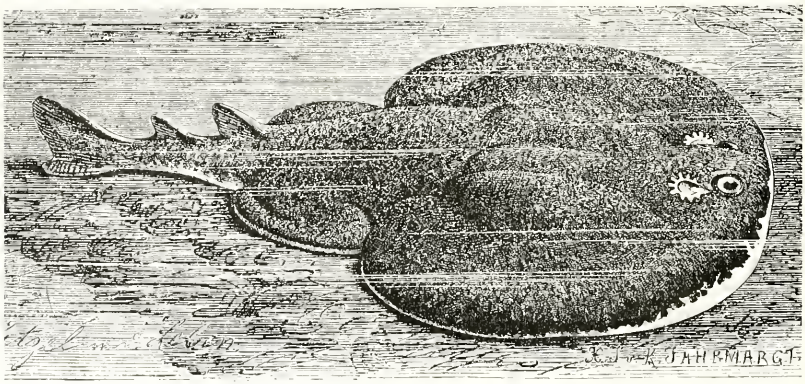
ELECTRICITY AND PHOSPHORESCENCE IN THE ANIMAL WORLD.

BY THE EDITOR.

MANKIND is materialistic by nature; so it is a matter of course that most people shrink from the idea of thinking spiritual realities as purely spiritual. They hanker after a belief in substance, and even the soul is supposed to be a spiritual essence; in fact, the name *spirit* itself is nothing but the thinnest substance known at the time of its formation, viz., the wind. The Latin word



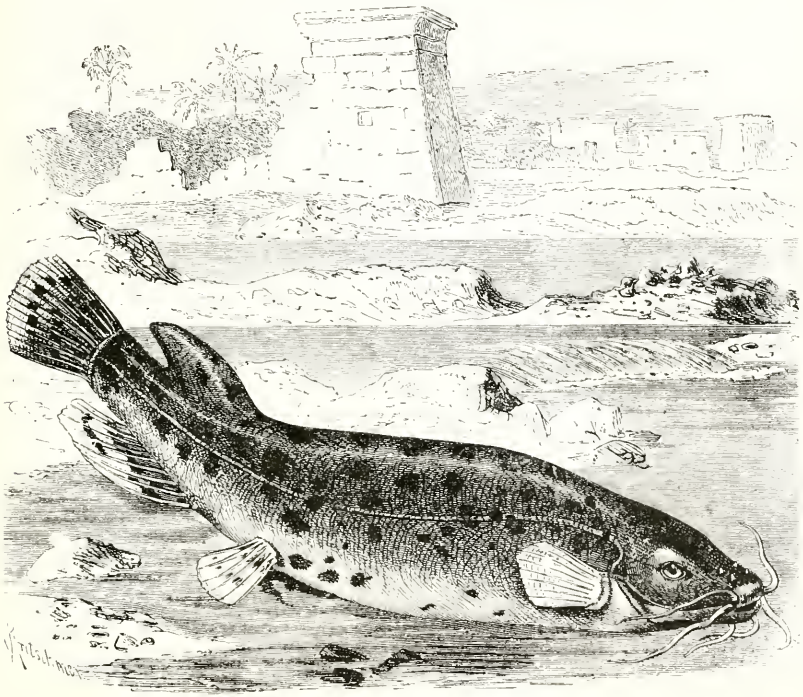
CRAMP-FISH (*Torpedo marmorata*).
One-fifteenth natural size. Weight, 50 to 75 pounds. (After Brehm.)

animus has the same significance, and it took some time for mankind to abandon the idea of finding in air the seat of the soul.

Since the discovery of electricity and its close connexion with light, our scientists have been forced to assume the existence of a luminiferous ether, a substance so much finer and more rarefied than air, that air in comparison with it is as coarse as clay is to our senses. This most sublimated of all substances, being the most

tenuous material known, appeals to our spiritualistic materialists, who are naturally inclined to utilise it for their hypothesis of the existence of a soul-substance. The fact is, however, that ether can no more serve the purpose than air. Soul is and remains a function due to organisation, and therefore form alone can be the essential feature of soul-life.

