the three hypotheses for which we have obtained partial experimental proof.

Heretofore I have not tried to assign priority to any one with respect to speculative ideas, since we have considered it our problem to show how far our experimental results were of significance to these now familiar ideas. We made a small step forward in giving a quantitative proof for the cosmic origin of the radiation in 1925, in that the longest wave-length observed, according to our method of calculation, agreed with the Einstein equation corresponding to the building of helium out of hydrogen; and last winter (February, 1927) we found clear and authentic proof that this and other atom building processes are actually the source of the cosmic radiation. We proved further, contrary to all previous assumptions, aside, perhaps, from the assumption of MacMillan, that the atom building process does not occur in the stars, but in the depths of interstellar space.

If there is any one besides Einstein who was a pioneer in the development of the theoretical ideas for which we have found experimental proof it is W. D. MacMillan. Any one who since 1918 may have sought to write the history of the atom building processes should have given him a deserved recognition.

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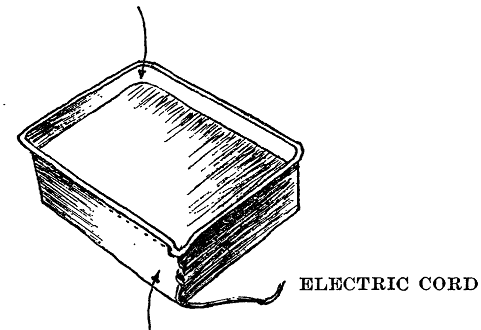
SCIENTIFIC APPARATUS AND LABORATORY METHODS

AN APPARATUS FOR HANDLING PARAFFIN RIBBONS

THE need for a convenient means of handling several paraffin ribbons at one time was the incentive for contriving the following piece of apparatus.

A good-sized photographic tray was fitted into the top of a metal box containing an electric heater and a thermostat. The tray was filled about half full of water. Water at a temperature of approximately 30° C. spreads the ribbon out smoothly yet is not so hot as to make the paraffin soft enough to be inconvenient to cut with small scissors.



The paraffin ribbons are cut to about the length of the tray and transferred to the water with a pair of tweezers. The bath is large enough so that several long ribbons can be spread out side by side. With the aid of a strong light and a hand lens the unwanted parts of the ribbon can be detected and removed from the bath. Then the ribbon is cut to proper lengths, the fixative-covered slide is slipped under the section and the piece of paraffin ribbon floated to the exact position.

The tray may be removed and a plate placed on top or the whole box turned over, resulting in an ordinary constant temperature embedding table, which can be used for drying slides and for softening the paraffin before dissolving the ribbon in xylol.

Briefly summed up, this piece of apparatus does the following: (1) Spreads the paraffin ribbon out flat and smooth. (2) Holds several long ribbons. (3) Undesirable parts of the ribbon can be detected and removed. (4) The paraffin ribbon can be easily cut to desired lengths. (5) Provides a convenient method for placing the piece of ribbon on the slide. (6) Turned over it functions as a large embedding table.

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SPECIAL ARTICLES

THE METABOLISM OF THE LOCAL EXCITATORY PROCESS AND OF THE PROPAGATED DISTURBANCE IN NERVOUS TISSUES[1]

IN an earlier paper I tried to show that the chemical changes produced in a tissue by means of an electrical stimulation differ from those caused by the physiological conduction of excitation waves. I was at first brought to this opinion by the following facts. Nearly all investigations of the metabolism of the excitatory process in the nervous system were carried out in such a manner that the part to be investigated was stimulated directly. Parker alone for methodical reasons stimulated the nerve outside of

[1] Some of these results have been communicated in an evening lecture at Woods Hole and published in the *Collecting Net*, Vol. IV, No. 8.

the chamber in which the CO_2 output was measured. And whereas nearly all other authors had found the gas exchange increased from 50 to 300 per cent., Parker obtained only an increase of about 14 per cent. This made me suspect that the differences between these results were caused by a difference between the metabolism of the local excitatory process and that of the propagated excitation waves, and induced me to pursue the question further.

