CHEMICAL STIMULATION OF THE NERVE CORD OF LUMBRICUS TERRESTRIS.

By A. R. MOORE.

(From the Physiological Laboratory, Rutgers College, New Brunswick, N. J.)

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Nerve cells of different functions cannot be differentiated histologically by staining methods. In order to prove chemical differences it is necessary to affect the function of a given type of neuron by the action of a chemical agent. Thus Baglioni[1] has demonstrated a chemical difference between sensory and motor cells in the frog and the squid, by showing that phenol is an excitant for the motor ganglia alone while strychnine stimulates the sensory ganglia only of these forms. Maxwell[2] has shown that the nerve cells of the mammalian cortex are stimulated by one class of substances which includes creatine and strychnine, but that such substances do not act on medullated nerve fibers. Only certain salts, such as the calcium precipitants and barium compounds, act upon medullated fibers. On the other hand these salts do not stimulate the gray matter of the brain. Tetraethyl-ammonium chloride is an exception in that it acts upon structures of both types.[3]

It is possible that chemical differences exist between nervous systems of various forms.[4] For example, coelenterates give no spasm response to strychnine, but echinoderms do, provided the concentration of alkaloid is sufficiently high, while cephalopods are as sensitive to strychnine as vertebrates are. On these grounds Parker[5] has suggested that strychnine might be used as a test for the presence of synapses, since sensitivity to strychnine on the part of different

[1] Baglioni, S., *Z. allg. Physiol.*, 1905, v, 43.

[2] Maxwell, S. S., *J. Biol. Chem.*, 1906, ii, 183.

[3] Maxwell, S. S., *Am. J. Physiol.*, 1918–19, xlvii, 283. Loeb, J., and Ewald, W. F., *J. Biol. Chem.*, 1916, xxv, 377.

[4] Moore, A. R., *Proc. Nat. Acad. Sc.*, 1917, iii, 598.

[5] Parker, G. H., The elementary nervous system, Philadelphia, 1919, 208.

phyla develops hand in hand with increasing complexity of the nervous system.

By such a method it seems possible to discover similarities and relationships in the chemical constitution of neurons which would otherwise remain undetected. With this purpose in view experiments have been carried out on chemical stimulation of the nerve cord of the earthworm, *Lumbricus terrestris*.

In an experiment the animal was decapitated, pinned down by the anterior end and the anterior portion of the nerve cord laid bare for a distance of about 2 cm. A piece of cord about 1 cm. in length was then separated from the underlying tissue. The substance to be tested was applied to the loosened part. Stimulation was shown by spasmodic squirming of the posterior segments of the worm. Control experiments were made by applying the stimulating substance to a part of the body wall after removal of the nerve cord from that section of the worm. No reaction of the posterior segments resulted.

It is of course impossible to separate the nerve cells from their processes in this form. Therefore excitants of the first class,[2] *i.e.*, calcium precipitants and barium salts, were effective in causing stimulation. $BaCl_2$ and KCl in concentrations isosmotic with the worm's blood caused strong responses immediately. Responses due to the action of Na_2SO_4 and Na_3 citrate were weaker but unmistakable. Tetra-ethyl-ammonium chloride in M/64 concentration made up in Ringer solution acted as a powerful excitant.

Of the substances belonging to the second group, camphor in one-fifth saturated solution, strychnine in saturated solution, atropine sulfate in M/8 concentration and picrotoxin crystals all caused strong reactions. But creatine, caffeine, and nicotine phenol had no stimulating action. Creatine, caffeine, and phenol were applied to the nerve cord in the form of crystals and solutions; nicotine in concentrations of 0.004 per cent and 0.4 per cent was made up in isosmotic Ringer solution.

When chemical excitation did take place the response was almost immediate—within a minute of the time of application. This is a noteworthy fact since in chemical stimulation of the mammalian cortex the latent period is 10 or 15 minutes and the latent period for

the action of nicotine in squid is 6 or 7 minutes at 24°C., the concentration of nicotine being 1,500,000.

In conclusion the facts presented suggest, (*a*) that the nerve processes of *Lumbricus terrestris* are similar in chemical constitution to the axis cylinders of the medullated nerve fibers of mammals; (*b*) that the neurons of the earthworm are more limited in their possibilities of chemical stimulation; *i.e.*, they are simpler in chemical constitution, than the neurons of cephalopods and of mammals.