H. B. Parks, San Antonio, *secretary and treasurer.* S. W. Bilsing was continued as the representative to the American Association Council and given the authority to represent the Texas organization at the next annual meeting.

Following the business meeting, three papers were given by members who were unable to attend on the first day. The best of these was a paper by O. M. Ball, supplementing his recent publication "The Eocene Plants of Texas." This paper was illustrated by lantern slides showing newly discovered and described specimens. One of them was a beautiful leaf recently found in a quarry in East Texas and has been named Warneri after S. R. Warner, of Sam Houston State Teachers College, who collected the specimen. S. R. Warner is a member of the academy and was in the audience and heard for the first time of the importance of his discovery and the fact that the plant was named for him.

H. B. PARKS,
Secretary

THE OKLAHOMA ACADEMY OF SCIENCE

THE twenty-first annual meeting of the Oklahoma Academy of Science was held on November 25 and 26 at the University of Oklahoma, Norman. The meetings were divided into four sections and the number of papers presented in each section was as follows: Biology, 37; geology, 19; physical sciences, 22; social sciences, 29, making a total of 107.

The president's annual address was presented following the luncheon on Friday by Dr. Herbert Patterson, of the Oklahoma Agricultural and Mechanical College. The title of this address was "A Challenge to the Social Sciences." One hundred and fifty members and guests of the academy attended the annual banquet on Friday evening and Dr. Andrew Ellicott Douglass, professor of astronomy at the University of Arizona, gave an illustrated lecture entitled "Dating Prehistoric Ruins of the Southwest." Dr. W. B. Bizzell also gave a talk on "The Spirit of Adventure in Research." Dr. Douglass gave a second address at the general meeting of the academy on Saturday morning on the subject of "The Sun Spot's Cycle and the Cyclogram Method of Cycle Study."

One hundred and ninety members were registered and about 275 people attended the meetings.

The following officers were elected for 1933:

President, F. E. Knowles, Enid, Oklahoma.
Vice-president, Section A (Biology), Ralph D. Bird, University of Oklahoma, Norman, Oklahoma.
Vice-president, Section B (Geology), C. W. Tomlinson, Ardmore, Oklahoma.
Vice-president, Section C (Physical Sciences), Wm. V. N. Garretson, Stillwater, Oklahoma.
Vice-president, Section D (Social Science), O. D. Duncan, Stillwater, Oklahoma.
Assistant Secretary-Treasurer, Duane Roller, Norman, Oklahoma.

HORACE J. HARPER,
Secretary-Treasurer

STILLWATER, OKLAHOMA

SCIENTIFIC APPARATUS AND LABORATORY METHODS

AN APPARATUS FOR DETERMINING THE ABSORPTION OF CARBON DIOXIDE BY LEAVES UNDER NATURAL CONDITIONS

THE equipment described below was designed primarily for studies involving a large number of determinations of the photosynthetic activity of apple leaves under field conditions. The chief features are, first, a simple CO_2 absorption unit which can be made up of standard glassware and which is efficient, even though the air passes through the liquid at a rapid rate, and secondly, a light-weight, closely fitting leaf chamber made of cellophane, which is easily attached and held in place without cumbersome supports. The apparatus is essentially a simplification of that described by S. Kostytschew, K. Bazyrina and W. Tschesnokov,[1] and by Schandrel,[2] but involves less elaborate technique, so that a large number of determinations can be carried out at one time. An electric current is required to operate the pump.

The absorption unit is a modification of the Reiset tower used by Brown and Escombe[3] and consists of a glass tube, about 60 cm long and 3 cm in diameter, which is supported in an upright position. A glass Gooch crucible, with fused-in fritted glass disks, is attached to the lower end of the tower by means of thin-walled rubber tubing and serves to break the gas stream into minute bubbles. The size of the pores in the disks used was 100–120 microns, but finer grades of porosity down to 20–30 microns are available. The small end of the crucible is fitted with a rubber stopper, through which extends a short piece of glass tubing. A standard mercury filter with fused-in fritted glass plate may be used as a gas distributor instead of the Gooch crucible, but it is more expensive.

The upper end of the absorption tower is connected

[1] S. Kostytschew, K. Bazyrina and W. Tschesnokov, *Planta,* 5: 696–724, 1928.

[2] Hugo Schandrel, *Wiss. Archiv. für Landw. Abt. A Pflanzenbau,* 3: 529–560, 1930.

