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PART I.

ORIGINAL COMMUNICATIONS.

ART. VI.—*A Note on the Action of Radium on some Organisms.* By HENRY H. DIXON, Sc.D., Assistant to the Professor of Botany, University of Dublin; and JOSEPH T. WIGHAM, M.D., Assistant to the Lecturer in Pathology, Trinity College, Dublin.

As the discovery of radium and its wonderful physical properties has lately aroused so much interest, the investigation of the action of its radiations on the growth of plants seemed likely to produce some interesting results. Accordingly, growing seeds were exposed to the action of a tube containing 5 mg. of radium bromide. Whether the seeds were exposed before or after germination, the effect produced was very small, slight but distinct reduction in the rate of growth of those within the distance of about 1 cm. being all that was observed. In one case a seed germinated immediately under the tube, and the plant grew up in contact with it. This result is of some interest in a negative way as showing the small effect produced on growing vegetable cells of the higher plants.

At the same time experiments were tried with more lowly organisms, as, for instance, with *Volvox globator*, a motile alga, very sensitive to light and air supply. Careful provision having been made to exclude as much as possible

all extraneous factors, the effect of introducing the radium tube into a test-tube containing these plants was tried. After a day's treatment no effect could be distinguished, as the organisms were distributed uniformly through the water in the test-tube, and were neither attracted to nor repelled from the radium tube.

The action, however, of the radiations on still simpler structures proved more marked, as shown by many experiments with bacteria. In these the organisms were either mixed with melted agar and poured into a dish, or else spread over the surface of agar which had been previously allowed to set. The tube containing the radium bromide was then supported over the surface of the culture and as close to it as possible, and the radiations were allowed to act for various times and under various conditions of temperature. The results were at once seen to be well marked. In many cases the organisms which were within a distance of 1 to 3 cm. failed to grow or were delayed behind the surrounding bacteria. In one of the latest of these experiments agar containing an emulsion of *Bacillus pyocyaneus* was spread in a layer in a Petri dish, exposed for three days in the cold to the radiations, and then incubated. The tube containing the radium bromide (in this case a dilute sample containing 5 mg. of the pure bromide in $\frac{1}{2}$ grm. of barium bromide) was supported over the centre of the culture and 2 to 3 mm. above it. A sterile patch, roughly $1\frac{1}{2}$ cm. in diameter, appeared after incubation immediately below the tube. It had an irregular margin, the deeper smaller colonies extending further inwards than those on the surface. This patch remained free from colonies, although incubated for several days longer.

In another experiment, a plate culture of *B. prodigiosus*, made by smearing the surface of agar spread on a flat plate, was exposed for 2 days with the radium tube (5 mg. of pure radium bromide) supported 4 mm. over the centre. The culture was then incubated at 20° C. as a suitable temperature for this bacillus, and developed in the usual way, except that in the centre, immediately under the position which had been occupied by the radium, a

sterile patch appeared about 1 cm. in diameter. The colour of the culture was the usual red, strongest round its edges and 2 or 3 mm. from the patch, and fading gradually towards the centre until the colonies ceased. This probably indicates that the colour production was injuriously affected by the radiations, even where they were too feeble to arrest the growth of the bacillus. A shadow thrown by a platinum bar 3 mm. thick, which was supported just over the surface of the plate, was sharply marked out in another case. This shadow, in which the colonies grew more vigorously than in any other position in the plate, could be traced after two days' incubation extending for a distance of 5 cm. across the plate through the apparently unaffected culture; later, however, the growth became more evenly distributed, and the shadow could be seen only where it crossed, or was in the immediate neighbourhood of, the sterile patch.

These experiments, which were successfully repeated with other organisms, such as *B. anthracis* and *typhosus*, render it most probable that it is the β radiations which produce this effect on bacteria. Of the other radiations the α rays are stopped by the glass of the tube, while the γ rays penetrate to a much greater distance than the maximum of 2 to 3 cm. which we observed, and would readily pierce through thin layers of glass and agar, which seem to completely stop those that are effective. The heat, again, given off by the radium is for these experiments quite negligible, while the light, although fairly strong from some specimens, appears to have little effect, since in one experiment a screen of very thin platinum foil had no appreciable effect in diminishing the inhibition of growth.

In our experiments three degrees of inhibition were observed in the region immediately under the tube containing the radium:—(1) In some cases in which the growth of the bacteria was rapid, having been early placed under favourable conditions, even while the radium was present its inhibitory action was not enough to hinder development, but only to slightly retard growth; (2) in others growth took place as soon as the radium was removed; and (3) in the greatest number of cases no growth occurred even after

prolonged incubation free from the action of the radiations. It became necessary, accordingly, to ascertain whether in this last series of experiments the bacteria were destroyed. With this object sub-cultures were made from the patch into broth tubes, in all but one of which the organism used grew readily, proving that in the patch there were living bacteria, which for some reason were unable to develop into colonies without being removed to a new culture medium. On the other hand, if the patch was inoculated with bacteria from outside, they failed to grow.

From this it naturally follows that some change had taken place in the medium in which the bacteria had been distributed, and it was possible that this change was directly due to the action of the radium. To find whether this was so, inoculated plates were exposed to the radiations for three days, and then inoculated by being brushed over with an emulsion of the bacteria. In every case the bacteria grew quite evenly, showing that the radium had not injuriously affected the medium. The possibility of diffusion alone being adequate to maintain sterility in such a patch may be seen from the following experiment:—A sterile patch was produced artificially by cutting out a piece of the agar from the centre of an inoculated plate, and filling up the hole with sterile agar. It was found that after two or three days' incubation bacteria would not grow on this patch.

These experiments, which were several times repeated, show fairly conclusively that the patch remains sterile because the bacteria in it, although not killed, are kept back until, by the growth of those in the rest of the culture, they are prevented from developing, either by the extraction of their food material, or by the introduction into the medium in which they are lying of toxins, or other products of metabolism. That there is very distinct diffusion could be seen by the examination of the results of experiments with *B. pyocyaneus*. This organism produces a green diffusible colour, which can be seen after two or three days' growth extending into the agar 5 mm. or more round isolated colonies, or 3 or 4 mm. inwards towards the centre of a sterile patch.