also to the generalization of the equations of electrodynamics of special relativity. Since gravitation is necessarily a four-dimensional space-time problem, this chapter merely serves to break the ground, but in Chapter XIV the reader finds the full treatment of the problem. The author's determination of tensor equations (previously mentioned) plays in well with his development of the subject, which is essentially a combination of Einstein's treatments of gravitation in his 1916 paper and in "The Meaning of Relativity," although the author makes no reference to the latter. Chapter XV is given over to a study of the solar field. In deriving the Schwarzschild form it is shown that the usual assumption that the field is independent of the time is unnecessary; this is an important result.

There are no footnotes, but at the end of the book there is a bibliography arranged according to the chapters in which the special subjects are treated. The book is well printed, and the only criticism as to form which I have to make deals with the page headings. It seems useless to put the title of the book at the head of alternative pages, when, had this space been used for section headings, it would have served a good purpose. Also an indication of chapter and section on each pair of pages would have made cross-reference easy.

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SPECIAL ARTICLES

SOME EFFECTS OF INSULIN AND GLUCOKININ ON MAIZE SEEDLINGS

IN experiments with a genetic type of maize, which is chlorotic and apparently unable to use its carbohydrates properly, tests were made to determine the action of insulin and glucokinin on the seedlings while still dependent upon the endosperm for food. The plants were started in sand, and when the first leaves began to unroll the seedlings were transferred to individual test tubes containing 20 cubic centimeters of distilled water and known quantities of either insulin or glucokinin. Each plant was supported at the top of the tube by absorbent cotton, and the roots were protected from the light. All of the fluid in the tube was poured off and fresh solution added every 48 hours, without removing the plant from the tube or disturbing its root system. Neither nutrient solution nor iron were given the plants during the experiment. The insulin and glucokinin were prepared by Collip's methods[1, 2] from fresh beef pancreas and onion tops, respectively.

[1] *Trans. Royal Soc.*, Canada, XVI, 1922.

[2] *Jour. Biol. Chem.*, LVII, 65–78, 1923.

As insulin and glucokinin produced in general the same response in seedlings, although different dilutions of the two substances were required, it is possible to group the results. In solutions carrying from 1 per cent. to 0.005 per cent. of glucokinin (or corresponding dilutions of insulin) growth was retarded, more or less, in direct proportion to the amount of glucokinin or insulin present. This retardation was particularly evident in the higher concentrations, and was more striking in root growth than in top growth. In the stronger solutions of both insulin and glucokinin the formation of secondary roots was practiaelly stopped. The growth of the primary roots and of such secondary roots as had appeared was behind that of the untreated controls growing in distilled water. The delayed growth of the tops was less evident during the first few days of insulin or glucokinin treatment, but became progressively more apparent as the experiment proceeded.

Seedlings grown in solutions of less than 0.005 per cent. glucokinin (or corresponding dilutions of insulin) showed some evidence of beneficial effects, as measured by the amount and character of root growth and the amount of top growth when compared with untreated controls. The retardation of growth by strong solutions and the beneficial effects of very dilute solutions were noted both in the series of chlorotic seedlings and in series of normal green seedlings treated with insulin or glucokinin.

A third reaction, an increase in the development of the chloroplastid pigments, was found in chlorotic plants growing in insulin and glucokinin solutions. Even when grown in strong solutions which were unfavorable to root development, chlorotic plants produced enough of the green pigments to appear distinctly green when compared with the untreated controls. A pair of chlorotic plants chosen at random, the one from an untreated series and the other from a series receiving so much insulin that the root growth was reduced to about one third normal, may serve as examples of the relative amounts of chloroplastid pigments developed. The untreated plant assayed less than 1 per cent. green pigments (chlorophylls), and the plant grown in insulin 28.7 per cent. in terms of the green pigments present in an untreated green seedling. The yellow pigments (xanthophyl and carotin) in the treated chlorotic seedling assayed almost 200 per cent. as compared with the untreated chlorotic seedling. Large numbers of seedlings of the strain of chlorotic maize used in these experiments have been grown under both field and greenhouse conditions, in connection with genetic studies, but no plant was ever found which had developed an appreciable green color.

