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PROCEEDINGS

of the WEST VIRGINIA ACADEMY OF SCIENCE

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Third, Fourth and Fifth Annual Sessions

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OFFICERS OF THE WEST VIRGINIA ACADEMY OF SCIENCE

OFFICERS OF THE THIRD ANNUAL MEETING

Bethany, November 26-27, 1928

President	John A. Eiesland, Morgantown
Vice-President	B. R. Weimer, Bethany
Secretary	John E. Winter, Morgantown
Treasurer	Miss L. M. Hackney, Huntington

Chairmen of Sections

Biology	A. M. Reese, Morgantown
Chemistry	A. C. Workman, Bethany
Geology and Mining	C. E. Lawall, Morgantown
Mathematics, Physics, Philosophy	C. N. Reynolds, Morgantown
Psychology, Social Science, Education	A. S. White, Huntington

OFFICERS FOR THE FOURTH ANNUAL MEETING

Morgantown, November 25-26, 1927

President	B. R. Weimer, Bethany
Vice-President	John L. Lilton, Morgantown
Secretary	A. S. White, Huntington
Treasurer	Earl R. Scheffel, Morgantown
Curator	John E. Winter, Morgantown

Chairmen of Sections

Biology	A. M. Reese, Morgantown
Chemistry	C. A. Jacobson, Morgantown
Geology and Mining	C. A. Lawall, Morgantown
Mathematics, Physics, Philosophy	C. N. Reynolds, Morgantown
Psychology, Social Science, Education	Andrew Leitch, Bethany

OFFICERS OF THE FIFTH ANNUAL MEETING

Elkins, May 18-19, 1928

President	John L. Tilton, Morgantown
Vice-President	H. F. Rogers, Fairmont
Secretary	P. D. Strausbaugh, Morgantown
Treasurer	H. T. McKinney, Bethany
Curator	John E. Winter, Morgantown

Chairmen of Sections

Biology	G. S. Dodds, Morgantown
Chemistry	Nicholas Hyma, Bnckhannon
Geology and Mining	D. B. Reger, Morgantown
Mathematics, Physics, Philosophy	C. E. Albert, Elkins
Psychology, Social Science, Education	H. T. McKinney, Bethany

Editorial Committee for Volume Two:—John L. Tilton, P. D. Strausbaugh, John E. Winter.

MEMBERS OF THE WEST VIRGINIA ACADEMY OF SCIENCE*

May 19, 1928

Albert, C. E., Dean of Davis & Elkins College, Elkins.
Ammons, Nelle P., Instructor Botany, W. V. U., Morgantown.
*Bancroft, Dr. Geo. R., Prof. Chemistry, W. V. U.
Bergy, Prof. Gordon A., Prof. Pharmacy, W. V. U.
*Bleininger, Dr. A. V., Physician, Newell.
Bloss, Dr. Jas. R., 418 Eleventh Street, Huntington.
*Bourn, W. S., Boyce Thompson Institute, Yonkers, New York.
*Brooks, Fred. E., Entomologist, French Creek.
Campbell, Carl G., Prof. Chemistry, Marshall College, Huntington.
Chase, E. F., Philippi.
*Chidester, Dr. F. E., Prof. Zoology, W. V. U., Morgantown.
*Clark, Friend E., Prof. Chemistry, W. V. U. Morgantown.
Cobb, Wm. H., Attorney, Elkins.
*Colwell, Dr. R. C., Prof. Physics, W. V. U., Morgantown.
*Colwell, Rachel H., Prof. Home Economics, W. V. U., Morgantown.
*Core, E. L., Instructor in Botany, W. V. U. Morgantown.
*Cramblet, W. H., Prof. Mathematics, Bethany College, Bethany.
*Cunningham, Dr. Holley E., Prof. Philosophy, W. V. U., Morgantown
Dadisman, Dr. A. J., Prof. Farm Economics, W. V. U., Morgantown.
*Davies, Dr. E. C. H., Prof. Chemistry, W. V. U., Morgantown.
Davis, Hannibal, Graduate Student, Cornell University, Ithaca, N. Y.
*Dodds, G. S., Prof. Histology, W. V. U., Morgantown.
*Dustman, R. B., Chemist, W. Va. Exp. Sta., Morgantown.
Farnsworth, Dana, Barracksville.
*Eiesland, Dr. John A., Prof. Mathematics, W. V. U., Morgantown.
Fenton, Dr. C. C., Prof. Pathology, W. V. U., Morgantown.
Forman, Dr. A. H., Prof. Electrical Eng., W. V. U., Morgantown.
Frame, Nat T., Agr'l Extension, Morgantown.
*Galpin, Dr. Sidney L., Prof. Geology, W. V. U., Morgantown.
*Garber, Dr. R. J., Prof. Agronomy, W. V. U., Morgantown.
Gardner, Dr. John H., Prof. Chemistry, W. V. U., Morgantown.
*Giddings, Dr. N. J., Prof. Plant Pathology, W. V. U., Morgantown.
Gwinn, C. W.
Hackney, Lillian, Prof. Mathematics, Marshall College, Huntington.
Harshbarger, Jennie, Instructor Boiligy, Fairmont High School, Fairmont.
Hammond, Elmer L., Asst. Prof. Pharmacy, W. V. U., Morgantown.
*Harris, Dr. T. L., Prof. Sociology, W. V. U., Morgantown.
*Hearne, Julius G., Wheeling.
Herndon, C. K., Chemist, Charleston.
Hicks, C. S., Fairmont.
Hill, Geo. H., Road Engineer, Charleston.
Hodge, W. W., Prof. Chemical Eng., W. V. U., Morgantown.
Holland, Claude L., 400 Locust Ave., Fairmont.

Horner, R. R., Clarksburg.
Hunter, J. Ross, Physician, 1013 Quarrier St., Charleston.
Hussell, John, 1105 Fourteenth St., Huntington.
*Jacobson, Dr. C. A., Prof. Chemistry, W. V. U., Morgantown.
Jones, Harris A., Meteorologist, Elkins.
*Jones, C. R., Dean College of Engineering, W. V. U., Morgantown.
Kaplan, Dr. D. B., Chemist, Morgantown.
Knight, Dr. H. G., Bureau of Soils and Chemistry, Washington, D. C.
Lambie, R. M., Chemist, Charleston.
Lawall, Chas. E., Prof. Mining Eng., W. V. U., Morgantown.
*Leitch, Dr. Andrew, Prof. Psychology, Bethany College, Bethany.
Lively, E. L., Prof. State Normal School, Fairmont.
Loar, R. A., Attorney, Morgantown.
Maxwell, C. W., Attorney, Elkins.
McKinney, Dr. H. T., Prof. Education, Bethany College, Bethany.
McMillan, Herbert, Prof. Chemistry, Morgantown.
Meharg, Lawrence, Wheeling.
*Molby, Dr. F. A., Prof. Physics, W. V. U., Morgantown.
Morgan, John J., Charleston.
Montgomery, J. G., 308 Seneca St., Oil City, Pa.
*Odland, Dr. T. E., Prof. Agronomy, Morgantown.
Parrack, H. O., student, W. V. U., Morgantown.
Phelps, Dr. Edward, Prof. Chemistry, Marshall College, Huntington.
Price, Andrew, Attorney, Marlinton.
Price, Paul H., State Geological Survey, Morgantown.
Purdum, R. B., Prof. Physics, Davis & Elkins College, Elkins.
*Reese, A. M., Prof. Zoology, W. V. U., Morgantown.
*Reger, David B., Asst. Geologist (State Survey) Morgantown.
*Reynolds, Dr. C. N., Assoc. Prof. Mathematics, W. V. U., Morgantown.
Rogers, H. F., Prof. Chemistry & Physics, Fairmont State Normal, Fairmont.
Rohr, H. D., Principal, Weston High School, Weston.
Rose, C. C., Attorney, Morgantown.
Saleski, R. E., Prof. German, Bethany College, Bethany.
Sargent, R. J., Marshall College, Huntington.
*Scheffel, Earl R., Morgantown.
Scott, S. A., Vice Pres. New River Coal Co., McDonald.
Shawkey, Dr. M. P., Pres. Marshall College, Huntington.
Shouse, J. B., Dean of Teachers College, Marshall College, Huntington.
Simpson, John N., Dean Medical College, W. V. U., Morgantown.
*Spangler, Dr. R. C., Prof. of Botany, W. V. U., Morgantown.
Spelman, H. J., State Road Commission, Box 426, Huntington.
Spray, Dr. Robt. S., Assoc. Prof., Bacteriology, Morgantown.
Staab, W. A., Prof. Mining Eng., W. V. U., Morgantown.
Stayman, Jos. W., Pres. Potomac State Normal, Keyser.

Stout, Wilbur, Geological Survey, Columbus, Ohio.
*Straley, H. W., III, Princeton.
*Strausbaugh, Dr. P. D., Prof. Botany, W. V. U., Morgantown.
Stubberfield, W. W., Belle Alkali Company, Belle.
Sumpstine, Wilson, Instructor Biology, Bethany College, Bethany.
Talbott, S. Benton, Prof. Biology, Davis & Elkins College, Elkins.
*Taylor, Dr. Leland H., Prof. Biology, W. V. U., Morgantown.
*Tilton, Dr. John L., Prof. Geology, W. V. U., Morgantown.
*Tucker, R. C. Engineering, Box 265, Morgantown.
*Turner, Dr. Bird M., Assoc. Mathematics, W. V. U., Morgantown.
Utterback, W. I., Prof. Zoology, Marshall College, Huntington.
Wade, Dr. S. S., Physician, Morgantown.
Wagner, John R., Glenville.
*Weaver, J. B., Clarksburg.
*Weimer, Dr. B. R., Prof. Biology, Bethany College, Bethany.
White, Arthur S., Prof. Sociology and Economics, Marshall College, Huntington.
White, Bennett S., Prof. Mechanical Design, W. V. U., Morgantown.
*Winter, Dr. John E., Prof. Psychology, W. V. U., Morgantown.
*Wolfe, H. S., Asst. Prof. Botany, W. V. U., Morgantown.
*Workman, Prof. A. C., Dean of Bethany College, Bethany.
Yeaton, Walter, Assoc. Prof. Geology, W. V. U., Morgantown.

Starred named are names of members of the American Association for the Advancement of Science.

CONSTITUTION OF THE WEST VIRGINIA ACADEMY OF SCIENCE

AS AMENDED AT THE ELKINS MEETING, MAY 18, 1928

ARTICLE I—**Name.** This organization shall be known as The West Virginia Academy of Science.

ARTICLE II.—**Membership.** Membership of this Academy shall consist of active members and corresponding members. Active members shall be residents of the State of West Virginia who are interested in scientific work. They shall be of two classes, to-wit: National members, who are members of the American Association for the Advancement of Science as well as of the West Virginia Academy of Science, and Local Members, who are members of the West Virginia Academy of Science but not of the Association.

Corresponding members shall be persons who are actively engaged in scientific work not resident in the State of West Virginia. They shall have the same privileges and duties as Active Members.

For election to any class of membership the candidate must have been nominated in writing by two members, one of whom must know the applicant personally; receive a majority of vote of the executive committee and a three-fourths vote of the members of the Academy present at any session.

ARTICLE IV.—**Fees.** Each active member shall pay in advance an annual fee of one dollar ($1.00) to the Treasurer of the Academy, due at each annual meeting; and, in addition, each new member shall pay an initiation fee of one dollar ($1.00) due at the time of his election to membership.

Corresponding members are exempt from dues.

ARTICLE V.—**Officers.** The officers of the Academy shall be a president, a vice-president, a secretary, and a treasurer. These officers shall be elected at the annual meeting from the active members in good standing on the recommendation of a nominating committee of three appointed by the President.

The Executive Committee consisting of the four above afficers and the President of the previous year shall have the authority to fix the time and place of meetings and to transact such other business as may need attention between the meetings of the Academy.

The Secretary and Treasurer only shall be eligible to re-election for consecutive terms.

ARTICLE VI.—**Standing Committees.** The standing committees shall be as follows:

A Committee on Membership appointed annually by the President, consisting of three members.

A Committee on Publications consisting of the President, Secretary, and a third member chosen annually by the Academy.

ARTICLE VII.—**Meetings.** The regular meetings of the Academy shall be held at such time and place as the Executive Committee may select. The Executive Committee may call a special session, and a special session shall be called at the written request of twenty per cent of members.

ARTICLE VIII.—**Publications.** The Academy shall publish its transactions and papers which the Committee on Publications deem suitable. All papers presented to the Academy for publication shall be of a scientific nature. All members shall receive the publications of the Academy gratis.

ARTICLE IX.—**Sections.** Members, not less than ten in number, may by special permission of the Academy unite to form a section for the investigation of any branch of science. Each section shall bear the name of the science which it represents, thus: The Section of Geology of the West Virginia Academy of Science.

Each section is empowered to perfect its own organization as limited by the Constitution and By-Laws of the Academy.

ARTICLE X.—**Amendments.** This Constitution may be amended at any regular annual meeting by a three-fourths vote of all active members present, provided a notice of said amendment has been sent to each member thirty days in advance of the meeting.

BY-LAWS

1.—The following shall be the order of business:

1. Call to order.
2. Reports of Officers.
3. Reports of Executive Committee.
4. Report of Standing Committees.
5. Election of Members.
6. Report of Special Committees.
7. Appointment of Special Committees.
8. Unfinished business.
9. New Business.
10. Election of Officers.
11. Program.
12. Adjournment.

II.—No meeting of this Academy shall be held without thirty days' notice having been given by the secretary to all members.

III.—Twelve members shall constitute a quorum of the Academy for the transaction of business. Three of the Executive Committee shall constitute a quorum of the Executive Committee.

IV.—No bill against the Academy shall be paid without an order signed by the President and Secretary.

V.—Members who shall allow their dues to be unpaid for two years, having been annually notified of their arrearage by Treasurer, shall have their names stricken from the roll.

VI.—The President shall annually appoint an auditing committee of three who shall examine and report in writing upon the account of the Treasurer.

In case a Section adjourns without electing a Chairman for the succeeding meeting, and in case the chairmanship of a Section becomes vacant between meetings through removal of the Chairman from the state or otherwise, the President of the Academy shall appoint the Chairman for the next meeting of the Section, and do so at as early a date as possible.

VII.—These by-laws may be amended or suspended by a two-thirds vote of the members present at any meeting.

ARRANGEMENT BY SECTIONS

Biology:—Botany, Zoology, Physiology, Medicine, Agriculture.

Chemistry:—Chemistry, Chemical Engineering, Pharmacy.

Geology and Mining:—Geology, Coal and Oil Engineering, Road Commission, Building Material.

Mathematics and Physics:—Mathematics, Physics, Mechanical Engineering, Electrical Engineering.

Social Sciences:—Philosophy, Psychology, Education, Economics, Sociology, History.

MINUTES OF THE WEST VIRGINIA ACADEMY OF SCIENCE

November 26 and 27, 1926

The third annual meeting of the West Virginia Academy of Science was held at Bethany College, Bethany, W. Va., November 26 and 27, 1926. Due to the small number of members present it was thought best to dispense with sectional meetings, and to have all the papers presented at general meetings.

The meeting was called to order by Dr. J. Eiesland, President of the Academy, after which the following program was carried out, with the exception that the papers did not appear in the exact order as given on the printed program.

See program attached.

At the close of the afternoon session the president appointed the following committees; which were to report at the business session the following day.

A nominating committee consisting of the following:

C. E. Lawall. A. C. Workman.
A. S. White. C. N. Reynolds.

A committee on resolutions consisting of the following:

R. C. Colwell. C. A. Jacobson.
W. I. Utterback.

At the close of the Saturday morning program the annual business meeting took place. In the absence of the treasurer, the secretary read the treasurer's report. The report showed a balance on hand of $204.75.

It was moved by Colwell and seconded by Jacobson that the report of the treasurer be accepted. Carried.

The following names were presented for membership in the Academy, and were duly elected: A. Leach, A. C. Collett, L. L. Lazelle, C. Garland, J. H. Gardner, and A. C. Workman.

It was moved by Lawall and seconded by Utterback that we establish the office of Curator, the incumbent of which will be assisted by three members of the editorial committee.

Inasmuch as this office was not included in the constitution, an amendment to the above motion was made by Weimer that this office be considered temporary pending an amendment to the constitution to include the office. Motion as amended carried.

The nominating committee presented the following report:

For President, B. R. Weimer.
Vice-President, J. L. Tilton.
Secretary, A. S. White.
Treasurer, E. R. Scheffel.
Curator, J. E. Winter.

It was moved by Colwell and seconded by Jacobson that the report of the nominating committee be accepted. Carried.

It was moved by Selvage and seconded by Colwell that nominations be closed, and that the secretary be instructed to cast a ballot for officers as reported. Carried.

Moved by Tilton and seconded by Jacobson that the outstanding bills be allowed. Carried.

The committee on resolutions made the following report:

Whereas, The West Virginia Academy of Science has just held its third annual meeting at Bethany College,

Whereas, The members of the Academy have been treated with the utmost courtesy, and consideration by the President, Members of the Faculty and the Students of Bethany College and also by the citizens of the town,

Be it therefore resolved that this Academy express its appreciation of their kindness, and extend to them the sincere thanks of this Academy of Science.

Respectfully submitted,

R. C. COLWELL
C. A. JACOBSON.
W. I. UTTERBACK.

It was moved by Tilton and seconded by Reynolds that the report of the resolutions committee be accepted. Carried.

It was moved by Tilton and seconded by Reynolds that the following resolution offered by Selvage be added to the preceding resolution. Carried.

Resolved that it is the sense of the West Virginia Academy of Science that the future of education and of various industries in the state is seriously menaced by the neglect of mathematics in our public high schools.

And be it further resolved that we put ourselves on record as recommending and desiring a definite amount of mathematics for all students who intend to enter college.

Adjournment.

J. E. WINTER,
Secretary.

PROGRAM

Third Annual Meeting of the West Virginia Academy of Science at Bethany.

Friday, 2:00 P. M.

and

Saturday, 9:00 A. M.

Address of Welcome .... President Cloyd Goodnight

Reply to Welcome .... Dr. John A. Eiesland
President of Academy

Presidential Address—Some Philosophical Aspects of the Einstein Theory .... Dr. John A. Eiesland

The Recent Controversy Over Instinct ...... Dr. J. E. Winter

The Coloring of Maps in Four Colors ...... C. W. Reynolds

Chemistry Papers

Further Development in the Chemistry of Diatomite
C. A. Jacobson

Vegetable Tannins .... C. E. Garland

Tantalide of Aluminum .... R. Wright Johnson

Methods of Synthesis of Natural Anthraquinone Derivaties .... J. H. Gardner

Some Facts Regarding the Structure of Crystals .. A. R. Collett

Solubility Relations of Isomeric Di-substituted Benzene-Derivaties .... C. L. Lazzell

Biology and Geology Papers

The Use of Nile-blue Sulphate in Determination of Method of Regeneration of Hydra Oligactis, Pallas .... B. R. Weimer

Some Reactions of Snakes .... A. M. Reese

Phylogeny and Ontogeny of Freshwater Mussels (Naiades) .... W. I. Utterback

Note on a Fossil Tooth from the Ames (upper) Limestone at Morgantown, West Virginia ... E. R. Scheffel

A Geological Trip Along the New Highway Southwest from Morgantown . . . . J. L. Tilton

Mathematics and Physics Papers

Radio Reception by Day and Night . . . .
R. C. Colwell
O. R. Ford
H. Hill

Some Current Mistakes in Lie's Line Sphere Geometry
Dr. J. A. Eiesland

Some Observations on the Rotation of the Plane of Polarization of Light Passing Through a Glass Rod Produced by Strains Due to Sound R. V. Cook

Preliminary Quantitative Experiments on Precipitation of Finely Divided Sediments Suspended in Water of Varying Purity . . E. R. Scheffel

Cubic Curves and Desmic Surfaces . . . . R. M. Matthews

Preliminary Quantitative Experiments on Phosphoresence in Flourite . . . . E. R. Scheffel

Friday, 5:30 P. M.

Dinner at Masonic Hall. Tickets, $1.00

Illustrated Lecture—"The Chemistry of Pottery,"
Dr. A. V. Bleininger,
Newell, W. Va.

Music by the Buffalo Serenaders

Friday, 9:00 P. M.

Moving Picture Show

Note: In case sectional meetings are held they will begin Friday afternoon following the general session and be continued Saturday morning.

Saturday, 11:00 A. M.

Business Session

MINUTES OF THE WEST VIRGINIA ACADEMY OF SCIENCE

November 25 and 26, 1927

The fourth annual meeting of the West Virginia Academy of Science was held at West Virginia University, November 25 and 26, 1927.

The opening session was called to order Friday morning at ten o'clock, President B. R. Weimer presiding. In the absence of President Trotter, who was to have given the address of welcome, Dean Jones of the College of Engineering welcomed the delegates, and spoke on the subject of the peculiar part the pure scientist plays in the development of the applied sciences such as engineering and agriculture. After the address by Dean Jones the minutes of the 1926 session of the Academy were read and approved.

The resolution on the study of mathematics in our high schools offered by Selvage at the Bethany meeting of the Academy was discussed. Dean Jones reported that in the College of Engineering the tests showed that while the general intelligence of students was higher than the average, the average in mathematics was lower.

It was moved and seconded that the matter of high school mathematics be referred to the committee on resolutions to be reported on at the Saturday business session.

The following committees were appointed:

Committee on nominations: Reese, Leitch, Harris.
Committee on resolutions: Hodge, Reger, McKinney, Taylor.
Committee on membership: Winter, Colwell, Strausbaugh.
Auditing committee: Jacobsen, Chidester, Rogers.

At the close of the business session the meeting adjourned until two o'clock.

SATURDAY MORNING

In the temporary absence of the President the Vice President took the chair.

It was moved and seconded that all outstanding bills be approved, and that the treasurer be ordered to pay them.

The membership committee presented the following names for membership: W. H. Cramblet, Bethany; H. T. McKinney, Bethany; J. H. Wagner, Glenville; R. B. Purdum, Elkins; C. E. Albert, Elkins; H. D. Rohr, Weston; and the following from the University; E. L. Core, R. B. Dustman, W. A. Staub, D. B. Caplan, S. B. Talbott, C. C. Rose.

It was moved and seconded that the secretary be instructed to cast a ballot for the election of the new members.

It was moved and seconded that the secretary be instructed to send a circular letter to all the scientists of the state, explaining the work of the Academy, and inviting them to membership.

The secretary was also instructed to write the presidents of the various colleges of the state asking them to provide traveling expenses for delegates to the Academy.

It was moved and seconded that the report of the resolutions committee be adopted.

RESOLVED, That in the death of Dr. I. C. White, who for thirty years was State Geologist of West Virginia, and who throughout his life embodied the best ideals of science, the West Virginia Academy of Science, the State of West Virginia and the world at large have lost a most valued personality. His illustrious achievements in the science of geology, his wholly gratuitous service to the State of West Virginia, his many philanthropic gifts of time and money to his community and state and his kindly and lovable personality have made his name immortal, and

RESOLVED, That this resolution be spread upon the minutes of this Academy and that copies be sent to his family and to the daily press of Morgantown.

Committee

W. W. HODGE, Chairman.
DAVID B. REGER.
H. T. McKINNEY.
L. H. TAYLOR.

The auditing committee reported that they had audited the accounts and found them satisfactory.

It was moved and carried that the report of the auditing committee be approved.

The nominating committee reported the following list of officers for the coming year:

For President, J. L. Tilton.
For Vice-President, H. F. Rodgers.
For Secretary, P. D. Strausbaugh.
For Treasurer, H. T. McKinney.
For Curator, J. E. Winter.

It was moved and seconded that the report of the nominating committee be accepted, and that the secretary be instructed to cast a ballot for the election of these officers.

It was moved and seconded that Dr. Giddings be our representative on the national council at the next annual meeting of the A. A. A. S. at Nashville.

It was moved and seconded that the following clause be added to section six (VI) of the By-Laws:

"In case a Section adjourns without elevating a chairman for the succeeding meeting, and in case the chairmanship of a section becomes vacant between meetings through removal of the Chairman from the state or otherwise, the President of the Academy shall appoint the chairman for the next meeting of the section, and do so at as early a date as possible."

It was moved and seconded that the Academy adopt the general scheme for distribution of Sections as follows:

Name of Section.

Biology:—Botany, Zoology, Physiology, Medicine, Agriculture.

Chemistry:—Chemistry, Chemical Engineering, Pharmacy.

Geology and Mining:—Geology, Coal, Oil, Engineering, Road Commission, Building Material.

Mathematics and Physics:—Mathematics, Physics, Mechanical Engineering, Electrical Engineering.

Social Science: — Philosophy, Psychology, Education, Economics, Sociology, History.

The question as to the time of holding the next annual meeting was discussed. The decision of the question was left to the discretion of the Executive Committee, but the consensus of opinion was that a meeting in the spring would be preferable to one immediately following Thanksgiving Day.

In this connection it was moved and seconded that, whatever the date chosen, the next meeting of the Academy would be held some time in 1928.

It was moved and seconded that the constitution be amended to make the term of the secretary three years.

The Academy received an invitation from the Elkins delegation to hold the next annual meeting at Davis and Elkins College.

Adjournment.

JOHN E. WINTER,
Acting Secretary.

PROGRAM

Fourth Annual Meeting of the West Virginia Academy of Science, at Morgantown, West Virginia, November 25-26, 1927

Executive Committee

B. R. Weimer, President . . . . Bethany
John L. Tilton, Vice-President . . . . Morgantown
A. S. White, Secretary . . . . Huntington
Earl R. Scheffel, Treasurer . . . . Morgantown
John E. Winter, Curator . . . . Morgantown

Friday, November 25, 1927

10:00 A. M. Greeting, President Frank B. Trotter, Physics Lecture Room, Martin Hall.

