

## THE EVOLUTION OF CONSCIOUSNESS.

*Together with a Diagram illustrating Certain Homologies  
in the Nervous System.*

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CONSCIOUSNESS is the faculty or function by which we become aware of the existence of our surroundings. It is obvious that we can only become aware of our surroundings by means of sensations aroused by them. A man in whom no sensations can be aroused is unconscious, he has no consciousness; and *vice versa*, a conscious individual is constantly experiencing sensations. During deep sleep no sensations are perceived; consciousness is in abeyance. The dependence of consciousness upon sensation is illustrated by Strumpell's remarkable patient, whose only communication with the outside world was by means of one eye, the other eye being blind, both ears deaf, and the whole surface of the body anæsthetic. Whenever the sound eye was closed, he went to sleep; in other words, he lost consciousness. Without sensation, therefore, consciousness cannot exist; the essential basis of consciousness is sensation.

The sensations experienced by any given individual can never be experienced by another individual. *I* know that *I* feel and see and hear, but it is pure inference on my part that anyone else can feel and see and hear. The inference is admitted to be justifiable, because other people respond to stimuli in much the same way as *I* do. Similarly we believe that the lower animals experience sensations. This will readily be admitted of vertebrates; but if it be suggested that invertebrates experience sensation, we are at once told that fitness of response to a stimulus does not entitle us to infer that the animal has experienced a sensation. But

there seems to be an inconsistency in this assertion, for fitness of response is as much evidence of sensation in one animal as it is in another ; therefore, it is as much evidence in an amoeba as in a man, and he who denies sensation in an amoeba should, to be consistent, deny sensation in his fellow men.

The suggestion that an amoeba experiences sensation is nothing new. There are many observations, especially by Carter and Romanes, which suggest that an amoeba not only has sensation, but that it even possesses such highly developed mental attributes as reasoning and memory. But all that I now wish to claim for the amoeba is that it feels, has sensation, and that it knows that it feels, is conscious. A thing which feels and does not know that it feels is inconceivable.

But sensation and consciousness are not the only functions of this unicellular organism. The cell which constitutes an amoeba has to carry out the functions of digestion, excretion, movement, reproduction, &c. In multicellular organisms, such as man, cells or groups of cells (organs) have become specially modified to perform these respective functions, and there is division of labour. Some cells (muscle) carry out the movements of the organism, and this is practically their only function ; some cells (renal, &c.) discharge effete products from the organism, and this is practically their only function ; some cells (ovary and testis) subserve the function of reproduction and some (neurons) the function of sensation, and in each case it is practically their only function. In each case all other properties of the animal cell have relatively diminished to a mere residuum in favour of the properties necessary to the special function of the cell.

On the other hand, the fact must not be overlooked that whilst these residual properties of the cell are considerably reduced, there is no reason to suppose that they are completely obliterated. All cells form definite chemical substances within themselves and discharge them. The muscle-cell is by no means the only contractile cell of the organism ; it is only the *most* contractile cell. And I submit

that the neuron is not the only sensitive cell of the organism, it is only the *most* sensitive cell. All the cells of the organism are sensitive to some extent; but sensation is, so to speak, specially worked up in the neuron. Again, if we have any right to say that an amoeba has sensation, we are also justified in supposing that each individual of that vast colony of "amoebæ," which we call a man, also has sensation.

Sensation in an amoeba has, presumably, only a rough resemblance to sensation in a man, and the same must be said of each individual cell of the human organism. There are great differences even among human beings in the acuteness of their sensations. For example, a highly-educated man experiences extreme pain during the extraction of a tooth, while a navvy scarcely winces at the operation. Lower animals are still less sensitive: Chauveau and Kauffmann were able to operate on the parotid region of a horse while the animal unconcernedly continued a feed of oats, and the presumption is that sensation is extremely elementary in an animal so low in the scale as an amoeba, and, with the exception of the neurons, still more elementary in the cells of the human organism.

It has been noted above that consciousness connotes sensation. I submit the converse to be true, that sensation connotes consciousness. We cannot conceive a thing which feels and does not know that it feels, apart from the hypothetical circumstance of it having never experienced more than one sensation. The conclusion is that every cell of the human organism feels and knows that it feels, that it is a conscious unit, that it has a very elementary mind.<sup>1</sup>

<sup>1</sup> The so-called chemiotactic phenomena observed in the case of leucocytes, which make their way towards an area charged with inflammatory products, suggest that those cells experience the feelings of pleasure and pain to some extent. It has been pointed out by Dr. Mercier that pleasure and pain, which induce the phenomena of attraction and repulsion, are the mental accompaniments of sensations which are respectively beneficial and harmful to the individual or its genus, and that evolution would naturally lead to the development of such tones of feeling. It may therefore be inferred that the leucocyte demonstrates a pleasurable tone of feeling, when it makes its way to an inflamed area. It may be going to its destruction, but it is beneficial to the whole organism that it should do so; just as it is beneficial to the genus "spider" that the male spider should engage in coitus, although it goes to its destruction in doing so.

