pounds prepared, good results were obtained by coupling immune sera with diazonium salts of para-toluidin, para-anisidine, atoxyl, sulphanilic acid, anthranilic acid, naphthionic acid and amino R salt.

(2) The preparations obtained have lost their species specificity. They were not precipitated by the potent anti-horse precipitating serum. They did not cause anaphylaxis when injected intravenously into guinea-pigs highly sensitized to horse serum nor did the injection of these compounds protect the animals against subsequent death from injection of unmodified horse serum. They did not cause skin reactions in horse-asthmatics.

(3) Several of the preparations secured by the different couplings were found to be mutually heterologous—that is to say, they did not sensitize guinea-pigs to each other.

(4) Antigenic properties of these preparations were found to be in general less marked than those of native serum and thus there is a possibility that their use may not be followed by serum sickness in as large a percentage of cases as is usual with unmodified horse serum.

(5) While these serum preparations have thus completely lost their species specificity as result of coupling, they retained nevertheless to a fair degree their specific immune properties. Though in general the antibody content of these preparations was found to be lower than that of the original sera from which they were prepared, we hope that by further improvement of the chemical procedures the antibody content of the final product may be sufficiently increased to make this procedure practical.

(6) In so far as experiments on mice and guinea pigs have thus far indicated, these preparations are not toxic. Only when given intracardially in the amounts roughly approaching (weight for weight) the therapeutic doses in man have we seen any evidence of untoward symptoms. But even in the most marked cases these symptoms lasted only for a few minutes following the injection and in general suggested that they may have been caused by the rapidity of injection alone.

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A POSSIBLE RELATIONSHIP BETWEEN HEMOGLOBIN AND CHLOROPHYLL AS SHOWN BY THE USE OF LIVER EXTRACT

THAT there is a striking chemical similarity between chlorophyll, the characteristic green pigment of plants, and hemoglobin, the red-colored material of the blood of animals, has been called to the attention of biochemists since the early part of the century. Treatment of both materials with an acid and then an alkali results in the respective porphyrins—phyllo-porphyrin and hematoporphyrin—differing only slightly in the amount of oxygen contained. Furthermore from both of these substances can be obtained (Nentski and Marchlewski, 1901) the same substance, hemopyrrol.

In addition to these similarities in chemical analysis, it is not unreasonable to expect physiological resemblances. Both are pigments, and, according to Palladin, both are instrumental in the transfer of oxygen. This is the recognized function of hemoglobin, and Willstätter and others have assigned a somewhat similar function to chlorophyll in the photosynthetic process. Manoilov more recently (1922) produced evidence that the chemical tests which distinguish male from female blood are equally applicable to male and female chlorophyll in dioecious plants.

With these as precedents it was thought of possible interest to see if the same substances which influence the formation of hemoglobin in the blood would have any effect upon the formation of chlorophyll in plants. For this purpose liver extract was selected because of its interest in the study of pernicious anemia. Liver extract is a specific for pernicious anemia, but its method of action is still a disputed point. Does it check the disease by preventing the destruction of the hemoglobin, by aiding in its formation, or both? Also is the effect upon the pigment or upon the stroma of the red cells? The present tendency is to favor the idea that its effect is upon the destruction of the red cells rather than upon their formation, but no good method seems to have been devised to test the precise nature of these effects.

On the assumption that liver extract might have an analogous action on chlorophyll and that from such experiments hints might be obtained as to the action of the extract on hemoglobin, corn plants (also peas, but results were not so good) were grown in clean, moist sawdust until the roots were about 2 inches long and the first leaves were well unrolled. The plants were then carefully washed and transferred to 300 cc of Knop's nutrient solution, after which they were placed in the light for three days or until they should become accustomed to the new conditions of the nutrient solution.

To the solutions containing the test plants was then added 0.5 cc of a solution of liver extract made by dissolving a tube of Lilly's commercial extract (about 4.5 gm) in 25 cc of distilled water. The plants were then transferred to a dark room and left for from

5 to 10 days. At the end of that time it was noticed that in every case the plants containing the liver extract in solution were distinctly greener than the controls without the liver extract. Some factor in the liver extract has apparently checked the destruction of the chlorophyll; this destruction of chlorophyll goes on constantly, but in the daylight the pigment is constructed as fast as it is destroyed. Whether this is the same effect as observed in the use of liver extract in cases of hemoglobin deficiency, such preliminary experiments can not decide. Purified extract or amino acid crystals from liver extract should be used instead of the crude extract. Also it should be of interest to see if the liver extract will aid in the formation of chlorophyll in seedlings completely etiolated. Miss Mary E. Reid (unpublished experiments) found that albino seedlings when fed liver extract in a similar fashion showed a greening in excess of controls.

Since laymen still like to get evidence upon the fundamental relationship of plants and animals, such experiments might be brought forward in support of the doctrine of the common origin of plants and animals, but such was not the original purpose of these rather elementary researches. On the other hand, these experiments as here reported were simply meant to be suggestive of the aid which the study of plant physiology may be able to render to the study of animal physiology on the assumption that vegetable and animal substances of a similar chemical nature and of common origin may be supposed to have a physiology at least similar if not strictly identical.

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THE LIFE CYCLES OF TRICHOGRAMMA MINUTUM IN RELATION TO TEMPERATURE

THE egg parasite *Trichogramma minutum* is an ideal organism to use in experimental work. Practically the only limiting factor in its production is the amount of food available. Under proper conditions, however, its food can be easily provided. In the laboratory, with an abundance of food at hand, it is one of the most easily reared of any highly developed organism. It can be reared at the rate of 52 generations a year. Reared under mass production methods, the average number of progeny per female is 12 and the sex ratio is about 0.5.

The adults are sexually mature when they emerge from their host, and they mate promptly so that the sequence of generations is uninterrupted. Because of the large number used in experimental work, individual variations are easily discounted. *Trichogramma* can be reared in the eggs of the common grain moth (*Sitotroga cerealella* Olivier) for endless series of generations in tightly corked glass vials in complete darkness. The amount of food consumed by each individual is practically constant, since as a rule only one individual develops in each host egg. Host eggs can be produced in sufficient quantities so that the average size of the eggs is constant.

Temperature appears to be the predominant, if not the only, ecological factor influencing the rate of development. The frequency of life cycles, however, is also dependent on the available host material. Under field conditions the frequency of cycles would range from one week in summer to several months in winter. Differences in length of cycles and in frequency possibly would register effects not recorded by artificial methods. Rates of development of other organisms can be compared for various sets of temperature conditions directly in terms of life cycles without resorting to developmental units or the summing of temperatures, particularly since such methods have not been perfected.

To insure uniformity of data, investigators should be supplied with a race of *Trichogramma* which has the widest range in developmental temperatures, in standardized units consisting of freshly parasitized eggs in sealed glass vials under refrigeration. Each unit should contain enough individuals so that variation can be eliminated when making observations to determine the end of the life cycle.

The period of continuous development ranges from as short as 6 days to as long as 80 days. When the temperature drops below 50° F., or rises above 90° F., its development is more or less discontinuous. Each insect is so small (a half dozen can be reared in a space of 1 cu. mm) that its response to changes in temperature is immediate.

Certain races of *Trichogramma* that are indigenous to cold climates, as in northern New England, show a wide range in degree of pigmentation correlated with developmental temperatures. When the adults of one such race show dark markings on the body, they have passed through part of their life cycle at temperatures below 70° F.

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