Electricity plays a very secondary part in the general functions of living organisms, and wherever it happens to be prominently employed it is specialised for definite uses which have nothing

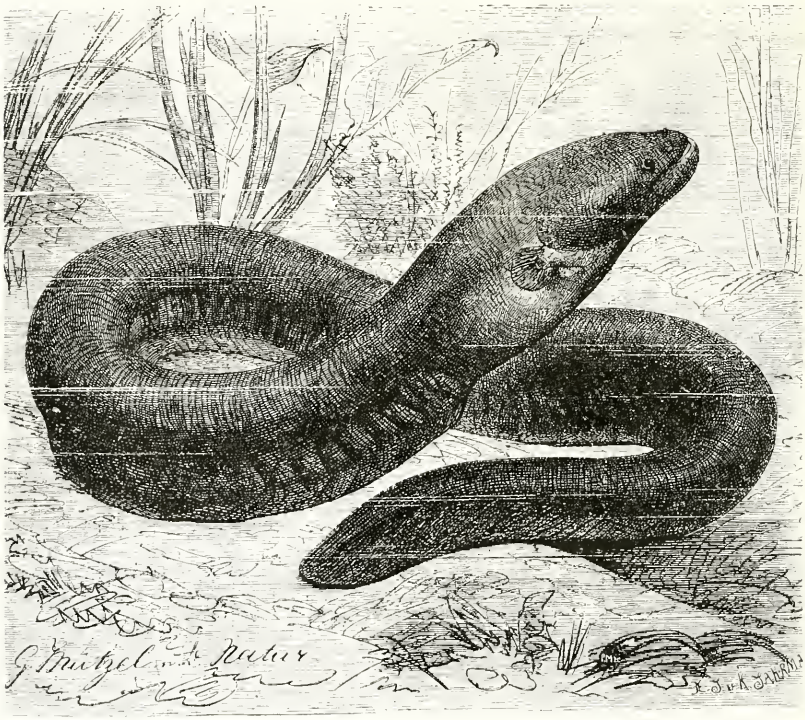


ELECTRIC CAT-FISH (*Malapterurus electricus*).
One fifth natural size. (After Brehm.)

whatever to do with the particular psychical functions of living organisms.

Du Bois Reymond has proved that every transmission of nervous irritation is accompanied with electrical phenomena. The apparatus connected with the nerve for measuring the electric tension shows a decrease of the strength of the current during a state of nervous activity. This was called by Du Bois Reymond *negative Schwankung*, "negative fluctuation."

The negative fluctuation of the electric tension, it may be incidentally mentioned, is not at all a phenomenon of nervous activity alone. Du Bois Reymond's law holds good for muscular fibres also. In a state of rest, the living muscle, like the nerve, shows in the galvanometer the presence of a low and constant current, which in a state of activity noticeably decreases, proving that a corresponding amount of electricity is being used in other directions.



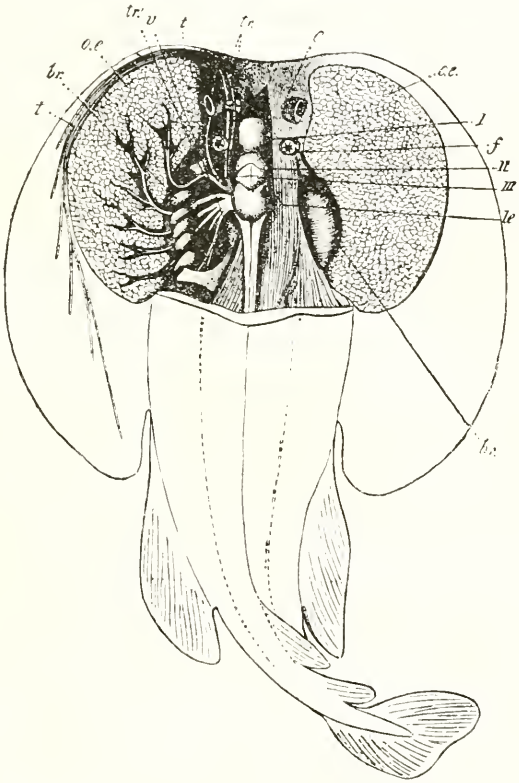
Electric Eel (*Gymnotus electricus*).
One-eighth natural size. (After Brehm.)

Obviously the part played by electricity in the animal organism is purely incidental and has no psychical significance whatever.

Electricity is used in many fishes as a weapon both for protective and aggressive purposes.