The sensations received by and through these conscious units are the elements which go to make up human consciousness; and the present communication is an attempt to show how this occurs. In order to avoid misunderstanding, let me at once state that I do not suggest that any part of the physical basis of human consciousness is situated, for example, in the skin; but that the sensations experienced by the skin have an indirect representation in consciousness.

The general plan of the nervous system, so far as the motor arrangements are concerned, was demonstrated many years ago by Dr. Hughlings Jackson. He pointed out that the muscles of the body were first represented in the cells of the anterior horns of the spinal cord and in the nuclei of the motor cranial nerves; that the muscles were next represented (re-represented) in the Rolandic region of the cortex cerebri and that there was a further representation in the physical basis of consciousness, this being situated, in all probability, in the prefrontal lobes.<sup>1</sup> At that time, the mode of arrangement of those parts of the nervous system, subserving the function of sensation, was but little understood; but now that we have data to work upon it will be advantageous to study the hierarchy of sensation in the same way.

In the first place, it is to be observed that there are some cells whose sensation is not represented in the central nervous system at all, *e.g.*, leucocytes and most of the cells of connective tissues. But the sensations of cells of the more highly-organised tissues (skin, retina, &c.) are represented in the following way.

Sensations of epithelial (skin) and muscle cells are first represented in the ganglia on the posterior roots or in their homologue—the Gasserian ganglion—the representation being in some cases furthered by special modification of the nerve ends into tactile corpuscles or muscle spindles. Sensations in the organ of Corti are first represented in the ganglion spirale. For the present I omit the consideration of smell and vision.

<sup>1</sup> In an epitome of this nature, it is impossible to do justice to Dr. Hughlings Jackson's work; but I feel confident that the Croonian Lectures for 1884 are too well known to the readers of this Journal to allow of misconception arising from any crudities of mine.

The sensations occurring in all these ganglia are represented in the gray matter in the floor of the fourth ventricle; that is to say, that the peripheral sensations are re-represented there. The posterior-root-ganglion sensations are represented in the nuclei gracilis and cuneatus, Gasserian-ganglion sensations in the sensory nucleus of the fifth cranial nerve, and ganglion-spirale sensations in the auditory nucleus.

The sensations of these various nuclei are in turn represented (those of the ganglia re-represented and those of the peripheral cells re-re-represented) in the cells of the gray matter at the base of the cerebrum, the cutaneous representation being in the optic thalamus and the cochlear representation in the posterior corpora quadrigemina.

Sensations of the portions of these basal masses of gray matter under consideration are in turn represented (the peripheral sensations re-re-re-represented) in the cerebral cortex, the representation of cutaneous sensations being, I submit, in the parietal lobe, and that of cochlear sensations in the temporo-sphenoidal lobes.

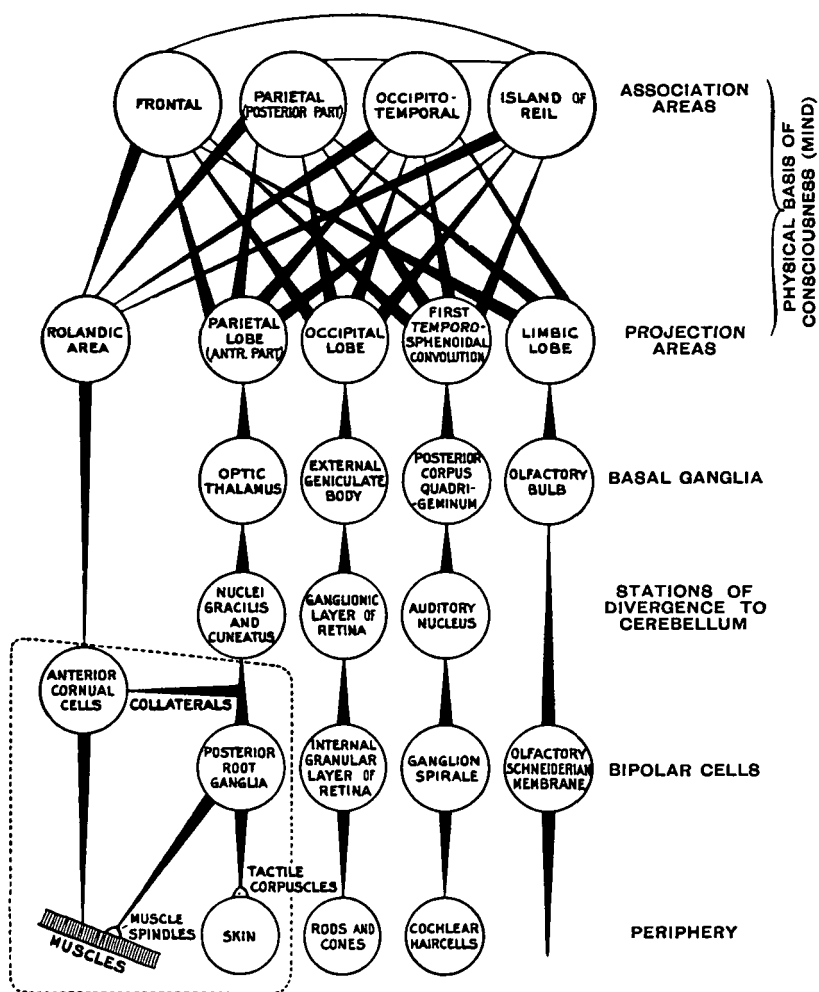
Lastly, the sensations aroused in these projection areas (to adopt Flechsig's terminology) are further represented in association areas (frontal lobes, islands of Reil, the parietal and occipito-temporal areas).

