due to injecting too much or a too strong solution. Except for the pain and discomfort I have never known any other complication arise as the result of thrombosis, nor have I heard of any in the practices of other doctors. Embolism and empyema are theoretically liable to occur, but happily in practice they do not happen, or only with great rarity.

What Type of Case is Suitable for the Injection Treatment?

There is much divergence of opinion on this point, and I can only give my own experience and method of classification. For purposes of injection I divide haemorrhoids into three classes. (1) Those in which I expect and usually obtain a completely successful result. Under this heading I include every case of internal piles, irrespective of size and extent of haemorrhage, provided that they are uncomplicated by fissure, fistula, sloughing, ulceration, prolapse of normal rectal mucous membrane, and are not markedly fibrous or polypoid. (2) Those where as a rule only partial success is obtainable although occasionally a completely successful result may ensue. By partial success is meant the disappearance of troublesome symptoms, such as bleeding, but prolapse may still exist to some extent. Under this heading I class partly fibrosed piles, haemorrhoids complicated with varying degrees of prolapse of the normal rectal mucous membrane, and those which from frequent prolapse have dragged the cutaneous lining of the anal canal down with them, the latter covering the lower part of the prolapsed pile like a cowl; when seen for the first time they may be mistaken for a polypus. Care is necessary in treating these two latter types of haemorrhoids, since there is danger of the fluid spreading under the skin if the injection is made low. In the treatment of this latter type of case the complication of sepsis (perianal abscess) is most likely to occur, and, unless the patient strongly objects, it is probably best to advise operation, as satisfactory results from injecting this kind of haemorrhoid are uncertain. (3) Those cases in which injections should never be attempted and for which surgical operation alone should be advised—for example, gangrenous, ulcerated, and sloughing piles, haemorrhoids almost or completely fibrosed, and those complicated by any other abnormal conditions for which operation will be necessary, such as chronic fissure, fistulae, polypi, and benign or malignant growths. As an operation will be necessary to remedy these conditions, the haemorrhoids should be operated on at the same time.

Instructions to Patient.

During treatment a daily action of bowels is essential, and a gentle laxative should be taken daily, if necessary, to ensure that the motions will be soft. The patient need not lie up after injection, and may carry on his usual routine work, but strenuous exercise such as cycling, horse-riding, or dancing should not be indulged in on the day of injection. Black coffee and meals immediately after injection should not be taken. Alcohol should be avoided or only used very sparingly. When treatment is completed the habit of regular daily evacuation of the bowels at a fixed hour should be advised. Straining at stool should be avoided and a mild laxative taken regularly if necessary.

I have described the technique of injection in detail as it is intended to be helpful to those practitioners who are employing this method of treatment for the first time; it is only by great attention to detail that successful results can be assured and ill effects avoided. Although a simple matter to those accustomed to ano-rectal work and only taking a few minutes to accomplish, yet for the beginner the difficulties attending the acquisition of the special technique attaching to the practice of ano-rectal work are similar to those encountered in other specialties, such as ophthalmology. It is advisable, therefore, that as much practice as possible under skilled tuition in the out-patient department of a general or special hospital should be obtained before attempting injection in private practice.

Messrs. Arnold and Sons (Bell and Croyden) have made to my specification "an outfit for the injection treatment of haemorrhoids" which contains everything necessary for the actual injection and for dealing with any complications that may arise.

**A Lecture
ON
BRAIN AND MIND.***

BY

R. J. A. BERRY, M.D., CH.M., F.R.C.S. EDIN.,
PROFESSOR OF ANATOMY IN THE UNIVERSITY OF MELBOURNE.

BETWEEN the primitive type of central nervous system, with its purposeful reflex unconscious actions, as seen in the earthworm, and the highly complex brain of man, with its manifestations of speech, thought, reasoning, delayed reaction to the stimulus, memory, and so on, there is an immense gulf. So much so, indeed, that it is not uncommon to find the human mind spoken of as though it were something which had no physical basis. The truth is that all mental phenomena depend strictly on physical construction, and that the elementary basis of such construction is always the neuron.

The nervous system is everywhere built up of a series of long conducting neurons, connected by a series of shorter neurons. The former comprise the receptor and effector neurons, the latter the internuncial. Medical and physiological attention has been chiefly devoted to the long conducting neurons, because lesions occurring therein have been fairly obvious and are of everyday frequency. In the study of the phenomena of mind and its aberrations it is, however, the short internuncial neurons which become of supreme importance. In the human cerebrum a sufficient number of such neurons are massed together to give those special reactions to the environment which we term "mind"; all mental phenomena are entirely conditioned by a highly complex series of neurons linked together in series of arcs.

