

day for the presentation of papers of general interest and continued, except for the luncheon hour, till 4:30 P.M. The Botany Section met from 2:00 to 4:30 P.M. on the first day.

The annual business meeting was held at 4:30 P.M., on May 6. At this meeting, resolutions of respect were read in honor of the memories of Mrs. Edna Metz Wells and Dr. William Louis Poteat. The executive committee reported the election of sixty-six new members and the reinstatement of thirteen former members.

In the high school science essay contest, sponsored by the academy, the first prize was awarded to Larry Hardin, Boyden High School, Salisbury, N. C., for his essay entitled "Science in Aviation."

Dr. Herbert F. Prytherch of the U. S. Bureau of Fisheries, Beaufort, N. C., was awarded the medal for the most noteworthy paper on the 1938 program. The title of Dr. Prytherch's paper was "Life Cycle of a Sporozoan Parasite of Oyster." The American Association for the Advancement of Science research grant was awarded to Dr. Henry W. Jensen, of the Asheville Farm School, for his project on "continuation of a study on the evolution of the dioecious flora of the southern Appalachians with special reference to the function of the chromosomes in sex determination."

The issuing of an annual membership card to each member in good standing was authorized by the academy.

The constitution for the academy was amended in such a way as to recognize three kinds of memberships, as follows: (a) active membership; (b) active scientific organizations membership; (c) life membership.

In the evening of the first day a complimentary picnic supper was extended to the members of the academy in Pullins Park by the North Carolina State College. Dr. M. L. Braun, vice-president of the academy, presided at the evening meeting. An address of welcome was given by Colonel J. W. Harrelson, dean of the administration of State College, after which Dr. W. E. Speas, of Wake Forest College, gave his presidential address, entitled "The Father of Nuclear Physics." This was followed by an informal reception by the State College Woman's Club.

In the forenoon of the second day the academy met in the following sections: General, Botany, Zoology, Mathematics, Physics, and the North Carolina Section of the American Chemical Society.

The following officers of the academy were elected for next year:

President: John W. Lasley, Jr., University of North Carolina.

Vice-President: Donald B. Anderson, North Carolina State College of the University of North Carolina.

Secretary-Treasurer: H. L. Blomquist, Duke University.

Executive Committee: The above officers and W. L. Porter, Davidson College; R. F. Poole, North Carolina State College of the University of North Carolina; and O. C. Bradbury, Wake Forest College.

Representative to the A. A. A. S.: Bert Cunningham, Duke University.

The following officers were elected by the various sections:

CHEMISTRY SECTION

Chairman: Neville Jones, Wake Forest College.

Vice-Chairman: E. C. Markham, University of North Carolina.

Secretary-Treasurer: Ivan D. Jones, North Carolina State College of the University of North Carolina.

Councilors: R. W. Bost, University of North Carolina, and D. G. Hill, Duke University.

Members of the Executive Committee: W. C. Vosburgh, Duke University; Edward Mack Jr., University of North Carolina; and Walter Jordan, North Carolina State College of the University of North Carolina.

MATHEMATICS SECTION

Chairman: R. C. Bullock, North Carolina State College of the University of North Carolina.

Secretary: E. A. Cameron, University of North Carolina.

PHYSICS SECTION

Chairman: W. E. Speas, Wake Forest College.

Secretary: F. W. Lancaster, North Carolina State College of the University of North Carolina.

ZOOLOGY SECTION

Chairman: Bert Cunningham, Duke University.

Secretary: Z. P. Metcalf, North Carolina State College of the University of North Carolina.

The Botany Section did not elect officers but left the appointment of officers to the executive committee.

The thirty-eighth annual meeting of the North Carolina Academy of Science will be held in 1939 at Wake Forest College, Wake Forest, North Carolina.

H. L. BLOMQUIST,
Secretary

SPECIAL ARTICLES

THE CHROMOPROTEINS OF PHOTOSYNTHETIC PURPLE BACTERIA¹

It is well known that chlorophyll extracted from

¹ From the Department of Biological Chemistry, Harvard Medical School, Boston, Massachusetts, and the Cruft

leaves with organic solvents has undergone alteration through the process of extraction, because the absorption bands of such solutions are displaced about 20 mμ

Laboratory, Harvard University, Cambridge, Massachusetts.

from their position when the chlorophyll is in the cells. Herlitzka² has made water soluble extracts of chlorophyll from spinach without changing the optical properties, and Lubimenko³ has pointed out that chlorophyll occurs naturally in combination with a protein. Stoll⁴ calls this compound "chloroplastin." Wurmser, Levy and Tessier⁵ have obtained such a water solution of colored protein from ground cultures of photosynthetic purple bacteria. It is not yet possible to make a mixture of known or unknown composition which will reduce CO₂ with visible light in a manner comparable to the process in the living plant. The advances in the knowledge of cellular respiration and especially fermentation were based on the discovery of active cell-free extracts by Buchner.⁶ Photosynthesis is still in the pre-Buchner stage. The study of the photosynthetic pigments in their naturally occurring form rather than as derivatives prepared by the extraction process is the first obvious step in the search for a photochemically active extract. The present discussion deals with a better method of preparing water solutions of these pigments from bacteria, and describes the properties of such solutions and their spectral absorption curves.