Professor Du Bois Reymond (the same who investigated the electrical nature of the nerves) and G. Fritsch have made important and thorough experiments with electrical fishes, and have

come to the conclusion that upon the whole the electrical organ consists of little boxes embedded in the membranes, in the same way as the cells of a hive form a series of prismatic, hollow spaces. These boxes are filled with a gelatinous substance. A number of powerful nerves enter the surface of these cells and form a delicate network constituting a kind of electric plate for each little box. Each electric plate consists of two closely connected cells, but the



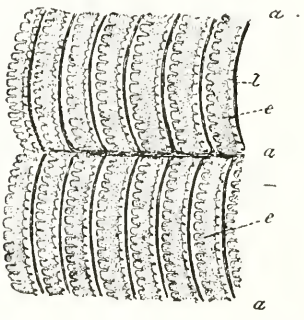
Upper view of the electric organ. The organ (*o.e.*) is exposed superficially only, at the right. Medially, it borders on the branchial sacs (*br.*), which are overlaid by a common constrictor layer, and may be seen separately exposed on the left-hand side. On the left-hand side may be seen also the nerve-trunks terminating in the electric organs (*o.e.*). The open cranial cavity also shows the brain: I. The forebrain; II. The midbrain; III. The hindbrain. *l.e.* Lobus electricus of the afterbrain. *v.* Nervus vagus. *tr.* Trigeminus group. *tr'.* Electric ramification. *o.* Eye. *f.* Spouting-orifice. *t.* Gelatinous tubes of the integument. *br.* Gills. (After Gegenbaur.)

ELECTRIC APPARATUS OF CRAMP-FISH (*Torpedo marmorata*).

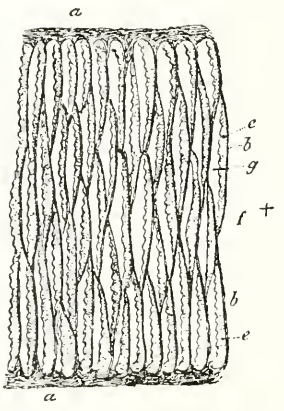
electric nerves are connected with one surface of the plates only, and this surface in all the plates of an electric organ is in the same fish always the same: in some it is the upper, and in others the

lower; and it is noteworthy that in either case the cell in which the nerve terminates is the electro-positive, while the other is the electro-negative.

Such is the general structure of the organ in the several electric fishes. In other respects, there are great differences. In the cramp-fish, also called the electric ray (*torpedo*), of the Mediterranean Sea and the Atlantic and Indian Oceans, the electric organs are flat and lie at both sides of the head, receiving their nerves, a branch of the fifth pair, viz., the *trigeminus*, and four branches of the tenth pair, viz., the *vagus*, from below. In the gymnotus, living in certain lakes and rivers of North and South America, two electric organs are situated on either side of the tail, immediately underneath the skin; and they are controlled by nerves coming from the caudal part of the spinal cord. The electric organs



Section of two columns of the electric organ of *Gymnotus*. *a*. Horizontal dividing membranes. *l*. Transverse dividing membranes, convex toward the head. *e*. Electric plates.



Section through a portion of the electric organ of *Malapterurus*. *a*. Integument. *b*. Septa. *e*. Electric plate. *g*. Gelatinous substance. *f*. Caudal side. (After M. Schultze.)

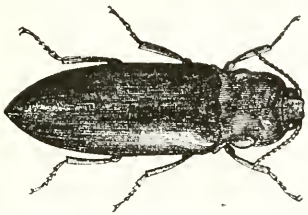
LONGITUDINAL SECTIONS OF ELECTRIC ORGANS.

of the malapteruroids of the rivers Nile and Senegal are situated underneath the skin along the whole length of the body, both to the right and to the left, separated merely by a thin wall divided like the little boxes into numerous cells, and controlled only by one pair of nerves coming from the dorsal part of the spinal cord, between the second and third pairs.

If the electrical nerves are cut, and if thus the connexion of the electrical organs with the brain ceases, further discharges become impossible. The electric power can be restored, however, if the ends of the cut nerves are irritated.

Strychnine affects the electric organs in a peculiar manner: it throws the animals into a kind of tetanic condition in which a series of involuntary discharges take place.