[3] H. T. Brown and F. Escombe, *Proc. Royal Soc.,* London, B 76: 29–111, 1905.

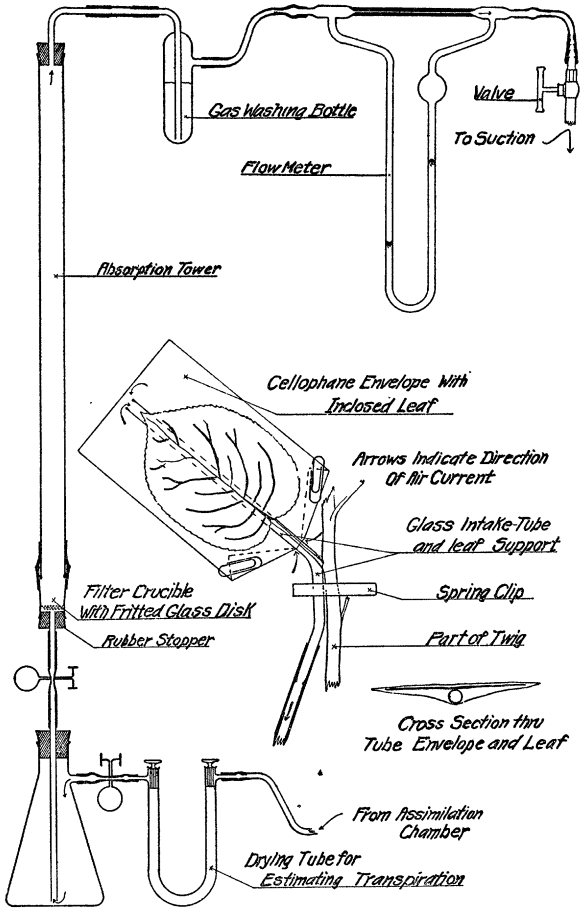

FIG. 1. Diagram of an absorption unit, and of an assimilation chamber.

by means of heavy rubber tubing to a flowmeter accurately calibrated with a Sargent wet test meter at different temperatures. The air passes through a dehydrating agent before it enters the flowmeter to avoid the accumulation of moisture in the capillary tube which has a bore of less than 1 mm and a length of 125 mm. An electric vacuum pump is used to pull the air through the system. By adjusting the sensitive gas valves, the mercury in the arms of the flowmeter can be kept at a definite level and the flow of air may thus be regulated to conform to a predetermined rate. The standard rate chosen for our preliminary tests was 100 liters per hour. The efficiency of the absorption unit is indicated by the fact that all carbon dioxide in the atmosphere is removed when passed through a column of 200 cc N/10 $Ba(OH)_2$ or KOH in a single tower at this relatively high rate, provided the solution remains sufficiently strong.

The reservoir containing the CO_2 absorbent consists of a 500 cc suction flask, fitted with a rubber stopper and a glass tube about 22 cm long. The glass tube touches the bottom of the flask, and its upper end, which extends above the stopper about 5 cm, is provided with a short piece of rubber tubing and a pinch-cock. A similar connection is found on the side arm of the suction flask.

A definite amount, usually 200 cc, of N/10 Ba $(OH)_2$ or N/10 KOH is allowed to flow from the protected stock bottle through a connected burette directly into the flask. To charge the flasks with the standard solution requires only a few minutes, after which all the pinch-cocks remain closed until the determinations begin. A large number of flasks may be filled in the laboratory to serve for many determinations in the field.

The leaf chamber, adopted as a standard after experimenting with many other types, consists of an envelope made from heavy-weight, moisture-proof cellophane. A special moisture proof paste must be used to seal the overlapping edges. The size may vary with the leaf to be studied. The envelope is slipped over a leaf which has previously been provided with a combination support and air intake. This consists of a glass tube which is bent as indicated in the diagram. It is held firmly in position against the stem by means of a spring clip so that the long arm passes on the under side of the leaf and supports it at an angle of about 30 degrees from the horizontal. A heavy-walled rubber tube attached to the glass support connects it with the side arm of the suction flask.