Structural Elements of a Neuronic Arc.

Neurons are always linked together, for functional purposes, in neuronic arcs. A neuronic arc, of the simple type found in the segments of the earthworm, consists of:

- (1) A sensitive receiving organ (receptor or sense organ).
- (2) A conductor—that is, a receptor, sensory, or afferent neuron, which transmits the stimulus received in the form of a nerve impulse in an inward or central direction.
- (3) Short adjutor internuncial neurons; usually limited to the grey matter of the central nervous system, and found, in the case of the earthworm, in the neuropile of each segment, and, in the case of man, in the association areas of the human brain.
- (4) A second conductor—that is, an effector, motor, or efferent neuron, which transmits the nerve impulse in an outward or peripheral direction to—
- (5) The effector apparatus, which comprises the muscles, glands, or other organs of response, and the terminals of the efferent nerves upon them.

In the earthworm these elements of a neuronic arc are found in every segment. The receptor or sense organ is in the cuticle. When suitably stimulated it causes the receptor neuron to transmit a nerve impulse to the neuropile within the ganglion of the segment. The impulse is then conveyed to the internuncial neurons, and may pass thence in one of two directions. Assuming for the moment that the impulse is confined to the segment concerned, then the effector neuron is aroused to a discharge of nerve energy, and so the effector apparatus—the muscle of the segment—is stimulated to contract, and there is thus a direct reflex response to the original stimulus. Such an action is an unconscious purposeful reflex action.

In the common earthworm there is no "brain." The so-called "end-brain" of the earthworm is merely a fusion of certain ganglia, which dominate the local activities of the several segments and enable the animal to react, as a whole, to the external and internal bodily stimuli. The histological construction of this "end-brain" of the earthworm does not differ structurally from that of the neuropile of the segments, except in so far as it contains a larger number of integrating internuncial neurons.

* The lecture was delivered last year as an introduction to a course of neurology in the University of Melbourne, and has been slightly curtailed for publication.

The purposive character of the reflex actions seen in the earthworm, or as obtained experimentally from the spinal frog, has sometimes lead to the belief that such animals—spinal cord animals—have a guiding intelligence. "At the present time we recognize that every reaction of a living being must be purposive, in the sense of being adapted to the preservation of the species, if the latter is to survive in the struggle for existence. The question as to whether we are justified in predicating the existence of even a germ of consciousness or volition in the spinal animal must be decided in the negative" (Starling). As Sherrington expresses it, "where even simplest ideas are not, there cannot be consciousness." Consciousness, then, like all mental phenomena, primarily depends on a relative sufficiency of neurons at the cephalic end of the neural tube, in which the memories of previous receptor impulses may be stored up, and these the earthworm does not possess.

Specialization of Internuncial Neurons.

As increasing functional demands are made upon the nervous system in accordance with the increasing rises in animal intelligence, from purposeful unconscious reflex actions to complete voluntary and conscious control over these actions—that is, the power of delaying or inhibiting the effector responses to the receptor stimuli—the internuncial neurons not only increase in numbers and complexity of connexions, but they begin to be specialized for such purposes as correlation, association, and integration. Further, they tend to be collected together, as their numbers increase, into cerebral vesicles, at the cephalic end of the neural tube.

Transitional Types of "Brain" between the Earthworm and Man.

The immense gulf between the primitive nervous system of the earthworm and the complex brain of man, both structurally and functionally, is bridged by living and intermediate animal forms. If the central nervous system of such living animal forms as the earthworm, sea lamprey, teleostean fish, alligator, dog, anthropoid ape, and man be regarded in series, it will be observed that there is continually being added on to the cephalic end of the neural tube additional numbers of neurons linked together in series of arcs, and that these additional neurons are developed within successively added cerebral vesicles. The last one of these to be added in each animal form constitutes the "end-brain"—a somewhat misleading term, because it does not follow that the end-brain of one animal is the same as the end-brain of a higher animal. In fact, it is not. As each one of these new end-brains is added there is a shifting forwards to it of the higher functions of which the animal is capable, and the last added assumes control over all the older ones. This process of shifting forwards of cerebral function to a newly added end-brain is known as "telencephalization." The histological construction of these successively added end-brains involves the additions of an increasing complexity of internuncial neurons, so that comparative anatomy compels the conclusion that, no matter what may be the behaviour or mentality of the animal, its physical instrument is always the neuron.