In view of the fact that insulin and glucokinin may not be absorbed readily by the roots of plants

(Dudley[3] states that only a minute amount of the active principle of insulin passes through a collodin sac), the ends of the primary roots were cut off in one series of seedlings, so that the solutions might enter the plants directly through the vascular bundles. Seedlings treated in this fashion made better growth in the stronger solutions of insulin and glucokinin than the seedlings with uncut roots. In this connection the growth of green seedlings from which the endosperm had been removed was followed. Seedlings with the endosperm removed, when grown in distilled water under the same conditions as treated plants, showed retarded growth and produced root systems strikingly similar to those of seedlings with the endosperm intact but grown in strong insulin or glucokinin solutions. These tests collectively suggest a comparison with the effects of insulin on normal and diabetic animals. Banting and collaborators[4] have shown that it is possible to lower the blood sugar in normal animals by doses of insulin to a point where the animal dies in apparently the same condition as an animal dying from hypoglycemia following the removal of the liver. The beneficial effects of small quantities of insulin given to diabetic animals have been observed by many experimenters. It seems possible, therefore, that the retarded growth of the seedlings in strong solutions of insulin or glucokinin was produced by an action of these substances which rendered the carbohydrates of the endosperm unavailable. Since plants with cut roots made better growth in strong solutions than plants with uncut roots the experiments suggest that the retardation of growth is produced by a fraction which is easily absorbed through the uninjured root cells, and that the increased growth of plants with cut roots was dependent upon the presence of a fraction not readily absorbed by uninjured roots.

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"VITAMIN A" DEFICIENCY IN POULTRY

THE occurrence of a destructive disease of poultry, resembling an infection in its manifestations, but thought and now known to be caused by incorrect feeding methods, was discussed in the report of the California Agricultural Experiment Station[1] for 1919–20. The opinion in regard to the etiology of the disease was based upon (1) negative results of bacteriological examinations and failure to transmit the disease to healthy fowls by inoculation, and (2) on success in controlling the disease in several flocks by increasing the amount of green food in the ration, decreasing the proportion of meat scrap and eliminating cocoanut meal.

The disease is characterized by (1) a discharge from the nostrils; (2) an ophthalmia producing a viscid secretion which glues the eyelids together, followed by the formation of a tightly adherent white film over the membrana nictitans and the accumulation of a mass of white caseous material in the conjunctival sacs; (3) the appearance of white pustule-like lesions one half to 2 mm in diameter on the mucosa of the mouth, pharynx and esophagus; and (4) in the later stages, weakness and emaciation. These symptoms have often caused the disease to be diagnosed as a form of avian diphtheria or roup by veterinarians and poultrymen. Besides the above lesions, the most prominent changes found on autopsy are pale, swollen kidneys marked by a network of very fine white lines which are urate-filled tubules.

The results of controlled feeding experiments conducted by the writer in 1920[2] suggested that the disease was caused by a deficiency of some vitamin in the ration and experiments just completed have shown this to be the case. In these experiments eleven pens of fifteen fowls each were fed a basal ration of mixed grains and meat scrap properly balanced for poultry but containing no yellow corn. No other food was given in pen I, the control. In pen II the basal ration was supplemented by a salts mixture consisting of calcium carbonate, calcium phosphate, sodium chloride, sodium sulphate and iron sulphate; in pen III by buttermilk; in pen IV by cod-liver oil; in pen V by dried yeast; in pen VI by orange juice; in pen VII by cod-liver oil and dried yeast; in pen VIII by cod-liver oil and orange juice; in pen IX by dried yeast and orange juice; in pen X by cod-liver oil, dried yeast and orange juice; and in pen XI by lawn clippings.

None of the fowls in the pens which have received cod-liver oil or lawn clippings have been affected, but the disease has occurred in all other pens, affecting 11 of the 15 fowls in pen II, which were fed buttermilk, and all the fowls in the other pens.

These studies throw light on the etiology of a serious poultry disease which the writer has previously designated as "a nutritional disease resembling roup." We feel that we are now justified in using the more definite designation "Vitamin A deficiency," for this disease, although the term "nutritional roup" might be more suitable for general use among poultrymen.

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[3] *Biochem. Jour.*, XVII, 376–390, 1923.

[4] *Amer. Jour. Physiol.*, LXII, 162–176, 1922.

[1] Report of the California Agricultural Experiment Station, 1919–20, p. 79.

[2] Report of the California Agricultural Experiment Station, 1920–21, p. 140.