After the assimilation chamber is in place, the flaps on the open edge near the base of the leaf are bent back and held in place on the under side by means of paper clips. The corners of the envelope may also be folded back to reduce the size of the chamber to a minimum. The cross-section shows how the envelope fits about the leaf so as to avoid "dead air spaces" which might possibly interfere with the free supply of fresh air and carbon dioxide. The glass tube keeps the cellophane a few millimeters away from the under side of the leaf where the stomates are chiefly found on material we have used. The envelope with the enclosed leaf is easily held in place and may be adjusted to any plane, using the glass intake-support tube as an axis. It is thus possible to expose the leaf at a right angle to the sun's rays if desired. With some modification, the support and cellophane chamber can be used for two or more leaves or even for a whorl of leaves on a spur.

The supply of fresh air enters through the small opening which is left around the glass tube and the petiole. A thermometer may be inserted in this opening to record the temperature within the chamber. After passing over the leaf, the air is drawn to the absorption unit through the glass tube at the upper edge of the envelope. The single arm of the intake tube may be replaced by a Y-tube or a T-tube so that the air is withdrawn from the corners of the envelope, thus tending toward a somewhat better circulation of air over all parts of the leaf.

In spite of the rapid movement of air through the chamber (100 L. an hour), the temperature of the chamber when exposed to the direct sun will be from 6 to 10 degrees C. higher than the surrounding air. Condensation of the water vapor transpired by the enclosed leaf may occur on the relatively cool lower and shaded side of the envelope, but since little or no moisture is lost through the upper surface of the leaf, there is practically no accumulation of water on the corresponding exposure of the envelope. Excessively high and injurious temperatures, due to concentration of the heat rays in different parts of the leaf, are thus avoided. After several hours' use the cellophane becomes wavy and the moisture-proof coating may disintegrate, but this does not seem to interfere seriously with the transmission of light, nor does it have any noticeable detrimental influence on leaf activity. The wet cellophane becomes flaccid, but resumes its original stiffness when air dried.

The water transpired by the leaf in the chamber may be estimated by having the air pass through a dehydrating agent before it reaches the absorption tower. The weight of moisture adhering to the envelope must be added.

After all parts of the apparatus are in place, the stop-cocks on the suction flask are opened. The air is pulled through the system at the standard rate of 100 L. per hour, regardless of the size of the leaf. This should insure an ample supply of air containing "normal" amounts of CO_2, and it may actually provide the leaf with more CO_2 than it would have access to in relatively still air.

In our experiments, six to eight complete units, as described above, are attached to the same suction tank and are operated at one time. The air moving through each unit, of course, is governed by a flowmeter for each tower. All but two units are used to measure the carbon dioxide absorbed after the air has passed the leaf in the assimilating chamber. The remaining two units are used for control of the amount of carbon dioxide absorbed during the operations of filling the flask and titrating the solution, and also to determine the amount of carbon dioxide absorbed from an equal volume of "normal" air obtained within a few feet and at the same level as that which is passed over the enclosed leaves. The air used in these controls is made to pass through a cellophane envelope which is identical with that used on the leaves, so that the temperature of the gas entering the system is the same in all cases.

The running time has usually varied from one half to three hours, although the apparatus may be operated for longer periods by using a stronger solution for absorption. After each run, the liquid is allowed to flow back through the filter into the reservoir flask and the absorption tower is repeatedly rinsed with small amounts of distilled water until about 150 cc has been used in each case. Where the precipitate of barium carbonate is very heavy, suction may have to be applied to the flask, but this is unnecessary for periods not longer than one hour, or when potassium hydroxide is used as the absorbent. After the tower is thoroughly cleaned of adhering alkali solution, the flask is disconnected from the system and the pinchcocks are closed. Flasks contained fresh solution are put in place, after which the suction may be started for another determination.

The amount of carbon dioxide absorbed during the operating time is determined by titrating an aliquot of the solution in the flask, after adding barium chloride. The error introduced by the absorption of CO_2 during the operations of charging the flasks and titrating the unused alkali has been determined to be negligible in our experiments. The great dilution of the hydroxide solution caused by the use of liberal quantities of distilled water in rinsing minimizes the amount of carbon dioxide absorbed during titration. Where the flow is accurately regulated, the controls give identical results. The activity of the leaf with respect to the utilization or production of carbon dioxide is determined by the difference between the amounts absorbed by these control units and by the other units.

In agreement with Lundegardh, and others[4] the amount of carbon dioxide in 100 L. of "normal" air has been found by the use of the above apparatus to vary from as low as 38 mg to as high as 70 mg in a warm, unventilated greenhouse containing about 100 young vigorous apple trees growing in tubs. The former concentrations are more frequent on a clear mild day in a ventilated greenhouse during the morning hours, while the higher concentrations occurred at night. There may be appreciable variation from one hour period to the next, so that controls are essential for every determination.

