but they excite in the sense-centre the sensitive points with which they are severally connected. Now, the shortening of these fibres does not alter their connection with the brain, consequently the sensitive points are stimulated into action by the shortened nerves in the same manner as they previously were by the nerves in their full length. The sensations are therefore alike in both instances. But then, with these internal sensations, others of an objective character, namely, those derived from touch proper, the muscular sense, and sight, have become associated. Thus, with the internal feelings belonging to the foot have become linked its solidity, size, figure, colour, &c., consequently, the former call up thoughts or notions of the latter. For instance, when a man who has lost his leg feels pain in the stump, the pain occurs in the self-same points in which it occurred before the leg was amputated. Stored up in the man's memory, however, there are certain notions which have become firmly associated with this sort of pain; in physiological language, certain actions of the brain-cells have been in the habit of being set up whenever such pain is experienced. These have now been rendered faulty and need to be replaced by a new set of actions. The man must, in fact, learn to connect with certain feelings the notion of the stump instead of the lost foot.

Our localised sensations, then, have their real seat in the brain; they, nevertheless, appear to have their seat in various localities of the body. This is accounted for by the fact that they are apprehended in trinal extension, while, as the seat of thought and emotion, the brain has, in consciousness, no local habitation.

The Velocity of Nerve-Force.

(*Abridged from the 'Revue des Deux Mondes,' August 1st,* 1867.)

THE nerve-current which transmits sensations to the brain, and the orders of the will to the extremities of the body, requires a certain time to travel in. Impressions coming from without are not perceived at the instant they are produced, they travel along the nerves at the rate of 20 to 30 mètres (25 to 40 yards) in a second, which is the same speed as that of the carrier pigeon, of a hurricane, or of a locomotive engine at its quickest, but very much less than that of a cannon ball. For instance, we can only be conscious of an injury to one of our feet about one twentieth of a second after it has actually occurred, and the commands of the will proceed equally lowly from the centre to the peripheries of the nervous system. In he human body the time thus occupied is unimportant, but let us

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take the case of a whale, where the telegraphic network of the nervous system is far more extensive. A boat attacks the whale, and a harpoon is driven into its tail. The impression thus produced has to travel over some forty yards before reaching the head-quarters of the will; a second is thus lost. How long a time is then required for reflection? That must depend upon circumstances; but at any rate it is certain that the will has need of some definite amount of time for its decision. The order to capsize the boat is despatched to the tail, but another second must elapse before the telegram reaches its destination, and in the time thus employed the whaling boat has pulled off and escaped the danger.

Several methods have been devised by physiologists for measuring the velocity with which nerve-force travels. Thus, a physician of the middle ages,* mentioned by Haller, fancied that this might be calculated by comparing the supposed diameter of the nerve-tubes with that of the aorta, as he supposed the velocities of the blood and "animal spirits" to be the inverse ratio of the vessels containing them, from which data he calculated that nervous influence travels 600 times more quickly than light.

Haller's own mode of procedure was scarcely more rational. He counted the greatest number of letters he could articulate in a given time, which he found to be 1500 per minute. Now the letter *r* requires, according to him, ten successive contractions of the muscle which makes the tongue vibrate, whence he concluded that this muscle can contract and relax 15,000 times, that is, can move 30,000 times in one minute. From the brain to the muscle the distance is one décimètre; if, therefore, the nerve-force passes over that space 30,000 times in a minute, it must travel at the rate of three kilomètres per minute, or fifty mètres per second. We need not point out that this process is a mere series of mistakes, but it is strange that the result should happen to be so near the truth.

No attempt was made until 1850 to study this question in a satisfactory manner, when one of the most distinguished of modern observers, M. Helmholtz, undertook its investigation. He at first employed Pouillet's "chronoscope," a machine in which a galvanic current of very short duration makes a magnetic needle deviate, the duration of the current being measured by the amount of deviation; by this means as short a time as some thousandths of a second can be measured. M. Helmholtz fixes one end of a muscle from the leg of a frog, and attaches the other to a small lever which forms part of a galvanic circuit, so that at the moment of contraction the

* The mediæval physicians and the schoolmen held as a consequence of Aristotle's and Galen's theory of "animal spirits," that time was required for their passage from one part of the nervous system to another; and it is even curious to remark how the later schoolmen opposed the Cartesians who thought the contrary;—an example of the advantages derived by the schoolmen from including even bad physiology in their scheme of philosophy.—J. R. G.