Five Epochs of Neuronic Arcs.

Every living animal react to its environment in accordance with the structural evolution of its nervous system—that is to say, its motions or behaviour must be strictly adapted to its requirements. If the environment be simple, little adaptation is needed and motion is correspondingly simple. Cajal recognizes five epochs or types of neuronic arcs through which centralized nerve control has passed. These are as follows:

1. The epoch of irritability, as in the sponges.
2. The epoch of the reflex arc, as in the coelenterates or sea anemone.
3. The epoch of the intersegmental reflex arc, as in the earthworm.
4. The epoch of the suprasegmental reflex neuron, as in the lower mammals.
5. The epoch of the psycho-associational neuron, as in man.

1. *The Epoch of Irritability.*—In the Porifera or sponges a stimulus, chemical or physical, received by a receptor cell on the surface of the organism, is transmitted directly to an effector or motor cell, which contracts immediately in response to the stimulus. This is the epoch of irritability, and is the primitive functional basis of the nervous system of all animals, man included. As there is no immediate tissue whatsoever between the receptor and the effector cell, a stimulus is immediately followed by a local reaction, and the exact nature of the response to the stimulus can be predicted with certainty.

2. *The Epoch of the Reflex Arc.*—In the coelenterates—for example, the sea anemone—the receptor stimulus from a limited area of reception is transferred, through a neuronic reflex arc of the very simplest type, to an extensive area of reaction. This stage, in which several parts of the body may be made to react in response to a single stimulus, is a very significant advance in the evolution of a nervous system, and necessitates the introduction of an intermediate element, the evolution of which results in the appearance of the rudiments of the nervous system. One cell becomes specialized for the receiving of impulses, and another for their transmission. The former eventually develops into the receptor system, the latter into the effector, whilst the two together form a neuronic reflex arc, which is the structural basis of all nerve phenomena, mind included.

3. *The Epoch of the Intersegmental Reflex Neuron.*—Where the animal body becomes definitely segmented, as in the earthworm, there is a further development, which assumes the form of a new neuron interposed between the receptor and effector elements of the neuronic arc. This new element may be tentatively termed the "internuncial neuron." By its agency incoming stimuli may be passed on to the effector neuron of the segment, or may be transferred to the head ganglion, where the receptor stimuli from all the segments may be co-ordinated and welded into a harmonious whole. These internuncial neurons are, in the earthworm, found in the neuropile and the head ganglia. By their means incoming stimuli may be brought into relationship with their own as well as other segments.

4. *The Epoch of the Suprasegmental Reflex Neuron.*—In all segmented animals, such as most vertebrates lower than the mammal, the reflex arc and the intersegmental reflex internuncial neuron suffice to regulate the motor reactions in the behaviour of the animal. All motions are immediate responses to the stimulus—that is, they are reflex actions, consequent on the translations, without any delay, of receptor stimuli into motor responses. In all such animals the behaviour will be in strict accordance with the stimulus. The combinations of these stereotyped performances will be limited in their scope and rigid in their form. In the higher animals immediate response to the stimulus would often be disadvantageous to the animal's welfare, and it becomes, therefore, essential to the well-being of both mammals and man to have a period of latency between the receipt of the stimulus and the motor reaction. The new element which so produces the period of latency by holding in check the motor response to the stimulus until the most favourable moment has arrived for its accomplishment provides the important factor of inhibition, which has attained its highest development in the brain of the normal man. The neuronic machinery by which this is brought about consists in the addition of an enormous number of suprasegmental neurons collected together into successively added end-brains. Behaviour is then no longer a matter of instantaneous impulse, but is made subject to a certain degree of supervisory review, guided by a primitive form of judgement which may be taken to mark the beginning of psychic life.

5. *The Epoch of the Psycho-associational Neuron.*—The final step in the centralization of the nervous mechanism, enabling it to attain the consummation of its functional capability, is reached with the addition of the psycho-associational neuron, and attains its highest development in man. By this means numerous associations are made possible between the various types of sensibility, including somaesthetic sense, vision, hearing, taste, and smell, out

of which the individual is constructed and upon which the foundations of all the higher faculties rest. (Tilney and Riley.)

Logical Deductions from Brain Structure.