One of my collaborators, v. Ledebur, made comparative investigations of the oxygen intake and the CO_2 production of the isolated spinal cord of the frog, stimulating with induction shocks either directly or by way of reflex through the sciatic nerve. In the first case he observed a strong increase of the gas exchange, while the reflexive, that is, the physiological, stimulation produced no increase, or only an insignificant one, in the normal spinal cord. In the organ poisoned with strychnine, evidently in consequence of the greater spreading of the excitation, the increase was larger, but still much less than with direct stimulation. It seems to me impossible to explain this in another way than by fundamental differences between the effects of local stimulation and of physiological conduction.

If this is the case with the central nervous system, it must be expected that the peripheral nerve behaves in the same manner. Therefore I performed in the Marine Biological Laboratory of Woods Hole and in the Physiological Laboratory of Breslau a number of experiments concerning the influence which is exerted on the oxygen intake of different nerves on the one hand by the local excitatory process and on the other hand by the propagated disturbance. I used for this purpose a microrespirometer, which allows either a part of the organ situated inside of the respiratory chamber or a part left outside of it to be stimulated by electrical shocks. Using the leg nerves of bull-frogs I was surprised to see that the increase of the gas exchange effected by direct electrical stimulation was incomparably less than I had observed in German frogs. Nevertheless, in a few experiments the increase of oxygen intake was distinct by stimulation inside the chamber, while the conducted excitation produced by the stimulation outside of the chamber did not cause any increase at all. This, however, can be shown much more distinctly with European frogs, which, as mentioned above, have a much larger increase of gas exchange when stimulated. While this increase with direct stimulation amounted to between 50 and 80 per cent., the propagated disturbance again did not cause any measurable increase. The derivation of action currents at the end of the experiments proved that the conductibility had been preserved. From these experiments certainly it must be concluded that the chemical changes produced locally by electrical stimulation differ distinctly from those caused by physiological excitation.

This is also made evident by experiments performed in a similar manner on the isolated spinal cord of the dogfish. Here too the stimulation outside of the respiration chamber did not increase the oxygen intake, while the stimulation inside of it produced an increase of from 40 to 75 per cent. If the movements of the tail on stimulating the spinal cord are taken as a test of excitability, the latter seems to have disappeared after one hour. Therefore in this experiment the physiological conduction was perfectly suspended, while the local excitatory process produced by artificial stimulation was preserved. This shows that the usual method of judging the local excitability by the reactions of a remote end-organ is quite subject to error.

There are a number of observations which agree very well with these ideas. Parker carried out an ingenious experiment about the gas exchange of unsevered nerves. He isolated a large part of the vagus nerve of snakes without cutting it. Then the neck of the animal was bent towards the heart and the vagus looped in the opposite direction. This loop was inserted into the respiratory chamber, where the CO_2 output was measured. No change of this CO_2 output was noted when the nerve was separated from its central and its peripheral connections and thus the passage of all impulses was interrupted. This observation also led Parker to the conclusion that the passage of normal impulses over a nerve does not call for an observable increase of gas exchange. Perhaps also the peculiar difference in the effect of the electrical stimulation upon the oxygen consumption of the nerve in bull-frogs and European frogs may be explained in such a way. It seems very improbable that the physiological conduction should be fundamentally different in animals so closely related; it is much easier to assume that the effect of artificial stimulation differs because of some unimportant structural peculiarities.

The artificial electrical stimulation of an organ has generally two different effects: changes starting the excitation waves and containing the processes of metabolism observable under physiological conditions; besides these changes the stimulation effects further local chemical processes which depend on the intensity of the current and have nothing to do with the processes taking place under normal conditions.[2]

[2] I think these views agree with the ideas expressed by Dr. Lillie in his review of my lecture (*cf.* the *Collecting Net, loc. cit.*).