Business, Physics Lecture Room.

11:45 Luncheon, University Cafeteria. (Section Chairmen see to seating by groups).

Visit to Chemistry Hall, immediately following luncheon. E. C. Davis will be in charge of the party.

1:30 P. M. President's Address, B. R. Weimer, Organismic Pattern. Physics Lecture Room, Martin Hall.

Meetings by Sections (following the President's Address

Biology. A. M. Reese, Chairman, 12 Science Hall.

Chemistry. C. A. Jacobson, Chairman, Physics Lecture Room, Martin Hall.

Geology and Mining. Charles Lawall, Chairman, 201 Chemistry Hall.

Mathematics, Physics and Philosophy. C. N. Reynolds, Chairman, Physics Lecture Room, Martin Hall.

In the absence of C. N. Reynolds the Sections on Mathematics, Physics, Philosophy and Chemistry will hold a joint session in the Physics Lecture Room, with C. A. Jacobson as Chairman.

Psychology, Social Science and Education. Andrew Leitch, Chairman, 33 Library Hall.

6:00-8:00 P. M. Dinner at "The Pleasante Inne," 466 High Street. One Dollar per plate. No speeches.

8:00 P. M. Address, Dr. David White, of Washington, D. C., "The Work of the National Research Council," Physics Lecture Room, Martin Hall.

Following Dr. White's address there will be a meeting of the members of Sigma Xi in room 16, Martin Hall.

Saturday, November 26

9:00 A. M. Business, and possibly remaining Papers, Physics Lecture Room, Martin Hall.

Following the Business Meeting: Excursion to the Pressed Prism Glass Company, the Tin Mill, and the Beaumont Glass Company. W. W. Hodge will be in charge of the party.

PAPERS

Biology, 12 Science Hall

E. L. Andrews, The Relative Values of Certain Cereals in Chick Growth.

E. L. Core, Ecological Studies on Spruce Knob.

P. D. Strausbaugh, Notes on the Flora of West Virginia.

H. S. Wolfe, Hastening the Ripening of Fruits with Ethylene.

Edw. J. Van Liere, The Significance of the Pericardium in Acute Cardiac Dilatation.

Myron M. Weaver, On the Mechanism of Pancratic Secretion.

F. E. Chidester, Recent Progress in Nutritional Physiology.

A. G. Eaton, Nutrition in Experimental Anemia.

W. I. Utterbach, Studies of Endocrine Gland among Mammals.

G. S. Dodds, Recent Studies on the Origin of the Green Cells of Vertebrates.

B. R. Weimer, Reversal of Polarity in Hydra by means of KNC.

Geology and Mining, 201 Chemistry Hall

Wilbur Stout, Monongahela Formations in Eastern Ohio.

R. C. Tucker, History of Coal Production in West Virginia.

John L. Tilton, History of the Development of the Department of Geology at West Virginia University.

Mathematics, Physics, Philosophy, Physics Lecture Room, Martin Hall

R. M. Mathews, Dual Syzygetic Pencils of Cubics.

O. R. Ford, Frictional Torsion and Precession.

R. C. Colwell, Sunset Fading Curves at Morgantown.

Psychology, Social Science, Education, 33 Library Building

Andrew Leitch, The Meaning of Natural Law.

Henry T. McKinney, The Method of Science and Philosophy in the Field of Pedagogics.

John E. Winter, Some Experiments in the Detection of Deception in Testimony.

T. L. Harris, Some Observations on Rural Life in Norway.

MINUTES OF THE WEST VIRGINIA ACADEMY OF SCIENCE

May 18 and 19, 1928

The fifth annual meeting of the West Virginia Academy of Science was held at Davis and Elkins College, May 18 and 19, 1928.

At ten o'clock on Friday morning the members of the Academy met with the students and faculty of the college in the morning convocation to listen to an address of welcome delivered by the president of the college, Prof. James E. Allen. The president of the Academy, Dr. John L. Tilton, responded for the Academy, and following this Mayor George W. Wilson extended the greetings of the city.

At ten-thirty the Academy went into business session with Dr. Tilton presiding. The first item of business was the appointment of committees by the president and the following members were named:

Committee on Membership: Rogers, Strausbaugh, McKinney.
Committee on Resolutions: Reger, Rogers, Eiesland.
Committee on Nominations: Weimer, Bancroft, Hyma.
Auditing Committee: Price, Davies, Chase.

The Secretary then read a letter from the Elkins Country Club inviting the members of the Academy to make use of the golf course during the time they were the guests of the city, which invitation was properly acknowledged by the President.

The following report of the executive committee was then presented for consideration by the Academy:

REPORT OF EXECUTIVE COMMITTEE OF THE WEST VIRGINIA ACADEMY OF SCIENCE

Elkins, May 18, 1928

There are certain items that have received the attention of the Executive Committee that should be recorded:

John E. Winter is acting as the third member of the Committee on Publication. The standing Committee on Membership at the present time, whose duties end with this meeting, consists of H. F. Rogers, Chairman, P. D. Strausbaugh and H. T. McKinney. Names presented for membership have all been acted upon favorably by the Executive Committee, as may be noted in the report of the Committee on Membership soon to be presented to the Academy.

In addition to the items of business named on the second page of the printed program, copies of which were sent out in season to meet the thirty days requirement named in Article X of the Constitution, there are facts concerning publication that may not be generally understood:—According to the laws of our state it is necessary that if our Proceedings are to be published by the State, they shall be published as Bulletins of a State Institution. Through the kindness of officials in charge and their appreciation of endeavors to maintain a West Virginia Academy of Science, No. 1 of Vol. 1 of our Proceedings was published as the August, 1926, Bulletin of the State University, the statement at the top of the cover together with the one at the bottom, permitting the University to mail the Bulletin as second class matter, a provision that is highly important to us as an organization. Of papers read at Bethany and at Morgantown (the Third and Fourth Annual Meetings of the Academy), there were not enough left for publication to constitute a No. 2 of Vol. 1 of our Proceedings. It was accordingly agreed that we should hold what is now ready for publication, add to it the Proceedings of the Elkins meeting (the Fifth Annual Meeting), including the papers presented, and have all go at once to the printer to be published as the August, 1928, bulletin of the University, receiving a series number as in the case of the Proceedings already issued (No. 1 of Vol. 1). We have accordingly asked to have the August number of the University series reserved for this report, have asked for an edition of 1,000 copies, and have also asked that in addition to that number, 50 separates of each paper to give the writers of each paper. If separates beyond this number are desired the writer is to make special arrangements for them and pay for these extra copies.

Further, as the Custodian required shelf space for Bulletins and Proceedings received in exchange, and required storage space for our duplicates, we have arranged with Dr. L. D. Arnett, the University Librarian, to give such exchange reports shelf room, to mail exchange reports to members of the Academy, and to keep such record as is customary in library loans.

We respectfully ask that you approve the two items above mentioned, i. e., arrangements for publication and distribution of the Proceedings, and arrangements for care and circulation of the exchanges. Some time we may be able to secure authority for an independent publication of the Proceedings, but that time has not yet arrived.

A second item affecting next year is the following: The Executive Committee of last year at first understood arrangements were under way for a meeting at Charleston that year. As A. S. White, who had the matter in charge, left the state during the year, the meeting was held at Morgantown. Your committee has taken up the question of a Charleston meeting and received an invitation to hold in that ctiy a joint session with the Kanawha Valley Section of the American Chemical Society. L. Kermit Herndon is the Vice-President of the Section, and Chairman of a committee on cooperation for a joint meeting. Such a plan meets with hearty approval of the present Executive Committee, and we respectfully ask that the invitation be passed on to the next Executive Committee, with the approval of the Academy as a whole, and that the meeting be held sometime in May, 1929.

The Secretary of the American Association for the Advancement of Science desired that the committee to represent our Academy at the meeting of the A. A. A. S. in New York next December be appointed at once. The committee assigned this duty to the one who is now serving as President of the Academy. We respectfully ask approval of this action, and such additional action with reference to representation as you may see fit to take.

Lastly, we assume that according to custom the officers elected shall serve from the end of one annual meeting to the end of the next annual meeting, and that accordingly the duties of the officers elected last November end tomorrow (May 19, 1928).

Respectfully,

(Signed) JOHN L. TILTON
P. D. STRAUSBAUGH
H. F. ROGERS
H. T. McKINNEY,
Executive Committee.

Each item of the report was considered separately and then the Academy adopted the report as a whole and ordered it to be included in the minutes. The items were disposed of in the following manner:

1. The proposed plan of publication of the proceedings was approved.

2. The proposal for the care of exchange publications was approved.

3. The Academy voted to accept the invitation of the Kanawha Section of the American Chemical Society to hold the next regular meeting in Charleston. The executive committee was also authorized to suggest that this meeting be held not later than May 10, 1929.

4. Appointment of Dr. John L. Tilton to represent the Academy on the executive committee of the A. A. A. S. at the next regular meeting in New York was approved.

It was proposed to amend Article IV of the constitution so that it should read as follows:

"Each active member shall pay in advance an annual fee of one dollar ($1.00) to the Treasurer of the Academy, due at each annual meeting; and in addition, each new member shall pay an initiation fee of one dollar ($1.00) due at the time of his election to membership."

Corresponding members are exempt from dues.

The Academy ordered that the amendment be made.

The Academy then considered a plan for a $25 prize for high school students in West Virginia in the school year, 1928-29. The proposed plan was approved. At the request of the Academy the president appointed Eiesland, Purdum, Bancroft and Davies to devise a plan for offering a prize to advanced college students.

PLAN FOR A $25 PRIZE FOR HIGH SCHOOL STUDENTS IN WEST VIRGINIA IN THE SCHOOL YEAR, 1928-1929

The West Virginia Academy of Science at its next annual meeting* will award a prize for the best essay of 2,000-3,000 words written and submitted to the Academy on the subject: **Out of Doors Where I Live.**

The object is to encourage local scientific study.

The plan is as follows:

First. On the first of February, 1929, each principal of a high school is requested to have a local committee select the two best essays submitted by students of his school on the subject named, ranking subject matter 75 percent and expression (including spelling) 25 per cent, the principal of the high school being responsible for the bona fide character of the production. On the first of March, 1929, these two essays (preferably typewritten) are to be enclosed in separate envelopes and each with a card giving the name and address of the writer together with the name of the high school which the writer attends, but without the name of the writer or location upon the essay, and mail the same to

*This will probably be at Charleston in May, 1929, as the Executive Committee has been notified that an invitation to meet at Charleston will be presented at the Elkins meeting.

the Secretary of the Academy. The Secretary† will assign a number to each essay and its accompanying card and retain the cards.

Second. The Executive Committee of the Academy will appoint a committee of five to each of whom in turn the Secretary will submit the essays.

Each member of this committee shall rank the essays on a scale of 100, in which 75 percent shall be for the subject matter and 25 percent for expression, and return to the Secretary the essays together with a list of the essay numbers and the grade accorded, but shall make no mark upon the essays.

The prize shall go to the essay having the highest sum total in the marking, as determined by the Secretary. In case of a tie the Executive Committee of the Academy shall decide upon the winner. This should be completed during March.

Third. The prize essay shall be assigned first place on the evening program at the next annual meeting of the Academy, and be read, preferably by the writer, who shall then be awarded the prize by the President of the Academy.

Fourth. All essays submitted shall become the property of the Academy, to be published or not as the Academy may see fit, but the winning essay shall be published as a part of the Proceedings of the Academy.

At the close of these transactions the meeting adjourned until 1:30 P. M., when the meeting was called to order by Vice-President H. F. Rogers. At this time the President's address was given.

Following this the various sections convened separately and the program announced for each section was carried out.

SATURDAY MORNING

At 9 o'clock the Academy was called to order by President Tilton. The report of the treasurer was then read and approved. The chairman of the Auditing Committee reported that the records of the treasurer were found satisfactory, which report was accepted.

Mr. Rogers, chairman of the Committee on Membership

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†The Secretary of the Academy is at present Professor P. D. Strausbaugh, Morgantown, W. Va.

then presented the following list of names: William H. Cobb, Elkins; C. K. Herndon, Charleston; Jennie Harshbarger, Fairmont; C. S. Hicks, Fairmont; Dana Farnsworth, Barracksville; Andrew Price, Marlinton; Fred E. Brooks, French Creek; Nelle P. Ammons, Morgantown; Claude Maxwell, Elkins; R. M. Lambie, Charleston; Roy R. Horner, Clarksburg; J. B. Weaver, Clarksburg; J. C. Hearne, Wheeling; L. P. Hanson, Morgantown; E. F. Chase, Philippi; Wilson Sumpstine, Bethany; H. O. Parrack, Morgantown; Harris A. Jones, Elkins; and C. W. Gwinn. These persons were then elected to membership by the Academy.

Dr. Eiesland then gave the report of the committee selected to devise a plan for a prize to be offered to advanced college students: "Your committee recommends that a prize loan of one hundred dollars ($100) be offered, without interest, to the individual student of science, of senior or graduate rank, who on application to the Executive Committee, is considered by them worthy of such assistance, the loan to be returned within four years after being granted."

(Signed)

JOHN EIESLAND
R. B. PURDUM
GEO. R. BANCROFT
E. C. H. DAVIES

The Academy approved the plan for a period of one year.

May 18, 1928

Final Report of Treasurer, West Virginia Academy of Science.

Received from Mr. E. R. Scheffel, Treasurer. Balance in bank by check	$270.93
Received from Mr. E. R. Scheffel, Treasurer. Check dues 1928	5.00
	$275.93
Total deposits, due up to January 1, 1929	105.00
	$380.93

Total amount, 8 checks, including No. 7 not cashed (15)	42.60
Correct balance on hand	$338.33
Less late checks paid May 16	16.75
	$321.58

H. T. McKINNEY,
Treasurer.

Examined and approved May 18, 1928.

ANDREW PRICE,
E. C. H. DAVIES
E. F. CHASE
} Auditing Committee

The following memorial was presented for the approval of the Academy: "The attention of the scientific world is directed to the important work of David B. Reger, Geologist, a member of the West Virginia Academy of Science, who has discovered the fossil trees of the Devonion Period in the Elkins region, and who has included the vast Cheat River field in the coal measures of the state. We consider that he has added to the sum of human knowledge in a signal way, and has enhanced the wealth and importance of West Virginia."

Signed ANDREW PRICE and JOHN L. TILTON.

This memorial was approved by the Academy.

The following special resolution was presented for the approval of the Academy: "Whereas, There is being manifested throughout the nation an increasing interest in our fauna and flora; and, Whereas, An intensive effort is being made to develop a more active interest in the natural history of our state; therefore, be it

Resolved, That the West Virginia Academy of Science earnestly recommend that immediate steps be taken to extend the Geological Survey to include such general biological studies and reports as had long been contemplated by the late Dr. I. C. White."

Signed

P. D. STRAUSBAUGH
B. R. WEIMER
A. M. REESE

The Academy adopted this resolution and ordered it to be made a part of the records.

The secretary then read the report of Dr. L. M. Peairs, the representative of the Academy on the Executive Committee of the A. A. A. S. at its last meeting in Nashville.

REPORT OF THE MEETING OF REPRESENTATIVES OF VARIOUS STATE ACADEMIES OF SCIENCE AT NASHVILLE, TENNESSEE, DECEMBER 26, 1927.

The representative from West Virginia was unable to attend this meeting in person but the following report of the meeting was secured from Professor W. C. O'Kane, the New Hampshire representative.

The meeting was attended by the Executive Committee of the American Association for the Advancement of Science and the time was practically all taken up with the discussion of the question of affiliation of the State Academies of Science with the American Association. No final decision in the matter was reached but it was referred to a committee of the American Association to be considered and definite plan presented at the meeting next year. The Executive Committee of the American Association is to arrange for meeting of the State Associations in connection with the annual meetings of the American Association in New York in 1928.

At the conclusion of the session a dinner provided by the American Association for the representatives of the State Academies was enjoyed by all.

Signed L. M. PEAIRS.

The report was accepted.

The reports of the chairmen of the different sections were received. Chairmen elected for the coming year were as follows: Biology, S. Benton Talbott; Chemistry, Carl G. Campbell; Social Sciences, John E. Winter; Geology and Mining, Charles E. Lawall; Mathematics, Physics and Philosophy elected no chairman, but chose to have their chairman appointed by the President in accordance with the provisions of Section VI of the by-laws.

David B. Reger, chairman of the Committee on Resolutions then offered the following resolutions:

"Resolved, That the thanks of the Academy be expressed to President and Mrs. Allen, and the Faculty of Davis and Elkins College for their hospitality shown in their entertainment of the fifth session of our organization.

Resolved, That we also thank the Elkins Country Club for its kind offer of the use of its golf course, the Rotary for transportation, and the city of Elkins for the welcome expressed through the Mayor, Mr. George W. Wilson."

Signed DAVID B. REGER,
H. F. ROGERS,
JOHN A. EIESLAND

Dr. B. R. Weimer, chairman of the Committee on Nominations, then moved that, inasmuch as the present officers of the Academy had served for only six months, they be continued in office for the ensuing year. This motion was seconded and was carried by the unanimous vote of the Academy.

A rising vote of thanks was accorded Dean Charles E. Albert, who had charge of all local arrangements, and whose efficient service contributed so much to the success of the meeting.

Following the announcement of final arrangements for the field trip which was made immediately after the close of this session, and which represented a new and generally approved feature in the program of the Academy, the meeting was adjourned.

P. D. STRAUSBAUGH,
Secretary.

PROGRAM

Fifth Annual Meeting of the West Virginia Academy of Science at Elkins, West Virginia, May 18, 19, 1928

Friday, May 18, 1928

Auditorium—Science Hall

10:00 A. M. Meeting of the Executive Committee, Room 106, Liberal Arts Hall.

10:30 A. M. Greeting, President James E. Allen.

Business.

Report of proceedings at Nashville with reference to State Academies of Science, L. M. Peairs.

Appointment of committees.

Consideration of proposed amendment to Article IV of the Constitution.

Change the present Article IV to read as follows:

Article IV. Each active member shall pay in advance an annual fee of one dollar ($1.00) to the Treasurer of the Academy, due at each annual meeting; and, in addition, each new member shall pay an initiation fee of one dollar ($1.00) due at the time of his election to membership.

Corresponding members are exempt from dues.

Consideration of plan for prize essays.

Payment of dues (in advance).

12:00 Luncheon, Tygart Hotel Dining Room, 50 cents. (Section Chairmen see to seating by groups).

12:30 P. M. Visit to the various laboratories and lecture rooms, under the guidance of Mr. Benton Talbott.

1:30 P. M. President's Address:
Scenic Geology in West Virginia, (illustrated by lantern slides). John L. Tilton, Chemistry Lecture Room.

2:15 P. M. Meetings by Sections.

6:00 P. M. Dinner at Tygart Hotel Dining Room. 75 cents. No speeches.

8:00 P. M. Address by Benjamin L. Miller, Professor of Geology at Lehigh University.

South America and its Mineral Resources (illustrated).

PAPERS

Meetings by Sections

2:15 P. M., Friday, May 18

Biology, G. S. Dodds, Chairman, Room 103, Liberal Arts Hall.

A. J. Dadisman; Factors Influencing the Yield of Apples. 25 minutes.

T. E. Odland: The Inheritance of Panicle Type in a Certain Oat Cross. 15 minutes.

R. J. Garber and M. M. Hoover: The Effect of Smut on Yield in Maize. 20 minutes.

L. M. Peairs: Present Status with reference to the European Cornborer. 15 minutes.

W. S. Bourn: Notes on the Flora and Fauna of Great Marsh and Adjacent Waters. (Lantern slides). 30 minutes.

Fred E. Brooks: Some Ground-dwelling Wasps of West Virginia. 20 minutes.

Earl L. Core: Plant Ecology of a Type Area in Northern West Virginia. 10 minutes.

Chemistry, Nicholas Hyma, Chairman, Chemistry Lecture Room.

Earl C. H. Davies: Rhythmic Bands by Evaporation. (Lantern slides). 20 minutes.

C. A. Jacobson and H. A. Pray: Fluosilicates of Organic Bases. 15 minutes.

Friend E. Clark: Opportunities for Chemistry in the State of West Virginia. 20 minutes.

H. F. Rogers: Greater Flexibility in Laboratory Courses. 10 minutes.

George R. Bancroft: The Preparation and Hydrolysis of Esters derived from Chlor-substituted Propyl Alcohols. 20 minutes.

Geology and Mining, D. B. Reger, Chairman, Room 107, Liberal Arts Hall.

D. B. Reger: Informal announcement of state geological reports that are available.

John L. Tilton: Two Illustrations of Wind Action in West Virginia. 5 minutes.

C. E. Lawall: Some Important Uses of Coal. 15 minutes.

W. A. Staab: Observations on Mine Timbering in the Scott's Run District.

Benjamin L. Miller: Origin and Utilization of Limestone. 15 minutes.

Paul H. Price: Pocahontas County "Marble" Deposits. 15 minutes.

D. B. Reger: Cheat Mountain Coal Field of Randolph County. 15 minutes.

Mathematics, Physics, Philosophy, C. E. Albert, Chairman, Room 106, Liberal Arts Hall.

H. E. Cunningham: Reactions Against Materialism. 20 minutes.

J. A. Eiesland: On the Singularities of the Flat Sphere Transformations. 20 minutes.

R. C. Colwell: On Oscillations of a Spinning Gyroscopic Top. (Demonstration)

Social Sciences, H. T. McKinney, Chairman, Room 102, Liberal Arts Hall.

T. L. Harris: A Sociological Study of Values of 4-H Club Work in Rural West Virginia. 20 minutes.

H. T. McKinney: Progressive Research, a Means of Improving College Teaching.

John E. Winter: The Spiritual Value of Scientific Method. 10 minutes.

Reinhold E. Saleski: The Social Value of Foreign Language Study. 15 minutes.

Saturday, May 19, 1928

Auditorium, Science Hall

9:00 A. M. Business, and possibly remaining papers.

10:00 A. M. Joint excursion to beds of fossil trees.

On stopping, local geologic relations will be explained by D. B. Reger, Acting State Geologist, the discoverer of the beds.

Following this the local floral relations will be described by P. D. Strausbaugh. The party will then devote half an hour to observation individually or by groups.

Note: Those who reach Elkins by train instead of by auto will be able to form groups to secure autos locally for this field trip. It is hoped all will plan to see what is possible of the wonderful local conditions.

1:00 P. M. Luncheon at Tygart Hotel Dining Room.

ECOLOGICAL STUDIES ON SPRUCE MOUNTAIN

By EARL L. CORE

(Department of Botany, West Virginia University)

This paper deals mainly with the flora clothing the slopes of Spruce Mountain in West Virginia and especially with that of the cold barren knobs on the summit. It is also concerned with the successions whereby burned-over areas in the vicinity of Spruce Knob are being re-occupied by vegetation. It should be added that although Spruce Knob is the highest elevation in West Virginia it is typical of dozens of other situations in the Middle Appalachian region which approach it in altitude.

Spruce Mountain attains an altitude of 4860 feet, the highest-lying land in the State of West Virginia. It is located in the western part of Pendleton County, about 16 miles from Franklin, the county seat. Circleville, a small town at the foot of the mountain, and the usual headquarters for tourists, has an altitude of 2054 feet above sea level.

Beginning at the plateau on Hunting Ground Mountain, Spruce Mountain extends in a northeast direction about 12 miles, the crest varying from one-fourth of a mile to nearly a mile in width. The sky-line runs almost unbroken at a rather even altitude with but few high knobs breaking the uniformity. More than five miles of the crest lies above 4500 feet, and most of that distance is over 4700 feet. The southern end rises gradually to the highest point, Spruce Knob. Spruce Knob itself is not really a knob but a long ridge not greatly elevated above the general level of the summit. On the east the mountain rises abruptly from the North Fork River bottoms. To the west, however, the slope is much more gentle, down to Seneca Creek beyond which rise the spurs of the Alleghenies.

With the passing of the ancient forests that once clothed the mountain-side, the larger wild animals of the region are fast becoming extinct. Wolves, once common, have not been seen since 1896. Wildcats are extremely rare, if not actually extinct. Black bears occasionally wander onto Spruce from the neighboring Allegheny ranges and seem to be increasing in numbers. Deer are rarely seen.

Temperature records made at Franklin by the United States Weather Bureau indicate the mean annual temperature of the river bottoms to be about 50° Fahrenheit. A resident of Circleville estimates that snow lies on Spruce Knob at least twice as many days during the year as at Circleville. During the year of the author's investigations, snow fell throughout the month of May and as early as October 20 drifts five to ten feet deep were encountered on the ridges.

In the rich river valleys, the plants are characteristic of the Carolinian zone, including hardwoods such as maples, oaks, hickories, and their shrubby and herbaceous associates. The cold summits, however, support only plants that can endure a northern climate, such as spruce and birch, representative of the Boreal Zone. The transition from the hard-wood forests at the foot of the mountain to the northern evergreen forests on the ridge is marked and very striking.

The flood plain along the North Fork River is composed of very rich soil, admirably adapted to cultivation. In consequence, primitive conditions no longer obtain anywhere. However, running back on the steep slopes of the Fore Knobs and into the deep ravines that dissect the mountain-side, are many acres of hardwood forests in which beech and maple trees are dominant. Halfway up the mountain side there is considerable terrace created by the erosion of a limestone bed lying between two more resistant sandstone layers. Much of the land is cleared and occupied by farms. The altitude is about 3000 to 3500 feet, the width approximately half a mile. The crops here are similar to those of the river bottoms, except that the season is shorter, the ripening period later, and the danger from an early frost consequently greater. The earlier varieties of corn usually mature but are sometimes caught by frost. The most profitable crops are oats and potatoes. On the upper side of the bench the transition is rather abrupt to the overlying formation which has a rich soil, too steep for cultivation but portions of which are cleared for grazing. From this point to the top of the mountain the change is gradual from the beech-maple through the oak-hickory and finally, near the summit into the spruce-birch typical of the Canadian forest.