High frequency vibrations have been used by a number of workers for breaking open bacteria, marine eggs and tissue cells to liberate the enclosed constituents. Through the courtesy of Professor G. W. Pierce and his collaborators in the Cruft Laboratory, I have had access to a powerful magnetostrictive vibrator and have found that sound waves of a frequency of 15,000 or 21,000 cycles per second will break open purple bacteria in a few minutes, freeing the cell sap which contains a water soluble colored protein. The white cellular debris can be centrifuged off from the deep brown or red liquid leaving a slightly opalescent solution. The solution does not have the capacity to reduce carbon dioxide as does the original suspension of bacteria.

Experiments were made with *Streptococcus varians* and *Spirillum rubrum*, both of which have been used for recent work on photosynthesis.⁷ A suspension of *Streptococcus varians* was put in the vibrator cup and samples taken at different times after the vibrator was started. The photosynthetic capacity, measured manometrically, and the amount of extracted pigment, measured spectrophotometrically, were determined for

each sample. During the treatment with sound waves, the destruction of photosynthesis runs an identical course with pigment liberation. It is likely that some of the enzymes responsible for the non-photochemical steps are spoiled by this treatment, since it is believed that the pigment is not appreciably changed by such extraction methods.

In order to study the absorption spectrum of the pigment, a photoelectric spectrophotometer was constructed.⁸ A Hilger constant deviation spectroscope with a dense flint glass prism was fitted with an exit slit, making the instrument into a monochromator. The spectroscope was intended for the visible spectrum out to 800 mμ, but since it was desired to extend the range, the prism was shifted in relation to the wavelength scale and recalibrated photographically, so that it could be used out to 1,000 mμ, which is also about the limit obtainable with the Cesium photocell. Light from a 6-volt, straight coil, street lighting lamp passed through the monochromator and, before falling on the photocell, went through an absorption vessel mounted in a sliding rack to facilitate the interchange of pigment solution and solvent. The collimator arm of the spectroscope stuck into a grounded light tight metal box containing the absorption vessel rack, photocell and one tube amplifier. The current from the amplifier was read on a galvanometer.

The width of the spectral range giving 100 mm deflection of the galvanometer was roughly 2 mμ at 700, but rose to 10 mμ at 1,000, and at 400 mμ. The precision of the deflection reading is about ± 1 per cent.

A curve has been given for the pigments in live *Spirillum rubrum* (see footnote 7) in the visible region and crude measurements were made in the infra red. With this spectrophotometer, more accurate determinations have been made on the supersonic extracts of this species. Ten liters of culture were obtained, and the bacteria centrifuged out, then broken open by supersonic vibration. This solution was used for the absorption curve shown in Fig. 1 and for most of the following work. The three infra red bands, 960, 875 and 790 mμ, the yellow one at 590 mμ and the blue one at 420 mμ, are due to bacteriochlorophyll, a substance found by Schneider,⁹ and by Fischer and collaborators¹⁰ to be similar to ordinary chlorophyll. It is a magnesium porphyrin compound, but has different side chains from chlorophyll. The bands at about 545,

² A. Herlitzka, *Biochem. Z.*, 38: 321, 1912.

³ V. N. Lubimenko, *Rev. Gen. Bot.*, 39: 547, 1927 ff.

⁴ A. Stoll, *Naturwissenschaften*, 24: 53, 1936.

⁵ R. Wurmser, R. Levy and G. Tessier. *Ann. de Physiol. et de Physico-Chimie Biologique*, 1: 298, 1925.

⁶ E. Buchner, H. Buchner and M. Hahn, "Die Zymasegärung." Munich and Berlin, 1903.

⁷ C. S. French, *Jour. Gen. Physiol.*, 20: 711; 21: 71, 1937.

⁸ It is a pleasure to thank Professors T. Lyman and O. Oldenberg and Dr. W. M. Preston for their kind assistance. I am also very grateful to Professor A. B. Hastings for many helpful suggestions throughout the work.

⁹ E. Schneider, *Z. Physiol. Chem.*, 226: 221, 1934; *Ber. d. Deutsch. bot. Ges.*, 52: 96, 1934.

¹⁰ H. Fischer, W. Lautsch and K.-H. Lin, *Annalen*, 534: 1, 1938.

