LECTURES

ON

THE GRAPHIC METHOD IN THE EXPERIMENTAL SCIENCES, AND ON ITS SPECIAL APPLICATION TO MEDICINE.

Delivered at the Medical Congress in Brussels, September 21st, 1875.

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THE respiratory movements, the action of muscles, the rapidity of transmission of the sensory and motor nervous agents, the normal or abnormal motions in walking, the buccal or pharyngeal motions which take place in phonation, all these varied acts do not interest the physiologist only, but are capable of furnishing valuable materials for enlightening the diagnosis of disease. Some of these phenomena entirely escape our senses; all are appreciable by the graphic method, and, as soon as they are thus inscribed, lend themselves to the most precise methods of estimation.

In order to inscribe the movements of respiration, Vierordt put the patients in the horizontal position. A lever rested on the sternum, and inscribed the movements of dilatation and retraction of the chest. It is more convenient to have recourse to the method of transmission already indicated for the study of the movements of the heart. A special "explorer", adapted to a chest-band, sets in motion at a distance an inscribing lever, and gives a trace in which the rise corresponds to expiration, and the fall to inspiration. In the physiological condition, the existence of a certain rhythm is observable. If, then, we vary the resistance which the air encounters on entering the chest, or that which it encounters during expiration, we cause a similar variation in the rhythm of the movements of the thorax. Thus prolongation of expiration reveals the existence of an obstacle to the expiratory forces. If, on the contrary, it be inspiration which is prolonged, it may be concluded that there is an obstacle to the introduction of air into the lungs.

Physicians now no longer consider pathological cases as a reversal of the laws of physiology. They are not astonished to see dyspnoea translated by changes of the respiratory rhythm—changes which are produced in the sense above indicated. The respiratory tracings obtained in asthma seem to show that there exist at least two distinct forms of this malady: one appears to be associated with spasm, and the other with atony of the bronchi.

It would be premature to put forward on this subject affirmations of too absolute a character; further researches can alone lay the foundations of the semeiology of the respiratory movements. One point seems, however, now well established; that is, that the functions of the heart and lungs may undergo, by muscular exercise frequently renewed, profound modifications. When young recruits are subjected to progressive training in the military gymnasia, it is observed at the outset that the movements of the heart and those of respiration are strongly accelerated under the influence of running. The movements of respiration have then very little amplitude, and are renewed as often as one hundred times in a minute. At the end of some months' training, the same subjects, after having run, give traces of the heart and respiration in which all perturbation has disappeared. The movements of the thorax are no longer accelerated; and, far from presenting a diminution of amplitude, they are, on the contrary, deeper than in the state of rest.

The inscription of muscular acts has profoundly modified physiological theories relative to the production of movement. Thus, in tetanus caused by strychnia, and in that which is provoked by induction-currents frequently repeated, the myograph reveals the existence of vibratory movements which the eye could not perceive. This instrument shows that the shortening of a tetanised muscle is produced by the fusion of a series of little elementary movements which we call shocks, and no one of which has time to be completed before the next one follows. It may be proved that voluntary contraction is a complex act, like tetanic spasm; and the energy of the effort developed by a muscle increases in proportion to the frequency of the shocks which are produced during its contraction.

As every muscle swells at the same time that it is shortened, this swelling may be explored by means of a special apparatus, and the

shocks of the contraction of the muscles in man may be inscribed. It is thus seen that pathological convulsions cannot any longer be grouped in two classes, according as they are tonic or clonic. Every tonic convulsion, in fact, is constituted by a series of shocks, which vanish from our senses in the shortening of the muscles; but the tracing which is obtained by inscribing these acts reveals the existence of multiplied shocks more or less completely fused.

