practice and devote himself to research was no longer regarded as an eccentric. With a new generation trained in accordance with the highest ideals not only in every branch of medicine but in the collateral branches of physics, chemistry and biology, Welch could move on to wider fields. The Rockefeller Institute was founded, with Welch as the one president that its scientific board has ever had. The Carnegie Institution was created, with Welch a dominant force. Conscious of the needs of humanity cluttered in cities, he established the Johns Hopkins School of Medicine and Public Health and made it so pre-eminently the leading institution of its kind that one quarter of its students are foreigners. Himself a man of wide culture, a living piece of scientific history, he capped this by founding and heading the Institute for the History of Medicine, not as an academic ornament to a university already great, but as a practical school where trends in medical research are studied and linked with the pulsating life of the world.

For fifty years Dr. Welch has been the guiding genius of medical research and teaching in this country, the most potent influence in raising the standards of public and private practice. "In the short span of a lifetime," Dr. Simon Flexner, his pupil, has written, "he raised medicine in the United States from a beneficent art to an expanding science."—*The New York Times.*

SCIENTIFIC APPARATUS AND LABORATORY METHODS

AN IMPROVED TECHNIQUE FOR THE ARTIFICIAL FEEDING OF THE BEET LEAFHOPPER WITH NOTES ON ITS ABILITY TO SYNTHESIZE GLYCERIDES

INSECTS vary greatly in their feeding habits, as many studies have revealed. They not only represent an exceedingly large group of organisms, but their life histories are most often very complex as well. Their nutritional requirements during the larval and adult stages are often quite distinct, and comparatively few chemically controlled nutritional experiments have been carried out with them.

Loeb[1, 2] found that *Drosophila* could be raised on a sterile medium containing sugars, ammonium tartrate and inorganic salts. However, when the flies were raised from the eggs under sterile conditions they were unable to propagate in the artificial medium. This difference is attributed to the fact that the larvae use yeast as their principal food.

Abderhalden,[3] in his experiment with the feeding of the beetle, *Anthrenus museorum,* on a diet of pure silk, observed that the insect was able to build from amino acids all the substances necessary in the economy of the larva and adult.

Because of the general physiological interest which attaches to this ability of certain insects to elaborate complex nutritional substances from simple diets, the present note is published in order to call attention to the ability of a homopterous insect (*Eutettix tenellus* (Baker)) to synthesize fats from simple carbohydrates, and also to call attention to an improved technique for feeding such insects upon artificial solutions of known composition.

Relatively few controlled studies have thus far been made on the nutrition of phytophagous sucking insects because of the difficulty in securing satisfactory feeding under artificial conditions. Carter,[4, 5] in two publications, has described a method applicable to the feeding of known solutions to homopterous insects. Carter's technique is, however, unsatisfactory from the standpoint of manipulation, changing feeding solutions, sterilization and—most important of all—in securing uniform feeding on the part of all caged leafhoppers owing to the difficulty experienced by the insect in finding and maintaining a satisfactory position upon the feeding membrane. Recently, Fife[6] has described a new technique designed primarily for observing the feeding of individual insects upon small droplets of nutrient solution.

Neither the Carter nor the Fife methods were entirely satisfactory for the purpose in view. In consequence, an attempt was made to devise a method whereby reasonably large numbers of leafhoppers could be fed simultaneously upon a nutrient solution —one which would obviate the error resulting from the failure of individual insects actually to find the nutrient solution, and in which mechanical difficulties in the way of feeding, resulting from the insecure foothold provided by the animal mesentery or capping membrane, recommended by Carter, could be eliminated.

1 J. Loeb, "The Simplest Constituents Required for Growth and the Completion of the Life Cycle in an Insect (*Drosophila*)," SCIENCE, 41: 169–170, 1915.

2 J. Loeb, "The Salts Required for the Development of Insects," *Jour. Biol. Chem.,* 23: 431–434, 1915.

3 E. Abderhalden, "Beitrag zur Kenntnis der synthetischen Leistungen des tierischen Organismus," *Zeitschr. physiol. Chemie,* 142: 189–90, 1925.

4 Walter Carter, "A Technic for Use with Homopterous Vectors of Plant Disease, with Special Reference to the Sugar-beet Leafhopper, *Eutettix tenellus* (Baker)," *Jour. Agric. Res.,* 34: 449–451, illust., 1927.

