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Phylogenetic Association in Relation to Certain Medical Problems

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Ether Day Address
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PHYLOGENETIC ASSOCIATION IN RELATION TO CERTAIN MEDICAL PROBLEMS.*

The discovery of the anesthetic properties of ether and its practical application to surgery must always stand as one of the great achievements of medicine. It is eminently fitting that the anniversary of that notable day, when the possibilities of ether were first made known to the world, should be celebrated within these walls, and whatever the topic of your Ether Day orator, he must fittingly first pause to pay tribute to that great event and to the master surgeons of the Massachusetts General Hospital. On this occasion, on behalf of the dumb animals as well as on behalf of suffering humanity, I express a deep sense of gratitude for the blessings of anesthesia. Two years ago an historical appreciation of the discovery of ether was here presented by Professor Welch, and last year an address on medical research was given by President Eliot. I, therefore, will not attempt a general address, but will present an experimental and clinical research.

Time will permit the presentation of only the summaries of the large amount of data. The great assistance rendered by my associates, Dr. D. H. Dolley, Dr. H. G. Sloan, Dr. J. B. Austin and Dr. M. L. Menten†, I acknowledge with gratitude.

*Address delivered at the Massachusetts General Hospital on the sixty-fourth anniversary of Ether Day, Oct. 15, 1910.
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The scope of the title of this paper may be explained by a concrete example.

When a barefoot boy steps on a sharp stone there is an immediate discharge of nervous energy in his effort at escape from the wounding stone. This is not a voluntary act. It is not due to his own personal experience (i.e., his ontogeny), but is due to the experience of his progenitors during the vast periods of time required for the evolution of the species to which he belongs, i.e., his phylogeny. The wounding stone made an impression upon the nerve receptors in the foot similar to the innumerable injuries which gave origin to this nerve mechanism itself during the boy’s vast phylogenetic or ancestral experience. The stone supplied the phylogenetic association, and the appropriate discharge of nervous energy automatically followed. If the sole of the foot is repeatedly bruised or crushed by the stone, shock may be produced. If the stone be only lightly applied, then there is also a discharge of nervous energy from the sensation of tickling. The body has had implanted within it in a similar manner other mechanisms of ancestral or phylogenetic origin whose purpose is the discharge of nervous energy for the good of the individual. In this paper I shall discuss the origin and mode of action of some of these mechanisms including certain phases of anesthesia.

The word anesthesia — meaning without feeling — describes accurately the effect of ether in anesthetic dosage. Although no pain is felt in operations under inhalation anesthesia, the nerve impulses set up by a surgical operation still reach the brain. We know that not every portion of the brain is fully anesthetized, since surgical anesthesia does not kill. The
question then is, What effect has trauma under surgical anesthesia upon the part of the brain that remains awake? If, in surgical anesthesia, the traumatic impulses cause an excitation of those wide-awake cells, are the remainder of the cells of the brain, despite anesthesia, influenced in any way? If influenced, they are prevented by the anesthesia from expressing the same in conscious perception or in muscular action. Whether the anesthetized cells are influenced or not must be determined by noting the physiologic function after anesthesia has worn off, and in animals by an examination of the brain cells as well. It has long been known that the vasomotor, the cardiac and the respiratory centers discharge energy in response to traumatic stimuli applied to various sensitive regions of the body during surgical anesthesia. If the trauma is sufficient, exhaustion of the entire brain is observed after the effect of the anesthetic is worn off; that is to say, despite the complete paralysis of voluntary motion and the loss of consciousness due to ether, the traumatic impulses that are known to reach the awake centers in the medulla also reach and influence every other part of the brain. As to whether or not the consequent functional depression and the morphologic alterations seen in the brain cells may be due to the low blood pressure which follows excessive trauma is answered by the following experiments, viz: the circulation of animals was first rendered static by over-transfusion, and was controlled by a continuous blood-pressure record on a drum, the factor of anemia was thereby wholly excluded during the application of the trauma and during the removal of a specimen of brain tissue for histologic study. In every such instance morphologic changes in the cells
of all parts of the brain were found, but it required more trauma to produce equal morphologic changes in animals protected against low blood pressure than in animals whose blood pressure gradually declined in the course of the experiments.

In the cortex and in the cerebellum, the changes in the brain cells were in every instance more marked than in the medulla. There is also strong negative evidence that traumatic impulses are not excluded by ether anesthesia from the part of the brain that is apparently asleep. This evidence is as follows:

If the factor of fear be excluded, and if in addition the traumatic impulses are prevented from reaching the brain by cocaine blocking, then, despite the intensity or the duration of the trauma within the zone so blocked, there follows no exhaustion after the effect of the anesthetic disappears, and no morphologic changes are noted in the brain cells. A still further negative evidence that inhalation anesthesia offers little or no protection to the brain cells from trauma is derived from the following experiment: A dog whose spinal cord had been divided at the level of the first dorsal segment, and then kept in good condition for two months, showed a recovery of the spinal reflexes, such as the scratch reflex, etc. This animal is known as a “spinal” dog. Now, in this animal the abdomen and hind extremities have no direct nerve connection with the brain. In such a dog a continuous severe trauma of the abdominal viscera and of the hind extremities lasting four hours was accompanied by but slight change in either the circulation or in the respiration, and no microscopical alteration of the brain cells. Judging from a large number of experiments on normal dogs under ether, such an amount
of trauma would have caused not only a complete physiologic exhaustion of the brain, but also morphologic alterations of all of the brain cells and physical destruction of many. We must, therefore, conclude that, although ether anesthesia produces unconsciousness, it apparently protects none of the brain cells against exhaustion from the trauma of surgical operations; ether is, so to speak, but a veneer. Under nitrous oxide anesthesia there is approximately only one-fourth the exhaustion on equal trauma as under ether; either nitrous oxide protects or ether predisposes to exhaustion under trauma. With this as a point of departure we will inquire into the cause of this exhaustion of the brain cells.