Another application of the myograph to man permits us to measure the rapidity with which the nervous motor agent is transmitted. The celebrated experiment of Helmholtz may be easily repeated on man by inscribing on a rapidly rotating instrument the instant at which a nerve is excited, and that at which movement appears in the corresponding muscle. Without asserting that this determination should be ranked amongst the ordinary methods of medical diagnosis, it may be hoped that it will throw light on the pathological physiology of the nerves and muscles. When a movement is produced after sensitive impression, whether from reflex action or as a voluntary manifestation of a received impression, it allows the duration of the nerve-transmissions of mental operations to be appreciated, by inscribing itself on the paper at the instant when the sensitive excitation has occurred, and that in which the motor manifestation has shown itself. We record an interval of time between these two acts which our senses would but ill appreciate, but which is revealed with exactness by the graphic method. In the measurement of the sensory nerve transmission, this interval is seen to increase in proportion as a more distant point of the nervous centre is excited; that is to say, in proportion as the nervous agent has to traverse a greater length of the sensory nerve in order to reach the centres. In the same way, in the measurement of the cerebral actions, the delay between the irritation and the movement which follows it is seen to increase, in the same proportion as the subject of the experiment performs a more complex intellectual operation between the impression he has received and the signal by which he must indicate that he has understood. The beautiful researches of Donders on the measurement of the cerebral actions are too well known to render it necessary to recall them in these pages; besides which, it would be very difficult to briefly set forth those bold and successful attempts at introducing exact measurements into the domain of physiology. In the preceding experiments, we treated of very short periods of time, measured with very great precision; and for this purpose physical science possesses a very powerful means—chronography—of which the original idea is due to Thomas Young, but which in later years has been greatly perfected. The essence of the method consists in inscribing on a smoked cylinder the vibrations of a diapason regulated to a certain frequency—say one hundred vibrations to the shock. The tracing of the diapason is formed by a wavy line, of which each undulation, more or less amplified, according to the quickness of the rotations of the cylinder, represents a hundredth part of a second. If two signals be simultaneously inscribed on the cylinder, of which the one corresponds to the commencement and the other to the end of the time to be measured, between these two signals a certain number of vibrations may be counted, expressing to how many hundredths of seconds this short interval of time corresponds. Thanks to the constant progress of chronography, we are now able to estimate periods which do not attain the hundredth part of a second, and even less. In this division of time there is, so to speak, no other limit than that self-imposed by experiment, when it seems to have attained a sufficient degree of precision.

Besides the direct employment of the diapason, which is sometimes not very convenient, the use is sometimes substituted of small instruments called electric chronographs, which, being light and portable, are easily arranged in connection with other inscribing levers in the different experiments. Certain electro-magnetic apparatus serve to produce signals. Their action is so rapid, that they are able to furnish more than five hundred different signals to the second. By means of this instrument, the vibrations of the larynx in speaking or singing are inscribed; and as, on the other hand, with special explorers, the movements of the lips, of the velum palati, and of the air which escapes during the emission of sounds can be inscribed, the study of the mechanism of phonation acquires an astonishing degree of precision. The linguist, the physiologist, and the physician, alike find interesting subjects for study by the use of this method.

I regret that time is wanting for me to show the application of the graphic method to physiology and to medical diagnosis; but, before concluding, I wish to show this method in a less special aspect, and to express my convictions as to the great future which is reserved for it throughout all the experimental sciences. The most perfect expression of a phenomenon is a curve, which, by divers inflexions, expresses the successive changes which have occurred. When a physicist or a meteorologist wishes to set forth in a satisfactory manner the result of

a series of meteorological observations, he traces a curve in accordance with the numerical values he has previously obtained. This curve, which rises, falls, or remains stationary, shows what has really taken place much more clearly than a column of figures, which is tedious and fatiguing to read down. The comparison of the two curves is as it were instantaneous; their identity and their dissimilarity strike the eye at once. The sum of every kind of observation can thus be expressed by curves: changes, pressure, weight, or bulk, or variations of intensity of any kind of force. Still more, all kinds of statistics lend themselves to the use of this method, and thus yield to the first essay results which could only be disengaged by a long and assiduous study. Therefore the use of the curve becomes daily more widely diffused, though not with sufficient rapidity for the wishes of those who realise the sum of its usefulness. How is it possible not to anticipate with impatience the day when long and obscure descriptions will give place to satisfactory representations? All who occupy themselves with experimental study or observations, readers overwhelmed and invaded by the accumulation of written documents, the economist, the statistician, the financier, the statesman, who accumulate around them volumes full of figures, one of these days will find, in one atlas containing some luminous curves, the whole essence of these crude materials. If the graphic method, however, possesses such great advantages from the aspect of the exposition of observed facts, how great is its superiority when the phenomenon of which it gives up the tracing belongs to those which entirely escape the perception of our senses! Here there is no longer any intermediary between the act and its graphic expression. Transformed into inscribing apparatus in meteorological observatories—the barometer, the thermometer, the hygrometer—incessantly determine the state of the atmosphere. Patient, conscientious, infallible, these instruments do what would be impossible to a legion of observers. Formerly, the boldest imagination could not have dreamed that the velocity of a cannon-ball could be seized at all points of the trajectory. This important problem, however, is now solved, and still greater velocities are determined at the present day. The graphic method is equally applicable to the measurement of extremely slow movements. We do not see the growth of a plant; but we can obtain the tracing of its increase, and record that, at certain hours and under certain influences, vegetation is accelerated or retarded. The method of making these determinations is in all cases identical. To force a stylé to move under the influence of the movement which it wished to inscribe is never a very difficult operation. This done, it suffices to receive the tracing on a surface which moves more or less quickly according to the movement which is intended to be inscribed. To measure the velocity of a projectile, a velocity of 200 to 300 *mètres* per minute is printed on the paper; whilst the growth of a plant should be inscribed on a paper which does not change its situation more than a few *centimètres* in the twenty-four hours.

