5545

Effect of Irradiation on Electrokinetic Potential, Agglutinability, Lysis and pH of Escherichia Coli Suspensions.*

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(Introduced by R. Adams Dutcher.)

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From a study of the effect of irradiation of aqueous suspensions of *Escherichia coli* with the rays from a B carbon arc, the following conclusions, which harmonize with our hypothesis concerning electrokinetic potential as a measure of activity, stimulation, injury, recovery and death[1] have been drawn:

1. Storage and exposure to atmosphere of room in which the irradiation was carried out were not the cause of the change in electrophoretic velocity noted after irradiation, nor did they change the ability to be agglutinated.

2. Insertion of Corex A glass filter lessened the action of the ultraviolet radiation considerably. This suggests that the shorter wave lengths are more bactericidal and charge-reducing.

3. It has been shown [using both Northrop-Kunitz (maximum and actual values) and Falk capillary cells] that irradiation, if of sufficient duration, produces a decrease in negative charge which accompanies death.

4. Data obtained with the Northrop-Kunitz cell (both maximum and actual velocity) indicate an initial stimulative action of the ultraviolet radiation, which makes itself felt in an increase of negative charge. This increase of charge was not often observed with the Falk capillary cell.

5. Short time irradiation, which merely stimulates or injures, permits of a return toward normal of electrokinetic velocities. Long time irradiation, which kills, produces a lasting effect.[2]

6. The time after irradiation at which comparative electrophoretic velocity readings are made must be carefully controlled if the irradiation is of brief duration.

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[1] Tittsler and Lisse, *J. Bact.*, 1928, **15**, 105.

[2] Osterhout, Injury, Recovery and Death. Lippincott, Phila., 1922.

7. Bacterial suspensions having practically the same charge can be prepared over a long period of time from different generations of the same organism.

8. Electrophoresis studies are more sensitive than the usual agglutination studies for detecting the effect of irradiation on the charge of *Esch. coli.*

9. The sequence of decreasing electrophoretic velocities is the same as that of increasing agglutinability except in the case of short (return to normal follows) and very long (lysis sets in) time irradiation.

10. The introduction of a Corex A filter practically causes this sequence of agglutinability to disappear.

11. Irradiation produced lysis which was greater the longer the irradiation.

12. Irradiation produced an increase in pH of the unrayed aqueous suspension whose pH was approximately 6.1. Since such change was also observed when the water itself was irradiated, it suggests the use of recently boiled water in future work.

13. Similar work, using 500 watt Mazda bulbs and Falk cells, showed eventual reduction of charge (which was preceded by a stimulatory increase), and evidence of lysis as indicated by clearing of the suspension. To accomplish similar effects, much longer times of irradiation were necessary than with ultraviolet rays.

14. X-rays produced no changes in electrophoretic velocities, nor did they produce bactericidal action.

Further evidence in favor of our hypothesis concerning electrokinetic potential as a measure of activity, stimulation, injury, recovery and death, is obtained from our work with the nitrogen fixing organism, *Rhizobium meliloti.* In general those cultures (history known) which were high nodule producers or high nitrogen-fixers had a higher negative potential than those of low abilities (Zucker[3]). An objection to the hypothesis is to be found in the work on heat killing of bacteria.[4]

Since this work was begun, a number of statements suggesting these findings have appeared. Norton[5] suggested that the changes that bacteria suffer when exposed to ultraviolet rays are accompanied, perhaps preceded, by changes in the electrical charges of the bacteria. Beaver and Muller[6] stated that red gold sols change to

[3] Zucker, *J. Bact.*, 1929, **17**, 18.

[4] Winslow, Falk, and Caulfield, *J. Gen. Physiol.*, 1923, **6**, 177.

[5] Norton, Newer Knowledge of Bacteriology and Immunology, Jordan and Falk. Univ. of Chicago Press, 1928, 374.

[6] Beaver and Muller, *J. Am. Chem. Soc.*, 1928, **50**, 304.

blue on exposure to ultraviolet rays, but by prolonged irradiation they are peptized to stable red sols. Falk and Reed,[7] working on the alterations in red blood cell electrophoretic potential produced by direct irradiation of blood *in vivo* reported a slight decrease of potential difference. Mayer[8] says, "So far no attention has been paid to the importance of the nature of the electrical charge on a substance that is irradiated by ultraviolet light. A study of the effect of light on body tissues from this point of view promises interesting results."

A detailed account of these findings will appear in a technical bulletin of the Pennsylvania Agricultural Experiment Station. For progress reports see [9, 10].

5546

Effect of Basic Diets on the Rate of Incisor Tooth Growth.

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In a series of studies on the effects of diet on bone healing and growth and tooth development and growth of the albino rat, it was decided to measure the rate of growth of the incisor teeth after the method of Addison and Appleton.[1] The following is a preliminary report.

The animals were males of approximately 6 months of age, and weighed between 190 and 300 grams, averaging 243 grams. All the animals on each type of study were kept under as nearly identical conditions as possible. A group of over 200 controls were fed on the standard diet of Smith and Moise.[2]

Other groups of 140 animals, were fed on a high-protein diet, on a high-fat diet, on a high-carbohydrate diet.[2] Similar groups were then given the standard diet with the salt mixture varied so as to result in a low-total salt diet in one instance, a (nearly) calcium-free

[7] Falk and Reed, *Am. J. Physiol.*, 1926, **75**, 616.

[8] Mayer, Clinical Application of Sunlight and Artificial Radiation. Williams and Wilkins, Baltimore, 1926, 355.

[9] Lisse, Bull., 1928, **230**, 6; 1929, **243**, 6; 1930, **258**, 8. *Penn. Agr. Exp. Sta. Ann. Reports.*

[10] Tittsler and Dozois, Bull., 1930, **258**, 28. *Penn. Agr. Exp. Sta. Ann. Reports.*

[1] Addison, W. H. F., and Appleton, J. L. T., Jr., *J. Morph.*, 1915, **26**, 43.

[2] Smith, Arthur H., and Moise, Theodore S., *J. Exp. Med.*, 1924, **43**, 13.