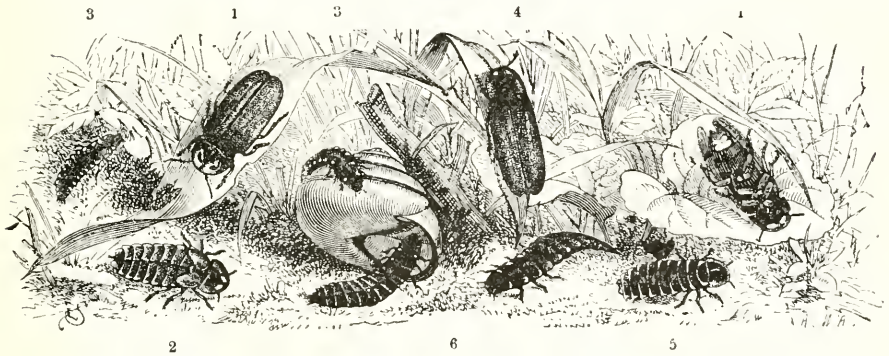
The cramp-fish, or the electric ray, was well known to the ancients, and is frequently depicted on the frescoes of Herculaneum. Dioscorides, one of the ancient authors, declares that its touch



LUMINOUS BEETLE (*Pyrophorus noctilucus*).
Natural size. (After Brehm.)

cures headaches, and later physicians used the fish as a cure for gout. This is the oldest information which we have concerning electricity in the service of therapeutics.

Among all the electric animals, the cramp-fish seems to be the strongest and the most formidable, for it is known to have killed by its discharge mules and horses; and we have reason to believe