For the gas exchange both kinds of changes differ vastly; the large increase of the oxidation, up till now regarded as the expression of the physiological excitation of the nervous system, is only an artificial product of the electrical stimulation. This must not refer to all chemical processes. Some years ago I found with my collaborators that the isolated central nervous system of the frog consumes sugar from the surrounding solution and that this consumption of sugar, especially of glucose, is very much increased by electrical stimulation. Now I performed a new series of experiments, where the sugar consumption was compared when the spinal cord was directly stimulated and when it was stimulated by way of reflex through the sciatic nerves. In contrast to the observations on the gas exchange the result was quite the same in both cases, as well in the normal, as in the strychninized organ. Therefore the increase of sugar consumption is no artificial product of stimulation, but a process really conditioned by the physiological excitation. As the sugar consumption produced by way of reflex is accompanied by only a small increase of oxygen intake, we must conclude that the main part of the sugar does not disappear through oxidation.

I can not close without thanking once again Dr. Jacobs for the extraordinary hospitality shown to me at the Marine Biological Laboratory in Woods Hole.

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THE OCCURRENCE OF A PELLAGROUS-LIKE SYNDROME IN CHICKS

A PELLAGROUS-LIKE syndrome in chicks has recently been obtained at this laboratory in an experiment which was originally designed to throw added light upon an unusual type of leg paralysis occasionally encountered in chicks fed semi-synthetic rations.

The external manifestations of this nutritional disease appear chiefly at the eyes, at the mouth corners and upon the feet. The edges of the eyelids become granular and contract so that vision is restricted. Later, a viscous exudate is produced which causes the eyelids to stick firmly together.

Crusty scabs appear at the corners of the mouth. These gradually enlarge and may even spread so as to involve the margins of the skin around the nostrils and underneath the lower mandible. The skin upon the bottoms of the feet and between the toes peels off. Afterwards, small cracks and fissures appear at these points. These enlarge and deepen so that chicks affected are sensitive to walking.

Feathering is retarded, and the few feathers produced are rough and staring. There is, however, no loss of down or feathers comparable to the loss of hair obtained in pellagra in rats.

Post-mortem examination of chicks that die almost invariably shows the presence of a pus-like substance in the mouth and of a grayish-white exudate in the stomach. The entire intestinal tract is almost entirely devoid of undigested food residues. The small intestines lack tonicity and appear atropic.

The liver is found frequently to vary in color from a faint yellow to a deep dirty yellow, and occasionally it may show hypertrophy. The kidneys reveal a tendency to enlargement and appear grayish-white or inflamed and hemorrhagic.

This syndrome first appeared in a group of White Leghorn chicks when about three weeks of age which were fed a normal diet except for the use of Merck's powdered egg albumin in place of the more common protein of animal origin. At six weeks of age the few chicks remaining averaged 128.4 grams in weight and the mortality was 72 per cent.

The substitution of purified casein for the egg albumin in the basal ration delayed the onset of the pellagrous-like symptoms but gave no improvement in growth. Granulation of the eyelids and encrustation of the mouth corners were less severe in this group, but most of the chicks developed feet conditions just as bad as those in the egg-albumin group. The average weight of these chicks at six weeks was 119.0 grams and the mortality was 36 per cent.

The addition of 2.5 per cent. of autoclaved yeast to the purified-casein basal diet improved growth, prevented granulation of the eyelids and encrustation of the mouth corners but did not prevent entirely the occurrence of scaly, cracked feet. Five per cent. of autoclaved yeast completely prevented all these conditions and produced still better growth. The best growth, however, was obtained by the addition of 10 per cent. of autoclaved yeast to the purified-casein basal diet. At six weeks, the average weight of the chicks in this group was 420.6 grams, a weight 33.4 per cent. greater than the normal average weight for White Leghorn chicks six weeks old used at this laboratory. No mortality was obtained in this group or any of the other groups which had received autoclaved yeast.

The data obtained in this experiment demonstrate the intense requirement of another species for the vitamin or vitamins present in autoclaved yeast, commonly called vitamin B_2, vitamin G or the P–P factor, and indicate that the chick may be a more suitable animal than the white rat for determining the quantity of this vitamin present in food-stuffs.

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