

This is a biological text intended for use by high-school students in the ninth and tenth grades. It is a carefully considered, well-organized book written by experienced teachers. The student is stimulated to think about things biological, especially those related to man, and his capacity is continually increased.

Topics are considered under twelve "units," presented as questions, in the following order: obtaining and using food, growth, reproduction, ecology, behavior, classification, economic biology, evolution and conservation.

A. S. PEARSE

DUKE UNIVERSITY

## SCIENTIFIC APPARATUS AND LABORATORY METHODS

### IMPROVED KYMOGRAPH RECORDING

SINCE the introduction of smoked, glazed paper for kymographic recording, numerous attempts have been made to obviate many of the disadvantages of this method. Of these attempts the most recent have been the successful efforts of Wichart, Thienes and Visseher,<sup>1</sup> and Patterson.<sup>2</sup> The former group of investigators employ cellophane coated with carbon sprayed from a pressure air gun, whereas Patterson delivers ink from quill pens against white, glazed paper. The former method allows for direct reproduction in the lantern by simple insertion between two glass plates but still retains the disadvantage of requiring carbonizing before and fixing after recording. Patterson's method simplifies preparation of a record which requires no shellacking but requires photographing for reproduction in the lantern.

More recently Warren<sup>3</sup> reported the use of cellophane as a transparent preparation, capable of receiving impressions from carbon paper in the typewriter or by pencil pressure. He cautions, however, against handling, which removes the carbon particles from the cellophane.

We have found cellophane an excellent recipient for India ink, which dries almost immediately and resists violent finger friction. Cellophane also takes red, blue and green ink (concentrated by evaporation to one half or one third volume), and thus allows for differential tracings to be made of any type of drawing, photograph or record.

We have further utilized the ink-taking properties of cellophane in keeping permanent records of physiological activity to be kymographically registered. Curved glass capillary tubes of very fine bore deliver ink to the cellophane, which is held in position on the kymograph drum by library paste or rubber bands. To afford less chance of breakage capillary tubes can also be bent to lead ink to the inner surface of ordinary steel writing pens, which are supported on light reed or aluminum recording levers. To render

the record easily discernible, the drum is first covered with permanent white facing—either enamel or paper.

This type of cellophane record requires no smoking nor fixing. The ink will not rub off unless it is moistened with water or alcohol, in which case the cellophane will retake ink at site of removal. Any part of the permanent record, as suggested by others,<sup>1, 3</sup> can be placed between glass plates and used directly in the projection lantern. The economy of the method, obviating smoking, shellacking and photographing parts of records, is apparent.

FREDRICK F. YONKMAN

SCHOOL OF MEDICINE

BOSTON UNIVERSITY

### AN INEXPENSIVE PYROMETER FOR TEMPERATURES UP TO 1000° C

THE use of an electrical muffle furnace in operations such as ashing of biological materials makes the control of temperatures up to 1000° C. highly desirable. Finding most manufactured pyrometers expensive we originally fashioned a simple thermocouple of chromel-alumel and calculated the temperature from e.m.f. as measured by a student potentiometer. Subsequently we used an inexpensive microvoltmeter procured through the Weston Electrical Instrument Corporation, Newark, N. J., who were kind enough to modify one of their standard instruments (Model 301) and equip it with a scale calibrated in centigrade degrees, the entire assembly making a direct reading pyrometer with a range up to 1000° C. accurate to  $\pm 10^\circ$  C. and obtainable at nominal cost.

No. 14 gauge pieces of chromel and alumel wires each about 3 ft. long were twisted together tightly for a distance of one inch. The twisted ends were protected from corrosion by means of a small silica test-tube packed with asbestos fiber. The free ends were insulated from each other by short lengths of silica tubing sufficient to bring the wires out of the back of the oven and were held in position far enough from the oven to avoid being heated by radiation. They were then connected to copper leads, which ran to the reading instrument. Changes of ambient temperature about this junction were not compensated for, and, for the accuracy desired, could be neglected. The modified microvoltmeter was made for us by the

<sup>1</sup> W. F. Wichardt, C. H. Thienes, M. B. Visseher, *SCIENCE*, 73: 99, Jan. 23, 1932.

<sup>2</sup> T. L. Patterson, *Demonstration, The Federation of Amer. Societies for Exp. Biol.* Philadelphia, April, 1932.

<sup>3</sup> K. L. Warren, *SCIENCE*, 76: 573, Dec. 16, 1932.

