No, the saddest aspect of the matter is this : that thousands of human beings can be interested in a treatment of the subject which restricts itself to a recital of the practical application —while no interest can be aroused in such a presentation of the subject as makes it a part of true human knowledge.

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ELECTRICAL FISHES.

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Some recent researches have added much to our knowledge of electrical phenomena in fishes. That certain fishes possess electrical properties has been known from classical times, and Oppian, with provertical poetic liberty, describes the shock produced by one of these creatures as passing along the angler's line and rod into the fisherman's body :—

> " His arm of sense bereft,
> Down drops the idle rod ; his prey is left,
> Not less benumbed than if he felt the whole
> Of frost's severest rage about the Arctic pole.

Pliny ventured the opinion that these mysterious powers were utilized in killing victims for food, and there is some ground for that view. Fishes classed as electrical belong to very widely separated orders and families but the total number of species is small.

Amongst the Sharks and Rays, the Torpedinidae and two or three species of Skate, alone, are known as electrical. Out of nine or ten thousand species of Teleosteans or Bony Fishes, not more than a dozen possess these remarkable organs,

which are very variable in position, sometimes being located near the head, at other times in the tail, while a new and hitherto unsuspected type of electrical organ is the scattered glandular form, which recent investigations have shown to be spread in the skin of one of our commonest fishes. Naturalists have hitherto been unaware of the fact that the common eel of our rivers and lakes is really an electrical fish. It is possible that extended studies will reveal many more common species endowed with this remarkable property.

The most complex form of electrical organ is that of the electric ray *Torpedo* of which several species exist. Five years ago I secured a living torpedo during an official survey on the Kerry coast, Ireland: an interesting capture when it is noted that Thomas Pennant a hundred years ago says of this fish that it "is very rarely taken in British Seas; the only one we ever heard of being took off the county of Waterford."

I found that the Irish fishermen stood in dread of it, called it a Mum Ray, a corruption no doubt of Numb or Cramp Ray; but begged for the liver of the fish, to which they attributed almost miraculous curative qualities. It was a clumsy ill-looking creature, and unlike the Skate was thick and fleshy at the lateral margin, round in front and lacking the pointed rostrum or snout. In the dirty ochre-coloured skin a rude hexagonal pattern appeared indistinctly, and on dissection, was found to correspond to the columns of modified soft muscle which constitute the electrical organs. They have been aptly compared to a collection of Voltaic piles, each consisting of electric plates of transparent homogeneous substance and invested by tendinous connective tissue, which sends alternating extensions between the plates. Over eleven hundred of these hexagonal columns are said to have been counted in a torpedo weighing seventy pounds. Five large nerve trunks pass from the medulla oblongata, on each side, to the organs, dividing up into 50,000 or 60,000 separate nerve fibres. The nerve terminations in the electric plates were found by Fritsch to precisely resemble those in muscular tissue. The organs occupy the entire thickness of

the body on each side of the massive flattened head. The current, it appears, passes perpendicularly from the underside of the body to the back or *vice versa*. The dorsal side, according to Packard's account, is positive, the ventral side negative, and the discharges are wholly under the control of the fish. In the Irish specimen referred to above this control was unfortunately so strong, not to say stubborn, that the creature refused to give any exhibition of its powers, though every inducement, persuasive and otherwise, was given to it to do so. M. de Quatrefages has recorded the variability of the Torpedo's electric potency, in some examples it is very feeble but in others it is so great as to be dangerous to man and quite fatal to birds and small animals. Repeated discharges weaken its power; but Professor Owen found that under the influence of strychnine the discharges become more powerful. They are accompanied by sounds perceptible by the phonograph. Thus a weak discharge provokes a short croaking sound, but a prolonged discharge of three or four seconds duration is marked by a somewhat lengthened groan. Ordinary muscular contractions, as is well known, are attended by faint sounds like the distant rumbling of carriage wheels.

The two common Skates, *Raia batis* and *R. clavata* it has been found possess curious organs inthe tail which Babuchin styled pseudo-electric. There is every ground for speaking of them, however, as truly electrical. They are, it is true, diminutive, and Prof. Burdon-Sanderson's researches ten years ago showed that their discharges were very feeble, but it is possible that they are either simply rudimentary and progressive in condition or degenerate and retrogressive, and thus differ from those of the Torpedo rather in degree of development than in kind. Into the vigourous discussion on this matter, participated in by the Duke of Argyll, Prof. J. C. Ewart and others in the columns of *Nature*, it is not necessary to enter here. Certainly the huge specimen of a skate, eight or nine feet across the "wings," which it fell to my lot to examine on one occasion, six years ago, possessed electrical organs resembling small corn-cobs situated on each side of the tail. No

electrometer or suitable apparatus was available to test the electro-motive force in a Skate of such enormous dimensions. The Sting Rays, with a tail exhibiting one or more strongly developed spines, and the Eagle or Whip Rays with a slender whip-like tail, appear to be wholly destitute of electric organs.

