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. Zoöl.*, 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 bioelectric potentials and currents is to be found in *Protoplasma*, 1928, iii, 447.

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

Infra-red (heat) energy, as such, could be removed from the sources of illumination (such as the quartz-mercury arc) by water cells of sufficient depth and possessing quartz bottoms. The visible and infra-red portions could be removed by water cells and solutions of certain substances or by special mediums transmitting selected portions of the ultraviolet light only.

The sources of energy used were infra-red lamps and arcs rich in ultraviolet irradiation. A large number of determinations on the energy received by the leaf under irradiation (from various sources and with various filters) was made as well as determinations of the relative energy of various lines of the spectrum of the quartz-mercury arc when operated at various voltages. Such measurements must be obtained if any attempt is to be made to correlate biologic reactions and reception of energy. So far as we know, this is the first attempt to correlate quantity and quality of incident energy with electrical and other changes in plants.

Sunflowers were used in general for experimental purposes during the summer; poinsettias were found satisfactory during the autumn months.

Although the experimental results have not been wholly consistent, the data obtained during the summer and autumn of 1927 and 1928 definitely show that marked changes in electromotive forces in leaves are produced by irradiation with infra-red and ultraviolet rays. The potential changes under heat rays from an infra-red burner are rapid and values as high as 0.3 volt change in potential have been obtained. The potential changes produced by irradiation with a quartz-mercury lamp have been similar to and in the same direction as those produced with infra-red irradiation. The visible portions of the spectrum of air-cooled quartz-mercury arcs operated at 90 volts did not produce changes, except small changes in the region of the short visible waves (violet end of spectrum). Irradiation with quartz-mercury arcs from which the infra-red energy had been removed by suitable water filters, hence allowing the incidence of visible and ultraviolet rays only, produced potential changes in the same direction as those produced by infra-red rays and of an order ranging from 0.005 to 0.10 volts. These data show that potentiometric changes are produced by infra-red and ultraviolet irradiation. The full significance of these results and their possible explanation (that potentiometric changes induced in the cells in the surface layer only of the leaf are being measured) will be discussed in the complete papers.

In general, the relationship between the response, R, as measured

by the change in potential difference produced by irradiation and the stimulus, *S*, of given spectral quality and quantity (that is, $S = kIt$, when *I* is the intensity of illumination and *t* the time of irradiation in minutes) is expressed by the equation $R = c \log S$. Equal quantities of energy in various portions of the spectrum as measured by radiometric methods (such as thermopiles), do not produce the same potentiometric changes in plants.

Ozone and oxides of nitrogen produced by the quartz-mercury arc or by other metallic arcs, operating at high voltages, through which air was drawn, the ionized or nascent gases then being conducted through suitable channels to the container surrounding the leaf under test, showed marked potentiometric changes and in the same direction as the changes produced by infra-red or ultraviolet irradiation. These observations lend support to the theory which we are advancing that ionization, due directly to ultraviolet light or indirectly to the ionized condition of the gas (air) which forms the medium surrounding the leaf, is responsible for the potentiometric changes observed. The rôle of loss of water under infra-red irradiation and the possible production and action of hydrogen peroxide under ultra-violet light in the presence of ionized gases will be discussed at length in the complete papers.

Spectrophotometric changes. The spectrophotometer built by Keuffel and Esser was used in the study of the color changes produced in leaves when exposed to radiation of various qualities and quantities. The type of water-cooled attachment, devised by Brunsting and Sheard, carrying the magnesium carbonate block which serves as a standard for reflection of light, was employed in this work because it enabled us to obtain spectrophotometric measurements from living leaves, intact with the plant, over as many periods and under as many conditions as desired.

After a few minutes' exposure of a given area (usually 2 by 4 cm.) on a leaf (intact plant) to infra-red irradiation it was found that considerable darkening of the exposed area occurred shortly after irradiation. The degree of this darkening increased with time until it finally reached a steady state. Repeated exposures of various leaves of different plants to irradiation with red, yellow, green and blue portions of the visible spectrum did not produce changes in spectrophotometric reflection. Ultraviolet rays, especially those below the limit of sunlight (practically speaking, 300 millimicrons), produced a definite bronze or brown-black effect in general. This was always true with the sunflower, but some exceptions, with actual apparent bleaching or equivalent loss of ordi-

nary chlorophyll, occurred under certain conditions in the leaves of poinsettias. Hence plants, as well as human beings, get a browned and darkened epidermis by exposure to ultraviolet rays. Microscopic examinations showed that these effects were accompanied with a breaking down of the outer layers of cells of the affected areas. Numerous changes in character and degree of coloration (browning or blackening) can be produced, however, by control of such factors as character of irradiation, supply of water to plant, humidity of surrounding air, presence or absence of ozone, and temperature.

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Motility of the Empty Stomach in Normal and Malnourished Asthenic Children.

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The problem is concerned with the motility of the empty stomach in normal children and in those who are of the asthenic type and in a malnourished condition, being underweight for the age and height. This preliminary report includes studies on 5 normal and 14 asthenic children. The age range was 4 to 14 years. In addition, there was one 17-year-old girl whose development and reactions were those of a child of 12 years.

The method used was that of Carlson.[1] A deflated balloon attached to one end of a rubber catheter was swallowed. The other end was attached by means of hard rubber tubing to a chloroform manometer fitted with a lever arranged to write on a moving smoked paper. The balloon was inflated at the beginning of the experiment and the pressure changes due to waves of contraction in the stomach were recorded. The experiments were run in the morning before breakfast after the child had fasted 14 to 16 hours. At least 3 experiments were performed on each child, each one lasting from 1 to 2½ hours. Those in which vomiting and gagging occurred were discarded. Care was taken to have the child in good condition, determined by a restful preceding night, and a normal temperature.

The tracings as taken included records of the respirations and

[1] Carlson, A. J., "The Control of Hunger in Health and Disease," Chicago, 1916.