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circuit is broken and the time registered by the chronoscope. The current is first sent directly through the muscle, and then through a given length of nerve which has been left adherent; the difference in time between the two cases gives the velocity of the nerve-force, which by this process is found to be 26 mètres (85 feet 7 inches) in a second.

In a second method, also employed by M. Helmholtz, the lever raised by the contraction of the muscle has a point which traces a line upon a sheet of blackened paper, which is kept moving from the moment of excitation, and the curve produced by the movement of the lever registers all the phenomena of the muscular contraction. This apparatus, called the "myograph," gives the velocity of nerve-force as equal to 27 mètres (88 feet 10 inches) per second; several modifications of the instrument by different physiologists have given very closely agreeing results, and have also shown that the velocity is diminished by sending an electric current through the nerve, or by a low temperature.

Experiments with the same object have been made upon man in the following manner:—An electric current is suddenly applied to the skin, the moment of application being registered by the turning cylinder of a chronoscope, and as soon as the person experimented on perceives the slight prick produced by the current he touches an electric lever by which a second mark is made upon the cylinder. The interval between the two, which can be thus measured, is made up of the following elements, viz. transmission of the impression to the brain, the mental process there gone through, the transmission of the voluntary impulse to the fingers, and the consequent muscular contraction. But if this experiment be performed on two different parts of the body, as, for instance, at the groin and at the great toe, all the other elements of the delay will remain the same except the time occupied by the transmission of the impression upwards, and the velocity of nerve-force in man can be thence calculated. M. Hirsch, the director of the Neufchâtel Observatory, was the first person to make these experiments, in 1861, and from them he concluded that nerve-force in man passes over 34 mètres (112 feet) in a second. Dr. Schelske has repeated the same experiments, and deduces from them a slightly less velocity, 29½ mètres (97 feet) per second. By similar means it has been shown that the rate of transmission through the spinal cord is the same as through the nerve trunks, and that a reflex action requires from one tenth to one thirtieth of a second more than the mere direct conduction of excitement to the muscles.

The time required for certain cerebral operations has been measured by Dr. De Jaager in the following manner. It was preconcerted that the person on whom the experiment was made should touch the lever with his right hand when he received an electric

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shock on the right side, and with the left hand when he received a shock on that side. The interval between the shock and the signal was found to be 0·20 of a second when the subject of the experiment had been told beforehand on which side the shock would be given, and 0·27 of a second when he had not been told; 0·07 had therefore been employed in reflection.

M. Hirsch, again, has found that on an average two tenths of a second must elapse before an observer can mark by a signal his perception of a sudden noise or flash of light, and MM. Donders and De Jaager have varied their experiments thus—one of them pronounced a syllable, the other repeated it as soon as heard; when the syllable had been agreed upon beforehand, there was an average delay of two tenths of a second; when it had not been so agreed upon, of three tenths of a second. These are, however, only average results, and subject to considerable individual variations, of which the "personal equation" of different observers of a transit is an example well known to astronomers.

J. R. G.

CLINICAL CASES.

Some further Observations in reply to Certain Strictures upon the Treatment of a certain class of Destructive Patients. By EDGAR SHEPPARD, M.D., Medical Superintendent of the Male Department of Colney Hatch Asylum.

THE profession, that part of it, at least, which involves our specialty, is indebted to the assistant medical officer of a county asylum for obtaining permission from his chief to publish the mode of treatment adopted therein towards a "certain class of destructive patients." Invited by me in general terms to a "dispassionate consideration" of an important subject, he puts himself individually forward, at "the request of the Editors of this Journal," to propound a system of which, nevertheless, he adds, he is not "the authorised exponent." He says that many communications have been received by the editors "condemnatory of the treatment Dr. Sheppard advocates, and, indeed, I may add, of the whole tone of his paper."

But be it known that I, too, have received communications from superintendents and other members of our association, endorsing the

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