The inevitable and only logical conclusion is that the neuron, particularly the short interpolated or internuncial neuron, is the physical instrument of mind, and that consciousness, memory, speech, thought, and reason can only manifest themselves when there are a sufficiency of neurons for the purpose. If, in the human being—in whom it is estimated there are 9,280 million neurons in the cerebral cortex—these neurons should be markedly deficient from any cause whatsoever, there are produced equally marked aberrations of intelligence and mind.

Other Factors in the Production of the Manifestations of Mind.

Although stress has been laid upon the importance of the neuron in all mental phenomena, other factors are concerned. Time will not permit of their discussion at the moment, but among them are:

1. The state of development and physiological condition of the neurons.
2. The number and nature of the receptor impulses transmitted to the central nervous system.
3. The potential energy developed by the neurons.

"One of the most striking characters of the neurons, at all events in the higher vertebrates, is that, contrary to the cells of other organs, the whole of those which the adult animal is to possess are present at birth, gradually taking on functional activity. There is no evidence of any regeneration after destruction or death of any individual neuron." (Bayliss.) "In the case of medullated nerves, the acquiring of the fatty or medullary sheath is the sign that the neuron is ready to transmit impulses." (Harris.) Without that sheath the neuron will not transmit impulses—that is, until development is completed the neuron cannot function. Notwithstanding that, physiologically, little is certainly known as to the functions of the myelin sheath in medullated nerve fibres, it appears to be certain that myelination is essential to a correct and normal functioning of the central nervous system, as opposed to the autonomic nervous system. But the anatomist is not unmindful of the fact that the whole of the white medullary centre of the cerebral hemisphere is entirely made up of many million myelinated association, commissural, and projection fibres, all lying in the closest juxtaposition, and he asks himself: Supposing those fibres should remain partially undeveloped—that is, only partially myelinated throughout the whole of life—can there be a normal mental functioning of the brain? Is it not more reasonable to suppose that under such conditions the nerve impulses will undergo dissipation before arriving at their correct destination and so give rise to hysterias and other mental conditions characterized by irresponsible reaction to the environment? Because, as Starling says, the main nerve tracts cannot be shown to be functional before the date at which they acquire their medullary sheath.

Again, the vast importance of temporary or permanent exhaustion of the nerve cells—that is, chromatolysis—in altering the mental reactions is not sufficiently realized. Sherrington's work has familiarized us with the incoming to the brain of enterceptive impulses from the viscera and internal bodily world generally; of proprioceptive impulses from tendons, muscles, joints; and exteroceptive impulses from the external world around us; but whether the real significance and profound influence of these impulses on brain structure and the manifestation of mind are equally well understood is another question. As Flack and Hill remark, "exteroceptive, proprioceptive, and enterceptive impulses stream into the central nervous system from the time of its embryonic development until death, ceaselessly modify the pattern of its structure, lay down the pathways of reflex actions, and establish habits." That splendid instance of scientific observation and logical deduction, Dr. J. S. Bolton's *The Brain in Health and Disease*, contains many examples of actual neuronc altera-

tion in brain structure—and therefore in mentality—as a result of a deprivation of incoming receptor impulses. Most of us who are called upon to study the aberrations of the human mind are fully and painfully aware of the fact that "in the case of children deprived of the senses of hearing and vision from birth there results the condition known as 'idiocy from birth from deprivation of the senses.' They experience fewer sensations than healthy children, and are therefore mentally deficient, and have fewer fully developed cortical neurons." No explanation of emotions, passions, and moods, or of their appropriate motor or effector responses or inhibitions, can be accepted which is not equally applicable to all living animals in accordance with their position in the evolutionary scale and their nervous systems. Such explanations must be further applicable to all conditions of health and disease under which those emotions are displayed, and this, in my judgement, is where psychology fails. Its explanations almost invariably forget these essentials, and its exponent almost equally invariably introduces his own personality into that of others. One's own individuality is compounded of one's own receptor impulses, and it is frankly impossible to believe that some other individual has experienced precisely the like impulses, or has had the same neuronc patterns for those impulses to traverse, and the same number of nerve cells for their storage.

What is nerve energy? Just as the physicist uses the term "gravity" to denote a force which he can measure, and the influences of which he can observe, but of whose nature he knows little or nothing, so has the neurologist to employ the term "nerve impulse" or "nerve energy" to denote a phenomenon of which he knows little beyond its observable effects, and yet there are many nervous diseases where it is not improbable that there is an altogether abnormal and irregular discharge of nerve energy.