Turning now to the South American electric eel, *Gymnotus*, we find electric organs differing much from those described. In these large creatures, five or six feet in length, they are lodged along each side of the body towards the under side, and mainly in the tail. Two pairs occur, the upper much larger than the more central pair. Each organ is divided into vertical plates by fibrous septa, and again into a countless number of small cells, arranged horizontally, instead of vertically as in the torpedo. The shock passes laterally from the head to the tail, and no less than two hundred pairs of spinal nerves send electric rami into the organs. The combined result is exceedingly powerful. A captive *Gymnotus* exhibited in London some time ago, was able to kill its victims at a considerable distance. It fed upon fish, and when one of the victims was dropped into the tank, the *Gymnotus* simply curved slightly, stiffened its body, and a shock was communicated through the water which struck the introduced fish lifeless with lightning rapidity.

Another form of electric organ is that found in the African siluroid, *Malapterurus*, a fish not remotely related to our mud-pouts and cat-fishes, to which it bears much external resemblance. A layer of cells, lozenge-shaped and about one-sixteenth of an inch in diameter, extends between the skin and the underlying muscles except in the region of the head and the fins. Just as in *Gymnotus*, the current passes from the head to the tail. It is comparatively feeble, and probably only defensive. Instead of a nerve supply consisting of many thousands of fibres, a single nerve trunk passes from the spinal cord to the organ on each side of the body. The Nile is the home not only of the electric Siluroid *Malapterurus*, but of the electric Nile pike *Mormyrus*. There are many species of *Mormyrus* and, in all, the electric organs are somewhat feeble and located mainly in

the tail. The thick lateral muscles present no unusual features and the electro-motive property is purely superficial, being confined to a glandular layer in the skin and best developed in the caudal region. *Mormyrus*, it may be added, is allied to the herring and pike families, and belongs to the same order as *Gymnarchus niloticus* which exhibits like *Mormyrus*, rather feeble electric powers.

Some researches recently conducted in Scotland by Dr. E. Waymouth Reid have yielded the remarkable discovery that a series of scattered cutaneous glands in the common eel, *Anguilla*, constitutes an electric organ of great interest. Eel-skin has long been an old wives' remedy for sprains and rheumatic affections, and carefully devised experiments have quite recently shown how an electric discharge (the electro-motive force of the tissue's "current of rest") results from the activity of the gland cells in the integument by which the body of the eel is enveloped. We have in this remarkable discovery another illustration of the fact that the commonest of common objects may yield scientific results of rare interest and profound importance. The French-Canadian peasant who wrapped around his sprained wrist a piece of eel-skin had little notion that the dried tissue of the fish really possessed some of the most marvellous and mysterious properties exhibited by the finny tribes.

That activity in the skin-glands of the eel is associated with an electric discharge of appreciable power is a fact which considerably enlarges our ideas as to the nature of electric organs. In the electric organs of the Torpedo, the Skate and *Gymnotus* there is full evidence that we have examples of transformed muscular tissue. The organs may differ in situation, arrangement and general anatomical features, but they have this in common that they have a direct nerve supply from the central spinal system and are under the immediate control of the animal. We know that in many lowly animals, tissues are found which are neither muscle nor nerve, but a union of both. The neuro-muscle cells of the jelly fishes (Medusae) are an example. These cells are so primitive in structure and function that they

have not yet exclusively taken up either muscle or nerve functions, but perform the purposes of both. The metamorphosed substance, soft, transparent, and homogeneous, of the electric organs referred to recall this remarkable tissue as though the muscular tissue in the fishes in question were retrograding as it were, and returning to the early neuro-muscular condition.

On the other hand, in the eel and the Nile-pike, we have another type of tissue no less interesting and curious. The gland cells of the skin, instead of devoting themselves solely to secretion, have metamorphosed their energy in such a way as to be effective in the production of electricity. They are so well developed in *Mormyrus* as to form quite a compact layer beneath the integument. In the eel they retain their more primitive scattered character. It may be that an unsuspected number of common fishes are possessed of powers similar to those of the eel. A mysterious tremor is said to be felt by the patient when a piece of eel-skin is applied to an affected part of the body. Can it be that the electro-motive force in the dried fishes' integument can be again aroused by the damp acid exudations of the human skin? At any rate we have in the surprising properties of the eel's glandular integument not only a key to the interpretation of many forms of electric organs in fishes, but possibly an explanation also of the luminous or phosphorescent features which many fishes exhibit. Biologists have perhaps not fully realised the large place which electrical phenomena fill in the complex vortex of animal life. All muscular contractions involve more or less marked electric phenomena. Muscle we have seen may become essentially electric in its properties, and it now appears that glands may assume the *role* of electric and possibly phosphorescent organs in fishes.