According to the accounts of old residents the top was formerly densely clothed with an excellent stand of spruce and birch, the spruce mostly predominating. As time went by, first one plot, then another was destroyed through the early settlers' careless use of fire. Thousands of acres are said to have been purposely burned in order to secure the resulting bramble thickets for deer pasture. Other acres were destroyed at various times until at present a very small portion of the crest of the mountain is covered with virgin timber and what remains is now being rapidly removed by a lumbering concern which recently completed a railway to the mountain top.

The denuded areas are being reoccupied by vegetation in various ways. The blackened stumps and logs seem to be just hidden by an exceedingly dense mat of a fern, **Dicksonia punctilobula.** This lasts many years and may be gradually replaced by various species of **Rubus** and by a heath formation consisting typically of **Menziesia pilosa, Vaccinium erythrocarpon, Diervilla Lonicera,** species of **Ribes** and other associated forms. Where sheltered, it seems that the heath is gradually succeeded by Crataegus and then, apparently, by spruce. In unprotected areas, however, the heath lasts almost indefinitely because of the tremendous force of the winds, which are inimical to the growth of tall trees. Many acres of the crest are covered with a monotonous expanse of heath meadow, which gives way where trampled or otherwise disturbed, e. g., in trails, to **Danthonia spicata.**

Many acres on the mountain top are being reforested naturally with solid stands of spruce. One area about a mile north of the Knob, on lower lying, more sheltered land, is estimated by the ranger to contain over a thousand acres of young spruce. It seems reasonable to believe that were natural conditions to obtain for several decades, much of the ridge would be reoccupied by spruce. The higher and more exposed knobs, however, would likely require a much longer time, on account of the extreme violence of the winds.

It can hardly be doubted that rigor of the climate excludes from the summits many species, especially those of a more succulent, ruderal nature. In a meadow land on the ridge, tilled by the forest ranger, many species common to the river bottoms occur, but with several striking exceptions. For instance, the author, in several days rambling during 1926 and 1927, has never seen pokeweed (**Phytolacca decandra**), milkweek, (**Asclepias syriaca**) ragweed (**Ambrosia artemisiifolia**) or Bouncing Bet (**Saponaria officinalis**) all extremely abundant in the river bottoms at the foot of the mountain. The ranger does not attempt to raise corn on his little farm; oats will do fairly well, however. Tomatoes ripen occasionally in his garden, but did not in 1927.

The remnants of the ancient spruce-birch forest fringing the mountain-top contains many species of a typical Canadian nature. The principal trees, at least near the summit, are spruce (**Picea rubra**) or birch (**Betula lutea**). The type species represented in the floor covering of a spruce forest is **Oxalis acetosella,** which one finds here in great abundance ornamenting a dense carpet consisting of many species of mosses and liverworts. Other distinctly northern species are **Lycopodium lucidulum, Allium tricoccum, Clintonia borealis, Streptopus roseus, Trillium undulatum, Saxifraga micranthidifolia, Viola canadensis** and **Circaea alpina.**

The slopes of Spruce Knob are quite steep on the eastern side, more gradual on the southern and western sides and continued for a long distance towards the north, as a ridge of relatively uniform altitude. The east, south, and west slopes are covered with great flags of sandstone rock, over which sprawl a few vines such as **Polygonum cilinode, Ribes prostratum,** and **Rubus idaeus var aculeatissimus. Carex brunnescens** is also quite common. These species belong to a typical alpine or boreal flora.

Spruce Knob itself, as noted above, is a large plateau, nearly a mile long, its many acres covered with scattered boulders, the general physiognomy of the vegetation being that of a monotonous heath meadow. In places spruce seedlings are rather numerous but scarcely higher than a man's head. Their crowns are extremely asymmetrical, all the larger branches being developed on the leeward side of the tree.

Summary: Spruce Mountain, the highest land in West Virginia, extends upwards from the Carolinian Life Zone at its base, through the Alleghenian to the Boreal Zone, capping its wind-swept summit. The following vegetation belts are distinguished:

1. The flood-plain of the North Fork River, mostly cultivated, but with many species of a Carolinian nature.
2. The foothills and steep slopes of the Fore Knobs, covered with a heavy forest of beech and maple trees.
3. The terrace created by the erosion of a limestone bed, mostly cleared, the species mainly of a Transitional nature.
4. The steep slopes just above, with forests of beech and maple merging into oak-hickory and finally, near the summit, into spruce-birch.
5. The burned-over areas on the ridge, being reoccupied by ferns and species of heath plants.
6. The higher knobs with a large percentage of boreal and sub-boreal plants.

The writer is indebted to Dr. P. D. Strausbaugh, under whose direction this study was conducted, for his helpful suggestions and criticisms.

THE PLANT ECOLOGY OF A TYPE AREA IN NORTHERN WEST VIRGINIA

By EARL L. CORE

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Northwestern West Virginia and southwestern Pennsylvania are covered with great beds of sandy shales, sandstones, and thin limestones belonging to the Permian series—the last great Paleozoic deposits of eastern North America. The entire region from the Chestnut Ridge anticline westward to the Ohio was lifted bodily at the time of the Appalachian Revolution; the mighty orogenic disturbances farther east dying out here in a great series of small anticlines and synclines. Throughout this area subsequent erosion has resulted in the development of a generally similar topography, with beautifully rounded hills, more or less gentle slopes and narrow valleys, typical of the series. This fact, coupled with the uniformity in climate and the absence of natural barriers, tends to bring the entire area, from an ecologic standpoint, into one vegetation-unit. It would seem that a somewhat detailed account of the flora of a small portion of this region might be of interest and possibly of some value.

The area selected for study was a farm of some 60 acres in extent, situated in the valley of Doll's Run, twelve miles west of Morgantown on the Morgantown-New Martinsville Turnpike. No absolutely virgin timber-land exists in the region, but the area selected is possessed of practically all the physiographic variations common in the section.

The soil is what is known as the Meigs Clay Loam, an association of undifferentiated soils impossible of separation. The principal types are Dekalb silt loam and Upshur silty clay loam. The Upshur occurs in characteristic red patches over the red shales from which it was derived. The Meigs type gives a hilly broken topography and here, as elsewhere, the ridges are narrow and irregular and the slopes descend steeply to narrow V-shaped valleys. It is also frequently characterized by the occurrence on hillsides of narrow benches caused by massive sandstone beds that have resisted weathering. On these terraces the soil is deeper and more productive than on the slopes. Rainfall runs off rapidly and the soil where not protected by vegetation quickly erodes, forming gullies. In the valleys there are traces of Huntington Silt Loam, a friable brown soil of alluvial origin.

The climate is a temperate one. Recordations of the United States Weather Bureau made at Morgantown show the mean annual temperature to be about 53° F., the mean January temperature about 30°, and the mean July temperature about 73°. Precipitation averages about 40 inches annually.

If we exclude man, then the influence of animals on vegetation is confined chiefly to the insects. Some smaller vertebrates (especially birds) are important as insect destroyers. Among phytophagous mammals may be listed such animals as rabbits, woodchucks, chipmunks, mice, rats, and squirrels.

The vegetation is naturally extremely diversified; the dry, barren ridges, the gentle, mesophytic slopes, the steep xerophytic bluffs, the narrow, damp ravines, the rich bottoms along the brooks, all giving rise to distinct and characteristic communities. Add to this the fact that much of the land has been cleared and is in various stages in its development towards the climax association and something will be understood of the complexity of the situation in this area.

It is possible to distinguish several distinct associations, among which may be mentioned: 1. brookside (mesic); 2. ravine (hydromesic); 3. cleared pastures (mesic); beech-maple forest (mesic); 5. oak-hickory forest (mesoxeric); and 6. bluff (xeric).

The extent of swampy ground is so small as to require no mention, the principal hydric species being found along the margin of brooks. Even along slopes as yet uneroded, the location of intermittent watercourses can be determined by the presence of their characteristic flora. Grasses and sedges, especially, form an extremely interesting border for the brooks, their curious inflorescences drooping over the stream.

For number of species, the moister ravines can scarcely be exceeded. These areas have not been cut over to the extent that has been practiced on the leveler portions, in consequence of the impracticability of cultivating them and it is here that the vegetation remains nearest to the primitive condition. From the extreme hydrism of the narrow ravines characterized by dripping walls covered with algae and liverworts one may note the trend towards mesism in the broadening valleys and the less steep slopes, admitting more hours of sunlight. That this process may be, geologically speaking, relatively rapid, is indicated by the "slumping" of trees, undermined by the erosion of earth from their roots.

The more gentle slopes have practically all been cleared and, while a little steep for cultivation, make excellent pasture lands. Where little grazing has been done for years, however, the slopes are in various stages of development towards the climax sere. The first stage seems to be one in which the vegetation is essentially herbaceous. Grasses, such as timothy, red top, and blue grass, may be predominant here. As the grasslands "deteriorate," more and more "weeds" creep in. Broom sedge (Andropogon virginicus) may cover many acres. The change of the seasons affects the appearance of these situations quite markedly. The vernal aspect may be low and monotonous, dominated by Potentilla canadensis, reddened in places by Rumex Acetosella. A blue tint may be added by the presence of colonies of thousands of bluets (Houstonia caerulea). Gradually other plants take their places and the fields become a solid white due to wild carrot, yarrow, and, especially, ox-eye daisy. Later in the year the white gives way to the yellow of the golden-rod and the various colors of the asters.

Bramble thickets may succeed this association or develop directly from the grassland. Here the canes become so crowded as to practically exclude other species. The raspberry (Rubus occidentalis) is often associated with the species of blackberry which form the bulk of such thickets. At about this stage the vegetation begins to be dominated by the hawthorne, Crataegus. Thickets composed of various species of this shrub are often formed so crowded that the floor may be absolutely barren of vegetation. Often the ground may be covered with dead blackberry canes, indicative of the developmental stage through which the area has just passed. The few openings in this hawthorne thicket always contain seedling trees, principally species of oak and hickory. As these plants grow to maturity, the heliophilous hawthornes gradually come to be replaced by the taller growing forest trees. In many places where the young hickories have been cut down in clearing the fields for grazing, the roots continue to send up their customary nutrients, resulting in the extremely vigorous growth to which the term "coppice" is applied.

Many moist spots are inhabited by colonies of thousands of individuals of Selaginella apus, forming a ground covering at the base of the grass culms. An interesting bit of research would be the taxonomic investigation of the countless individuals of lichens, which live on the ground or on pieces of wood and other debris scattered throughout the grasslands.

In the original clearing forest trees were often left standing. These, developing unhampered by surrounding trees, come to have most beautiful, symmetrical crowns—very aristocrats among trees. Many of these old trees found in the open are now dead or dying but are kept green by various lianes which twine up the dead trunk, ornamenting it "like a totem pole." Chief among plants with such a habit of growth is the Virginia creeper (Psedera quinquefolia).

The climax association, the beech-maple forest, occupies so few acres and the individual plots are so small that anything like a complete enumeration of species characteristic of the primitive forest is no longer possible. In wet seasons during the summer and fall mushrooms often develop with a surprising abundance of species and individuals. The oak-hickory forest occupies the more xerophytic slopes and is here usually characterized by a development of undergrowth much more restricted than that found in the climax forest. Most xerophytic of all are the steep shale bluffs which border the brooks and form steep cliffs 50 to 100 feet high. Some of these shaly banks may be almost wholly destitute of vegetation, save for some extremely xerophytic lichens mosses, and ferns.

Along railway beds two plants noted with a remarkable frequency are Equisetum arvense and Euphorbia maculata. An interesting situation is the hanging over of old colonies of introduced plants near the sites of old houses or gardens. All other traces of such works of man may be vanished but these exotics still continue to live and prosper in their strange environments. In somewhat the same category belong many of the common weeds which infest cultivated gardens and rich soil about buildings but which are unable to compete with ordinary pasture land species.

SUMMARY—The area studied is typical in its topography, soil, and vegetation, of the entire region between the Monongahela and the Ohio, covered by the Dunkard series of Permian deposits. The region has been so affected by the works of man that little or none of the primitive situation still obtains; the chief interest from an ecologic standpoint being the method by which abandoned farms are developing towards the climax sere.

I am indebted to various reports of the West Virginia Geological Survey for notes on the geology of the region under study. Thanks are due to Dr. P. D. Strausbaugh, under whose guidance the study was undertaken.

FACTORS INFLUENCING THE YIELD OF APPLES

By A. J. DADISMAN

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Since 1920, and even before, many of the apple growers in the Cumberland-Shenandoah region have reported repeatedly that their orchards were not bearing fruit satisfactorily. Some growers described the orchards as "sick" and needing attention. In order to diagnose the case, West Virginia, Virginia and Pennsylvania Agricultural Experiment Stations, together with the U. S. Department of Agriculture, pooled their interests and prepared for action. In the summer of 1926, trained men from the three states and the U. S. Department of Agriculture visited almost 500 growers, operating approximately 15,000 acres of orchard, containing more than 561,000 trees. Data were collected for a six-year period, 1921-1926, inclusive.

From an analysis of the data collected, it was found that the five-year average yield was 1.2 barrels of apples per tree. The year 1921 was not included in the average yield since there were almost no apples producd in that region that year.

The variations in the yield from year to year in different orchards were caused by a great many factors. Low yields were usually attributed by growers to the following causes: Frost, off-year, failure of fruit to set, hail, diseases, insects, and drought. When orchards were located in frost pockets, or on poor or shallow soils, good yields in all years were not possible. Low yields may also be the direct effect of poor and indifferent management either of the trees or of the soil.

Growers generally attributed more losses to frosts and freezes than to any other single cause. Many orchards were damaged by frost or freezing every year, and in some years the damage was particularly great. In 1921 frost and freezing caused an almost total loss of the crop throughout the region, except in a few isolated cases. Frosts were again particularly severe in the northern portion of this region in 1922. In 1923 a frost occurred in the southern end of the region, and in 1925 frost again caused great damage in the northern sections.

The upper part of the Shenandoah Valley suffered greater damage in 1922 than did the lower sections of the valley or the Piedmont section; in 1923 the conditions in this respect were reversed, according to the growers' reports. In the upper part of the Shenandoah Valley and in Pennsylvania, the three years 1922, 1925 and 1924, in the order given, were most severe for the growers whose orchards were on poor sites. In 1922, 1923, and 1926 frost was severe in Albemarle, Nelson, and Franklin Counties, Virginia. In 1923 and 1925 the frost damage was outstanding in Augusta, Amherst and Rappahannock Counties.

In this region the average date of blooming and that of the last killing frost in the spring are very nearly the same. The low temperature danger point for fruit blossoms, or for fruit just set, ranges in most cases from 27° to 29° F. Buds will withstand somewhat lower temperatures than blossoms.

In most of the years when frost damage was heavy the apple trees bloomed earlier than usual. There is a great deal of variation in spring temperatures from year to year and since for most plants the temperature at which vegetative functions begin may be taken at 43° F, there is a great deal of variation in dates of blooming.

Orchardists are often inclined to overestimate the damage to their crop by a frost at blossom time, for there are usually many more blossoms on a tree than are required to set a full crop, and a frost that leaves a fair percentage of blossoms unharmed may cause no serious reduction of the crop.

There is a very close inverse relationship between the mean spring temperature and the production of apples. The period during which temperatures apparently have greatest influence in determining the blossoming date is that from February 7 to March 21. Analysis of spring temperatures at six official stations of the Weather Bureau, located in the apple-producing section of West Virginia, and total production of apples in Virginia for the years 1906-1925, indicate that if the temperature for the period February 7 to March 21 is above the normal it may usually be expected that blossoming will be early, that many orchards will be damaged by frost, and that yields will be low. Conversely, if the mean temperature for this period is below normal, blossoming will be delayed, and yields will usually be good. In 1921, for example, the season was unusually early, apple trees blossomed about three weeks earlier than usual, and a freeze killed most of the crop in the entire region. On the other hand, 1926 spring temperatures were below normal, blossoming was delayed in many places, there was little frost damage, and one of the largest crops on record was produced.

Some orchards seem to be so located that they are troubled with frost almost every year. Practically all orchards were frozen in 1921, with the result that there was practically no crop in the region. It is evident, however, that frequency of frost damage alone does not account for all the variations in yield.

Air drainage afforded by the elevation of an orchard site above the immediately surrounding land is a very large factor in the elimination of frost damage. Orchards on elevated sites gave better average yields for the period 1921-1926, and there was also less variation in annual yields for such orchards in comparison with yields for orchards with little or no elevation above surrounding land.

There is a considerable variation between sections in the percentage of the orchard acreage having poor air drainage. Evidently this factor was not given the consideration it should have had when the sites for many of the present orchards were selected. In each section there are many orchards on sites that have good air drainage, and there are many good sites still available for orchard planting on which it is to be expected that frost damage would be low.

Pockets from which cold air will not drain are particularly to be avoided. The importance of this matter was repeatedly pointed out by the different growers. Orchard surveys by the Weather Bureau in the Western States show that on a frosty morning a rise of 50 feet on a slope will sometimes cause the thermometer to register a temperature 10° to 20° F. higher than that at the base of the hill. In the East, temperature variations as a rule are not so pronounced as in the drier western sections, but there is often sufficient difference to protect fruit on the higher grounds.

Hail frequently damages the apple crop in some orchard in the Cumberland-Shenandoah Valley apple region, both by reducing the yields and by lowering the quality of the fruit left on the trees. In the period 1922-1926 some damage from hail was reported each year, but particularly in 1924 and 1925. Apple growers whose orchards were located on the immediate leeward (eastern) side of mountain gaps reported more frequent damage than did other growers. Where orchards are already located, air damage must be considered as one of the risks of the business which may sometimes be serious.

Droughts occasionally damage the apple crop in various sections of the valley. Drought affects first, and most seriously, those orchards located on hillsides where the soil layer is thin, is lacking in moisture, retains little vegetable matter, and is subject to washing. Orchards on locations that are favorable from the standpoint of an elevation that gives good air drainage and protection from frost, frequently suffer from drought, which results in small-sized fruit and a general lack of thrift in the trees. Orchards with deep soils, well supplied with humus, suffer little from drought. Thin soils and soils in poor tilth may be improved by regularly plowing under green crops that have been grown for the purpose. Where soil washing is serious, sod must usually be maintained or the orchard must be terraced.

In the 494 orchard blocks studied there were 486 groups of trees, each containing a single variety, located on a definite slope, for which the yields were recorded. Forty-two additional groups of trees had no noticeable slope. Of the 486 groups of trees, 170 were on an eastern slope ,96 on a southeastern, 93 on a western, 89 on a southern, and 38 on a northern slope. A slope is important in comparison with a level area largely because it insures a certain degree of atmospheric drainage. If a nearly level area has adequate air drainage, a slope would offer little or no superior advantage. The relative merits of slope in any particular direction depend almost entirely on the surrounding topography rather than on the direction of the slope itself. The slight differences in the reported yields in these orchards indicate that for this region as a whole the direction of slope is not an important factor.

The soils of the Cumberland-Shenandoah Valley and the Piedmont section studied are, in general, suitable for apple production. In most of the sections, however, there are soils and soil formations on which orchards show effects attributable to poor soil conditions. Thin shale soils lying on hardpan or rock, and otherwise rich soils of shallow depth over rock are of this kind. Trees planted in the poorer soils do not thrive and those planted in shallow soils, even if the soils are rich, are likely to be short lived and to suffer from soil exhaustion, drough, and disease. There is an abundance of rich mellow soils with deep well-drained subsoil in the region, and the best orchards are found on them.

Soils that were originally suitable for orchards may lose much of their value through unwise treatment or neglect before or after the orchard is set. A site which is desirable because of elevation and other factors may lose its value for profitable orcharding if care is not exercised to keep the fertile soil in place. Soil lacking in humus will wash away more easily than soil well filled with decayed vegetable matter. It was estimated that about one-eighth of the total orchard acreage in one locality was made unsuitable for profitable orcharding because of soil washing. The yield per tree on the part that was badly washed averaged one-third less than the yield per tree on the remainder.

The prevalence of relatively low yields of apple trees in the region seems to be variously associated with factors other than direct damage from frost, hail, and drought and the depredations of insects and disease. Soil and tree management vary greatly in different orchards.

Practice with respect to cultivation was almost equally divided— 172 blocks were kept in sod, 175 were regularly cultivated, and 147 were in sod in some years and plowed up in others. There were many instances of good yields in both sod and clean-cultivated orchards. Local conditions should determine the method; but in steep, rough places it is nearly always advisable to have the orchards in sod.

The use of more fertilizer in many orchards, particularly of nitrates, would greatly increase yields. So many factors affect yield that it is difficult to determine the actual influence of a single factor. Lack of color may be due to dense foliage and may be avoided to some extent through proper pruning. Lack of maturity is not a question of too much nitrate of soda as often as it is of unseasonably high temperatures and rainy weather.

Insects and diseases are constant threats to the growers of the region and frequent losses occur as a result of the production of large quantities of low-grade fruit whenever treatment is neglected. In the principal apple-producing counties of these three states a free spray information service is available through the State Agricultural Experiment Stations. This type of service consists of the dissemination of exact information as to the dates of emergence of insects and the dispersion of disease spores which vary from season to season with the weather conditions. This makes possible the exact timing of the necessary spray applications to effect the largest possible degree of control of insects and diseases.

On the average there were 50 acres of orchard to be sprayed for every spray outfit on the farms visited. To attempt to spray 50 to 100 acres of orchard with one spray outfit, year after year, simply means that this operation is not done well, and a large percentage of undesirable fruit results. In general, one spray outfit for each 30 acres of orchard would give more satisfactory results.

Apple trees, as generally cared for in this region, tend to bear every other year. The trees do not bear heavily, and set fruit buds the same year. After a heavy crop one year the tendency is for the orchard to bear a light crop the next. However, well-nourished trees, properly pruned, tend to bear a good crop every year. The irregular bearing is, to a considerable extent, taken out of the category of necessary evils, and responsibility for it can be placed largely in the hands of the grower. No evidence was found that any variety was particularly irregular in bearing if well cared for in all respects.

A number of growers attributed low yields to failure of fruit to set. It was commonly observed that the low yields of the Winesap and varieties of the Winesap family were ascribed to this factor. These varieties are largely self-sterile and must be cross-pollinated by some other variety.

The blossoming period is a critical one for the apple tree in this region. Climatic conditions are variable; the weather may be cold, and rain may fall often enough to keep the flowers drenched almost the entire period of blossoming. Such conditions are unfavorable to pollination.

Many orchards show the effects of crowding. The older orchards in the region were usually planted 30 by 30, 33 by 33, and 36 by 36 feet, and in some cases they were planted even closer one way, such as 15 by 30 feet. In orchards which were planted 30 by 30 feet, 25 years ago, and in which the trees are thrifty, the branches are now touching in the row middles. This not only makes cultivation and spraying difficult, but it influences yield and color of fruit largely because so much of each tree is shaded. Such orchards will present even greater difficulties as the trees grow older. In the more recent plantings, permanent trees have been spaced 40 by 40 feet, the distance advised by growers of long experience. An orchard of standard varieties set 40 by 40 feet will have 27 trees per acre. If fillers are placed at the intersection of the diagonals of the squares made by the permanent trees, the production of 21 additional trees may be obtained during the early bearing years of the orchard. In cases in which there is plenty of land suitable for orchard a better plan would be to grow the additional trees on other land rather than to grow them as fillers.

During the life of an orchard many trees are lost. Disease is probably the chief immediate cause of loss, particularly with certain varieties. Loss tends to be high where trees lack thrift because of thin soils, drought, and the like. The loss of trees is serious and is an important factor in accounting for the low production per acre.

The method of pruning sometimes contributes to tree losses as well as to low yields. Where trees are pruned in such manner that all the fruiting wood is out on the end of the branches, there will be considerable limb breakage, and frequently an entire tree is split or broken to such an extent that it must be removed.

The production of apples is an important industry in many sections of West Virginia. The best orchardists are beginning to consider these various factors which limit their production; and the most successful growers will be the ones who make every known effort to secure good yields of quality fruit each year from their entire orchards.

THE RELATION OF SMUT INFECTION TO YIELD IN MAIZE

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(Abstract)

Selfed lines of maize which were grown under smut epidemic conditions were studied and data presented as to the relation of smut infection to yield.

The work was begun at the West Virginia Agricultural Experiment Station in 1920 and has continued to the present. The smut epidemic was produced by a heavy application of horse manure in the spring before plowing, and a second application of manure treated with smut spores when the corn was about knee high. The selfed strains have been grown continuously on the same plat and there has never failed to be a satisfactory smut infection as shown by the degree of infection of the strain used as a check.

Each strain has been grown in duplicate rows of 50 single stalk hills per row. Notes on smut were taken at three times during a season, the first after the corn was in silk, the second a month to six weeks later, and the third when the corn was husked. The smut notes were taken of individual plants and recorded on especially prepared mimeographed sheets which show date, plate of infection, and size of smut boil.

The difference in smut infection among selfed lines is marked and in fairly homozygous material will be found to persist from year to year. In data presented, strains with low infection show an average of 1.1 to 2.1 percent for the years 1922-1927; while other strains of medium infection show an average of 19.9 to 28.4 percent for the same years. The most susceptible strain has an average infection of 54 percent.

Selfed strains are not only definite in their response to degree of infection but show a striking difference in regard to place of infection. Thus one strain may show only tassel infection, a second may show only infection of the ear, while still another may show only basal infection. The tendency of selfed strains of maize to show striking differences in the loci of smut boils as well as in the degree of infection, indicates differences of a genetic nature within the strains compared.