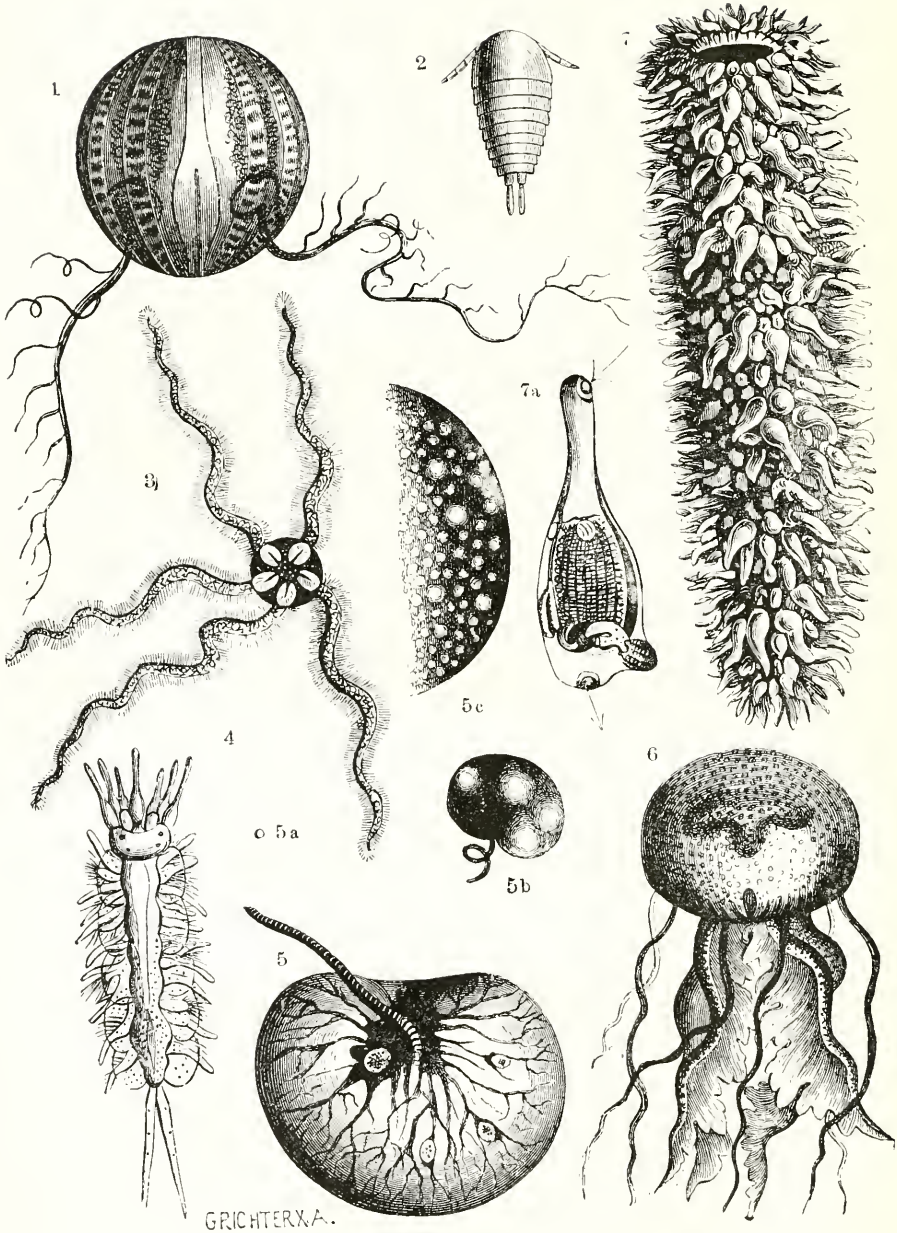


Small glow-worms (*Lampyris splendidula*): 1. Male, dorsal and ventral views; 2. female; 3. Larva. Large glow-worms (*L. noctiluca*): 4. Male; 5. Female; 6. Larva. Numbers 1, 2, and 4 only have been enlarged. (After Brehm.)

GLOW-WORMS.

that its presence has depleted some lakes formerly well stocked with fish. Its contact is most anxiously avoided by all fishes.

The psychic life of the electric fishes does not present any striking qualities, and we have no reason to assume that they range higher than other fishes which have attained the same stage of evolution.

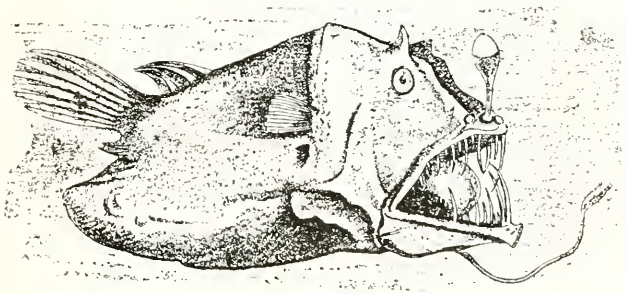


PHOSPHORESCENT MARINE ANIMALS.

(After Schleiden.) For descrjption, see opposite page.

Electricity, it appears, has nothing to do with another remarkable and mysterious phenomenon, viz., phosphorescence.

There are a number of phosphorescent beetles, such as glow-worms, fire-flies, or lightning-bugs, which make their appearance in the hot summer months, especially about the middle of June. The phosphorescence constitutes an important part in the sexual relations of these beetles, as it helps the sexes to find each other. As a rule, and especially in the European species, the winged male beetles swarm through the air, while the wingless females stay on the ground. The light expires soon after fecundation, the males die at once, while the females live long enough to deposit their eggs. In America the female of the common fire-fly enjoys the same advantages as the male: both are winged and both enjoy the liberty of swarming about in hot summer nights.



Torch-Fish (*Linophryne lucifer*).
(After Collet.)

The number of phosphorescent maritime animals is very great, especially among those which inhabit the deeper parts of the ocean. The accompanying plate shows in Fig. 1 a striped jelly-fish.[1] Fig. 2 is a phosphorescent crab (*Sapphirina fulgens*). Fig. 3 is a phosphorescent sea-star, called *Ophiura fragilis*. Fig. 4 shows a phosphorescent ciliate, called *Polynoe fulgurans*. The fifth illustration shows a specimen of Noctiluca which is represented in 5*a* in its natural size, in 5*b*, 5*c*, and 5 in magnified sizes. Fig. 6 represents the phosphorescent jelly-fish *Pelagia noctiluca*; Fig. 7 the *Pyrosoma giganteum*, a large phosphorescent animal of cylindrical shape, somewhat magnified.

A peculiar animal is the torch-fish (*Linophryne lucifer*) which haunts the recesses of the deeper parts of the ocean. He carries a torch on his upper lip, which in appearance is not unlike our mod-

[1] Schleiden calls it *Rippenqualle*.

ern electric light. This torch, together with a long phosphorescent filament hanging from his lower jaw, is used for alluring prey. The fish is armed with long, sharp teeth. Our illustration (reproduced from Collett) shows the voracious robber of the deep in the act of swallowing some victim which is disappearing in his powerful maw.

