THE EXPERIMENTAL METHOD IN MEDICAL SCIENCE. SECOND COURSE OF THE CARTWRIGHT LECTURES OF THE ALUMNI ASSOCIATION, COLLEGE OF PHYSICIANS AND SURGEONS, NEW YORK, DELIVERED JANUARY 24, JANUARY 31, AND FEBRUARY 7, 1882

Published @ 2017 Trieste Publishing Pty Ltd

ISBN 9780649524884

The Experimental Method in Medical Science. Second Course of the Cartwright Lectures of the Alumni Association, College of Physicians and Surgeons, New York, Delivered January 24, January 31, and February 7, 1882 by John C. Dalton

Edited by Trieste Publishing Pty Ltd.
Cover @ 2017

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BY

JOHN C. DALTON, M.D.

NEW YORK
G. P. PUTNAM'S SONS
27 AND 29 WEST 23D STREET
1882

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THE EXPERIMENTAL METHOD IN MEDICAL SCIENCE.

LECTURE I.

GALVANI AND GALVANISM IN THE STUDY OF THE NERVOUS SYSTEM.

Mr. President and Gentlemen of the Alumni,— In discharging the agreeable duty which you have kindly imposed upon me, of giving the Cartwright Lectures for this year, I propose to offer a few historical sketches, which shall illustrate the manner in which certain parts of our scientific knowledge in medicine have been attained. The connection between scientific and practical medicine is furthermore so close, that permanent improvement in the one is inseparably dependent on that of the other; but this connection becomes much more apparent when we trace the history of any particular department for a considerable period of time. By this means we can see how much of the doctrine accepted by our predecessors has survived the ordeal of a century, and what were the methods of investigation which produced in their hands the permanent results which we enjoy to-day. However much we may pride ourselves on the advances made during our own time, we may be sure that by far the greater part of our actual knowledge is a legacy from the past. It has been winnowed in successive generations from the errors and imperfections which always accompany its first acquisition; and it is probable that many of our own discoveries will require a similar depleting treatment in the future. But we may learn to rely with confidence on such methods of study as have heretofore proved valuable; and we may, perhaps, save ourselves the trouble of exploring certain paths, when we see that others have followed them before, and have found that they lead nowhere.

If we can say that any one department in physiology, pathology, and therapeutics, is now distinguished by a special activity of investigation and growth, it is probably that of the nervous system. A very large part of this advance has been made by the application of electric stimulus in determining the motor or sensitive properties of different nerves, their influence on the heart and blood-vessels, the localization of special centres in the brain and spinal cord, or the diagnosis of morbid alterations in the cerebro-spinal axis; and the use of electricity in restoring the power of movement or sensation when impaired by disease is now acknowledged to be, in many cases, a most serviceable means of cure. This has all come, directly or indirectly, from the experiments of Galvani, nearly a hundred years ago, on the nerves and muscles of the decapitated frog.

In 1789 Galvani was professor of anatomy in the University of Bologna. In addition to the regular duties of his professorial chair, he had made a number of valuable investigations in comparative anatomy, such as those on the structure of the kidneys and urinary ducts of birds, and on the organ of hearing in the same class. Like most of the scientific men of his day, he was also greatly interested in the phenomena of electricity, which was then fast developing into an important department of physics. The condition of electrical science at that time was as follows. The machine for producing frictional electricity by a rotating glass cylinder and cushion had been brought to practical completion, and was in common use, with its prime conductor and insulating supports. The two opposite kinds of electrical excitement, known as vitreous and resinous, or positive and negative, were fully recognized, as well as the distinction between conductors and non-conductors; and even some of the phenomena of induced electricity were known, though explained in a manner somewhat different from that which is now in vogue. Besides the electrical machine, experimenters were already in possession of the Leyden jar, by which a large quantity of electricity may be stored in a given space; the electrophorus, by which a moderate charge of electricity may be obtained at will from a permanent source; several varieties of electrometers, or electroscopes, for detecting the existence and amount of slight electric disturbances; and Volta's "condenser," in which small quantities of electricity from a feeble source might be accumulated, and made apparent by the electrometer. Finally, Franklin had shown, by his daring experiment with the kite in the thunder-storm, that the lightning of the clouds was identical in its nature with the spark from an electrical machine; and this had largely directed the attention of investigators to the study of atmospheric electricity, as compared with that produced by artificial means.

Considering the long list of results which have followed from Galvani's early observations, the manner in which they were first made is a topic of much interest.[1] He was in his laboratory, engaged on experiments with the electrical machine, and had, lying upon the table near by, a freshly dissected frog, prepared for some other purpose in such a way that the denuded hind legs were connected with the spinal column by the crural nerves. One of his assistants, accidentally touching the nerves of the animal with the blade of a scalpel, saw the legs convulsed; and, on watching more closely, it was seen that the contraction occurred only at the moment of drawing a spark from the conductor of the machine. Once Galvani's attention attracted to so remarkable a phenomenon, his mind turned instantly to the investigation of its conditions. He abandoned all other occupations, and seemed absorbed in the attempt to detect its causes, and to learn their mode of operation. He determined, in the first place, that the discharge of the conductor, and the contact of the scalpel with the frog's nerves, were both necessary; for the muscular contraction would not take place with either of them alone. But, even when both conditions were present, sometimes the muscles contracted, and sometimes they did not. Puzzled by this variation, but still confident that it must have a reasonable cause, he at last found that it depended on the way the scalpel was held in the fingers. If grasped by the end of its non-conducting ivory handle, there were no convulsions in the legs when the spark was taken from the machine; but if held in such a way that the fingers touched the steel blade, or the rivets which held it in place, the muscles were always thrown into action. The human body, therefore, served as a con-

[1] Aloysii Galvani de Viribus Electricitatis in Motu Musculari Commentarius. De Bononiensi Scientiarum et Artium Instituto atque Academia Commentarii, 1791. Tomus septimus, p. 363.

ductor; and Galvani replaced it with success by an iron wire, which he attached by one extremity to the spinal column, above the origin of the nerves, by a brass or copper hook, leaving the other end in communcation with the ground. Then he could dispense with the scalpel altogether. He varied the contrivance in many ways, turning sometimes the attached and sometimes the free end of the conductor toward the electrical machine, increasing or diminishing its length, and at last adding a second conductor attached to the muscles of the leg. He took especial pains to exclude the possibility of any direct transfer of electricity from his machine to the dissected frog, and yet convinced himself, by the aid of Volta's electrometer, that in some way or other an electric discharge passed through the frog, and was the exciting cause of its convulsions.

These experiments were all performed with artificial electricity obtained from the electrical machine. Galvani then passed to his second series of observations, to see whether a similar effect would be produced by atmospheric electricity. On the approach of a thunder-storm, he arranged one of the conducting wires so that its upper extremity was in the open air, near the roof of his house, and its lower extremity connected with the frog's spinal column, while the other wire, attached to the muscles of the leg, communicated below with the water in a well; and he then waited, like Franklin, for the discharge of a thunder-cloud. The result followed as before, and every peal was accompanied by a convulsive motion in the dissected frog. He especially noticed that the convulsions were simultaneous, not with the sound of the thunder, but with the electric discharge; for, as he says, "the muscular contractions and movements of the animal, like