A study of the number of barren plants among the smutted and smut free plants with the same genotype reveals the fact that there are approximately two times as many barren smutted as barren smut-free plants. The barrenness among 1188 smut free plants from selfed lines

was 19.8 percent as compared with 38.0 percent among 868 smutted plants from the same selfed lines.

Studies were made of the difference in yield between infected and non infected plants in selfed lines and certain F_1 crosses. In a comparison of smutted and smut free plants of strains infected primarily in the tassel there was found to be a difference of 20.1 grams in favor of the smutted plants. This is the only instance where a significant difference was found within selfed lines.

The data from the F_1 crosses were analyzed by using Student's Method in comparing the yields. In pairing yields account was taken of the place of infection. When yields of plants infected in the tassel were compared with the yields of adjacent smut free plants of the same genotype, there was found to be a significant difference in favor of the smutted plants.

It is believed that the greatest reduction in yield, owing to smut, among corn plants of the same genotype was brought about by barrenness of the host induced by the fungus. Differences in yield of smut free and smutted plants were demonstrated but these differences were not significant except in cases noted above.

THE INHERITANCE OF PANICLE TYPE AND LIGULE IN A CERTAIN OAT CROSS*

By T. E. ODLAND

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In a study of the inheritance of various qualitative characters and their inter-relationship in a certain oat cross, two of the characters concerned were panicle type and the liguled condition. In this cross one of the parents, Garton 784, has a side or horsemane type of panicle while the other parent, Early Gothland, has an open spreading type panicle. The two types are shown in the accompanying photographs. The Early Gothland variety has a prominent ligule at the juncture of the leaf blade and sheath while the Garton 784 has no ligule.

The inheritance of these two characters has been studied in different oat crosses by a number of other investigators. Nilsson-Ehle[1] found that the liguled condition segregated in a monohybrid ratio in one cross while in others its inheritance could be explained on the basis of two or three factor differences. Love and Craig[2] found that the inheritance of ligule was due to a one factor difference in some varieties of oats and two in others. Garber[3, 4] found a two factor difference for the inheritance of ligule and a one factor difference for the inheritance of panicle type. Quisenberry[5] found a two factor difference for panicle type in the oat cross which he studied. Gaines[6] and also Wakabayshi[7] found irregular segregation for panicle type in the F_2 generation and obtained forms breeding true for the intermediate condition as well as for open and side panicles in the F_3 progenies. Nilsson-Ehle[8] explained the inheritance of panicle type on the basis of one, two, and three factor differences in various oat crosses. This author found a very close association in inheritance between panicle type and ligule in certain crosses.

In the present study the first cross was made in the summer of 1922. In the succeeding five years F^1, F^2, F_3, and F_4 generations were grown both in the field and in the greenhouse. The parents were grown each year for comparison with the hybrid material. The mater-

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1Botan. Notiser, Lund., pp. 257-298. 1908.
2Jour. Heredity 9:67-76. 1918.
3University of Minnesota, Tech. Bul. No. 7, 1922.
4Jour. of Hered. 13:40-48. 1922.
5West Virginia Agr. Exp. Station Bulletin 202. 1926.
6Washington Agr. Exp. Sta. Bulletin 135. 1917.
7Jour. Amer. Soc. Agron., 13:259-266. 1921.
8Lunds. Univ. Aarsskr., N. F. Afd. 2, Bd. 5, No. 2, pp. 122. 1909.

Oat panicle types. Garton 784 on left and Early Gothland on right.

ial was grown in 5 foot rows spaced one foot apart in the field with the plants spaced 3 inches apart in the row. In the greenhouse the plants were grown either in pots or spaced as in the field. The notes on the type of panicle and the presence or absence of the ligule was taken before the plants were harvested.

The ligule is ordinarily a very easy character to classify in inheritance. Occasionally, however, a plant is found where the ligule is so poorly developed that it resembles a liguleless plant. The panicle is more difficult to classify definitely. There is considerable variation in the expression of this character and it appears to be influenced considerably by the environmental conditions and by the stage of maturity of the plants.

Inheritance of Ligule

The F_1 plants resulting from this cross were all liguled indicating that the liguleless character is recessive. In Table I the result obtained in the various F_2 populations grown is presented. The results obtained were practically identical with the calculated ratios when it is assumed that the inheritance of this character is due to two independently inherited duplicate factors.

Table I. Inheritance of ligule in the F_2 generation.

Year	Number of F_2 plants		Deviation	Probable error	$\frac{\text{Dev.}}{\text{P. E.}}$
	Liguled	Liguleless			
1923	270	20			
1924	495	34			
1925	411	25			
Total observed	1176	79			
Calculated 15:1 ratio	1176.6	78.4	0.6	5.81	0.10

In all the different F_2 populations grown it was found that the liguleless condition was very closely associated with the side type of panicle. On account of this relationship it is necessary to take both into consideration in analyzing the data for either one in the F_3 progenies.

If the liguled condition is dependent upon a two factor difference as the F_2 generation indicated, it would be expected that all liguleless F_2 plants would breed true in the F_3 generation while some of the liguled forms would breed true for this condition and others would segregate. With one exception, in which the F_2 plant was evidently classified wrongly, all liguleless F_2 plants continued in the F_3 bred true for this condition.

Inheritance of Panicle Type

The F_1 plants were all classified as intermediate although there seemed to be considerable variation in the expression of this character. Some of the F_1 plants resembled more closely the open type of panicle while in others the reverse was true.

No open liguleless forms were found among any of the F_2 populations grown. This relationship suggests that there either is a very close linkage between one of the factors for ligule and the factor or factors for panicle type or that the absence of both of the factors for the liguled condition prevents the factor or factors for open panicle from functioning. Since no open liguleless plants were found among the 1255 F_2 plants grown, it is assumed the latter was the case. On the assumed basis that the liguled condition is dependent on independently inherited duplicate factors and the open panicle type depends on a single factor difference independent of the two factors for ligule, but inhibited from functioning by the absence of both of the factors for ligule, it would be expected to obtain in the F_2, a proportion of 45:15:4, of open panicled liguled plants, side panicled liguled, and side panicled liguleless plants respectively.

The results obtained in the various F_2 populations are shown in Table II.

Table II. Inheritance of ligule and panicle type in the F_2 generation.

Year	Ligule present		Ligule absent	
	Open	Side	Open	Side
1923	191	79	0	20
1924	380	115	0	34
1925	280	131	0	25
Observed total	851	325	0	79
Calculated 45:15:4 ratio	882.4	294.1	0	78.4

$$X^2 = 4.368 \qquad P = 0.116$$

The agreement of the observed with the calculated is fairly close, in 12 times in 100 trials deviations as great as these might be expected from chance selection. The agreement between the observed and calculated in 1924 is very close while in the other two years there is considerable variation. The F_3 progenies showed that in 1924 there were very few F_2 plants misclassified as to panicle type while in both of the other years a number of plants were classed incorrectly. If a correction were made for the F_2 plants which were evidently misclassified as to panicle type as shown by their F_3 breeding behavior the agreement between observed and calculated would be very close. The F_2 data therefore strongly support the assumed factorial analysis for the inheritance of ligule and panicle type.

In 1925 and 1926, F_3 and F_4 generations were grown from a large number of selected F_2 plants in order to test the breeding behavior of the F_2 plants in the later generations. In the various F_3 and F_4 progenies grown the breeding behavior of the F_2 plants, with only a few exceptions, substantiated the assumed factorial analysis. The results indicated therefore that panicle type in this cross is conditioned by a single factor difference, that the ligule is conditioned by a two factor difference and that the presence of both factors for the liguleless condition in the homozygous state prevents the development of an open panicle.

THE EUROPEAN CORN BORER

By L. M. PEAIRS

(Professor of Entomology, West Virginia University)

Undesirable aliens are not confined to the human species. Immigration of foreign insects is now restricted by means of Federal quarantines. These have been in force, however, for a comparatively short period of time. Probably during the early years of such quarantines before the machinery was in complete operation, the European corn borer managed to evade the vigilance of the port inspectors. It was probably brought in in shipments of broom corn, which were carried to various parts of the country and resulted in the establishment of the borer in two or three different localities. One of these was in eastern Massachusetts, another near Schenectady, New York, still another in western New York; in addition to this also at least one center of infestation was established in Canada. The first corn borer both was found in this country in 1917 and within a few years quite extensive areas in Massachusetts and New York had become heavily infested. Infested territory has been extended so that it now includes the greater part of Massachusetts and some of the other New England states, most of New York state, two-thirds of Pennsylvania and Ohio, large areas in Indiana and southern Michigan, as well as the whole of lower Ontario. In the fall of 1926 two specimens of the insect were found in the northern panhandle of West Virginia; in 1927 no insects positively identified as the corn borèr were found within the limits of the state. This fact is not surprising and does not, by any means, indicate that the insect was not present. It takes some time for it to become established in numbers within a given area. When relatively few of the insects are present, the finding of them is largely a matter of chance even when thorough inspections are made.

The behavior of the insect in its European habitat indicates that it can exist in most portions of the United States where its food plants are raised and we have no reason to believe that it will not eventually occupy all such territory. Its annual spread since its introduction has been relatively rapid. Even last year with the $10,000,000 Federal appropriation for prevention of the spread, the insect occupied considerable areas of new territory.

Although we believe that it will eventually be found in practically all parts of the country, it seems quite certain that it will be much less injurious under some soil and climatic conditions than under others. In territory which has already been infested for some years, the insect has reached its maximum destruction only in relatively limited areas. A question of particular interest in this respect has to do with the probable behavior of the insect in the South where it may be expected to feed extensively upon cotton, as well as upon the corn. Whether it will prove to be more injurious under southern climatic conditions than in the North is a question the answer to which will have much to do with determining the future status of the insect.

The corn borer itself is a caterpillar not unlike the larva of the codling moth although it becomes slightly larger and is grayish white in color, with fairly distinct darker markings, while the codling moth is more nearly pure white. The corn borer is entirely distinct from the ordinary well-known green-corn worm, or corn ear worm, although the latter is sometimes mistaken for it. It is very much like some native insects which normally bore in the stems of certain weeds but occasionally are found in corn stalks. The adult is a small, rather obscurely colored moth, which will be recognized, if at all, by comparison with the colored pictures of the insect which have been well distributed through the agency of the U. S. Bureau of Entomology. Difficulties with identification will attend only the early years of the presence of the insect. In any locality, once it becomes thoroughly established, anyone concerned will know it only too well. However, since early knowledge of the fact that the insect is present in new territory is extremely important, it is urged that all observers send insects which may possibly be the borer to the Experiment Station for positive identification.

The main food plant of the insect is corn but it feeds on a large number of other plants, including garden vegetation and many coarse weeds, as well as some ornamental plants. The eggs are laid usually in July; newly hatched larvae feed first on foliage, then adopt the boring habit. They frequently bore first into the stem just below the tassel and into the midribs of the leaves. Later they bore into the stalk, into the ear, and cobb, and when they are present in large numbers will practically destroy the corn. They reach full growth late in the season. When the corn is ripening, they work toward the base of the plant and spend the winter as larvae within the stalks and stubble of the corn, and in stems of weeds and in other situations where they may find suitable shelter. The great majority always will be found in parts of the corn plant itself. They transform to pupae usually during the month of May in their winter quarters and the moths are on the wing during a part of June and most of July.

Control of the insect has been found to be extremely difficult. It is inaccessible to insecticides. Control by natural means, mainly through the introduction of parasitic and predaceous enemies from its original home, is being thoroughly investigated but the outcome will be uncertain for many years. Control measures for immediate use, which have been found to be most effective and are, therefore, being stressed by all agencies, are based upon the overwintering habits and include the destruction of all parts of the corn plant and other plants in which the insect may pass the winter, or the treatment of such materials in such way as to kill the larvae within them. Among the main practices recommended are cutting the corn as close to the ground as possible, and running the stalks through the ensilage cutter, or shredder.

No one acquainted with the situation expects the insect to be exterminated in any part of its present range. Neither does anyone expect its spread to be prevented. The spread, however, may be materially retarded by the control program being carried out through the U. S. Department of Agriculture, for which special appropriations have been been made by Congress.

It is impossible to predict just how injurious the insect may become in West Virginia. Certainly there are parts of the state where it will do a great damage. Probably it will be less injurious in other parts of the state and it is entirely probable that it may never reach serious proportions in many localities. The interests of the state require that we accord to all control agencies our fullest cooperation since even at the best the insect seems bound to become one of the worst insects ever introduced into the state.

Many introduced insects in the past have done great amounts of damage but have partially made up for this by the modifications of agricultural practices which they brought about. The San Jose scale, for instance, is largely responsible for the advancement made in orchard spraying practices, which are now applied only to a limited extent against the scale itself but more for other insects. The cotton boll-weevil revolutionized agriculture in the South and caused great initial losses to the population but probably resulted in a greater degree of prosperity than the region could have known otherwise. The European corn borer may, through the nature of the methods required for its control, bring about a greater degree of cooperation among the farmers than it has been possible to secure otherwise. If it accomplishes this, it may not be, after all, entirely without its redeeming features.

(Note: Inspection in 1928 has revealed the presence of the insect in Brooke Ohio and Marshall Counties.)

PHYLOGENY AND ONTOGENY OF NAIADES

By W. I. UTTERBACK

(Professor of Biology, Marshall College)

While the author of this paper was seeking data for a graduate thesis on Freshwater Mussels (**Naiades**) under the direction of the Department of Biology in the University of Missouri, it was his good fortune to be appointed for a few summers as a Scientific Assistant in doing field work for the benefit of the Pearl Button Industry under the Bureau of Fisheries. Some time was spent at the United States Fisheries Biological Station, Fairport, Iowa; however, most of the time was spent in making mussel surveys of the lakes and rivers of Missouri and adjoining states under the direction of the Fairport station. The result of these surveys were realized in several economic reports to the government Department of Commerce and in the author's graduate theses, "The Naiades of Missouri," an illustrated and descriptive catalogue of two hundred pages and twenty-nine plates, and reprinted from The American Midland Naturalist, Vol. 4, No.'s 1-10, 1915-1916.

In working out the Phylogeny of **Naiades** it is the author's belief, after several year's of intensive studies in field, library and laboratory, that the ultimate taxonomic system will be based far more upon larval characters and anatomical structures than upon shell characters, from the fact that the soft parts are more constant morphologically and less liable to parallelism and convergence. Yet we should not lose cognizance of the importance concerning shell characters. External factors may so shape the shell as to individualize it, but, under normal conditions, do not often destroy all traces of identification with some group. Since validity is so dependent upon the examination of the hard and soft parts of a large series of individuals it was felt that the species, as recorded in the author's catalogue for Missouri, were fairly settled within their genera, from the fact that extensive and intensive field studies made this possible. The ecologic facts secured in these field surveys were especially interesting. For example, in the three hundred mile survey of the Osage River, the largest tributary of the Missouri River in the interior of the state, it was found that the flat or compressed forms found at the headwaters, where the water was shallower and swifter, become more swollen and heavier shells further down the stream where the water was deeper and more sluggish. More accurate idea of the morphology (especially of soft parts as to color, form, etc.) was obtained while the specimens were fresh and uncontracted as examined afield.

For the world around the Phylogeny of **Naiades** naturally falls into two families, **Margaritanidae** and **Unionidae.** The latter falls into three definite sub-families, **Unioninae, Anodontinae** and **Lampsilinae.**

In the shell characters of Family I the structures of the inner and outer surfaces are not constant enough to be considered in the diagnosis; however, it may be said in a general way that the shell is narrowly elliptical, no sculpturing on disk, low beaks, epidermis black, so-named "Spectacle Case" in most species of this primitive group because of its general likeness of form. Most fossil forms, which come under Margaritanidae, can be easily identified because of this general shape.

So variable are the shell characters of Family II that a better diagnosis may be made for each of the sub-families. For the first **sub-family, Unioninae,** the shell is mostly heavy, hinge teeth complete and with no sex dimorphism; for the second **sub-family, Anodontinae,** the shell is mostly light and thin, hinge teeth lacking, with no sex dimorphism; and for the third **sub-family, Lampsilinae,** the shell is variable in thickness and weight, has well developed hinge teeth and a definite sex dimorphism. It has seen suggested that the shell characters of the first sub-group may be due to the fact that the species are fluviatile for the most part, that those of the second group are mostly lacustrine, while those of the third group are both fluviatile and lacustrine, since the swift current of rivers tends to building up a thicker heavier shell while pond and lake conditions tend to the opposite.

In the Naiad Phylogeny one very noticeable fact is seen in that all **spineless** post-embryos (technically called **glochidia**) are followed in the adult life by well developed cardinal and hinge teeth, while those glochidia which are spined, as seen in the Anodonta types, are followed in the adult forms by poorly developed hinge teeth, and, in most cases, by no teeth at all. As previously stated, the most reliable bases for classification are on anatomical characters. Also the glochidial characters, as well as the breeding habits, are much more constant than shell characters.

For Family I, **Margaritanidae,** we find no water tubes in gills, diaphragm incomplete, siphons suppressed, all four gills marsupial, post-ventral margin of mantle undifferentiated; glochidia very small, semi-circular, ventral margin dentated; **tachytictic** (i. e., short period, or summer breeder).

For the animal of Family II we note that water tubes are present in the gills, diaphragm is complete, siphons not suppressed, marsupium formed by all four gills, or by two outer gills, or by the posterior ventral parts of the two outer gills alone. For the first group of this second family the postventral margin of the mantle is slightly crenulated and in the third group this part is very definitely differentiated by tentacles, flaps, etc. Also in the first group the glochidia are aproni-form, spineless and borne in conglutinates (i. e., definitely formed masses); in the second group the glochidia are sub-triangular, spined and non-conglutinated—thus coinciding with the forms of the first group and hence showing **atavism**, or reversion to type, as characteristic of the principles of evolution.

The laws of evolution are also shown in a better adaptation for the survival of the embryos as seen in the following anatomical characters of the third sub-group, Lampsilinae:—

(1)—Mantle edge antero-ventrad to branchial opening of female with special structures, such as papillae, tentacles, flaps, etc.

(2)—Siphonal openings with a tendency to become tubular.

(3)—Marsupia mostly occupying the posterior part of outer gills with thinner ventral edges of ovisacs near the postero-ventral edge of mantle specialized with tentacular structures.

Those morphological adaptations are for better aeration of the embryos thus resulting in a minimum mortality. A greater mortality is discovered in the first two groups due to a lack of provision for a proper aeration of the early and late embryos; however, the second group, Anodontinae, have a better provision for survival of the embryos than the first group, Unioninae, by possessing water tubes in their gills, and larger palpi. The Anodonta type of glochidia may have an advantage over that of the Unio forms in the possession of spines on the ventral edges of their valves as well as long embryonic byssal threads which enable more readily to catch on passing fish hosts and encyst even on fins and scales.

The breeding seasons for these three sub-families also show better provisions for survival of the embryos in the second and third groups in that the first group, and also the first family, **Margaritanidae,** have a short breeding season during the summer (technically termed the **tachytictic**), while most of the species of the second and third groups have a long breeding season during the winter (or bradytictic). Of course there are some species which do not adhere to these general breeding habits, the most notable being **Megalonaias heros** which has been discovered to be breeding in late winter. Even **Cumberlandia monodonta,** type of Family I, **Margaritanidae,** has been found to produce two broods in one summer.

In order to more clearly define the Phylogeny of **Naiades** we would characterize the type species of two or three representative genera of each of the three sub-families of the second family.

Fusconaia undata, known by its trade name of "Pigtoe," is the most primitive of the **Unionidae**, having a thick, trigonal shell showing no true sex dimorphism; soft parts yellowish; marsupia formed by all four gills; conglutinates club-shaped, light red. This species was hidden in synonomy for many years until Mr. Bryant Walker, a close student on Naiades, brought it to light through diligent study. Many varieties of this species occur according to its various ecologic conditions.

Megalonaias heros, known as "Giant Heros" because of the most ponderous shell of all mussels, will be characterized more in detail since it is taken as a type for an Ontogenetic study and can also be considered as a good intermediate type of the Unioninae.

Pleurobema Utterbackii may also be selected as a good intermediate type for this group. This species was a stranger found by the author on a government mussel survey in the White River of Southern Missouri. A good series of shells were sent to Mr. L. S. Frierson, another authority of mussels, especially for the Southwest of our country. He proved the novelty of the form, wrote up the first description and dedicated it to the author of this paper. Its shell is somewhat elliptical, beaks large and full, epidermis tan colored, gills long tapering posteriorly, siphonal openings blackish, suppressed. Gravid females are desired to make a complete description.

Uniomerus tetralasmus, known as "Pone Horn Shell," is the highest of the Unioninae. Being found in the same habitat of the second sub-family, **Anodontinae,** it is often confused with some members of that group because also of its similarity of shell, but can be distinguished by presence of hinge teeth. Its position is mainly due to its marsupia being confined to the outer gills and profusely crenated incurrent siphonal opening. It was the good fortune of the author to discover its glochidium and to write and illustrate it for the first time.

Symphynota costata, known on the market as "Squaw Foot," while not a type taken by students for this genus, yet it is a good representative of the lowest form of the second sub-family, Anodontinae. Its shell is most easily identified because of its sharp post-dorsal ridge with costal markings on this slope; marsupium is typically Anodontine and has one of the largest glochidia on record, being .38X.39mm.

Lastena suborbiculata may be taken as an intermediate form for Anodontinae. This is known locally as "Heel Splitter" and is very easily recognized by its very large suborbicular shell having about the same general shape and convexity of a dinner plate. As characteristic of most Anodontine species its supra-anal opening is wide and palpi long. Marsupia are confined to the outer gills and its glochidia are large, golden, spined and about as long as broad. The author also had the pleasure of discovering this glochidium, describing and illustrating it for the first time.

Strophitus edentulus is the highest type of this sub-group, **Anodontinae,** since its marsupia are confined to the outer gills, palps long, mantle edge somewhat differentiated; glochidia large, length greater than height. This and **Lastena ohiensis** are the only species on record so far which do not normally possess a fish host for the metamorphosis of its larva, yet it is strange that these non-parasitic forms should have such a wide geographic distribution.

The lowest forms of Sub-Family III, Lampsilinae, fall into the Ellipsaria-Group. Marsupium most primitive in that the whole outer gill is occupied; yet advantage is secured for the aeration of the embryos in rendering the ventral edges thin by distention and in throwing the marsupia into folds thus increasing the surface for greater exposure to the water currents. A good type is **Ellipsaria clintonensis.**

The middle group of **Lampsilinae** may be termed **Obliquaria-Cyprogenia.** Number of ovisacs reduced, but greatly enlarged and elongated and placed at the great vantage point for oxygeneration of the embryos.

The highest forms of **Lampsilinae,**—as well as of all **Naiades,**—may be included in the Proptera-Lampsilis Group. In this division the best adaptation for the proper respiration of the embryos is secured by situating the numerous, dilated ovisacs in a more or less kidney-shaped marsupium near the incurrent opening where the postero-ventral margin of the mantle is set with papillae, flags, etc. The first members of this group have the mantle edge only slightly crenulate and lamellate while beyond the genus, **Proptera,** is the culmination of the modern structure in the arrangement of the inner edge with papillae or flaps close to, or remote from, the outer edge. The highest genus is Truncilla, good-types of which are **T. Curtis** and **T. Lefeveri.**

The relation of **Naiadgeography** to Phylogeny of the Freshwater mussels is very interesting especially as the author found it in his mussel survey of the state of Missouri. The zoogeography of the **Naiades** of that state and adjacent territory in relation to the restoration of the ancient geographic conditions of the Mississippi Valley is an interesting problem. With the Ozark Uplift in the south and the Missouri River, known as the "Old Muddy," flowing entirely across the center of the state as "The Great Faunal Barrier" we note distinct mussel faunae which coincide with the different physiographic provinces; yet these faunae, which distinctly show that they are primitive for North Missouri, intergraded for Central Missouri and modern for South Missouri, seem to occur as apparently contrary to geologic facts. The unique mussel faunae of that state are determined by the ecologic conditions of the physiographic features such as muddy, sluggish streams of the north, swift, clear streams of the south and mediocre streams for the central portion.

From the fact that the author found that primitive species, Cumberlandia monodonta, at several points in Central Missouri, its known distribution was carried farther south and west of the Mississippi than ever recorded before. While the author was a resident on the west slope of the Rockies he noted that the mussel fauna there fairly well coincides with that as reported for the east coast of Asia. From this we might infer that some time in the remote past there were definite terrestrial connections with North America and Asia.

Megalonaias heros (Say), known as "Giant Heros" in trade parlance, was not chosen as a type for Ontogenetic study because it is most typical of all **Naiades,** but because he has given this form the most intensive study. From this study he has been able to discover such peculiar characters as to give it rank as a type of a new genus, **Megalonaias.** This creation of a new genus was only made after due deliberation with the leading authorities on **Naiades.** The following animal and shell characters have justified the elevation:—

(1)—A tendency of the inner laminae of the inner gills to become more or less united with the visceral mass.

(2)—The gravid marsupium, an enormously distended pad, colored purplish with reddish rusty splotches here and there parallel with the septa.

(3)—Thick, sole-shaped, subsolid conglutinates with rusty brown margins discharged more or less whole with glochidia lying all through the conglutinated mass.

(4)—A large, vital glochidium with post-ventral margin obliquely rounded.

(5)—Breeding season intermediate, or tachytictic with late season (i. e., bearing glochidia in late winter but sterile during summer).