It has been convenient to leave the senses of vision and smell for separate consideration. Sensations of the peripheral visual elements (rods and cones) have their first representation in the bipolar cells of the internal granular layer of the retina, just as the sensations of epithelium are first represented in the bipolar cells of the posterior-root ganglia.

Sensations of the retinal bipolar cells are represented (rods' and cones' sensations re-represented) in the ganglionic layer of the retina. The cells of the ganglionic layer, therefore, correspond to the medullary nuclei of other sense departments.<sup>1</sup> Sensations of the ganglionic layer are in turn represented in the external geniculate body, just as

<sup>1</sup> It will be remembered in this connection that the retina is an outgrowth and hence a part of the central nervous system.

sensations of the medullary nuclei are represented in other gray matter at the base of the cerebrum. Sensations of the external geniculate body are represented (the rods and cones



sensations re-re-re-represented) in the occipital cortex. The highest representation of these sensations is in association areas, especially in the angular gyrus.

For olfactory sensations the cell stations are fewer, perhaps because no connection with the cerebellum exists in the case of smell. Sensations of cells of the regio olfactoria of the Schneiderian membrane are first represented in the layer of mitral cells in the olfactory lobe. Re-representation of mitral cell sensations takes place in the cortex of the limbic lobe and re-representation in the association areas.

The appearance of the bipolar cells of the Schneiderian membrane suggests that they are nerve-cells, whose processes extend to the mitral cells of the olfactory lobe. If this be so, there are free nerve endings exposed to the air in the region of the Schneiderian membrane.

The above considerations deal with the senses of touch, muscle-sense, hearing, and smell; the many other senses have been omitted, mainly because our knowledge of their anatomical basis is incomplete.

The accompanying diagram will help to elucidate the above points. The connections figured between the projection and association areas are strictly in accordance with Flechsig's researches, and it will be seen that the cortex cerebri is a colony of neurons, which have very numerous intercommunications. It is a colony of the most sensitive, and therefore of the most conscious, cells of the organism. The combined consciousness of these cells constitutes the consciousness of the colony, and this is none other than the consciousness of the organism.

The projection areas must not be excluded from the physical basis of consciousness until it has been demonstrated that destruction of the association areas results in complete loss of sensation to the organism as a whole. Until this has been proved we must conclude that the physical basis of consciousness consists of the whole cerebral cortex.

#### ADDENDUM.

It has been observed that fitness of reaction to a stimulus may be accepted as a criterion of consciousness. But fitness of reaction frequently occurs independently of the cerebral

cortex. Such is the case when an ordinary reflex action occurs; this is seen at its best in the classical example of the brainless frog.

When the brainless frog draws its foot away from a stimulus there is a fitness of reaction to the stimulus. And similarly with the other reflexes; there is a fitness of reaction to the stimulus when the eyelid brushes away a particle from the conjunctiva, when sneezing results from irritation of the nostrils, vomiting from irritation of the fauces, coughing from irritation of the larynx, &c., &c. In each case there is an attempt on the part of the organism to get rid of the offending body; yet all these suitable reactions occur independently of the cerebral cortex.

We must therefore conclude that there are many centres of consciousness (colonies of conscious units) in the nervous system other than the cerebral cortex, each of these colonies having a combined total consciousness of its own. One such colony is marked off by the dotted line in the diagram; it is the colony subserving the function of the skin reflexes.

These colonies are severally the physical bases of the consciousness of separate individual parts of the organism, and are no part of the physical basis of consciousness of the organism as a whole. The consciousness of a man is the consciousness of no other part of his nervous system than his cerebral cortex, although there are many centres of local consciousness scattered throughout the organism.