Weston Electrical Instrument Corporation when we had furnished them with the following information: Nature of the thermocouple, range of temperature desired and total resistance in ohms of the thermocouple and its leads. Comparison of the readings of this instrument with the calculated temperature from e.m.f. measurements from room temperature to 1000° C. agreed to within  $\pm 10^\circ$  C. As the temperature of various points within the oven may vary by as much as  $\pm 25^\circ$  C., this accuracy is quite adequate.

WILLIAM C. STADIE

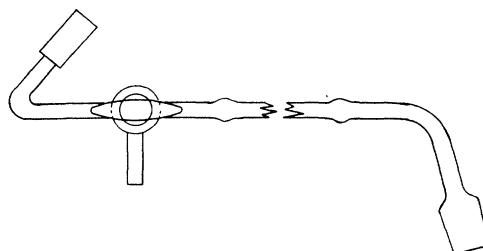
SYDNEY L. WRIGHT, JR.

THE JOHN HERR MUSSER DEPARTMENT  
OF RESEARCH MEDICINE  
UNIVERSITY OF PENNSYLVANIA

#### MODIFICATION OF THE BACKLIN-KIRK COMBUSTION CHAMBER FOR MICRO- DETERMINATION OF CARBON AND LIPOIDS

IN the manometric determination of lipoids the combustion chamber is highly evacuated at the time it is to be removed from the Van Slyke manometer. In the original Backlin chamber<sup>1</sup> a stop-cock is present at the top of the combustion chamber which may be opened at this time to relieve this pressure which

facilitates removal of the rubber connection to the manometer. At best this operation involves some risk of damaging the manometer. The chamber, as modified by Kirk,<sup>2</sup> has eliminated this stop-cock, thus necessitating removal of the rubber connection against the low internal pressure of the chamber. A simple method of reducing the hazards of such procedure is to add a three-way stop-cock (cf. diagram) in the



delivery tube of the chamber. After the upper cock of the Van Slyke absorption chamber has been closed this stop-cock may be turned to admit atmospheric pressure before detaching the delivery tube.

WM. L. DOYLE

ZOOLOGICAL LABORATORY  
THE JOHNS HOPKINS UNIVERSITY

## SPECIAL ARTICLES

### A PROOF OF THE LAW OF EFFECT

PSYCHOLOGISTS and physiologists all agree that the behavior of man and of many other animals is modifiable by the experiences of life. He learns, so that the situation, S, which at first evokes, say, responses 1, 2, 3, 4 and 5 equally often, comes to evoke one response, say 4, always or ninety-nine times out of a hundred. The connection  $S \rightarrow 4$  has become enormously strengthened relatively to  $S \rightarrow 1$  or  $S \rightarrow 2$  or  $S \rightarrow 3$  or  $S \rightarrow 5$ .

Concerning the forces producing learning there has been great disagreement. The writer (1898, 1914 and 1931) has maintained that the after-effects of a modifiable connection work back upon it, and that, in particular, a satisfying state of affairs accompanying or directly following a connection strengthens it. Troland maintained a similar doctrine.

The great majority of psychologists have maintained, on the contrary, that the strengthening of any connection is due to forces operating within the connection itself or prior to it. Repetition or frequency of occurrence, recency, intensity, finality or consummatoriness, tendency to attain equilibrium, and other features of the process have been alleged to be adequate to explain the strengthening of connections.

I have presented recently evidence from a variety

of experiments to show that a satisfying after-effect of a connection does in fact strengthen it under conditions equalized in respect of all other forces than the satisfying after-effect.<sup>1</sup> It is the purpose of this report to present an entirely independent experimental proof of the strengthening influence of a satisfying state of affairs upon the connection of which it is the after-effect and important new facts concerning the method of action of that influence.

We provide in an experiment a long series of situations to each of which several responses are possible, one of which is arbitrarily followed by a reward, any other being followed by a punishment. For example, a series of words is said by the experimenter, to each of which the subject may respond by any number from 1 to 10. If he says the number that has been chosen to be "right" he is rewarded; if he says any other, he is punished. So we have a long sequence of connections and after-effects, in the form Word 1  $\rightarrow$  number, reward or punishment, Word 2  $\rightarrow$  number, reward or punishment, Word 3  $\rightarrow$  number, reward or punishment, Word 4  $\rightarrow$  number, reward or punishment, etc.

<sup>2</sup> Peters and Van Slyke, "Quantitative Clinical Chemistry-Methods," Williams and Wilkins, 1932.

<sup>1</sup> "The Fundamentals of Learning," E. L. Thorndike, 1932.

<sup>1</sup> E. Backlin, *Biochem. Zts.*, 217: 483, 1930.