(6)—Adult shell most ponderous of all **Naiades.**

(7)—Juvenile shell most sculptured of all **Naiades.**

The goal in the individual race-course (i. e., the ONTOGENY) of all forms of life is the reproductive cell; however, the logical point of start and finish is the mature life which marks the Etiology for the germ cell in a phenomenon we call death so that another ontogenetic life cycle may be perpetuated. Yet, in the last analysis, we scientists, who deal so much with the material and natural law, may lose sight of the spiritual and supernatural in the fact that the GREAT JEHOVAH (the "SELF-EXISTENT ONE") is the Alpha and Omega whether we consider Evolution in the life history of the individual, or even of all phyla.

Our type species, **M. heros,** has been claimed by some students as hermaphroditic, but as the author has found sperm within the gonads of the visceral mass without being accompanied by ova of those individuals that possess gills without the crowded septa of the female proves the sexes distinct and separate. Hence before the fertilization period spermatogenesis takes place in the gonads of the male and oogenesis of the gonads of the female.

It is a problem as to where, when and how fertilization may take place. It is inferred, however, that it may occur at the time of ovulation when the ova are enroute from the genital aperture to the openings of the ovisacs in the suprebranchial canals which are located at the top of the gills. Others think the fertilization may occur after the ova are deposited in the ovisacs of the marsupia. Since sterile ova are so often found in the ovisacs one might be led to think that the latter inference is more truly correct. Sperm masses discharged from the excurrent siphon of individuals kept in an aquarium and microscopically examined are found to be clinging together in globular forms as some Colonial Protophyta, such as Pandorina and Volvox. When the globular mass comes into contact with the ova the matrix ruptures and the individual sperm are freed. The object of the globular conglutination is for locomotion since the individual flagella, protruding from the matrix, just as seen in **Volvox globator,** all move in unison so that the movement is powerful and rapid.

Immediately after the fertillzation, as in all Mollusks, an unequal segmentation takes place. The Ovum, being holoblastic, i. e., without nutrient parts, all parts take place in the segmentation. Since unequal segmentation takes place in this pre-embryonis stage of development there is eventually a hollow ball formed. This is the blastula stage with its segmentation cavity surrounded by a single layered wall of micromeres (or small cells) and macromeres (or large cells) of equal number. This recapitulation of the Colonial Protozoon is very evident. Also the gastrula, formed by the invagination of the blastula, is an evident recapitulation of a simple **Porifera.**

All this pre-embryonic life takes place in early winter. All these so-called "eggs" of segmentation, blastulation and gastrulation are enveloped in jelly-like globules, just as in case of frogs' eggs. If gravid females bearing these early embryos are taken from their natural beds and roughly handled they will "abort" the eggs in broken conglutinates.

In late winter the ripe glochidia are formed and discharged in unbroken conglutinates. By laboratory tests the author has kept the glochidia of this species alive in cold, clear fresh water exactly thirty days (five times longer than the life of any other mature glochidia submitted to this watchglass test.) This unusual vitality of the larvae is an adaptation to its prolongation of breeding season into late winter when they are discharged into the ice-cold water and left to their fate, for it is the belief of the author that they are discharged as soon as mature and may wait at least a month on the bottom of the stream until fish hosts start up stream to spawn or until the salamander host may come out of hibernation.

The parasitic life of the larva is an interesting one. As may be familiar with most of us, when this larva was first discovered it was thought to be a distinct form of an animal parasite and was called **Glochidium parasiticum,** but later, upon tracing its further development, it was found to be only a dependent phase in the life history of the mussel. However, the name, "glochidium," was still retained. As probably you may have observed the glochidium contracts its valves in such a snapping motion that when a passing fish attempts to swallow down the glochidial masses as food most of them may snap on the gill arches where they encyst. It is in this life of about four to six weeks that, in addition to securing food from the host, these so-called "hoboes" steal a ride for many miles from their original spawning beds.

As soon as this dependent life has run its course this post-embryo escapes from its cyst and falls upon the bottom of the stream as a tiny juvenile at first only about the size of a kernel of wheat. Some forms develop threads called byssi which attach to sticks and stones to prevent them being carried away by swift water currents. In case of **heros** juveniles no such byssal threads have been discovered. The author has had the rare opportunity to make much study of the juvenile shells of **M. heros** to find them most profusely sculptured with nodules, apiculations, corrugations, etc. Like children the juveniles are very active; however, the most sluggish of all **Naiades** is the adult as some individuals are known to remain in one position in a mussel bed for many months.

THE PROBLEM OF ORGANISMIC PATTERN

By BERNAL R. WEIMER

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It has been known since ancient times that the offspring of an organism tend to resemble their parents—to exhibit gross and microscopical structures which are essentially similar not only to those of the immediate parents but to those of its early ancestors as well. Various attempts have been made to explain this phenomenon but very little serious effort was made and fruitful results obtained until the beginning of the present century when DeVries, Tschermack, and Correns working independently rediscovered Mendel's Law, which he had worked out experimentally and reported several decades before. Apparently the form and pattern of the organism was due to certain unit characters which segregated independently at some period in the life cycle of the organism and were transmitted from parent to offspring. Thus, Darwin and Weisman, previous to 1900 had put forth corpuscular theories to explain heredity. Darwin in his theory of pangenesis suggested that this hereditary process is in a manner centripetal and consists in the migration of small, ultra-microscopic particles from the various regions of the organism into the germ tract. By this means the parental characteristics were transmitted to the offspring. Weismann's theory, on the other hand, was centrifugal rather than centripetal in that these particles or determinants, grouped in a complex system of ids, idants, and so forth, were in the germ cells or germ line originally and in development there was a sorting out and segregation of these particles to different regions of the developing organism. Here under their influence, there developed the various structures. In other words the determiners for the eye with its attendant structures went to the eye region, those of the hand to the hand region, and so on.

These earlier theories and explanations for the pattern of organisms have been either cast aside in toto or so modified and revised that they bear little resemblance to the original. Today the most widely accepted explanation for the phenomenon is known as Mendelism. Here again heredity is explained by postulating a number of entities called genes. These particles are located, hypothetically, in the chromosomes of the cell and under their influence a relatively undifferentiated mass of protoplasm, known as the egg, develops and the resulting individual takes on its hereditary pattern. According to this theory there is no centrifugal or centripetal behavior on the part of the genes,—that is to say a sorting out or gathering in to be resorted,—but every cell inherits a complete set of determiners. Theoretically, a cell in the eye would have not only the factors for eye color but those which determine the color of the hair, the shape of the nose, length and number of fingers and so forth. To repeat, every cell inherits the entire germ plasm or the pattern of an entire organism.

Inasmuch as an attempt is being made to discuss a theory which is today very widely accepted, a brief examination of its fundamental principles seems desirable. In the first place what is a gene or factor? Morgan offers two guesses; one, that "it is a quantity of material fluctuating about a mode;" second "a gene may be a definite molecule." He refuses to commit himself in favor of either conception. Jennings in his excellent little book, Prometheus, refers to them as "discrete packets of diverse chemicals." Shelford speaks of the gene as the "meta-physical basis of heredity." Thus various definitions of other individuals might be quoted, but when these are considered, it seems that the best that can be done is to say that a gene is a something which, according to the Mendelian school of heredity, is responsible for an hereditary characteristic.

The genes are supposed to be located in the nucleus of the cell, more specifically in the chromatin which is arranged in small strands like strings of beads. According to Morgan the genes are located in definite places in the chromosomes and are arranged in linear order. The number of chromosomes in a cell consists of a variable number of pairs of like or homologous chromosomes constant for each species, one set being derived from each parent at the time of fertilization of the egg. At a certain stage in the life cycle of the organism these homologous chromosomes—that is each pair of similar "strings of beads"—coil around each other in the process known as synapsis. Later they separate but in the separation part of the material chromosome may be found in the paternal chromosome and the corresponding part of the paternal in the maternal. Thus a paternal chromosome which in a certain locus might carry a gene for red eyes, may now have a portion of the maternal chromosome with a gene for green eyes and, hypothetically, the reverse would be true of the maternal chromosome. This constitutes what is known as crossing over. Morgan and his associates in their careful and brilliant study of the genetics of the fruit-fly, Drosophila, apparently have been able to detect these instances of crossing over and from the percentage of cross-over characters plus the additional evidence derived from the microscopical study of the germ cells, they have prepared chromosome maps of Drosophila. Each gene and hence each hereditary character or pattern factor has been placed in a definite locus in linear order in a certain chromosome.

The writer trusts that this brief exposition of elementary Biology will be pardoned but it seemed very desirable to present these present-day rather wide-spread ideas of Mendelian principles. On these important underlying principles the present theory and practice of heredity rests. Further analysis seems to indicate that, theoretically, the organism is created with fixed and determined characteristics. "Predestination," in the words of Jennings, "in the present world, is an actual fact." All that environment can do is to prevent or permit hereditary characters to develop. "Hereditary is everything, environment almost nothing." This is the doctrine which is being broadcast by so-called popularizers of science by means of fanciful pictures of colored rabbits and by publication of new decalogues. This is the background for present immigration restriction and the basis of eugenistic legislation.

But to return to the theme of organismic pattern, what criticism can be made of the foregoing principles of heredity? In the first place no one, not even the geneticist himself, knows or is sure of the nature of the gene. Apparently its functioning is manifested clearly. It seems probable there is something in the cell which acts as a bearer of hereditary pattern but further than that nothing definite is known. The earlier idea that each gene manifested itself in only one characteristic of the organism has been superseded by the thought that a characteristic is rather the product of many genes.

Attention has been called previously to the fact that theoretically the genes are located in definite loci in the chromosome and are arranged in a linear order. The evidence for this generalization as well as for a number of others in genetics, has been provided by experiments on Drosophila. It should be borne in mind that the fruit fly is a highly specialized animal and only one of a large group. In the next place these animals have been kept for many generations under the abnormal environmental conditions of the laboratory which as we shall point out later, do very markedly affect their general structure.

Again, when these data from which has been deduced the concept of linear arrangement of the genes, are further analyzed, it is clearly seen that this linear arrangement is nothing more than a graphic presentation of data. Any series of data such as temperature differences can be graphed in the same way but yet no one would consider this arrangement as a temperature map.

Furthermore, the necessary data for gene localization and chromosome mapping are derived from the study of crossing over which can take place only where the chromosomes undergo what is known as parasynapsis; that is, pairing off side by side. During this pairing the interchange of genes is supposed to take place according to the chiasmatype theory of Janssens. This theory rests on observations made on one or two insects only and has been criticized recently by McClung who points out that there is no evidence that an interchange of material can take place here. The theory of crossing over meets further obstacles in those forms where instead of parasynapsis, what is known as telosynapsis takes place. That is, the chromosomes unite end to end rather than side by side. Another interesting bit of evidence, from the critics viewpoint, is a recent paper of Huxley in which he reports that crossing over apparently takes place in Gammarus, an animal which has round chromosomes, which excludes the possibility of parasynapsis. Further, it is rather difficult to conceive of a linear order of the genes in a round chromosome.

If each cell inherits the entire germ plasm and all the genes, there must be present a rather stable mechanism of some sort which brings about an equal distribution of germinal particles when a cell divided to form two daughter cells. This mechanism apparently is furnished by the mitotic spindle on which the chromosomes arrange themselves longitudinally and divide. Theoretically each gene likewise divides. Following the division the new double set of chromosomes separate, a complete set going to each opposite pole and hence to each daughter cell. A survey of the literature shows a wide disagreement among investigators in regard to the nature and role of the spindle in cell division. Some would interpret it as lines of force in a magnetic field. Others hold to the idea that it is a definite morphological structure. Further there is division of opinion as to whether the spindle is a contributing factor or a result of approaching cell division. Some work has been reported which would indicate that the germ cells of monoezia, a flat worm, multiply by amitosis rather than mitosis. If such observations have been correctly made, it would appear that the chromatin of a mother cell has been distributed to the two daughter cells irrespective of chromosome arrangement and genic division.

There have been just presented some of the fundamental generalizations underlying the commonly accepted explanation for heredity and the corpuscular idea of organismic pattern. According to this view which is open to criticism from various angles, environmental factors are relatively powerless. However, a careful survey of biological literature dealing with pattern indicates that environmental factors must be considered. As Jennings say, "What any given cell shall produce, what any part of the organism shall become, depends not alone on which it contains—its 'heredity'—but also on its relation to many other conditions; on its environment."

Among those animals whose heredity is better known than that of any other organism, the fruit fly Drosophila, flies have been found with irregular and deformed abdomens with imperfect joints between the segments. These characteristics have been assigned to certain chromosomes and are said to be sex-linked. Yet if the flies are reared in dry air these characteristics fail to appear. Again some flies show a tendency to produce supernumerary legs but if the offspring presumably inheriting this tendency are kept under proper temperature conditions, these extra appendages fail to appear. Various other instances of pattern change in Drosophila due to environmental factors might be given.

Another very striking example of environmental influence on the organism is that of the Mexican axolotl. This amphibian was very early described as an aquatic animal with persistent external gills, a heavy broad body, and a flattened tail for swimming. In this form the animal became sexually mature, reproduced and the succeeding generations showed the same general characteristics. Some of these animals were kept in this condition in the Zoological Gardens at Paris. After some years environmental conditions changed and so likewise did the axolotl pattern. The external gills disappeared, the body became smaller and slender, the animals left their aquatic habitat for land and there remained.

Perhaps the strongest propagandist for environmental influences as moulders of the organism is Child. According to Child the "organism is inexplicable without environment. Every characteristic of it has some relation to environmental factors." The organismic pattern is a result of heredity plus environment and its unity and order, and physiological differences, relations and harmonies between parts, are meaningless except in relation to an external world.

The beginning of pattern; namely, the establishment of axes and symmetry, Child has shown in his numerous researches on different organisms, both plant and animal, is the direct result of environment. According to his theory of axial gradients there is set up in the protoplasm regions of high metabolic rate which tend to dominate and control centers of low metabolism, excitation being conducted from one to the other thus forming the mechanism of the control exercised by the dominant region. These gradients in metabolism are factors which determine the direction of growth and differentiation and so are the basis of geometric space relations in the development of the organism. In the regeneration of a hydroid, a hydra or a flat worm the end attaining the highest rate of metabolism develops a head, or better apical structure. This region dominates the next region below and so on down the axis and axes until a new animal is formed. In other words the quantitative changes set up along the axis or axes of the organism bring about qualitative changes in the various regions. To illustrate, if the "head" or apical region of a hydroid stem is removed and the apical end of the remaining piece stuck in the sand leaving a free exposed basal region, the former "head" or apical region differentiates as a "foot" and the former "foot" region becomes the "head" or apical region. The explanation offered for this reversal of polarity and change in pattern is that the end covered with sand has available a relatively low oxygen supply and in consequence its metabolic rate is lowered. On the other hand, the free end, the former "foot" region, has optimum environmental conditions sofar as metabolism is concerned. The result is a reversal of the metabolic gradient relations which is manifested in the organism by a change in form. If environmental conditions are such that each end of a hydroid stem has the same rate of metabolism, a bipolar or two-headed form will result.

One other instance of environmental effect will be cited. Stockard, by the use of various agents in the water, has been able to rear cyclopian fish,—that is, forms with only one huge median eye instead of the usual paired condition. Bellamy has been able to get essentially similar results for the tadpole. By the use of different reagents under controlled environmental conditions, the reverse of the results described above has been obtained,—that is, a fish with a relatively short body ending anteriorly in a wide head with a pair of very large eyes.

From Child's viewpoint the production and maintenance of organic form is a dynamic process. Development of pattern is not a process wholly dependent upon factors working within the organism but it is an interaction between the organism with its hereditary potentialities, whether located in gene or soma, in nucleus or cytoplasm, and the surrounding environment. Child very aptly compares the organism to a flowing stream. The flow of the water is a dynamic process and is comparable to the chemical energy flowing through the organism. The banks and bed of the stream represent general morphological features. The source of the stream or the initiation of this current is due to some environmental factor—some chemical interaction. As the stream flows along, the current is subject to modifications due to the configuration of the banks and bed which in turn are modified by the course of the current. If some barrier is interposed to this current which alters its intensity, the stream may slow up and deposition take place. In other words structures form. If, on the other hand, the rate of flow is increased, erosion follows with consequent modifications of the bed and banks of the stream. It has been possible experimentally to retard or accelerate this dynamic current in the organism as has been shown, by changing environmental factors with consequent alteration in the organismic pattern.

There is positively no doubt that there are certain hereditary characteristics which are handed on from parent to offspring in a very definite way but the fact remains that the realization of these hereditary potentialities is dependent on the environment. One seems justified in assuming that there may be present in organisms characteristics and patterns which have not been realized thus far due to the lack of knowledge of the appropriate environmental stimuli. Nature and nurture thus are two inseparable factors in the determination of organismic pattern.

THE STAINING OF HYDRA

By BERNAL R. WEIMER

(Professor of Biology, Bethany College)

In connection with some studies on the reconstitution of Hydra, it occurred to the writer that if some method could be devised for marking the various regions in an animal and if these markings would persist, the process of reconstruction could be followed and interpreted much more easily and accurately. However, in reviewing the literature there seems to be little or no application of any of the so-called vital dyes to the invertebrates, particularly the Coelenterata.

Various investigators in studying regeneration in Hydra following grafting have made use of animals of two different species which differed from each other, among other characteristics in color. In this way the fate of the graft could be traced. Others have used individuals of the same species which differed from each other in color shade. Both of these procedures are open to criticism in interpretation of results. In the case first mentioned there are undoubtedly present species differences other than color between the animals used, such as differences in the metabolic rate of the animal as an individual and differences in gradient patterns. In the second case in individuals of the same species color differences seem to be indicative of different physiological conditions. Observations tend to show, for example, that young Pelmatohydra oligactis Schulze (Hydra fusca L.) are lighter in color than old animals. The same color difference seems to be true of starved animals as compared to those fed. From data gathered by various investigators on Tubularia and Planaria, there are marked physiological differences between young and old and starved and fed animals with respect to metabolic rate and consequently, capacity for reconstitution under various conditions. Obviously some method of vital staining would remove the necessity of using such methods of marking as previously described and permit experimentation under more normal, controlled conditions.

Of the various strains considered, nile blue sulfate seemed the most suitable for the work on Hydra, particularly Pelmatohydra which is brown in color. The use of nile blue sulfate as a vital stain has been confined for the most part to embryological investigations and applied here for marking the eggs or the embryos. Goodale ('17) used nile blue sulfate in marking the eggs of Spelerpes bilineatus, the dye being applied locally in solid form in the least possible amounts by means of a needle. The dye particle was left for a few moments and then removed by washing. A too prolonged application or the application of the dye in excess amount was found to be toxic. Detweiler ('17) used the dye in aqueous solutions of 1:100,000 up to 1:500,000 but concluded that the ratio of 1:150,000 was optimum. In this case the entire animal was stained. Smith ('14) applied an aqueous solution by means of a fine pipette and was able to get some blue spots which persisted. Vogt ('25) uses nile blue sulfate in vital staining by first staining finely divided agar in aqueous solution of the dye, (conc. 1:100 to 1:1000) and after a few days applying in water one of the colored pieces of agar to the tissue to be stained. The color diffuses over after an interval of several hours to one day. However the stain is not well localized. To localize the dye by this method, the stained agar must be inclosed in glass, tinfoil or paraffin.

After various trials, the method which was found most successful was that of Goodale. The animal, Pelmatohydra oligactis (Hydra fusca L.) was placed on a glass slide and the excess water removed from around the animal by means of filter paper. The animal was then transferred on the slide to a dissecting microscope and the smallest possible particle of nile blue sulfate applied in the desired region by means of a needle. Almost immediately the animal was washed from the slide into a stender dish containing water and thoroughly washed in currents of water by means of a pipette. A blue spot was found on the animal at the place of application of the dye. The animal was then sectioned in any way desired and in the following process of reconstitution of the pieces the blue color was found confined to the original colored cells or the new cells derived from this group as the following example will serve to illustrate.

An animal was stained as described above and a piece removed by two parallel cuts, transverse to the longitudinal axis of the animal. This cross-section, when removed from the animal appeared as a ring of tissue with the blue spot (stippled area) at one point of the circumference. This ring of tissue was then divided into two equal portions by a cut, which passed through the blue spot. The two pieces were allowed to reconstitute and at the end of four days two small animals were found similar in marking.

Evidently the process of reconstitution has been as follows; the two cut lateral ends of each semicircle had approached and fused, thus forming two small rings. Further process of reconstitution had then ensued governed by the original polarity of the pieces as is indicated by the color pattern. Further application of this standing method has been made in investigations not published as yet.

BIBLIOGRAPHY

Detweiler, S. R.: '17. On the Use of Nile Blue Sulfate in Embryonic Tissue Transplantation. Anat. Rec., Vol. 13.

Goodale, H. D.: '17. The Early Development of Splerpes bilineatus. Am. Jour. Anat., Vol. 12.

Smith, B. C.: '14. An Experimental Study of the Concrescence in the Embryo of Cryptobranchus allegheniensis. Biol. Bull., Vol. 26.

Vogt, W.: '26. Gestaltungsanalyse am Amphibienkeim mit Örtlicher Vitalfarbung. Arch. f. Entw'mech., Bd. 106.

REVERSAL OF POLARITY IN HYDRA BY MEANS OF KCN

By BERNAL R. WEIMER

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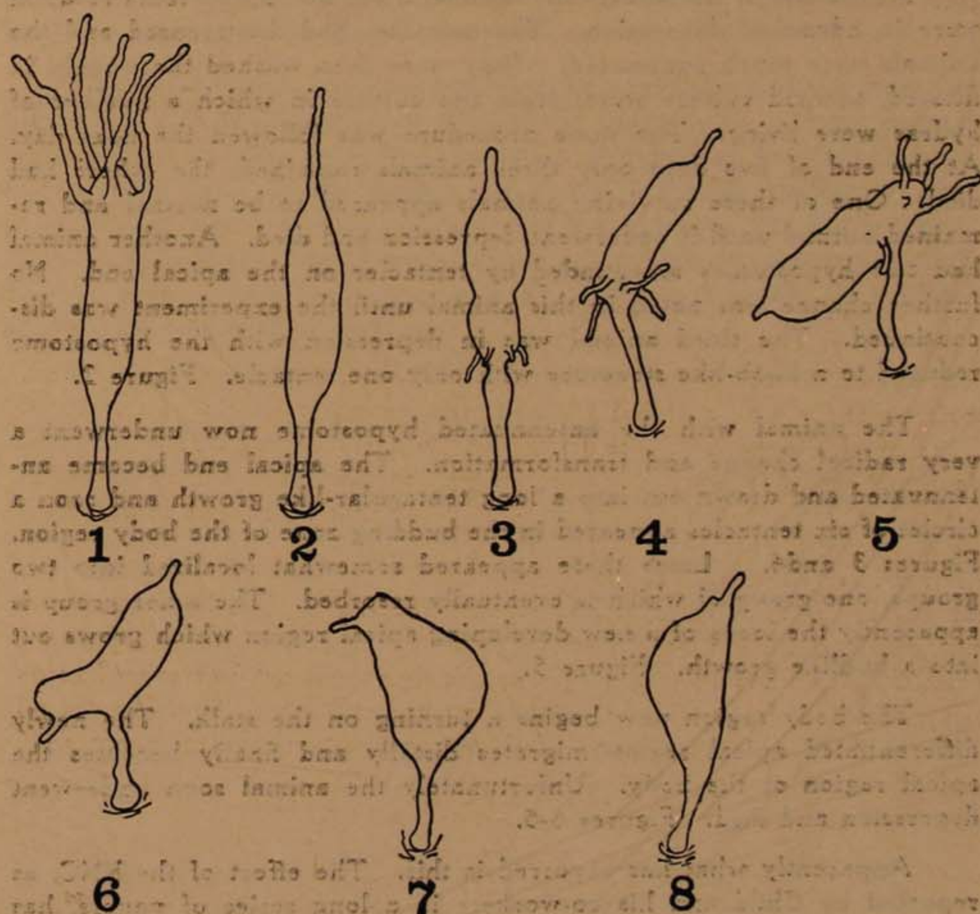
The animals used in this experiment were the large brown hydras recently classified as Pelmatohydra oligactis (Schulze) Pallas, (H, fusca L.) See Figure 1. They were collected from a lagoon in Jackson Park, Chicago, Illinois, and brought to the laboratory about six months before experimentation was begun. Hydras will live and thrive in laboratory cultures made from aerated well water provided the debris is removed regularly from the cultures. They may be fed on Daphnia, though until they become acclimated they must be fed on Cylops or Dero until they are able to capture the former.

About the middle of January of this year there were selected from



the cultures a number of large, non-budding P. oligactis. All the animals were in good physiological condition and of as nearly uniform size as possible.

Solutions were made up of m/5000, m/10,000, m/15,000 and m/20,000 KCN in water from the cultures. Small stender dishes having a capacity of approximately 30 milliliters were filled with the fluid and in these the animals were placed in lots of six. A control group was placed in a dish having only culture water.

Twenty-four hours after placing the animals in KCN those in the m/5000 showed evidence of marked depression and 48 hours after, all were dead. The animals in the m/10,000 were dead at the end of 72 hours. The animals in the more dilute solutions of cyanide, while showing signs of undergoing depression, yet were not affected so rapidly. Meantime the control animals appeared to be perfectly normal. Since this report is concerned primarily with the animals in the m/15,-000 KCN solution, the protocol for the others will be omitted.

At the end of three days the hydras in the m/15,000 KCN solution were in advanced depression. The tentacles had disappeared and the animals were much contracted. They were then washed thoroughly in filtered, aerated culture water from the culture in which a number of hydras were living. The same procedure was followed the next day. At the end of five days only three animals remained; the others had died. One of these surviving animals appeared to be normal and remained normal until it underwent depression and died. Another animal had two hypostomes surrounded by tentacles on the apical end. No further change was noted in this animal until the experiment was discontinued. The third animal was in depression with the hypostome reduced to a knob-like structure with only one tentacle. Figure 2.