5 Walter Carter, "An Improvement in the Technique for Feeding Homopterous Insects," *Phytopathology,* 18: 246–247, 1928.

6 J. M. Fife, "A Method of Artificially Feeding the Sugar-beet Leafhopper," SCIENCE, 75: 465–466, illust., 1932.

After considerable experimentation an apparatus was finally developed (Fig. 1) consisting of a shallow "saucer" to which had been sealed a vertical L tube. This vessel is capped with a mesentery membrane of the type recommended by Carter. The solution is added to the feeding apparatus until the liquid is in

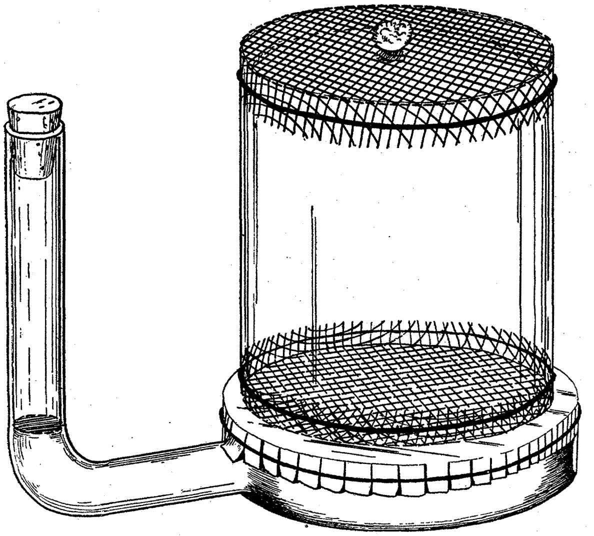

FIG. 1. Apparatus devised for simultaneously feeding large numbers of homopterous insects on a nutrient solution.

contact with the entire surface of the membrane by means of the side arm, which is corked to prevent contamination. This feeding vessel may be washed and sterilized in alcohol without removing the membrane or impairing its efficiency. For use with this feeding dish, a cage made of a 3-inch cylinder of 1⅝-inch glass tubing, capped at both ends with a fine open-mesh cloth such as Georgette or scrim, is employed. The upper end of the cloth capping has a small opening for admission of the test insects, which is at other times closed by a cotton plug. The cage containing the test insects is placed upright upon the membrane surface over the solution. With this arrangement, feeding will begin almost at once and freely continue as long as the insect lives. No evidence of unwillingness or inability of the leafhopper to locate the solution or to feed upon it was found. Furthermore, with this arrangement it was possible to transfer feeding insects from one solution to another without handling them, merely by lifting the cage from one saucer to another. From 25 to 50 test beet leafhoppers may be confined in this cage without apparent overcrowding.

In a study of the primary nutritional requirements of the beet leafhopper numerous experiments were conducted in which the insects were fed upon solutions of simple sugars. Among other things it was ascertained that certain of these sugars (monosaccharides and disaccharides) were capable of sustaining life from 200 to 300 hours at 70° to 80° F. under conditions of continuous illumination. In all cases the sugars employed were of Kahlbaum's quality.

In connection with these studies, it became of interest to ascertain whether or not the insect was able to build up or maintain fat reserves from pure sugar solutions. To test this the following experiments were conducted.

In the first experiment about 50 overwintered females of *Eutettix tenellus* were removed from hibernation cages and fed by the method just described upon a distilled water solution containing 1.5 per cent. glucose and 1.5 per cent. fructose, which was changed daily. The test was conducted at 70° to 80° F. under continuous illumination. At the intervals indicated in Fig 2, from 7 to 9 of the insects were removed and analyzed in duplicate for total fats, according to the micro method developed by Fulton.[7] Determinations in all cases checked within two to three tenths of one per cent.

It will be noted that the fat content of the leafhoppers in this test, beginning at 34.2 per cent., gradually increased, reaching a peak of 42.2 per cent. at the end of 144 hours, thereafter gradually declining to the end of the test period. In this experiment two of the test insects died from natural causes.

As a check to the foregoing, determinations of total fats were made on overwintered females fed only on distilled water. Although they had the same fat content (34.2 per cent.) at the beginning of the test as those in the foregoing experiment, at the end of 72 hours this had decreased to 12.5 per cent.

In the second experiment two sets of about 65 newly matured spring brood females were fed, as described above, upon a solution of the composition just indicated. In both this and the third experiment described later, the feeding insects were held at a constant temperature of 80° F. and 50 per cent. relative humidity. From 6 to 7 insects were removed from each series at the time intervals indicated in Fig. 2 and total fats determined, in duplicate, for each series. The results in all cases checked within two to three tenths of one per cent. As will be noted, the form of the "fat curve" corresponds very closely with that previously determined on the basis of overwintered females. It is of interest to note the extremely low (16.3 per cent.) initial fat content of newly matured females, as compared to overwintered females (34.2 per cent.). The fat content built up from this value to its maximum of 32.2 per cent. at the end of 120 hours, thereafter gradually decreasing.

[7] R. A. Fulton, "Fluctuations in Fat Content of *E. tenellus* (Baker) Relative to Hibernation and Overwintering Ability" (in press).

