definite, showing that some other factor determines its behavior. The salient pinhole in position *I* is, as a rule, strongly positive; the reentrant behavior in position *II* more strongly negative, but there are many exceptions.

Pinholes Nos. 1, 0, 4, 7, Fig. 3, were punctured in much thinner aluminum foil, and the favorable effect of this is at once apparent in the improved efficiency of the probes. In other respects the remarks already made apply. Nos. 4, 7 were constructed with greater skill.

These experiments at once indicate the nature of the missing factor; for heretofore the thickness of the foil has been ignored. It is clearly of greater importance than the diameter of pinhole.

Following this suggestion I next pricked pinholes in mica plate, split as thin as admissible and much below .01 mm. The results in Fig. 4 show the enormously increased efficiency obtained, ordinates being even five times as large as those in Fig. 2, referring to the original thick foil. No. 5 was only examined for diameter .02 cm. In No. 6 there is but little difference between the first two diameters. In puncturing the third, the hole was accidentally frayed to about twice the area wanted and beyond the admissible range. Hence the low efficiency.

There is, however, always difficulty in successfully enlarging the pinhole. For instance, in No. 8 the original efficiency (diam. .02) is very large, particularly in the negative. On enlarging the bore to .035 and .042 cm, its sensitivity is nearly lost. No. 9 is another peculiar case, in which the fine pinhole is negative in the salient and positive in the reentrant position, a rare inversion of the usual occurrence.

The final graph shows the corresponding behavior of an efficient glass pinhole, one of the best. The fine hole mica probe is thus of the same order of excellence.

If we take the highest of the s values corresponding to any thickness of foil ϑ, and plot s against ϑ, we get a graph of hyperbolic contour, giving a mean estimate of sensitivity based on the results obtained. The smallest manageable thickness of plate is thus essential; in other words, the pinhole should be a sharp circle and anything of the nature of a capillary tube, however short, is detrimental. The viscosity of air is here liable to ruin the experiment.

And yet the two sides of the pinhole behave quite differently to the current of air propelled through it by the alternating nodal pressure. Hence the production of vortices at the pinhole by the acoustic pressures seems alone to account for the observed results. The oscillating air columns in contact and in opposite phases at the pinhole are successively shooting vortices into each other and the pressure difference results because, owing to the structure of the pinhole in question, one of the air columns does this more efficiently than the other. As the pinhole dominates, the hydrodynamic forces in pulsating media (Bjerknes) have no relevancy.

CARL BARUS

BROWN UNIVERSITY

THE NUTRITION OF PLANARIAN WORMS

PLANARIAN worms exhibit differences in growth capacity according to their diet. They eat animal tissues with great readiness and show resulting variations in growth, depending upon the variety of tissue used and upon its condition as well. The worms thrive upon raw liver and have been kept indefinitely in our laboratory upon this as an exclusive diet. It was found,[1] however, that the power of liver to promote growth was diminished by heat and that the diminution depended upon the temperature to which the liver was subjected and upon the time of the exposure. Brain cortex is also an excellent food for the worms, and its power to promote growth is likewise diminished by heat.

In an attempt to determine whether the principle so important for the well-being of planarian worms could be separated from the intact tissue, the following procedure was employed. Liver from freshly killed guinea pigs was ground with sand and an equal weight of ether. The resulting paste was spread in a thin layer upon large glass plates and dried by an electric fan at room temperature for several hours. At the end of the drying the liver, which was in a highly friable condition, was ground to a fine powder in a mortar. It was then extracted five times with amounts of ether equivalent to the original weight of the liver, and the ether extract was evaporated with the electric fan. The product was a vaseline-like, brownish paste.

In all our experiments Planaria maculata was used. Each experimental group was kept in a finger bowl and consisted at the beginning of thirty worms. Since planarian worms multiply by fission neither average lengths nor number of worms alone could express the total growth, and it was decided to use as an index the total length of all the worms in a group. The length of the worms was estimated by placing them in a Petri dish over a piece of polar coordinated paper covered with a glass plate. As the worm glided along fully extended its anterior extremity was centered upon the center of the paper, and by following the movements of the worm with the Petri dish a really satisfactory estimate of the length of

[1] Wulzen, R., Univ. of Calif. Pub. Physiology, 1926, VII, 1.

the worm could be obtained. The worms selected for use were all seven, eight or nine mm in length and the total length of the worms in each group was found.