The animal with the antennuated hypostome now underwent a very radical change and transformation. The apical end became antennuated and drawn out into a long tentacular-like growth and soon a circlet of six tentacles appeared in the budding zone of the body region. Figures 3 and4. Later these appeared somewhat localized into two groups, one group of which is eventually resorbed. The other group is apparently the locus of a new developing apical region which grows out into a budlike growth. Figure 5.

The body region now begins a turning on the stalk. The newly differentiated apical region migrates distally and finally becomes the apical region of the body. Unfortunately the animal soon underwent depression and died. Figures 6-8.

Apparently what has occurred is this. The effect of the KNC, as reported by Child and his co-workers in a long series of papers, has been to lower the metabolic rate of the apical end of the animal. When this occurred the budding zone, a subordinate region, is released from the dominance of the apical end and so begins to form apical structures, the tentacles.

This actively growing region maintains or even increases its metabolic rate in relation to the rest of the piece and after a time becomes the dominant region. It then controls the remaining tissue which forms structures normally found proximal to the apical region. Apparently a complete reversal of polarity has taken place in the body region.

There is another possibility which should be considered,—that what has been formed is a bud which migrates to the apical end of the body and there takes control of it. This actually occurs when the apical half of the body is removed and the pieces not subjected to the action of KCN. In this instance the bud region has been released from the dominance of the apical end by removal of the former dominant region by KCN. Either method has resulted in release of a subordinate region which then forms apical structures. Further discussion of this point will be found in a paper now in press. However, if one has seen both processes, a difference in action will be noted.

Another peculiar phenomenon was the appearance of the tentacles before any sign of a bud-like swelling of the body region. Under normal conditions of budding there first appears a well-marked out-growth from the budding zone of the body. Later the tentacles appear on this in groups of two. In this instance just the opposite has taken place. This might indicate that there is taking place here some process other than budding, which leads one to think that this is a case of reversal of polarity rather than budding.

RHYTHMIC BANDS BY EVAPORATION

By E. C. H. DAVIES*

(Associate Professor of Chemistry, West Virginia University)

The attention of the author was drawn to this phenomenon by lecture experiments performed in a course on colloids. Filter paper immersed in water acquires a negative charge. When a filter paper is put in a negative colloid (most dyes are negative) the water is drawn up by capillarity, and is closely followed by the colored solute. People have assumed that with a positive colloid there would be precipitation a short distance above the solution surface. According to Thomas and Garard[1] the electric charge on colloids is not reliably obtained by this capillarity on filter paper. They find that the height of ascent depends upon: the dilution, presence of electrolytes, surrounding atmosphere, and the nature of the paper. They point out that ordinary positive colloids are concentrated sols while ordinary negative colloids are mostly dilute and they think that this matter of dilution influences coagulation by filter paper, to a greater extent than the charge upon the colloid.

After making a series of such class demonstrations in 1922, it was noticed[2] that spontaneous evaporation of a blue dye from one of the beakers left several bands upon the filter paper. Further experiments at constant temperature (37°C) showed that good bands were obtained only by evaporation at constant temperature. Seven different kinds of filter paper were tried and 62 dyes were used at concentrations of 0.04 percent and 0.005 percent. Each solution was tested for refractive index for light, surface tension, viscosity, conductivity, and Tyndall light cone in order to see if consistently high or consistently low values for any of these properties would indicate the presence of electrolytes or other classes of impurities which might account for bands obtained with certain of these dye solutions. There are no striking relationships between the formation of bands and these physical properties.

However, it was found that in nearly all cases the dye was, at the end of the evaporation, almost entirely removed from the beaker and that practically all of the dye contained in the 150 cc of solution was finally collected in bands. At the place of band formation the dye is, therefore, quite concentrated and much more viscous than in the original solution.

In 1922 C. D. L. Ropp, working with the author, obtained some

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*For much of the experimental work, the author is indebted to L. V. Clark and V. R. Karickhoff.

[1]A. W. Thomas and I. D. Garard, S. Am. Chem. Soc. **40**, 101;106 (1918).

[2]E. C. H. Davies, Jour. Am. Chem. Soc. **44**, 2705-2709.

very regular circular bands by using narrow strips of Canton flannel (about 8 mm. wide).[1] The 250 cc beaker contained about 125 cc of .005 per cent dye solution and the strips of cloth acted as siphons from which drops fell upon pads consisting of about three sheets of rather hard, crepe filter paper. It was at that time apparent that the underlying requirement was that the drops should at first be more rapid and that each successive drop should fall a tiny bit slower than its predecessor. This results in at first wetting a large area, which becomes smaller and smaller as the experiment progresses. In 1923 some preliminary experiments were made in an attempt to replace the siphon wick by a dropping funnel. The funnel was so fixed that the air pressure above the dye solution was made more than one atmosphere with the idea that it would gradually fall and give a decreasing rate of dropping. This did not prove satisfactory. In 1927, at the suggestion of the author, V. R. Karickhoff used a 4.5 cm wide glass tube with parallel walls for the dropping funnel. It contained about 180 cc of the dye solution. Both a glass stopcock and also a rubber with screw clamp were tried. In each case the stopcock was opened only slightly, so that at first there were about 15 drops of dye solution falling per minute. The use of stopcocks was found impractical because they tended to turn themselves off.

Finally, the stopcock was replaced by a small capillary tube which was closed in a gas flame until the opening was of such a size that, with 180 cc of dye solution in the glass tube, the initial rate of flow was 14 drops per minute. The drops were allowed to fall upon the center of a pad of three rather hard finish, crepe, filter papers in an oven at 38.5°C. The papers were weighed down around the outer edge in order to prevent warping. With a 0.04 per cent solution of Lake Scarlet R, this method gave just as good rhythmic bands as those which had been obtained in 1922, with the wick siphon. With this arrangement it is evident that the constantly decreasing height of dye solution in the tall dropping funnel will result in each successive drop falling a tiny bit slower than its predecessor and that the area of filter paper being wetted will, throughout the experiment, be slowly and regularly diminishing. This bears out the statement made in 1924 that "It seems necessary to have a gradual decrease in the rate of flow as evaporation progresses."

Furthermore, rhythmic bands of dyes have been made on cotton cloth, unglazed porcelain and glass plates. Thus it seemed evident that the filter paper was simply the medium upon which rhythmic bands were produced and to which they were attached. It should, then, be possible to obtain similar, rhythmic, evaporation bands by simply evaporating a suitable dye solution on a watch glass. Here, also,

[1]The width and length of the Canton strip must be varied according to the thickness of the cloth and the temperature used for evaporation.

evaporation first becomes evident at the outer edge and the area being wetted by dye solution is slowly and regularly decreasing just as on the filter paper. The experiment is easily performed and has the decided advantage that it is possible to examine the bands under the microscope. In this way we have already studied about 40 dyes and about 15 other colloidal solutions. Evaporation was carried out in an electric oven at 50°C. The rhythmic bands have been examined under the microscope. Of the solutions examined one of the best for regular bands is a 0.04 per cent solution of Lake Scarlet R while a 0.04 per cent solution of Alizarine Sapphire[1] gave the most beautiful deposits. In taking photographs of these evaporation bands no camera was used. The watch glass with its bands was used like a negative and the prints made by exposure to light with photographic paper under the watch glass. The width of the watch glass was measured and recorded on the prints. Slides have been made from these prints and it is going to be possible to quantitatively study the bands as they are projected upon a screen. This study has not been completed. However, the bands have been examined in detail under a binocular microscope and results recorded. It is not, at this time, thought best to enter into details for each case. When Lake Scarlet R is viewed under the microscope, the wide bands appear to contain several narrow bands, and have no pronounced crystalline structure. In some cases of rhythmic, evaporation bands, there are crystal fronds in the outer edge of the band, growing toward the center of the glass. The outer edges of the rhythmic bands tended to be heavier than the inner edges. Toward the center of the watch glass there was less tendency for banding. The degree of convexity of the watch glass has an important influence upon the character of the bands and their distance apart.

The tendency for formation of rhythmic evaporation bands seems to be rather pronounced for such colloidal solutions as those of: gamboge, arsenious sulfide, prussian blue, tannin with gold, and antimony sulfide. It is hoped that we may be able to further study these under the microscope and to make a rather exhaustive study of the evaporation of true solutions, colloidal solutions, and of the solidification of pure liquids and liquid mixtures.

These evaporation bands are very similar to the rhythmic crystallization observed by E. Küster[2] when trisodium orthophosphate, cupric sulphate, ferrous sulfate, potassium ferrocyanide and ammonium sulfate separated from gelatin solutions by drying at room temperature. Also it is similar to rhythmic agate-like structures observed by A. v. Fischer[3] when very thin layers of molten sulfur solidify. Fischer claimed that the sulfur on solidifying contracts and draws up liquid sulfur by capil-

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[1]National Aniline and Chemical Company dyes.
[2]Kolloid. z., **14**, 307-19 **(1914)**.
[3]Kolloid. z., **16**, 109 (1915).

larity, thus forming a ridge of sulfur deeper than the average depth while adjacent to the ridge is a depression where solidification has overtaken the sulfur before that lost to the ridge can be gained from the surrounding belt.

SUMMARY

A preliminary study has been made of the formation of rhythmic, evaporation bands by four different methods of which two are described for the first time. Results are not complete but seem to lead to the conclusion that rhythmic, evaporation bands are more common than has been supposed. Results may help to explain the formation of some of the rhythmic striations found in rocks.

THE METHODS OF SYNTHESIS OF THE NATURAL HYDROXY METHYL ANTHRAQUINONE DERIVATIVES

By J. H. GARDNER
(Department of Chemistry, West Virginia University)

It is the purpose of this paper to present a progress report on work now going on in three laboratories, two in this country and one in Switzerland. In a sense, this is a report of a race which has been in progress since 1920, and shows no sign of ending.

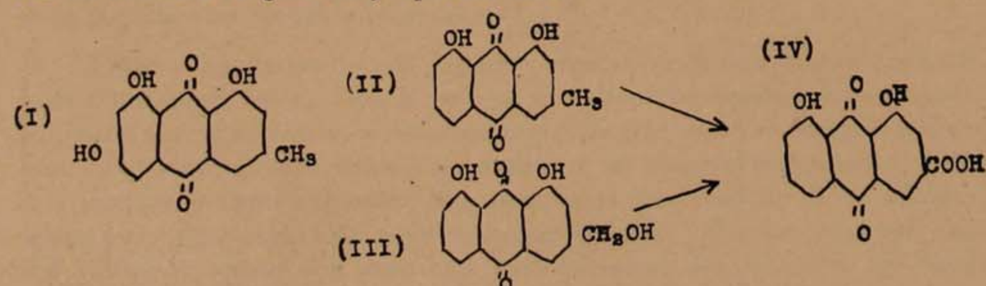
In spite of the great progress made in the synthesis of natural medicinal compounds and of new materials often superior in their results, the natural purgatives have remained entirely a mystery until investigations of the last few years started the clearing of the path.

For many years, it has been known that many natural purgatives such as cascara, rhubarb, and aloes, contain derivatives of hydroxy methyl anthraquinones. Analytical students have made the structures of these compounds fairly certain, but the first synthesis of a natural hydroxy methyl anthraquinone derivative was not accomplished until 1922. Since that time, the race for results has progressed merrily.

The most important member of this class of compounds is emodin (Formula I), occuring in rhubarb, cascara, and various other plants used in the preparation of purgatives. Along with emodin, and occasionally in emodin-free plants, there is found chrysophanic acid (Formula II).

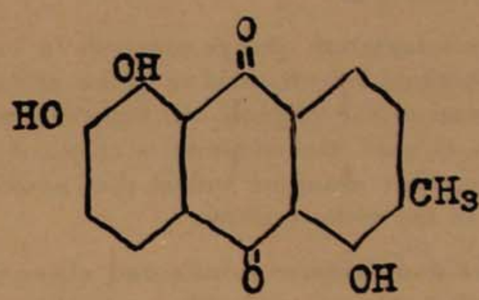
One of the active ingredients of aloes is an isomer of emodin, aloe-emodin (Formula III). It is an anthraquinone carbinol, a member of a practically unknown class of compounds.

As we shall see shortly, the structures of the first two have been established by synthesis, and the structure of aloe-emodin is made practically certain by its relationship to chrysophanic acid. In the first place, both chrysophanic acid and aloe-emodin, on oxidation, give the same acid, rhein (Formula IV). In addition to this, aloe-emodin can be reduced to give chrysophanic acid.



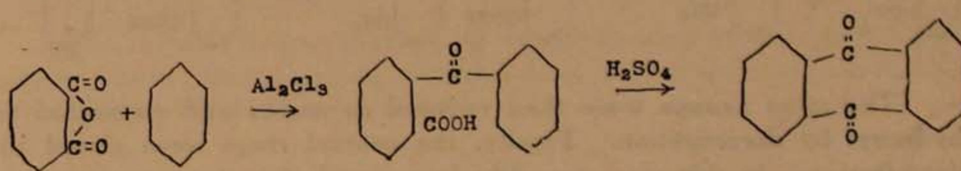
III.

Another ismoer of emodin, morindone (Formula V), is of some importance as a dyestuff. Its structure has also been verified recently by synthesis.

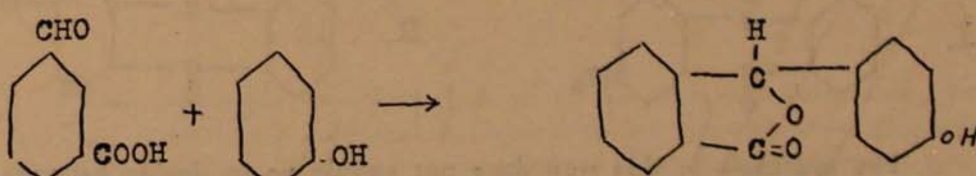


V.

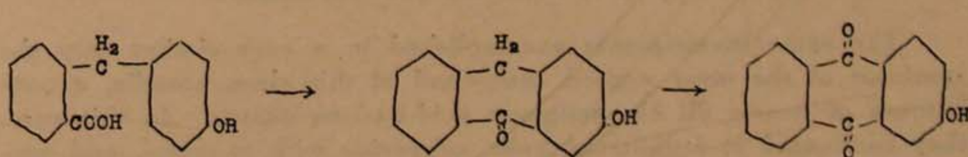
There have been two general methods used in the synthesis of these compounds. The first was that of Friedel and Crafts, in which a phthalic anhydride is condensed with a benzene derivative to give an o-benzoyl benzoic acid, followed by dehydration, usually with sulfuric acid, to form an anthraquinone:



The second was that of Bistrzycki and Yssel de Schepper, consisting in the condensation of an o-phthalaldehyde acid with a phenol or phenol ether to form a phthalide:

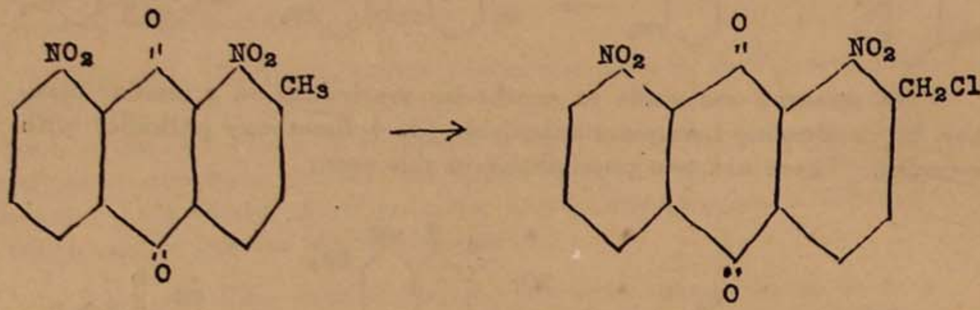


This, on reduction, yields a benzyl benzoic acid, which, on dehydration and oxidation, gives an anthraquinone:



The first method has been the one most generally used.

Since we are attempting to prepare hydroxy anthraquinones, the first method must also be applied to phenols, or to compounds which can be converted into phenols, rather than to benzene. The original papers of Friedel and Crafts would lead one to believe that the conanthraquinone. This compound was chlorinated, giving the carbinol chloride, but he was unable to effect its hydrolysis to the carbinol.

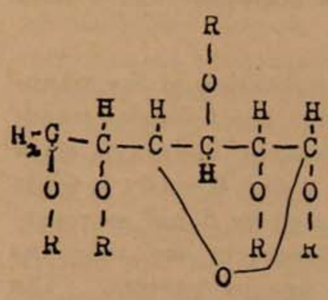


MOLECULAR COMPLEXITY OF TANNINS AND RELATION TO SOLUBILITY AND COLOR PROPERTIES

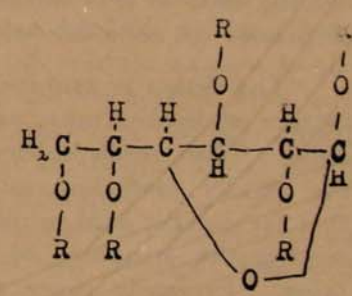
By C. E. GARLAND
(Department of Chemistry, West Virginia University)

Astringent substances which are classified as tannins occur quite widely in nature. Their distribution in plants is subject to seasonal variation and similar to other plant products they are always found more concentrated in certain parts than others. The physiological significance of this class of compounds is not as yet properly understood. Many theories have been proposed but none have been properly substantiated. Possibly the most tenable one is that they are substances which have had some part in the carbohydrate metabolism of plants and have later been thrown off as a byproduct. Evidence for this is their relatively high concentration in the bark. The mechanism of their removal from one part of the growing plant to another is a subject for consideration, especially in the case of the condensed or more highly polymerized varieties.

First attempts at classification were made on their reactions with iron salts. Ferric chloride gives a blue coloration with pyrogallol tannins and green with tannins containing catechol. More recently Freudenberg has proposed to divide the tannins into two general divisions as follows: 1. Hydrolysable tannins. Those in which the benzene nuclei are joined to larger complexes by means of oxygen atoms. 2. Condensed tannins, where carbon linkage hold the phenolic rings in combination. Gallotannin or so called Chinese tannin is the best example of the first group. Fischer and Freudenberg, by their researches

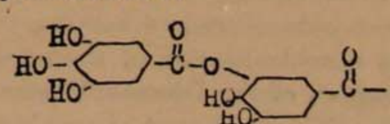


Alpha glucoside.



Beta glucoside.

R = Digalloyl radical.



beginning about 1910, choose to represent this particular tannin as a penta-digalloyl glucoside of a mixture of alpha and beta glucose, in which the beta modification predominates.
The exact moleculat configuration is as yet to be definitely establishe.d. They are reasonably sure however of a few things concerning the molecular arrangement. Each molecule contains the residues of ten molecules of gallic acid to one of glucose and it is thought that each pair of gallic acid residues are joined together in the meta position, for on hydrolysis of the completely methylated tannin approximately equal quantities of the trimethyl and meta-para dimethyl gallic acids result. Fischers researches have shown the meta position linkage to be more stable than the para.

The condensed tannins are best represented by the Catechu and Kino varieties. These are considered as derivatives of a substance known as Catechin which has been shown to contain a phloroglucin nucleus. The exact structure of the substance Catechin, which these tannins give on alkaline decomposition, is likewise an unsettled question. It is apparent that Catechin is in some way combined with glucose, which, like the free Catechin itself, is polymerized to a higher complex. The solubility of these tannin complexes depends on the nature of the condensation and attempt to break them up is not without its effect on the Catechin nucleus itself.

It will be seen then that tannin molecules are very complex. Attempted determinations of a molecular weight for gallotannin have given values varying from 1587 to 3700 (in water solution). It is true that free hydroxyl groups tend to increase the solubility of organic compounds but when the molecular proportions begin to reach this size the state of true molecular solution begins to disappear and a state of pseudo or colloidal solubility results.

The action of tannins with regard to their application in the manufacture of leather must necessarily be viewed from the colloidal standpoint. Their weak acidity is due to the free phenolic hydroxyls since the affinity coefficient as determined is of the order $K = 10^{-5}$ while that for digallic acid, which was formerly considered by Schiff as representing the structure of gallotannin, is approximately ten times as large. Evidently there are no free carboxyl groups present. The hydrogen ion furnished by this very weak dissociation is sufficient to render the tannin colloid stable by being adsorbed on the surface of the particle. This adsorbing of positive charges renders the colloidal tannin negative. The collagen or proteinaceous matter constitutes the connective tissue of hide substance bears a positive charge and so the tanning process is a neutralization of these two oppositely charged colloids. This application of the Donnan Membrane Theory was first proposed as the Proctor-Wilson theory of tanning and has received general acceptance. In the manufacture of leather the salt effect of neutral salts and the sensitivity of tannin solutions to slight changes in hydrogen ion concentration is regulated by methods which are applicable to colloids in general.

Water soluble extracts of vegetable tannins contain, in addition to these astringent substances themselves, other materials, which, though they may be more or less adsorbed by hide substance, are not true tannins. The Official Method of the American Leather Chemists Association reports a commercial tannin analysis in terms of: tannins, non-tannins and insolubles. The non-tannins associated with the hydrolysable tanins are for the most part gallic acid and sugars produced by partial decomposition. Substances which are capable of combining with hide substance under the conditions of the analysis are reported as tannins. Some which are not in reality tannins may be accounted for as tannins by the official method since the hide powder used is a very active adsorbent. On the other hand some of the insolubles may be retained on the surface of the leather and give a softer and more pliable surface. This the tanner does not pay for on the basis of the analysis. As a matter of fact he usually objects to a very high concentration of the latter, because they tend to build up in the tanning vats as they are strengthened up from time to time with fresh concentrated extract. No practical method of completely removing these from extracts has as yet been obtained. Centrifugal methods give most promising results but mechanical difficulties have been encountered. A completely cold water soluble extract would save considerable expense to the tanners in diluting the concentrated extracts for use in the tanning vats. Insolubles consist chiefly of polymerized tannins in which the particle size has exceeded the limit of colloidal solubility. The temperature at which the extraction is carried out has an effect on the amount of insolubles formed. High temperatures also tend to produce more non-tannins by hydrolysis. A small amount of calcium oxalate is also present. Some of this is found deposited on the evaporator tubes and as a sludge in storage tanks. The quantity of oxalate is not sufficient to make its recovery as oxalic acid of value. A small quantity of acetic acid is likewise found in the dilute extracted solutions. A French process is known to have been patented for acid recovery in the evaporator system and some research has been done in this country, especially during the war period, but at present none is known to be in operation in this country.

For many centuries an iron derivative of tannic acid or iron tannate has been known and used in the manufacture of inks. Because of this same reaction an increase in the overhead cost in the commercial manufacture of vegetable tannins is brought about. Any contact with iron must necessarily be avoided and outside of the chippers or bark mills the material in process is allowed to come in contact only with either wooden, copper or aluminum equipment. Approximately three-fourths of the iron present is introduced in preparation of the wood or bark for the leaching, and it has been estimated that two square feet of exposed iron surface in a tank car is sufficient to make the extract objectionable so far as the color of the leather produced is concerned. Apparently the free hydroxyl groups form iron salts.

In a series of experiments adding the acetate salts of manganese, calcium and copper no darkening effect was produced in the solution, as determined by colorimeter readings, or observed on pieces of test leather tanned with the treated extracts. Chestnut wood extract was used and from this it may be concluded that these metals, if they react at all, do not form colored salts with gallotannin, the principal tannin present.

Many investigators have attempted to find a suitable means of improving the color properties of commercial tannin extracts. The difficulty encountered in trying to remove the coloring material lies in the the fact that the color bodies possess chemical properties quite closely related to the tannins themselves. Any precipitant used always removes, at the same time, a large amount of tannin. This has been found to be the case with blood albumen which has been used to some extent commercially.

Tannins and related amorphus plant products of high molecular weight, present real problems so far as pure organic chemistry is concerned. The identity between synthetic and the natural materials cannot, by the means now available, be established without leaving a shadow of doubt.* Even color reactions may often be misleading since we can never be sure whether they are the result of true chemical reaction or partly produced by adsorption effects.

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*For a rather complete list of references on tannin syntheses see article by the author in the November number of the Journal of the American Leather Chemists Association, 1924.

GREATER FLEXIBILITY IN LABORATORY COURSES

By H. F. ROGERS
(Professor of Chemistry, Fairmont State Normal School)

When a good working laboratory course has been developed so that the laboratory equipment exactly suits the manual of laboratory directions and the instructor in charge is familiar enough with the precautions and special points to advise the students in the successful performance of each exercise, it is a temptation to let well enough alone. Every instructor of General Chemistry laboratory knows how much trouble is involved in changing laboratory manuals. It means of course some changes in equipment, but even more trouble is experienced in determining the workableness of the exercises described in any newly adopted book.

It is of course highly desirable, however, to make changes in laboratory courses. Our own ideas are changing, conditions and the interests and needs of our pupils change. We must keep abreast of an advancing science. We can easily make our class-room and lecture presentations yield to the desired changes, but the manuals written for us are more unwieldy.

The writer has found that the best way to accommodate his laboratory courses to such changes in laboratory work as he has felt impelled to make is by writing and mimeographing either supplementary exercises or modifications of certain laboratory directions.

Some examples of such directions are herewith presented. (Only two are here printed: one, a supplementary exercise, of which part "c" of the procedure is a new "slant" on the subject in hand; the other is a modification of an exercise given in almost all of the general chemistry manuals). There is nothing especially new or novel in preparing one's own laboratory directions and passing them out in mimeographed form. I present the idea in this way: it enables one to continue to use a well tested and on the whole satisfactory laboratory manual and still permit him to vary his course to suit his own varying instructional ideas and also suit better the varying needs of the pupils. We are working out and trying out a considerable number of such supplementary and modified exercises in our general chemistry course at Fairmont.