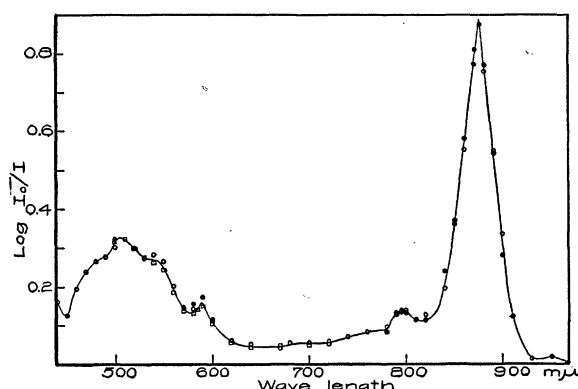


Fig. 1

510 and 480 $m\mu$ are due to Spirilloxanthin, a substance prepared in crystalline form from this species by Van Niel and Smith,¹¹ who found it to be red carotinoid with 15 double bonds. Only light absorbed by the green pigment is used for photosynthesis.

The question is now raised whether this colored extract is the same as the pigment in the intact cells. To test this, the infra red absorption curve of the intact pigment in the cells was measured by using a light scattering control of cells bleached with H_2O_2 , and compared with the curve obtained from the supersonic extract. This experiment was done with *Streptococcus varians*; it shows exact agreement in position of the infra red bands in the bacteria and in the extract, and roughly about the same height as indicated in both curves in Table 1. Considering the ap-

TABLE 1
RELATIVE ABSORPTION COEFFICIENTS FOR *in vivo* AND EXTRACTED BACTERIA PIGMENT OF *Streptococcus varians*

	795 $m\mu$	855 $m\mu$
Intact pigment	5.8	15.3
Extracted pigment	7.7	18.1

proximate nature of the scattering control, the height agreement is quite satisfactory. As far as light-absorbing capacity is concerned, the extract is closely similar to the intact pigment which is not true for extracts made with organic solvents.

The extract of *Spirillum rubrum* was diluted with buffers of various pH values and the mixtures centrifuged free of precipitate. The absorption of the solutions was then measured at 875 $m\mu$ to determine the pigment concentration. There is a region of insolubility between pH 3.0 and 4.5. The pigment is precipitated by 0.5 saturated $(NH_4)_2SO_4$.

As far as I can tell by fractional precipitation and adsorption experiments, both the green bacteriochlorophyll and the red spirilloxanthin are attached to the

¹¹ C. B. van Niel and J. H. C. Smith, *Arch. f. Mikrobiol.*, 6: 219, 1935.

same or to similar protein molecules, for it has not yet been possible to separate out fractions of different color. Since Stoll's (see footnote 4) name of "chloroplastin" can hardly be applied to pigments from organisms such as bacteria and blue green algae which do not have chloroplasts, I would suggest the term "photosynthin" as a general name for compounds of photosynthetic pigments such as bacteriochlorophyll with protein and use "chloroplastin" specifically for such compounds containing ordinary chlorophyll from higher plants and yellow green algae.

C. S. FRENCH

HARVARD MEDICAL SCHOOL

RESPIRATION OF WHEAT INFECTED WITH POWDERY MILDEW

WHEAT seedlings infected with the powdery mildew, *Erysiphe graminis tritici*, soon show visible symptoms of physiological derangement and die in three to four weeks if kept at 18–22° C. This paper reports a preliminary study of respiration in healthy and mildewed wheat.

Control and infected seedlings of Marquis wheat were grown at 20° C. in adjacent compartments of a chamber lighted from above by a 1000-watt Mazda bulb. Inoculation with mildew occurred when the first leaf was fully expanded. Oxygen consumption of healthy and inoculated primary leaves at 20.5° C. was measured by means of Warburg manometers at frequent intervals over a period of three and a half weeks.

Fig. 1 shows that after inoculation the respiration

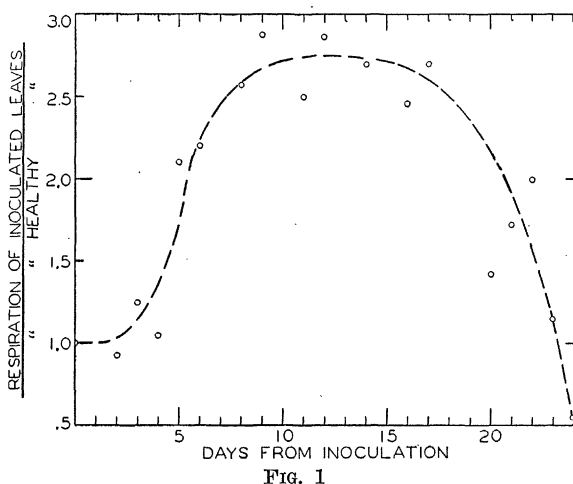


Fig. 1

rate of infected leaves rose rapidly and reached a maximum value 2.5–3.0 times that of the controls in about 9 days. The rate of respiration was maintained at a high value for about a week, and then began to decline, finally falling considerably below that of the controls. Table 1 shows that fungus respiration was