In order to insure a uniform diet, any food mixture given to planarian worms must be thoroughly blended. This led to the selection of brain tissue as the basic food, because its soft consistency after heating renders it capable of intimate incorporation with the liver extract. A paste was made from thin slices of the cortex of sheep's brain, the white matter being excluded as much as possible, and a portion of this was retained without further treatment to feed the control group. Then the rest was placed in a closed vial and immersed in boiling water for fifteen minutes. This was again mashed to an even consistency and a second experimental group was fed on this "heat treated" brain. A third group was fed upon "heat treated" brain which had been thoroughly blended with fresh ether extract of liver in the proportion 500 mg brain to 50 mg ether extract. In this way it was possible to compare the following foods as to their growth-promoting effects:

(a) Untreated brain cortex,
(b) "Heat treated" cortex,
(c) "Heat treated" cortex + liver extract.

The worms were kept in an incubator at 23° C. They were fed twice a week for a period of six weeks and at the end of that period were again measured. Photographs of the experiments were also taken and these make more emphatic the results revealed by the figures. A partial table of the results obtained is given here.

Food	Total length of 30 worms at beginning	Total length of 30 worms at end	Increase in total length
1. Cortex of sheep, raw......	222 mm	558 mm	336 mm
2. Cortex of sheep, heated at 100° for 15 min.	230 "	302 "	72 "
3. 0.5 gm. cortex of sheep heated at 100° for 15 min. + .05 gm. fresh ether extract of fresh guinea pig liver	226 "	502 "	276 "

The worms fed upon heated brain tissue alone grew very little in comparison with those fed upon raw brain. Moreover, the figures show that the addition of ether extract of fresh liver to the diet of heated brain restored the growth-promoting power of the heated brain tissue almost to normal. Not only were the worms fed upon heated brain tissue small but they were also quite thin and in a failing condition, while in the other groups the worms were fat and apparently prospering.

These experiments have been repeated with variations with the same general results. In one series the ability of cod liver oil to restore the damage done by heating the brain tissue was tried. Three drops of ordinary, commercial cod liver oil were added to 0.5 gm of the heated brain tissue and the mixture was fed to worms for a period of three weeks. The worms which received cod liver oil showed even less growth than those which were fed on heated brain tissue alone. All the mixtures used have been well taken by the worms. They advance to the various foods quickly, and as far as can be judged by appearances they eat as heartily of such foods as heated brain tissue mixed with cod liver oil as they do of the raw brain tissue.

I have already shown that the growth-promoting power of liver for planarian worms is diminished by the exposure of the liver to much lower temperatures than that used in the above experiments. The destructive effect of heat is manifested with the use of temperatures as low as 30°. The highly labile character of the substance involved would seem to differentiate it from the vitamins with the exception of Vitamin C, while the fact that Vitamin C is not ether soluble would again place a division line between the substance active in these experiments and the highly labile C. Moreover, the vitamin rich cod liver oil can not restore the damage done for the growth of planarian worms by the heating of brain tissue.

What the heat labile constituent of certain tissues may be which is so necessary a factor for the growth of planarian worms is a question, but our experiments tend to show that it can be extracted from the tissue by ether. Osborne and Mendel[2] have appreciated the excellent growth response following the addition to the diet of rats of small amounts of certain organized masses of cells, such as liver or yeast, and have recognized the possibility that there are within the cells certain constituents of dietary importance which are at present unappreciated.

Further details of these experiments will be published later. The value of the planarian worm as a subject for studies in nutrition has been demonstrated and this laboratory is engaged in developing various aspects of the field.

ROSALIND WULZEN

PHYSIOLOGICAL LABORATORY,
UNIVERSITY OF CALIFORNIA

[2] Osborne, T. B., and Mendel, L. B., *Journal Biol. Chem.*, 1926, LXIX, 661.