I. NASCENT OR ACTIVE HYDROGEN

Discussion: The student should consult his text-book for any theoretical explanations he can find as to the difference in activity between hydrogen when just liberated from some compound and hydrogen gas as collected in a vessel. What is meant by atomic hydrogen? by molecular hydrogen? Consult your text-book or other references under the heading of atomic structure. What explanation do you find as to the greater stability of molecular hydrogen?

In the following laboratory study of the activity of hydrogen under various conditions, we shall use an acidified solution of potassium permanganate. Oxidizable substances introduced into such a solution are oxidized at the expense of the oxygen of the $\bar{MnO_4}$ ions (purple), which results in the formation of the almost colorless manganous ions (Mn^{++}) with a consequent discharge of the purple color. The reaction by which the oxygen becomes available may be represented by the following equation:

$$4KMnO_4 + 6H_2SO_4 = 4\ MnSO_4 + 2K_2SO_4 + 5O_2 + 6H_2O$$

The mere addition of acid to potassium permanganate does not bring about the reaction expressed by this equation. Only when oxidizable substances are present will the reaction take place. What valence change in this reaction does Mn undergo? Is Mn electronized or de-electronized?

PROCEDURE

(a) To 5 or 10 cc. of a faintly pink solution of potassium permanganate, add an equal volume of dilute sulphuric acid and mix by shaking. Drop into this mixture a piece of mossy zinc. What do you observe?

(b) Now arrange a small hydrogen generator. Prepare a similar mixture of potassium permanganate and dilute sulphuric acid and allow hydrogen gas to bubble from the generator through the mixture, interposing a gas wash-bottle containing water, so as not to allow any particles of zinc to pass into the permanganate-acid mixture.* Let the hydrogen thus bubble for a long enough time to enable you to determine whether or not reduction of the permanganic acid occurs.

(c) Into this same acidified permanganate solution put some clean copper shavings. Allow hydrogen from the generator to pass against the surface of the copper and through the solution. Does copper displace hydrogen from the acid present? How would you designate the effect of the presence of copper? May it be that zinc acts in the same way in (b)? Bring this point up for class discussion. Would you be interested in trying the effect of others of the less active metals?

II. ELECTROLYTIC CONDUCTION

Object: To determine what class of substances conduct electricity in water solution and certain other facts about the conductivity of solutions and liquids.

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*Note: The acidified permanganate solution is essentially a solution of permanganic acid. With this view the reaction should be written in two stages:

$$2KMnO_4 + H_2SO_4 = 2HMnO_4 + K_2SO_4$$
$$H_2SO_4 + HMnO_4 + 5H = 4H_2O + MnSO_4$$

Apparatus: Instead of the apparatus described in your laboratory manual,* use the apparatus provided by the instructor. Write your own description of this apparatus. The chief feature of this apparatus is the placing of electrodes close enough together to permit the testing of small amounts of material contained in a test-tube or watch glass.

Test the conductivity of the solutions called for in the conductivity experiment in your manual, noting as directed the relative conducting power of each as well as can be judged by the brightness of the filament. Wash carefully the electrodes after each test.

In addition make the following conductivity tests:—

a. Glacial acetic acid.

b. Ammonium hydroxide.

c. A mixture of these. What salt is formed? Are salt solutions usually good conductors? See table of degree of ionization.

d. Lactic Acid. Sp gr. 1.21.

Add one drop of water and test again. Continue to add water, drop by drop, testing conductivity after each drop.

e. Anhydrous actone.

f. The same into which is dissolved. O.1 to 1 gram of sodium iodide.

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*Ex. 39. Walton and Kranskopf.
Ex. 53. Smith's Laboratory Outline of College Chemistry (Kendall).
Ex. 69. Holmes A Laboratory Manual of General Chemistry.

SOME IMPORTANT USES FOR COAL

By C. E. LAWALL
(Professor of Mining, West Virginia University)

Never before in the history of the coal industry has it been so necessary to develop and devise new methods for the utilization of coal. The great potential capacity of the bituminous coal mines has caused the coal industry to be over developed so that it now seems imperative that new and better uses for coal be found so that there will be new demands for coal and its many varied by-products which may be manufactured in large quantities.

There are two ways to increase the demand for coal. One way is to show people what a wonderful raw material bituminous coal is for it must be remembered that bituminous coal is not only a fuel but that it is also the raw material of many of the chemical products of organic chemistry; and another way is to find new and important uses for the by-products, which are now obtained from coal and to discover new by-products by developing new processes for treating the coal under heat, pressure or by reactions with other substances.

When more new and important uses for coal are discovered its intrinsic value will be increased and the wastefulness of our coal burning and of our by-products which are grave problems facing the industry will be decreased.

BY-PRODUCTS

By-products are substances produced in the operation of a specific process, in addition to the substance of result primarily sought. Thus in hunting game for food the hides and the feathers are by-products; in hunting game for hides or pelts, the carcasses are by-products.

In older countries, the custom of utilizing by-products has been practiced for many years, though in young countries where there are abundant resources of raw material and where competition is not so severe, by-products are often wasted and even become sources of nuisances. An example of this is the by-products, which are given off from coal when it is coked in the old bee-hive ovens. The smoke and fumes and dirt which are given off from the bee-hive ovens around Connellsville and Uniontown, Pennsylvania, where no attempt is made to recover by-products, are a real nuisance to the inhabitants of these cities. It is found, however, that as the population increases the necessity for abating nuisances becomes urgent and with a diminution of the quantity of raw material and with an increase of competition, additional attention is given to the utilization of by-products. Bituminous coal has arrived at that period when much work is being done and will be done on its by-products.

Naturally the by-products that are the first to be utilized are those that are most readily observed and whose uses are most obvious. Thus it came about that William Henry Perkin in 1856 first observed that analine coloring matter could be extracted from coal tar and this discovery is what gave impetus to the coal tar industry, which has been expanding so rapidly during the past several years. What is needed now, however, is more study and research work on these by-products to develop uses and new products which are not so obvious.

The important primary by-products of coal which are obtained in the coking process are:—Gas, ammonium compounds, coal tar products and fuel oil. From these primary products hundreds of other products can be manufactured and the increasing importance of these by-products has led to the investment of millions of dollars in by-product coking ovens and in chemical industries. The by-product ovens are superseding the bee-hive ovens so that we do not find any more bee-hive ovens being built in West Virginia and many that have been built are being demolished to make room for something else.

In 1913 nearly three-fourths of our coke was made in bee-hive ovens, while in 1925 more than three-fourths of our coke was made in by-product ovens.

The unfortunate thing about the passing of the bee-hive coke oven in West Virginia is that we are not replacing the old bee-hive oven with new by-product ovens. We seem to be content to mine out our valuable coal resources and sell coal to people outside the state who from the by-products extracted from it get many times over the price paid for the coal at the mines. The state of Wisconsin, which has no coal resources has more by-product coke ovens than has West Virginia, and other states are likewise processing our coals. In this way other states are really getting the most out of West Virginia coal. If West Virginia would process more of its coal the coal industry would bring much more wealth into the state than it is bringing in at present.

GAS FROM COAL

The gases obtained from coal are used for power, heating, lighting and cooking. Gases from coal are important sources of power today because water gas, coal gas and producer gas all have their special fields of usefulness and as the demand for coke, tar and ammonia products increases the greater will be the quantity of coal used for gas making.

The gases from by-product coke ovens carry ammonia which is washed from the gas and then converted into ammonium sulphate, which is sold as a fertilizer. In nearly every modern by-product coke plant you can see large quantities of this material manufactured.

COAL TAR

When bituminous coal is heated to a rather high temperature the volatile products pass off in this distillation process. As these products are cooled they separate into two layers:—an upper aqueous portion containing ammonia in solution, and from which the ammonia salts of commerce are derived; and a lower layer of heavy black oil, which is coal tar. Coal tar contains variable quantities of 1, Hydrocarbons, the most important of which are Benzine, Toluene, Napthalene and Anthracence; 2, Phenols, the most important of which is carbolic acid; 3, Basic materials including small quantities of aniline and pyridine and other substances.

The constituents of coal tar are first partially separated by fractional distillation. This process depends on the fact that in a mixture of substances of different boiling points, those of lower boiling point distil over before those of higher boiling point; each substance being present in greatest quantity in that fraction distilling over at or about the temperature of its particular boiling point. Thus, for example, in a solution of alcohol and water, the alcohol could be separated from the water by fractional distillation because alcohol has a lower boiling point than water and at a temperature around the boiling point of alcohol most of the alcohol would distil off.

The distillates thus obtained from coal tar by this fractional distillation process are: (a) light oil, from which is obtained benzine and naptha; (b) middle oil from which is obtained carbolic acid and napthalene and their derivaties; (c) heavy oil; (d) anthracene oil and (e) finally pitch in the residue from this distillation process. It is possible that many other products may be made from pitch and at present a man at West Virginia University is doing research work on this problem.

From the above we see that from coal we obtain coke for heating and smelting; coal gas for power, heating and lighting and cooking; and coal tar and its derivatives among which are:

Light Oil	Heavy Oil
Middle Oil	Pitch

and from these in turn we may derive:

Ammoniacal liquor	Water proofing material
Ammonium sulphate	Sheep dip
Crude naptha	Dye stuffs
Carbolic acid	Perfumes
Creosote oil	Saccharine
Toluene	Disinfectants
T. N. T.	Local anesthetics
Benzol	Flavoring extracts and many other substances.

In 1925 America produced 528 million gallons of coal tar and 60 percent of this tar recovered was consumed as fuel instead of being treated to recover its phenols and cresols. This is an example of the woeful waste of our resources.

FUEL OIL

During the past fifteen years a number of scientists have been working on methods for producing crude oil from coal and several methods have already proved successful. More and more scientists are turning their attention to the problem of making oil from coal and thus far coal seems to be practically the only raw material that can be used in this process.

The principal natural sources of liquid fuels are petroleum and the gasoline frequently formed in natural gas, but as our petroleum and natural gas reserves become exhausted new sources of supply must be found and it may be in the future that we will obtain our fuel oils from coal carbonization processes which in addition to furnishing fuel oil will yield a number of valuable by-products.

One laboratory process at the present time is able to extract from bituminous coal a substitute for gasoline at a cost of about twenty cents per gallon. The importance of such a process can easily be realized when we note how rapidly the consumption of gasoline is increasing. As we have a supply of bituminous coal in West Virginia sufficient to meet our demands for fuel for centuries to come we can readily see the importance of a process that will be able to extract motor fuel from coal quickly and cheaply so that the supply of motor fuel may be replenished and the demand for coal increased.

Plans have already been completed in Germany for the construction of the first large refinery for the Aniline Dye Trust, which will use the Bergius process to convert poor quality coal and coal screenings into gasoline, kerosene and lubricating oils worth many times the market value of the coal used. The economic importance of this process may be understood when it is noted that the officials of the Aniline Dye Trust are confident that within the next few years their process will make Germany independent of American and British oil companies and already the American patent rights of this process have been purchased by the Standard Oil Company.

PRODUCTION OF COAL TAR CHEMICALS

The importance of the coal tar industry can be noted from the following table:

(Quantities in thousands of pounds; values in thousands of dollars)

1925

Item	Production Quantity	Sales Quantity	Sales Value
Intermediates	210,630	86,066	19,756
Finished Products	119,624	111,731	59,802
Dyes	86,060	79,018	36,948
Color lakes	10,770	10,652	5,055
Photographic chemicals	327	349	475
Medicinals	3,238	3,295	6,332
Flavors	2,207	2,149	1,409
Perfumes	2,335	3,371	884
Tanning material Synthetic phenolic resins	14,687	13,897	8,699

*1926 Commerce Year Book.

Thus we note the importance of coal to us by summing up the various things it provides. It furnishes the necessary power to carry on our industries. It plays an important part in the iron and steel industry, which product is so important in our commerce today and it provides heat and light for our homes and heat to prepare our food.

From its product coal tar we obtain benzol from which anti-knock motor gasolines are made, also T. N. T. for our explosives; photographing materials; water-proofing material for our garments and roofing material, tar for our highways; also many fragrant perfumes and flavoring extracts are derived from coal tar. Saccharine, a substitute for sugar being three hundred times as sweet as sugar, is a coal tar product. In addition to all these products, coal tar furnishes us with many disinfectants, stain removers, local anesthetics, synthetic drugs, such as aspirin as well as many important dye stuffs.

IMPORTANCE OF THE INDUSTRY

In conclusion I might say that coal is the foundation of the industrial and commercial development of our country and our state. It is the leading product of West Virginia, last year our state having produced 146 million tons of coal which placed it at the head of the bituminous coal producing states.

What we must do now, however, is not be content to only mine coal but we must develop ways and means of processing the coal within the state so that we can utilize to the fullest extent the vast quantities of raw material we possess. All this will require intensive research work on the part of scientists and this work can be done at the University if fuel research scholarships are established by men in the coal industry.

The reason Europe is ahead of America in coal research work is because several institutions in Europe are supported either by the government or by the coal industry while in America the United States Bureau of Mines is the only government institution that devotes any of its facilities to the study of coal. I feel sure that remarkable progress could still be made in finding new products from coal and as new products are found new uses will develop if the industry would support some fellowships at the University on this important study.

In 1865 W. Stanley Jevons wrote, "Coal in truth stands not beside, but entirely above all other commodities. It is the material source of the energy of the country—the universal aid—the factor in everything we do. With coal almost any feat is possible or easy; without it we are thrown back into the laborious poverty of early times. The progress of science and the improvement in the arts, will tend to increase the supremacy of steam and coal."

The progress of science continues to increase the supremacy of coal making it each year a more valuable raw material which can be converted into many and varied useful products.

ORIGIN AND UTILIZATION OF THE LIMESTONES

By BENJAMIN L. MILLER

(Professor of Geology, Lehigh University)

(Abstract)

In recent years, with the development of the manufacturing industry in the United States, our limestones have become increasingly important so that they merit the attention they are now receiving. This increased importance and interest extends to almost every portion of the country, and minute determinations of their physical and chemical characteristics are being made to determine their economic qualities

ORIGIN

As a result of investigations, we have considerably modified our views concerning the origin of the various kinds of limestones. Probably most of our older geologists were taught that our limestones were all derived from the shells or skeletons of calcareous-secreting animals. Those limestones in which no recognizable fossil remains could be found, were explained as due to the disintegration of the organic remains by wave action or their obliteration by subsequent crystallization or dolomitization. Although we do find limestones of the coquina type in almost every geologic period back to the early Paleozoic, the author has become convinced in his studies of recent years, that bacteria and algae have probably contributed more to the formation of our Paleozoic limestones than have the various animals that possess the ability to extract calcareous matter from the ocean waters. Seldom do we have any structures preserved that can be attributed to these low forms of plant life and consequently some persons have been inclined to believe that much of the structureless portions of limestones represents purely chemical precipitation without any connection with organisms. This view does not seem plausible because of the unusual conditions requisite to bring about sufficient concentration to result in the precipitation of the carbonates. That bacteria and algae, by their life activities, are responsible for the deposition of carbonates in warm shallow ocean waters at the present time has been well established and we believe similar plant forms are largely responsible for the precipitation of the structureless portions of our limestones of previous geologic periods.

In this brief paper it is impossible to do more than briefly refer to the origin of dolomite, a second topic of careful investigation. The literature on this subject is so voluminous and controversial as to forbid any adequate summary of the various observations and theories offered by geologists in this country and abroad. My observations have led me to believe that considerable of the magnesium carbonate has been extracted by the organisms direct, but that the limestones containing a large amount of the material have been subsequently enriched by the substitution by chemical processes of magnesium carbonate for a portion of the calcium carbonate. We know that a number of organisms build up within their endo- or exo-skeletons both calcium and magnesium carbonates. Many analyses of the skeletons of marine invertebrates and calcareous algae are available, most of which show the presence of magnesium carbonate. One species of algae from the coast of Florida contains 25.17 per cent.

Unless organisms in the past had the ability to extract from ocean water a larger amount of magnesian salts than is possessed by forms living now, it is evident that secondary action has been involved in the formation of our magnesian limestones, inasmuch as numerous strata contain more than 40 per cent $MgCO_3$. The secondary change may have been enrichment either by the removal of $CaCO_3$ or by replacement. In all probability both processes have taken place and in most cases it is difficult to say which method has prevailed.

A disputed point concerns the time when and place where the leaching of the $CaCO_3$, or its replacement, occurred. Geologists seem to favor the belief in the change having been effected mainly in the ocean bottom when the limestone existed in the unconsolidated condition as ooze or loose shells. Magnesium exists in ocean water in much larger quantity than does calcium, averaging about 3.72 per cent of the salts contained in solution. By the action of decaying organic matter in warm, shallow waters, the solution of $CaCO_3$ and also the substitution of magnesium for calcium are believed to have gone forward most rapidly. The effect of decaying organisms is shown by the selective replacement of fossil shells by dolomite in some limestones in which the matrix remains calcite.

In most cases the action of sea water probably ceased rather uniformly at shallow depths in the deposits and the variation in composition in individual beds is not marked. In places, however, one finds a bed changing in a short distance laterally from a dolomite to a low magnesian limestone. Conditions of this kind are interpreted to mean a continuation of the alteration, after the deposition of overlying deposits, due to some physical characters that gave ready access to the magnesian waters in certain places but not everywhere.

There are many other problems concerning the details of original deposition and subsequent alterations of limestones that have not been adequately investigated.

UTILIZATION

The utilization of our limestones is a matter of extreme interest at the present time and the uses have now become so numerous that space forbids a complete enumeration. We are rapidly learning that certain kinds are desirable for specific purposes and less desirable or useless for other purposes. As a result, the demands are now being made for limestones possessing very definite physical or chemical qualities or both. Frequently, stone less desirable than wanted can be substituted and is used where it can be obtained at considerably less cost. In some lines of chemical manufacturing, however, only the stone possessing the particular characteristics desired can be used and it is obtained regardless of whether the cost is much higher or not. In the utilization of limestone, regard is paid mainly to the physical characteristics in some instances and in other cases solely to the chemical composition. Naturally, the physical character is generally dependent upon the chemical composition although this is not always the case.

Uses in which physical characteristics are specified: The oldest use of limestone is for building purposes. This is still an important use in many districts and there are a few localities where limestones and marbles are quarried for shipment to all parts of the United States. In most localities where limestone is found, however, its use for structural purposes is extremely local because of its lack of some of the features that render it especially adaptable for building purposes. The factors that determine its value are mainly hardness, color, regularity and proper spacing of bedding and joint planes and ease of quarrying and dressing.

Since the use of concrete for structures has become so general and the building of concrete and macadam roads so common, there has arisen a great demand for crushed limestone. No other kind of stone has been so generally utilized. For these uses hardness and resistance to wear are the features that receive especial attention. The magnesium and siliceous varieties fulfill best these specifications.

There is another use for limestone that is gradually extending. This is as a fine powder that is serviceable where an inert substance is desired. It is used as a filler in a number of products and for dusting coal mines to prevent coal dust explosions. For these purposes the demands are for stone that is free from quartz or chert and hence easily pulverized.

Uses in which chemical characteristics are specified: Limestone, or products made from limestone, enter into the manufacture of almost countless products. Perhaps lime is the most common mineral substance in chemical manufacturing. In general, four classes of limestones are sought.

Perhaps the greatest demand is for practically pure $CaCO_3$ stone and unfortunately this is the most rare. There are always requests being made for stone that contains upwards of 95 per cent $CaCO_3$ and stone that contains 97 per cent $CaCO_3$ or better commands a premium and will justify shipment for distances of several hundred miles. These are most valuable for the production of high grade lime required in the manufacture of various chemical products. There is also a demand for this variety of stone in the manufacture of special kinds of cement and for use in the manufacture of ordinary Portland cement where the bulk of the stone is too low in lime and must be brought up to the required percentage by the addition of high grade limestone.

A second demand is for limestones with a minimum percentage of silica, the lower the better. Preference for low $MgCO_3$ is also usually expressed, although not in all cases. The greatest use for this type of stone is as a flux. Admittedly, many limestones with rather high silica content and highly magnesian are used because it may pay to use poorer grade material close at hand, and hence cheaper, than to bring better stone from a distance.

The same type of limestone has long been used for the manufacture of lime for agricultural and other ordinary purposes. In the days when most of the farmers in limestone regions burned their own lime, use was made of almost every grade of stone.

The cement industry calls for another variety of limestones. They prefer argillaceous limestones and must have stone low in magnesium carbonate. In a few places, argillaceous limestones have been formed with almost exactly the composition demanded for the raw mixture for the kilns. Usually, however, it is necessary to add either high grade limestone to increase the $CaCO_3$ content or shale or clay to increase the SiO_2, Al_2O_3, and Fe_2O_3.

A fourth class of limestones in demand is that in which there is a large amount of magnesium carbonate and a minimum percentage of silica. The most extensive use for this type of stone is in the open hearth steel furnace. No exact composition is usually demanded for this use. A rather new use for this grade of magnesian stone is for the extraction of the $MgCO_3$. For this purpose a stone containing more than 40 per cent $MgCO_3$ is desired. The product is marketed as the hydrated basic carbonate of magnesium or magnesium alba or calcined and sold as magnesium oxide. The products are used for pharmaceutical purposes, as a toilet article, or in the manufacture of rubber articles. Most of it, however, is mixed with shredded asbestos and moulded into forms for covering steam pipes where it acts as an excellent heat insulator.

The above four classes of limestone supply most of the economic needs of the present, although we might further subdivide each of the classes and specify other minor types. Further differentiations of particular kinds of limestone for specialized uses are certain to come, so it is well that we study our limestones with more detail in order that limestone users may know where to obtain the particular character of stone required.

MARBLE OF POCAHONTAS COUNTY, WEST VIRGINIA

By PAUL H. PRICE

(Assistant Geologist, West Virginia Geological Survey)

INTRODUCTION

For many years the marble deposit of Pocahontas County, West Virginia has been quite generally known. As long as 25 years ago George C. Underhill of Vermont made a brief report on this deposit for some interested parties, and in July of last year the writer prepared an advance report for the Chesapeake and Ohio Railroad Company.* At the time of Underhill's report there was no railroad in the immediate vicinity, but since then the Chesapeake and Ohio Railroad Company has built a road following the Greenbrier River within close proximity to this deposit.

The present report is made after at least three visits to the area. These visits include a close examination of the rocks as they appear at their outcrops which have been exposed to the elements for centuries. Such facts as character, position, thickness, color and availability were determined. Also samples were taken for chemical analysis and microscopic examinations.

The writer realizes the uncertainty of such an examination but as no excavation or core drilling had been done it affords the best data obtainable under such conditions. It is hoped that in the near future sufficient interest of marble quarriers will cause the deposit to be faced up or the area to be core drilled.

LOCATION

This deposit is located in the general vicinity of Hillsboro, in the southwestern part of Pocahontas County, West Virginia. It has an outcrop of from three to five miles extending around Little Mountain toward Raintown near the headwaters of Stamping Creek, and could best be reached by a siding from the Greenbrier Branch of the Chesapeake and Ohio Railway from the mouth of Stamping Creek beginning 0.7 mile north of Seebert. A good grade could be secured along the old lumber railroad right of way up Stamping Creek and the distance would varry from three to five miles, depending upon the place of opening.

*Advance Report on The Marble Deposit of Pocahontas County, West Virginia. Potahontas Times, July 28, 1927.

The following topographic map shows the location with reference to the surrounding area. Figure I.

GEOLOGY

The marble deposit comes near the top of the Greenbrier Limestone Series of rocks which is a subdivision of the larger group of Mississippian rocks of the Carboniferous System. It lies about midway between the base of the Pottsville Series and the base of the Pocono Series.

The Greenbrier Limestone is a series of limestone layers or strata, of sedimentary origin (deposited in water) made up largely from the lime of sea organisms. Since the deposition of this formation along with thousands of feet of overlying strata, it has been forced above sea-level to its present position along with the rest of the Allegheny Mountain System. It does not, however, lie in the complex folded area, but upon the west limb of the most westerly pronounced fold in this county, which is in the vicinity of Huntersville, its position being about eight miles northwest of the axis of this main fold, with a gentle slope of three to five degrees to the northwest. Under these conditions it is not likely that the marble would be found fractured or broken.