In the enumeration just made, it may be noted that only very simple movements are treated of, moving in a rectilinear direction, sometimes in one direction only, sometimes alternately in two opposite directions. How, indeed, would it be possible to seize those capricious movements which arise in all directions of space? Though more complicated, however, my problem is not insoluble. Everyone is acquainted with the pantograph; everyone knows that, if the outlines of any given object be followed with one limb of this instrument, the other reproduces the same figure either reduced or enlarged. An analogous arrangement allows the inscription, at considerable distances, of all movements on the same plane. My apparatus is, like the two others described, composed of two parts, of which the one is the explorer and the other the receiver. These two parts transmit the movement to each other by air-tubes; each carries a point; and if one of them be led so as to trace a circle, you will see the other point likewise trace a circle; write your name with the first point, and your signature will be reproduced by the other instrument. An easily understood arrangement admits the reproduction of the movement according to its three dimensions in the space.

With these complex transmissions, there is no movement which cannot be reproduced. A flying bird, if of sufficient size, can carry instruments constructed on this principle; the creature, bound by one or two India-rubber tubes to the inscribing instruments, gives the curves of every movement it performs. Thus the trajectory of the wing at every moment of the flight is determined: the torsion movements which are imparted to it by the resistance of the air, even to the oscillations and to the jerks the body of the bird receives from the reaction of its wing-strokes.

I here terminate this exposition, which, though perhaps too long, is yet very much compressed. I have been able to show partly the results of a method which is yet in its infancy, and which, without doubt, will attain still greater perfection. Should we not, therefore, expect much

from the graphic method? Should we not hope that, thanks to its employment, experimental science will advance with a sure and rapid step? Such is my profound conviction, and one which I should like to see widely shared.

CLINICAL LECTURE ON A CASE OF CYSTIC DISEASE OF THE LOWER JAW.

Delivered in University College Hospital.

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GENTLEMEN,—The patient whom I bring before you, before sending her to Eastbourne, is the woman upon whom, a month ago, I performed an operation for cystic disease of the lower jaw. She was sent to me by Dr. Parsons of Dover, and was admitted on November 3rd, 1875, with the following history. About nine years ago, the patient first noticed a lump of the size of a pea beneath the tongue, on the right side, which gave her some pain, and for which a tooth was extracted. From that time, she had a succession of abscesses (?) in the lower jaw, some of which discharged in the mouth, and one externally, and for which she had several teeth extracted. Dr. Parsons sent her to me three years ago, and I then recommended her to come into the hospital; but she declined, and went on with a steadily increasing tumour of the lower jaw on the right side. About nine months ago, the tumour seems to have begun to increase with some rapidity, and, two months ago, the following characteristic event happened. While eating, the patient felt a sudden crack in the lower jaw, and this occurred twice in the same week; and upon each occasion she felt great pain in the floor of the mouth and upon moving the tongue. Upon admission, there was really very little to be seen externally, and I show you a photograph taken at the time to remind you of the fact that, excepting a very small projection beneath the skin in front of the angle of the jaw, there was nothing to call attention to the patient's face. On looking into the mouth, however, the tumour was at once obvious; and I show you a cast taken from the jaw at that time (Fig. 1). The right

Fig. 1.

side of the lower jaw is seen to be greatly expanded from immediately in front of the ramus to beyond the median line, the tumour measuring two inches across at the broadest part, and reaching under the tongue. Its surface was lobulated and rounded, firm and osseous in the greater part, but yielding distinctly on pressure in two or three places. The mucous membrane was entire over the tumour, except at one point where there was an opening, from which a discharge constantly exuded. The incisor teeth of the right side were displaced over to the opposite side, and were loose. The central incisor of the left side was displaced completely in front of the other teeth. The left canine and