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Influence of Ultraviolet Light, Solar Irradiation and Cod-Liver Oil on Production, Fertility and Incubation of Eggs.*

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During the summers of 1926 and 1927 several sets of experiments were conducted in which eggs (from the same flock of white leghorns) were incubated under normal and under abnormal conditions. In all instances eggs were arranged in such a manner that some groups did not receive irradiation from a quartz-mercury arc whereas other groups were irradiated for 10, 15 or 30 minutes a day, respectively. In general, these experiments showed that the daily average loss of weight for each egg when normally incubated amounted to 0.35 gm. Under abnormal incubation (with excessive moisture in the incubator) the loss of weight when the eggs were not irradiated was about 0.20 gm. With normal incubation, irradiation with ultraviolet light shortened the period of incubation 24 to 48 hours in about 20% of the eggs. The percentage hatch of

* An attempt has not been made in this abstract to review the literature. Reference, however, should be made to the work of Hart, Steenbock, Lepkovsky, Kletzien, Halpin and Johnson, *J. Biol. Chem.*, 1925, lxxv, 571-595 (and appended bibliography); Hughes, Titus and Moore, *Science*, 1925, lxxii, 492-493, and Hughes, Titus and Smits, *Science*, 1927, lxxv, 264.

normally incubated irradiated and nonirradiated eggs was practically the same. With abnormal incubation, ultraviolet irradiation increased the daily loss of weight and, with 30 minutes of irradiation, normal loss of weight was produced. Chicks hatched with abnormally incubated eggs when irradiated 15 to 30 minutes a day were in general normal. Without irradiation, pendant or unabsorbed yolk sacs were much in evidence. The hatch under normal incubation without irradiation was, in one of the experiments, 75%, and with irradiation 70%, and under abnormal incubation, without irradiation, 13%, and with irradiation 30%. These experiments indicate that irradiation with quartz-mercury arcs tends to increase the rate of metabolism of the incubating eggs and that, under abnormal incubation and unphysiologic conditions, *ultraviolet irradiation is an accessory in maintaining normal metabolism*. This viewpoint is substantiated further by various other investigations we have made on the effects of radiant energy on the germination and growth of seeds and the changes in metabolic rates induced in plants by irradiation of suitable quantity and quality.

Transmission of radiant energy and gases through eggshells.—Spectrograms obtained with a wide spectroscopic slit and with exposure of a photographic plate for 2 to 5 minutes indicate that the shell and membrane transmit ultraviolet light to about 300 millimicrons whereas the membrane alone transmits to about 270 millimicrons. Proof is furnished, therefore, from the spectroscopic standpoint that radiant energy of wavelengths known to produce biologic effects can be transmitted through the combined shell and lining membrane. From the results which we have obtained regarding the influence which irradiation from a quartz-mercury arc exerts on the development of abnormally incubated eggs and so forth, we may conclude that sufficient radiant energy of a stimulating character can be transmitted to the ovum of the incubating egg to act as an accessory factor in normal development when this development is taking place under abnormal or unphysiologic conditions.

One other possible source of metabolic significance should be mentioned, namely, the presence of ozone and oxides of nitrogen. These gases are produced by quartz-mercury arcs and are, in part at least, in an ionized condition. In the exchange of gases taking place between the air and the incubating egg, it is possible that these ionized or activated gases may pass into the egg and exert an influence on the metabolic processes within the egg. Such an hypothesis is substantiated in part by the marked effects produced in the potential differences present in leaves of plants which are supplied with

gases sucked from the region of enclosed arc discharges as reported by Sheard and Johnson.

In other experiments, the shells of eggs were removed from an area of approximately 5 sq. cm., care being exercised to prevent puncture of the underlying membrane. The areas from which the shell had been removed were closed with microscopic cover slips of glass and of quartz respectively. These cover slips were attached so as to provide air-tight seals. Daily exposure of the ovum of normally incubated eggs to ultraviolet irradiation for 30 to 60 seconds through the glass cover slips did not produce changes in the development or growth of the embryos. When exactly similar experiments were carried out through quartz cover slips, various types of abnormal development were produced. These will be described in detail in the completed paper. These results show that there is sufficient transmission of ultraviolet radiation by quartz (over and above that transmitted by equal thicknesses of glass) and the membrane lining the shell to produce marked changes in embryonic development.

Effects of solar irradiation and cod-liver oil on production and fertility of eggs.—Three groups of 5 hens and cockerel (all from the same good quality stock which had been out of doors all summer) were housed in separate compartments in an experimental hen house in the autumn of 1927. All groups were fed the standard Wisconsin ration containing full quota of all food constituents and vitamins except vitamin D. Group 1 was enclosed behind a large window of quartz-containing glass (vitaglass), group 2 behind ordinary window glass and group 3 behind ordinary window glass, with 2% by weight of cod-liver oil added to the diet. A southern exposure was used and the windows were not washed or cleaned during the progress of the experiments. Starting in January, 1928, all eggs from each of these groups were gathered and incubation of the weekly product made. Curves giving the relationship between the percentage production, percentage fertility and weekly period of incubation showed that the best production and fertility of eggs were obtained with stock housed behind ordinary window glass with 2% by weight of cod-liver oil added to the standard Wisconsin ration, followed closely by the results from stock housed behind quartz-containing glass (vitaglass or helioglass). The production and fertility of eggs from hens kept behind ordinary window glass and fed the standard ration without cod-liver oil fell off gradually from January to April, finally decreasing to 40 to 50% of the values obtained with hens kept under the other 2 conditions. These ex-

periments indicate that: (1) there is evidently sufficient ultraviolet light transmitted by such quartz-containing glass as vitaglass or helioglass in the winter months in Minnesota to keep production and fertility of eggs at a high level; (2) 2% by weight of cod-liver oil is slightly superior in the results obtained as compared to the use of quartz-containing glass such as vitaglass or helioglass, and (3) ordinary window glass screens out irradiation from winter sunlight which is beneficial to the maintenance of high production and fertility of eggs.

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Potentiometric and Spectrophotometric Changes in Plants Produced by Infra-Red and Ultraviolet Irradiation.*

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Potentiometric changes.—Various types of electrodes, to be described later, were used in the work to be reported. In general, however, electrodes of thin tinfoil were used and were attached to the leaves or stems of plants by means of acid-free kaolin ground in a mortar with a little water and glycerine after the method of Sen.¹ In investigating potentiometric changes in leaves, both before and after irradiation, one electrode was fastened near the base of the leaf and the other one was placed at or near the tip of the leaf. Leads were then carried to a Leeds and Northrup potentiometer, using a high sensitivity galvanometer.

Various spectral filters, such as Corning Glass Company filters of special make (G 554 FF, G 24, G 34 R, G 584, G 586 A, G 586 AW, G 392, G 984 B, G 985 B, G 986 A) and transmitting only infra-red, red, blue and ultraviolet rays, and so forth, respectively, were employed.

* The literature bearing on electrical potentials developed in plants is not given. Reference, however, should be made to Scurti and Cortese, *Ann. Chem. Applicata*, 1927, xvii, 407-414; Taylor and Whitaker, *Protoplasma*, 1927, iii, 1-6, and Lund and Kenyon, *J. Exp. Zool.*, 1927, xlviii, 333-357. The researches of C. M. Child and W. J. V. Osterhout regarding the occurrence and nature of gradients are both numerous and valuable. An excellent résumé regarding bio-electric potentials and currents is to be found in *Protoplasma*, 1928, iii, 447.

¹ Sen, *Proc. Roy. Soc.*, 1922, xciv, 216.