The elements of a neuronc arc are, certainly in all higher vertebrates, structurally discontinuous—that is to say, there is a break between any two of the three elements, termed a synapse or neurosynapse, which the nerve energy generated by a neuron has to cross in order to stimulate the next neuron. Now "nerve cells are constantly generating, receiving, or storing up nerve impulses," whilst another function "of the nerve cell is the delivery or transmission of impulses which it generates, receives, or stores up." (Tilney and Riley.)

The mammalian cerebral cortex is built up on an infragranular basis (Watson) and a tri-laminar arrangement of nerve components, with the granular cells (Golgi Type II and others) on the exterior, whilst the human cerebral cortex is extended by the addition of two other layers outside the granular layer—that is to say, it is a five-laminar cortex. The whole construction of the vertebrate nervous system is such as to compel the conclusion that the innumerable short cortical cells of the human cerebral cortex, particularly those within the association areas, are the physical storehouses of memory, and hence of speech, reason, and thought. When, therefore, a well known English medical man writes that "nothing but hopeless confusion can result from the mixture of brain cells and ideas," I would rather state that it is exactly this divorce which is responsible for the hopeless confusion, and that the sooner we begin to visualize all mental phenomena in terms of cerebral neurons the more rapid will be our progress. If the ideas are not in the brain cells, where are they? And why is the human microcephalic idiot so hopelessly devoid of ideas if it is not because he is so grossly lacking in brain cells?

Speech.

The whole phenomena of the acquisition of speech and the allied arts of reading, writing, and so forth, as well as their loss or impairment by disease, are much more nearly related to numbers of neurons than has been supposed. Marie urges that in true aphasia intellectual impairment is invariably present. He considers that the notion of intellectual impairment should dominate the doctrine of aphasia. On neurological ground alone it is difficult to see how anyone can fail to be of Marie's opinion.

Man is the only animal gifted with the powers of

speech, with large association areas and an adequate supragranular cortex; and even then his neurons have to be laboriously taught to acquire those properties of speech; reading, and writing which go to make education possible. If he is under-neuroned from the outset the acquisition of these properties is correspondingly difficult, and his intellect or mind will be correspondingly impaired.

The conception, which has so long been held in medicine, that there is some particular part of the cortex, such as Broca's area, which is the one and only area concerned in speech, is erroneous. At the best the occipital end of the third frontal convolution can be little more than the place of origin of, perhaps, the final common effector pathway. In the acquisition of speech many of the neurons of the association areas are vitally concerned, and it is by no means impossible, or even highly improbable, that many of these neurons are the physical storehouses of words and phrases. In accordance with neurological principles these neurons are parts of complicated neuronics arcs, and hence speech is often reflex or automatic in its manifestations.

Examples are common in which the mechanism of language is employed in a purely mechanical manner. Imbeciles can at times learn by rote long paragraphs of the meaning of which they are quite ignorant. Children learn a large portion of their lessons in the same unintelligent way. Many word complexes are often gone through in a purely mechanical manner, whilst the individual repeating them is thinking of something else. In the majority of persons the word vocabulary in daily use is very limited, and the phrase vocabulary is both extremely limited and remarkably stereotyped, and is often quite automatically employed.

Whilst it is extremely likely that there are, in the association areas of the human brain, regions where there is a convergence of neuronics arcs concerned in certain educational functions, such as writing, reading, and so on, it is most improbable that these are absolutely restricted areas, and consequently we should never expect, on neurological grounds, to find the same lesion producing precisely the same results in any two individuals, because there is the actual position of the lesion to be considered, its depth, the numbers of neurons possessed by the individual, and the number actually destroyed by the lesion. Hitherto clinical medicine seems only to have taken into account the precise site of the lesion, and seldom the depth, hence much of the confusion.

In the human brain the purely physical portions of the human neopallial cortex—that is, those concerned with sight, hearing, taste, general sensibility, voluntary motion, etc.—remain much as in other mammals, except that they are more richly endowed with supragranular cortical neurons linked up with each other and with other portions of the cortex by internuncial neurons, whereas the association areas become greatly extended. Comparative anatomy, evolution, and histology, all compel the conclusion that the association areas of the human brain are the suprasegmental equivalents of the neuropile of the common earthworm. It is, therefore, the neurons of the association areas which form the physical instruments of speech, thought, reason, and the higher mental faculties, and the additions of these faculties is always strictly in accordance with additions of neurons linked together in complex arcs, until, according to Herrick, the sum total is reached, in the human cerebral cortex, of 9,280 million neurons—a number immensely in excess of that possessed by any other animal.