*On the Cause of the Exhaustion of the Brain Cells from Trauma of Various Parts of the Body Under Inhalation Anesthesia.*

Numerous experiments on animals upon the effect of ether anesthesia *per se, i.e.*, ether anesthesia without trauma, showed that although certain changes were seen there was neither the characteristic physiologic exhaustion after the anesthesia had worn off nor were there seen the characteristic changes in the brain cells. Turning to trauma, in a study of the behavior of individuals as a whole under deep and under light anesthesia, we at once found the cue to the discharge of energy,—the consequent physiologic exhaustion and the morphologic changes in the brain cells.

If, in the course of abdominal operations, rough manipulation of the parietal peritoneum is made, there is frequently observed a marked increase in the respiratory rate and an increase in the expiratory force,
even to the extent of an audible expiratory groan. Under light ether anesthesia severe manipulation of the peritoneum often causes such vigorous contractions of the abdominal muscles that the operator may be greatly hindered in his work.

Among the unconscious responses to trauma under ether anesthesia are purposeless moving, withdrawing of the injured part, and if the anesthesia is sufficiently light and the trauma sufficiently strong, there may be an effort directed toward escape from the injury. In injury under ether anesthesia every grade of response may be seen, from the slightest change in the respiration or in the blood pressure to a vigorous defensive struggle. As to the purpose of these subconscious movements in response to injury, there can be no doubt, — they are efforts at escape from the injury.

Can anyone picture the actual result of a formidable abdominal operation extending over a period of half an hour or more in an unanesthetized human patient if extensive adhesions are broken up, or if a large tumor is dislodged from its bed? In such a case would not the nervous system discharge its energy to the utmost in efforts to escape from the injury, and would the patient not suffer complete exhaustion? If the traumatata, under inhalation anesthesia, be sufficiently strong and repeated in sufficient numbers, the brain cells will finally be deprived of their dischargeable nervous energy and become exhausted just as exhaustion follows a strenuous and too prolonged muscular exertion, for example, such as is seen in endurance tests. Whether the nerve energy of the brain is discharged by injury under anesthesia, or whether by ordinary muscular exertion, identical morphologic changes are seen in the nerve cells. In
shock from injury, in exhaustion from overwork (Hodge and Dolley) and in exhaustion from pure fear, the general functional weakness is similar, — in each a certain length of time is required to effect recovery, and in each there are morphologic changes in the brain cells. It is quite clear that in each of these cases the altered function and form of the brain cells are due to an excessive discharge of nervous energy. This brings us to the next question, viz: what determines the discharge of energy from trauma with or without inhalation anesthesia?

On the Cause of the Discharge of Nervous Energy from Trauma in Animals Under Inhalation Anesthesia as Well as in the Normal State with Special Reference to Medical Problems.

I looked into this problem from many view-points and there seemed to be no solution until it occurred to me to seek the explanation in certain of the postulates which make up the doctrine of evolution. I realize fully the difficulty and the danger in attempting to reach the generalization which I shall make later and in the hypothesis I shall propose. There is, of course, no direct final proof of the truth of even the doctrine of evolution. It is idle to consider any experimental research into the cause of phenomena that have by natural selection required millions of years to develop. Nature has made the experiments on a world-wide scale; the data are before us for interpretation. Darwin could do no more than collect all available facts and then frame an hypothesis that best harmonized the facts. Sherrington, that masterly physiologist, in his volume entitled “The Integrative
Action of the Nervous System,"' shows clearly how the central nervous system was built up in the process of evolution. Sherrington has made free use of Darwin's doctrine in explaining physiologic functions, just as anatomists have extensively utilized it in the explanation of the genesis of anatomical forms. I will assume, therefore, that the discharge of nervous energy is accomplished by the application of the law of inheritance and association, and that this hypothesis will explain many clinical phenomena. I shall present such evidence in favor of this hypothesis as time and my limitations will admit, after which I shall point out certain clinical facts that may be explained on this hypothesis.

According to the doctrine of evolution, every function owes its origin to natural selection in the struggle for existence. In the lower and simpler animal life, indeed, in our human progenitors as well, existence depended principally upon the success with which three great purposes were achieved, viz: (1) self-defense against or escape from enemies; (2) the acquisition of food; and (3) procreation; and these were virtually the only purposes for which nervous energy was discharged. In its last analysis in a biologic sense this statement holds for man of to-day. Disregarding for the present the expenditure of energy for procuring food and for procreation, we will consider the discharge of energy in self-preservation. The mechanisms for self-defense which we now possess were developed in the course of vast periods of time from the lowest forms through all the intermediary stages to our present estate. One would expect, therefore, that we are now in possession of mechanisms which still may discharge energy on adequate