The apparatus has been used to study the efficiency of apple leaves on plants grown under different conditions of nutrition. In some of our experiments, as high as 25 per cent. of the carbon dioxide contained in the "normal" atmosphere was removed by passing over a single leaf, but as a rule the amount removed was less than 10 per cent. The amount of carbon

[4] Henrik Lundegardh, ''Environment and Plant Development.'' Trans. Eric Ashby. Edward Arnold and Company, London. 1931. p. 264.

dioxide absorbed during one-hour periods per 100 sq cm of healthy leaf surface exposed to the light varied from less than 1 mg to as high as 25 mg, with 2 to 10 mg the most frequent rate during the morning hours. In a few cases during daylight hours in the forenoon, the leaves actually increased rather than reduced the carbon dioxide content of the air. The respiratory rate is determined during the day by excluding light from leaves whose photosynthetic activity was established during the preceding hour, or by making determinations during the night.

In general, our preliminary results, obtained with the apparatus described, conform with those recorded by the Russian authors previously referred to, and they indicate that wide fluctuations in the activity of a given leaf from hour to hour and from day to day are to be expected, even though the temperature and other environmental factors are the same in successive periods. Nevertheless, a relatively active leaf seems to hold its rank compared to others under many varying conditions. The apparatus described should therefore be useful for many studies involving a knowledge of the leaf efficiency as influenced by a number of conditions or treatments.

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SPECIAL ARTICLES

THE FUNCTION OF THE ADRENAL CORTICAL HORMONE AND THE CAUSE OF DEATH FROM ADRENAL INSUFFICIENCY[1]

THE functional significance of the adrenal cortex is unknown; practically all investigators of the problem agree upon this point. Various tentative hypotheses have been advanced to account for the function of these glands, but none of these hypotheses, or all of them taken together, have materially advanced the problem of cortical function.

We are of the opinion that data now in our possession, merely a brief outline of which will be presented here, explain in large measure the function of the adrenal cortex and the cause of death from adrenal insufficiency. The nature of the data is such that it is highly important to have in mind a clear picture of the type of experimental animal employed.

Bilaterally adrenalectomized dogs are used: they have well-healed wounds, are perfectly normal healthy animals at their peak weight. Any one viewing these dogs would be quite unable to distinguish them by appearance or behavior from control unoperated individuals. From the day of gland removal they are injected daily with adequate maintenance doses of the cortical hormone until ready for use. Some of the animals have been bilaterally adrenalectomized for nearly two years, others for lesser periods. In all cases, however, they were permitted to develop severe symptoms of insufficiency by withdrawal of extract, and then revived and returned to normal health by adequate injections of hormone. This is the routine procedure in the laboratory before any adrenalectomized dog is regarded as a fit subject for experimentation. Several of the older animals have passed through this routine eight to ten times. Our adrenalectomized dogs are, by all anatomical and physiological criteria employed, perfectly normal healthy animals, except that they lack adrenal glands. We reiterate and emphasize this point purposely. When an experiment starts, the cortical hormone is withheld and the animal allowed to become prostrate from insufficiency. Adequate doses of the hormone are then given and the animal returns to normal.

Study of such animals reveals some new and interesting data which, for the sake of brevity and clarity of presentation, will be given as bald statements. The more important points supporting these statements will be discussed more in detail later.

(1) The function of the adrenal cortical hormone is the regulation and maintenance of a normal circulating volume of fluid within the vascular system. In the absence of the hormone, fluid is continually lost from the circulation presumably by transudation through the capillary walls, with the result that the adrenalectomized animal is unable to maintain his normal blood volume, and eventually dies from circulatory collapse due to insufficiency of circulating fluid.

(2) Accompanying the progressive decrease in blood volume is a progressive fall of blood pressure to the death level. The decline in arterial pressure is apparently a direct result of the decreased volume of circulating fluid.

(3) The decrease in blood volume and blood pressure are not terminal phenomena, but first appear within twenty-four to seventy-two hours after discontinuing hormone injections and before active symptoms of insufficiency appear. Both volume and pressure steadily decline to the death point, which may not occur until eight to twelve days later.

[1] The expenses of this investigation, including the cost of enlarging this issue of SCIENCE to make early publication possible, have been defrayed by a grant from the Josiah Macy Foundation of New York.