Summary.

In concluding this brief and necessarily imperfect account of the dependence of function—that is, mind—upon structure—that is, the neuronics arc—I am necessarily compelled to set forth certain apparently dogmatic statements, leaving the evidence upon which they are based to a later part of the course. These are as follows:

1. The mode of cortical association between the conducting limbs of neuronics arcs would appear to be a much more important subject than has been supposed, and to play a vital part in all mental phenomena. A close study of the structural details by which this is brought about seems to

lead to some quite new conceptions of memory, mind, and speech.

2. The cerebral cortex is a vast collection of neuronics arcs, with a complex series of internuncial neurons between the limbs of these arcs. In everything but simplicity these conform to the type found in all vertebrates.

3. In the more recently evolved suprasegmental portions of the nervous system the mode of union of conducting limbs of neuronics arcs appears to differ from that of the relatively simple type of the older segmented portions.

4. These differences in the mode of union appear to be strongly suggestive of the fact that it must be the many short neurons of the suprasegmental portions of the nervous system which have, as their special properties, the storing up, transformation, and dispersal of nerve impulse or nerve energy, and consequently the granular and associational neurons of the cerebral cortex must be the physical storehouses of memory. This appears to harmonize with known neurological evidence, to throw much light on many mental processes and functional nervous disorders, and to be not inconsistent with physiological opinions as to the possible functions of the neurosynapse.

5. The association areas of the human brain are the fields for all the higher mental functions—such as thought, memory, reason, and speech. The capabilities of the human individual in these directions will differ according to the number and mode of connexion of fully developed functioning neurons within these areas. "Special talents are due to differences in organization of special parts of the cortex." (Howell.) These areas—particularly the prefrontal—are underdeveloped in low-grade aments (idiots and imbeciles) and to a lesser extent in high-grade aments (mental defectives). (Bolton.) The importance of all this is that we are now beginning to know and to be able to prove that there are quite a number of human individuals who, from some cause or another, do not possess their fair share of cortical neurons. Dr. Bolton's work—as well as that of others—affords ocular and indisputable proof of this, and yet we go on expecting these unfortunate people to react to their environment in a normal manner, and delude ourselves with the idea that psycho-analysis can replace nature. As "bricks cannot be made without straw," neither can a brain deficient in cortical neurons give a normal reaction to the environment. From the neuronics standpoint all human individuals may be divided into three great groups: the cerebral aments who swell the ranks of our prisons, gaols, reformatories, and asylums, though I must not be supposed to imply that all such are aments; normal neuronics individuals who constitute the vast majority; and the multi-neuronics geniuses with more than their fair share of neurons. As a matter of fact there are far more cerebral aments outside these institutions than in them, and many of them find their way into our consulting rooms, where they remain largely unrecognized, or drift into the hands of cranks or quacks who are not improbably as under-neuroned as their victims.

6. Man is the only animal with highly developed association cortical areas. He is the only animal to speak, think, and reason, and he does so because he has not fewer than three times as many cortical neurons as any other animal; hence, a study of brain structure is an essential first step in the study of mind and its aberrations.

REFERENCES.

- F. Tilney and H. A. Riley: *The Form and Functions of the Central Nervous System; an Introduction to the Study of Nervous Diseases*. New York, Paul B. Hoeber, 1921.
 E. H. Starling: *Principles of Human Physiology*. Third edition. London, J. and A. Churchill, 1920.
 D. F. Harris: *Nerves*. London, Williams and Norgate, 1913.
 J. Shaw Bolton: *The Brain in Health and Disease*. London, Edward Arnold, 1914. "Recent Researches on Cortical Localization and on the Functions of the Cerebrum," article in *Further Advances in Physiology*, edited by Leonard Hill. London, Edward Arnold, 1909.
 Alex. Hill: *The Body at Work; a Treatise on the Principles of Physiology*. London, Edward Arnold, 1908.
 C. Judson Herrick: *An Introduction to Neurology*. Philadelphia and London, W. B. Saunders Co., 1921.
 W. H. Howell: *A Textbook of Physiology for Medical Students and Physicians*. Seventh edition, Philadelphia and London, W. B. Saunders Co., 1918.