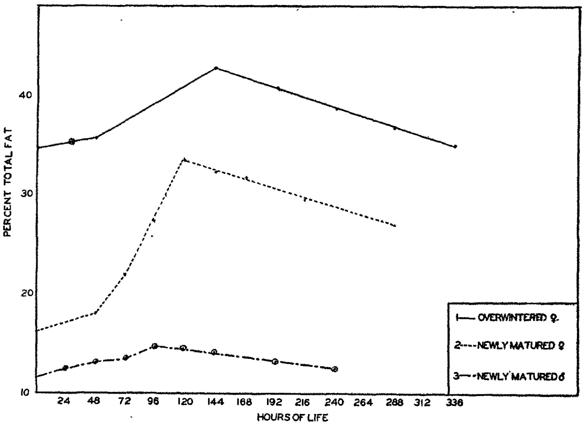

FIG. 2. Variation in fat content of overwintered *Eutettix tenellus* fed upon a mixed solution of 1.5 per cent. fructose and 1.5 per cent. glucose, showing evidence of the ability of *Eutettix tenellus* to synthesize fats from carbohydrates.

During the period of this test three to four of the caged leafhoppers in each set died from natural causes.

At the same time the foregoing test was made, a third experiment upon newly emerged males was conducted. In this experiment two sets of 75 males each were fed upon solutions of the same composition previously described. Six to seven insects were removed at the time intervals indicated in the graph (Fig. 2) and total fats determined in duplicate for each series. In this set determinations checked in all cases within four to five tenths of one per cent. Although the fat content of the males is consistently lower throughout (starting at 11.5 per cent. and attaining a maximum of only 13.2 per cent. at 96 hours) the general form of the "curve" is still clearly the same as previously determined for both overwintered and newly emerged females. In this experiment 7 to 9 males from each set died from natural causes.

It is clearly apparent from the results of the foregoing experiments that the beet leafhopper is capable of synthesizing glycerides when fed only upon glucose and fructose. This ability does not continue indefinitely, however, and its cessation is undoubtedly correlated with the general insufficiency of the pure sugar diet which reflects itself, after a more or less extended time, in those general metabolic disturbances which ultimately result in death.

R. A. FULTON
J. C. CHAMBERLIN
BUREAU OF ENTOMOLOGY
TWIN FALLS, IDAHO

SPECIAL ARTICLES

VASOMOTOR REPRESENTATION IN THE CEREBRAL CORTEX[1]

IT has long been known that vasomotor conditions of the body are regulated in part by the central nervous system, but the anatomical position of the regions involved in this control has not been sufficiently studied. In 1880, W. Hale White[2] reported changes in body temperature in human beings, and in rabbits, after lesions of the corpus striatum. Since that time, the hypothalamus has come into prominence as the area chiefly responsible for regulating body temperature. Keller[3] and Bazett[4] find that a cat maintains constant temperature when the hypothalamus is intact, but fails to do so when it is destroyed. Moreover, Cushing[5] in 1932 reported changes in body temperature following intraventricular injection of pituitrin, the accompanying hypothermia, vasodilatation and diaphoresis being attributed to the action of the drug on a possible parasympathetic center in the hypothalamic area.

The presence of unilateral vasomotor changes accompanying lesions restricted to the cerebral cortex suggests that higher centers may also be involved in the more delicate vasomotor adjustments. In 1876 Eulenberg and Landois[6] found that stimulation of the post-central region in dogs and rabbits resulted in a rise in skin temperature of the contralateral extremities, and in 1888 Gowers[7] observed that vascular changes were often present in the paralyzed limbs of patients with hemiplegia. Bechterew[8] in 1911 concluded, both from the work of other investigators and from his own experiments on dogs, that stimulation of certain cortical areas influenced heart rate and blood pressure, and in addition he cited cases of traumatic lesions of the "central gyrus" in man with

[1] From the Laboratory of Physiology, Yale University School of Medicine.

[2] W. Hale White, "The Effect upon Bodily Temperature of Lesions of the Corpus Striatum and Optic Thalamus," *Jour. Physiol.*, 2: 1, 1890.

[3] A. D. Keller, "Observations on the Localization of the Heat Regulating Mechanisms in the Upper Medulla and Pons," *Amer. Jour. Physiol.*, 93: 665, 1930.

[4] H. C. Bazett, B. J. Alpers and W. H. Erb, "Hypothalamus and Temperature Control," *Arch. Neurol. Psychiat.*, 30: 728, 1933.

[5] H. Cushing, "Papers Relating to the Pituitary Body, Hypothalamus and Parasympathetic Nervous System." Springfield, Ill., Charles C. Thomas, 1932.

[6] A. Eulenberg and L. Landois, "Über die thermischen Wirkungen experimentellen Eingriffe am Nervensystem und ihre Beziehung zu den Gefassnerven," *Virchow's Arch.*, 68: 245, 1876.

[7] W. R. Gowers, "A Manual of Diseases of the Nervous System." London, J. and A. Churchill, 1888.

[8] W. v. Bechterew, "Die Funktionen der Nervencentra." Jena, Gustav Fischer, 1911. Vol. 3.