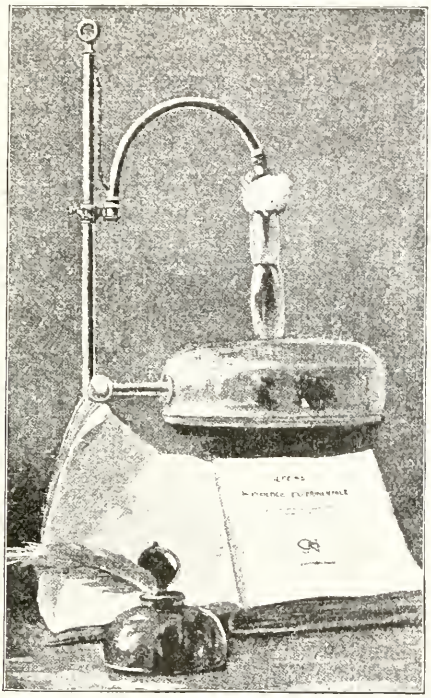
"Many fishes of the deep sea," says Dr. Günther, "are provided with more or less numerous, round, shining, mother-of-pearl-colored bodies, imbedded in the skin. These so-called phosphorescent or luminous organs are either larger bodies of an oval or irregularly elliptical shape placed on the head, in the vicinity of the eye, or smaller round globular bodies arranged symmetrically in series along the side of the body and tail, especially near the abdominal profile, less frequently along the back. The former kind of organs possess in the interior a lenticular body, like the lens of an eye, and are considered by some naturalists true organs of vision (accessory eyes), the function of the latter, which have a glandular structure, being left unexplained by them."

The cause of phosphorescence has been a subject of much investigation and doubt, but the problem cannot as yet be considered as satisfactorily solved. It seems that the light is produced by phosphorus-freighted materials which are slowly consumed by combination with oxygen, and thus the process must be regarded as a mild and slow combustion. Phosphoric acid has been found in the ashes of the organs which exhibit the strange phenomenon. Humidity and the introduction of oxygen favor phosphorescence, while dryness and lack of air render it impossible. Heinemann observed that the phosphorescent organs of animals if cut out would continue to glow in dry air for not longer than four hours, while in a damp atmosphere their light would last more than twelve, and sometimes twenty-four, hours.

"The fact that," says W. E. Hoyle, "the nervous system is so often closely connected with the luminous organs indicates that the exhibition of the light is either dependent on the volition of the animal or is the reflex result of the stimulation of sensory nerves (Panceri). In the glow-worm the distribution of tracheæ (air-tubes) throughout the photogenic apparatus, and the fact that carbonic acid extinguishes the light while oxygen intensifies it, suggest that it is due to some form of slow combustion, while the fatty contents of the luminous cells of this and many other animals point to the probability that a fat containing free phosphorus is the active agent in the process. Since a large number of luminous organs retain their power after the death of the animal, and even after

desiccation and subsequent moistening, there seems no necessity to adopt the theory that we have to deal with an instance of the direct transformation of vital into radiant energy."

At present, Prof. Raphael Dubois, of Lyons, France, is engaged in producing cultures of photo-bacteria for the purpose of using them in lamps. Our illustration shows one of them, taken from a photograph published in *La Nature*, showing that the light



BACILLARY LAMP.

Cultures of photo-bacteria, used for illuminating purposes. (From *La Nature*.)

is sufficiently clear to allow even small print to be read without difficulty.

The lamp consists of a flattened globe attached to a stand. The upper part of the globe is covered with tin-foil which serves as a reflector. The inside is filled with a bouillon prepared from oil cakes, which serves as nutriment for the phosphorescent bacteria. The cylindrical attachment on the top of the flattened globe is filled with sterilised cotton to prevent the intrusion of hostile germs which would destroy the photo-bacilli. Through a tube and

bulb attachment on the margin air can be pressed into the bouillon which causes the bacteria to develop their vitality, and thus makes the lamp give out a more radiant light.

If the lamp is kept at rest, the bacteria may live for months quietly upon the nutriment with which it is filled. If it is constantly used, the bouillon in the globe will last for several nights without standing in the need of replenishing.

The light produced by these bacteria does not generate any noticeable heat. At the same time, the chemical rays are very weak; accordingly, it was necessary in taking the photograph to have the plate exposed for several hours in order to produce a clear picture Thus, this living lamp might become useful as a substitute for the red light in the photographer's dark room.

The most remarkable quality of the light of the living lamp, however, is its similarity to the Roentgen ray, for it penetrates opaque bodies also and passes through wood and paste-board.

We need not add that the psychic life of phosphorescent bacteria is apparently a purely physical phenomenon; it may be subservient to higher ends in their lives but is in itself not a psychical event. Although these animalcules may be used for "enlightening the world," they do not seem to rank higher than other bacteria, just as electric fishes and fire-flies cannot be regarded as superior to other fishes and beetles.