DEGREE OF METAMORPHISM

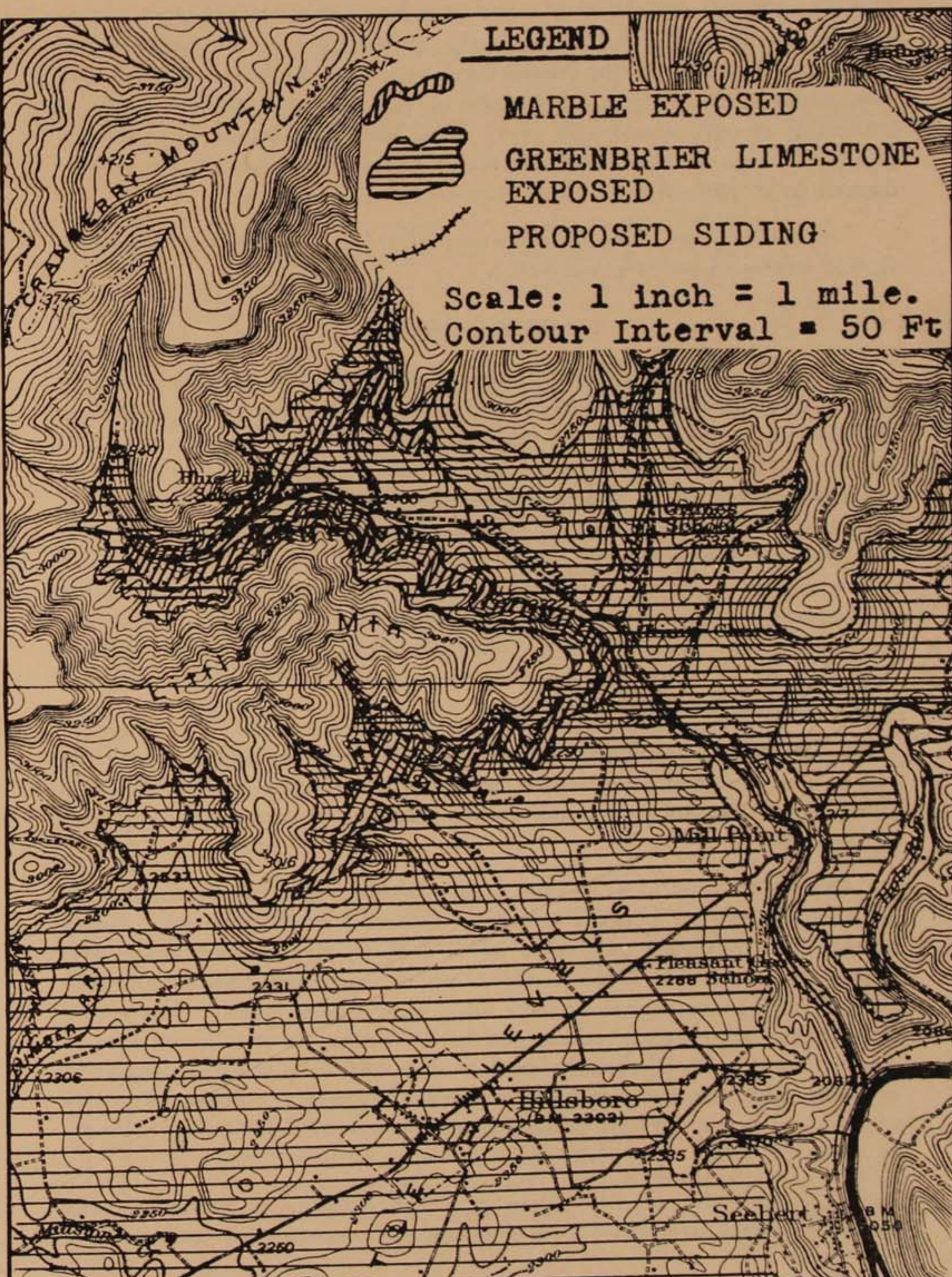
By metamorphism is meant the change that has taken place in these rocks since their origin. That some change has taken place, brought about by stresses when these rocks were elevated and folded, is to be expected. In some cases complete recrystallization takes place, destroying the original character and obliterating any evidence of the fossil life contained therein. In this deposit, however, such is not the case as many specimens of beautiful organisms are yet to be seen, the appearance of which in polished surfaces adds greatly to its beauty. The extent to which it has been metamorphosed, however, can be determined by means of the carbon ratio of the coals from its immediate vicinity. This ratio is determined by dividing the amount of fixed carbon of the proximate analysis of a local coal by the sum of the fixed carbon and the volatile matter of the same analysis. The higher the carbon ratio the greater the metamorphism. The following carbon ratios were computed from analysis of coals nearest the marble area:

No. 1. Calvin May, prospect in Pocono Coal . Carbon ratio 83.
No. 2. Preston Clark Heirs . . . . Carbon ratio 73.
No. 3. Pocahontas Coal and Land Company . . Carbon ratio 68.

THE GREENBRIER LIMESTONE SERIES

The Greenbrier Limestone Series in Pocahontas County, with one

FIGURE I.


LEGEND
MARBLE EXPOSED
GREENBRIER LIMESTONE EXPOSED
PROPOSED SIDING
Scale: 1 inch = 1 mile.
Contour Interval = 50 Ft
CRANBERRY MOUNTAIN
Mill Point
Hillsboro
Seebert

exception, lies west of the Greenbrier River and extends the entire lenth of the county for a distance of some 55 miles. This formation decreases in thickness from the southwest to the northeast. In the southern end of the county along Droop Mountain it attains a thickness of some 600 feet, while at Edray it has decreased to 400 feet and in the vicinity of Durbin it is only about 220 feet. The following figure (2) gives a general section of the limestone series and the position of the marble deposit in it. See Figure II.

It can be seen that a formation of this thickness and character should prove to be of great value.

MARBLE HORIZON

It is in the vicinity of Hillsboro that the Union Member, coming near the top of the Greenbrier Limestone, has attained a character that classifies it, to the trade, as a grade of marble. This member which is highly fossiliferous contains such marine life as blastoids (Pentremites), crinoids, brachiopods, corals, gastropods, and bryozoa (Archimedes). Along with this abundance of marine life are millions of minute concretions resembling fish roe which are called oolite. Either at the time of deposition or by later infiltration from circulating waters (probably the former) sufficient coloring was carried in to give it a pleasing appearance to the eye, and more especially when given a polish. These deposits vary in color from a red or maroon to a pinkish tinge and from that to the various shades of gray.

This marble phase varies from 25 to 40 feet in thickness with the red or maroon at the top which is highly fossiliferous and oolitic, and blends into a light fossiliferous oolite, with the various shades of gray at the base.

Above the red is a 20-foot highly fossiliferous, fine-grained dark-gray limestone that possibly could be used as a building stone. Along Marble Run there is a concealed interval of 35 feet beneath the above-named gray and then a ten-foot stratum of very fossiliferous light-gray limestone with some of the fossils filled with a pink calcite, thus giving a beautiful appearance when polished. From these observations it shows that there is a workable face of about 40 feet with the possibility of using both the overlying and underlying layers for different grades of building stone. If this could be done it would extend the thickness to some 75 feet.

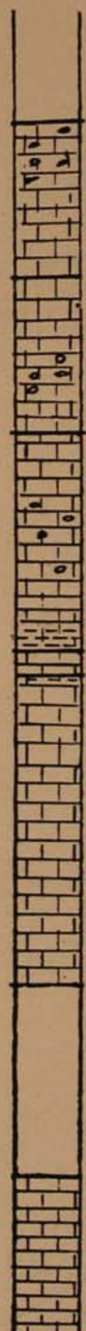
Although the marble phase of these deposits is limited to the darker shades it presents a very pleasing appearance when polished.

Figure II.

CALCAREOUS MEMBER OF GREENBRIER SERIES

(Descending stratigraphic order)
Scale: 1 inch = 80 feet.

SECTION

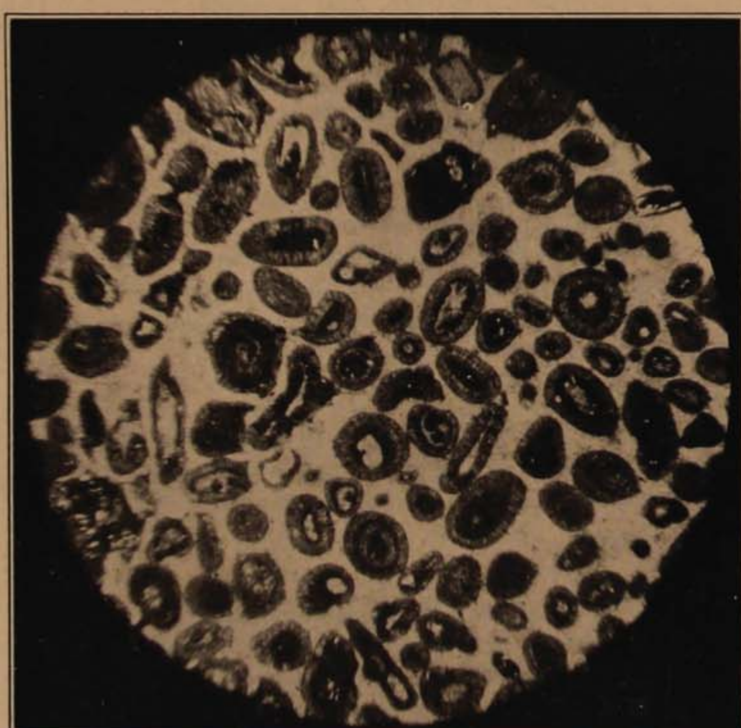


GENERAL DESCRIPTION	THICKNESS Feet
Alderson; (Glen Dean and Golconda Age) Dark-gray and somewhat sandy with crystalline streaks, very hard, numerous fossils, bryozoa (Archimedes) brachipods, crinoids, (especially Pterotocrinus) corals, and a few pelecypods	50 to 75
Union; (Marble Member), (Gasper and Fredonia Age) See heading Marble for its description	75 to 100
Pickaway; very hard and dark, brachipods, gastropods, bryozoa, and crinoids	150 to 175
Taggard; fossiliferous oolitic, usually contains a few feet of red shale both above and below	15 to 15
Patton; somewhat shaly at top, but hard and pure, weathering gray at the base. Usually contains 5 to 10 feet of light-gray oolite. Some sections show occasional nodules of black chert	100 to 150
Sinks Grove; blue, hard, and somewhat sandy, weathers yellow at top and dark-gray at the base. Often contains nodules of black chert	50 to 75
Hillsdale; (St. Louis Age as correlated in Kentucky) massive, hard, gray, and blue fossiliferous limestone. Basal 15 feet contains nodules of dark and gray chert. Profuse marine fossils, especially Lithostrotion proliferum and L. canadense	50 to 75
Total	490 to 665

MICROSCOPIC STRUCTURE

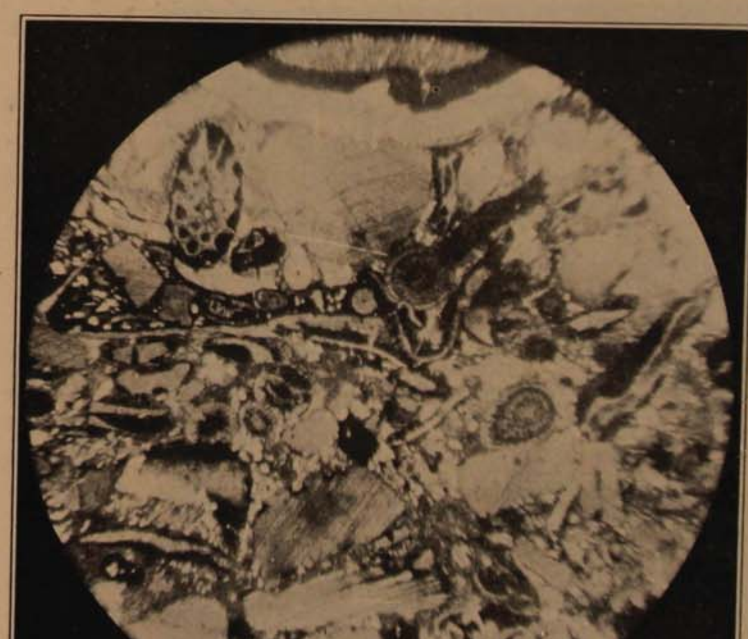
A better idea of the character, contents and structure can be gained from an examination of thin sections of rocks under the microscope. These samples were all taken from the area in the vicinity of Hillsboro.

As would be expected the predominating constituent is calcium carbonate largely from the shells of marine organisms, ranging from 76 to 97 per cent. Silica, both colloidal and crystalline, is present in small quantities ranging from a little over one to 13 per cent. A small amount of ferric iron is present to give it color, along with other small amounts of alumina, magnesium carbonate, with a trace of phosphoric acid in samples Nos. 1 and 5.



No. 1. Photomicrograph Light-gray Oolite.

No. 2. Photomicrograph. Pink or Dove-colored Oolite.
X about 20.



No. 3. Photomicrograph. Dark-gray Oolite.
X about 20.

No. 4. Photomicrograph—Dark-gray (Crinoid Stem) Oolite. X 20.

No. 5. Photomicrograph—Dull Red. Outcrops near Raintown. X 20.

CHEMICAL ANALYSIS OF POCAHONTAS COUNTY (LIMESTONE) MARBLE

(Analyses made by B. B. Kaplan, Chemist, West Virginia Geological Survey).

	No. 1	No. 2	No. 3	No. 4	No. 5
Silica (SiO_2)	1.28	2.68	6.56	9.60	13.00
Ferric Iron (Fe_2O_3)	0.10	0.60	0.60	1.20	2.02
Alumina (Al_2O_3)	0.46	1.72	3.18	2.76	4.00
Magnes. Carb. ($MgCO_3$)	0.41	0.75	1.40	2.04	2.01
Calcium Carb. ($CaCo_3$)	97.22	94.16	86.83	81.72	76.84
Phosphoric Acid (P_2O_5)	trace	0.00	0.00	0.00	0.69
Loss on Ignition	0.60	0.10	1.10	1.86	1.25
Total	100.07	100.01	99.67	99.18	99.81

No. 1. Light-gray oolite from the Union Member of the Greenbrier Limestone, from the J. S. McNeil Property.

No. 2. Pink to dove-colored oolite, from the Union Member of the Greenbrier Limestone, from the J. S. McNeil Property.

No. 3. Dark-gray oolite from the Union Member of the Greenbrier Limestone. Property of J. S. McNeil.

No. 4. Dark-gray (Crinoid oolite) from the Union Member of the Greenbrier Limestone, near Hillsboro.

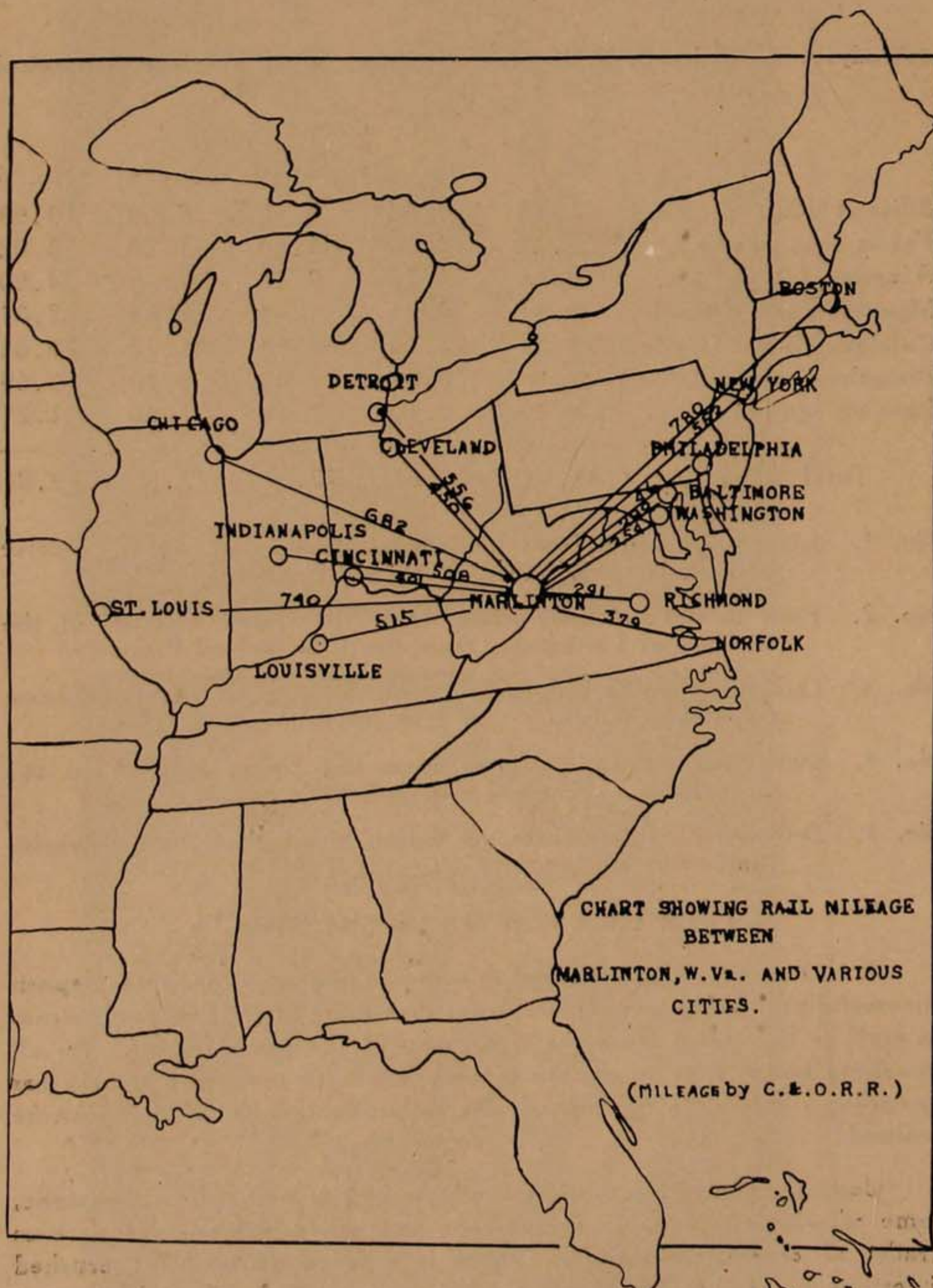
No. 5. Dull red. Sample from the Union Member of the Greenbrier Limestone at Raintown.

OTHER USES FOR SUBJACENT STRATA

It is the writer's opinion that in order to operate this marble deposit successfully it would be necessary to utilize some of the subjacent strata as well as the waste from the quarrying of the marble itself. As all quarriers know, it is an expensive proposition to prepare a quarry for operation. But often by utilizing the by-products a good profit can be realized.

Beneath the marble there is available 200 to 300 feet of limestone, some of which is suitable for cement and other portions for various grades of crushed limestone. There is a large demand for crushed limestone for road building, railroad ballast, etc. There is at the present time an inquiry for a quarry in this vicinity that could furnish 300 tons of crushed limestone a day. There is little doubt that this area will produce suitable stone.

FIGURE 3.


BOSTON
NEW YORK
PHILADELPHIA
BALTIMORE
WASHINGTON
RICHMOND
NORFOLK
DETROIT
CLEVELAND
CHICAGO
INDIANAPOLIS
CINCINNATI
ST. LOUIS
LOUISVILLE
MARLINTON
682
556
740
515
291
379
CHART SHOWING RAIL MILEAGE
BETWEEN
MARLINTON, W. Va. AND VARIOUS
CITIES.
(MILEAGE by C.&.O.R.R.)

AVAILABILITY TO MARKET

The following figure (3) gives the railroad mileage to the principal markets of the east. It can be seen that the area under consideration lies near the center of the best markets east of the Mississippi.

CONCLUSIONS

In conclusion I would say that in the area under discussion there is an abundance of "marble" that ranges in color from red or maroon to several shades of gray, any of which is suitable for building stone and from 25 to 40 feet of which can be used for decorative purposes when polished.

Along with the marble is some 200 to 300 feet of limestone, part of which is suitable for the manufacture of cement while other portions are suitable for any grade of crushed limestone.

Because of its proximity to the markets, along with the increasing demands for all the above products, it is the writer's belief that this deposit will not long remain undeveloped.

THE CHEAT MOUNTAIN COAL FIELD OF RANDOLPH COUNTY, WEST VIRGINIA

By DAVID B. REGER

(Acting State Geologist, West Virginia Geological Survey)

LOCATION

The Cheat Mountain Coal Field lies in a narrow basin in central Randolph County, extending into Tucker County on the north and Pocahontas on the south. The North Potomac (Georges Creek) Syncline in which it is situated extends much further northward through West Virginia, Maryland, and Pennsylvania but for the purpose of this paper discussion will be limited on the north by the valley of Dry Fork of Cheat River which cuts the basin in two 3½ miles south of Hendricks, Tucker County; and on the south by the head of Shavers Fork of Cheat 3½ miles west of Cass, Pocahontas County.

Within the limits named the dimensions of the field are roughly 54 by 4 miles the longer axis having a direction of approximately North 30° East and the shorter North 60° West. In Tucker County it embraces the valley of Otter Creek bounded on the west by McGowan Mountain and on the east by Shavers Mountain; in Randolph it includes the valley of Shavers Fork of Cheat from Meadows Station to Faulkner, Bowden, Flint, Bemis, Cheat Bridge, and on southward to the Pocahontas line, as limited on the west by Bickle Knob, Pond Lick Mountain and Cheat Mountain and as strictly bounded on the east by Shavers Mountain and Back Allegheny; in Pocahontas it includes the extreme southern end of the Shavers Fork valley limited on the west by Cheat Mountain and Mace Knob, on the east by Back Allegheny, and on the south by the Thorny Flat.

TOPOGRAPHY

The physical aspect of this region is extremely rough. At the mouth of Otter Creek the railroad elevation is 1,787 feet and at the head of the same stream the divide is 3,110 feet. West of Otter Creek McGowan Mountain is generally 3,500 feet or more, terminating with Bickle Knob which is 4008. On the east the summits of Green and Shavers Mountain vary from 3,500 to 3,750 feet. This valley is all cutover land almost totally uninhabited and having no roads except the trails maintained by the Monongahela National Forest which owns the surface.

On Shavers Fork the river at Meadows is 2,150 feet and rises to 4,500 feet at its head, being a turbulent stream all the way. Cheat

Mountain on the west, with the exception of certain low gaps, varies from 4,005 feet at Pond Lick Mountain to 4,705 feet at Mace Knob. On the east Big Knob of Shavers Mountain east of Bowden is 3,825 feet and Bald Knob north of Cass is 4,842 feet, while the Thorny Flat at the head of the river is 4,839 feet. Centering about Bowden there is a farming community but from Bemis southward the valley is uninhabited except for settlements at Cheat Bridge and Hopkins. This upper valley is all out-over and without trails except that it is traversed longitudinally by a railroad and is crossed by a highway at Cheat Bridge.

TRANSPORTATION

On Dry Fork the Central West Virginia and Southern Railroad, tributary to the Western Maryland Railway at Hendricks, passes the mouth of Otter Creek. On Shavers Fork the Durbin Branch of the Western Maryland, from Elkins to Durbin, passes up the valley from Meadows through Faulkner, Bowden, Flint and Bemis to Cheat Junction where it tunnels through Shavers Mountain and connects with the Cheasapeake and Ohio Railway at Durbin.

From Cheat Junction, south of Bemis, a lumber railroad, formerly known as the Greenbrier, Cheat and Elk, extends up Shavers Fork to Spruce where it divides, with one branch crossing Back Allegheny to Cass on the Chesapeake and Ohio and with another running westward to Bergoo on the Elk River 10 miles above Webster Springs. The Greenbrier, Cheat and Elk was built by the West Virginia Pulp and Paper Company for logging but in 1927 was acquired by the Western Maryland and hence has become permanent.

From Elkins eastward State Route 53, which is mostly unimproved, passes through and across the lower valley of Shavers Fork at Faulkner and Bowden. At Bemis an old county road from Beverly to Glady crosses Shavers Fork but is impassable across Cheat Mountain and passable only with difficulty across Shavers Mountain. At Cheat Bridge State Route 56 from Huttonsville to Durbin, generally known as the Staunton and Parkersburg Pike, crosses Shavers Fork. This road is partly graded and passable most of the year.

The structure of the field is that of a very narrow basin, generally dipping northeastward and having a fairly flat middle portion from which the coal rocks rise rather steeply to the great mountain escarpments of McGowan and Cheat on the west, and Shavers and Back Allegheny on the east. Southward the basin gradually rises and flattens until it is almost imperceptible at the head of Shavers Fork and soon afterward merges into the bolder structural slope which forms the northern rim of the Greenbrier valley. The axis of the North Potomac

GEOLOGY AND ROCK STRUCTURE

Within the coal field the rocks are entirely of Carboniferous age, the outcropping subdivisions in descending order being as follows:

SYSTEM	SERIES	GROUP	DESCRIPTION
Pennsylvanian	Conemaugh	———	(100′+); Poorly exposed in top of Green Mountain.
	Allegheny	———	(100-150′); Poorly exposed in top of Green Mountain.
	Pottsville	Kanawha	(350-650′); Sandstones, shales and coals, best exposed around Bemis and on Otter Creek.
		New River	(200-325′); Sandstones, shales and coals, Sewell, etc.; widely exposed.
Mississippian	Mauch Chunk	Bluestone Princeton Hinton Bluefield	(700-1,200′); Red shales, sandstones and limestones; no valuable coals; widely exposed.
	Greenbrier	———	(200-400′); Mostly limestone; outcrops around Bowden and at mouth of Otter.
	Pocono	———	(50-150′); Sandstones and shales; no good coals; outcroops west of Bowden.

Omitting further description for the sake of brevity the following table of intervals for various points, using the Sewell as the base, will be useful:

TABLE OF INTERVALS ABOVE AND BELOW SEWELL COAL

	Otter Creek	Bowden	Bemis	Cheat Bridge	Hopkins
Upper Freeport Coal . . . . (a)	(800)	. . .	. . .	. . .	. . .
Upper Kittanning Coal . . . . (d)	(760)	. . .	. . .	. . .	. . .
Middle Kittanning Coal . . . . (d)	. . .	. . .	. . .	. . .	. . .
Lower Kittanning Coal . . . . (d)	(725)	. . .	(900)	. . .	. . .
Clarion Coal . . . . (d)	. . .	. . .	. . .	. . .	. . .
Homewood Sandstone (top)	700	. . .	875	. . .	. . .
Upper Mercer Coal . . . . (d)	625	. . .	825	. . .	. . .
Lower Mercer (Stockton) Coal . . . (d)	600	. . .	800	. . .	. . .
Quakertown Coal . . . . (c)	500	600	700	(700)	. . .
Chilton Coal . . . . (c)	. . .	. . .	560	560	. . .
Cedar Grove Coal . . . . (c)	400	. . .	530	540	. . .
Alma Coal . . . . (d)	. . .	. . .	490	510	. . .
Campbell Creek (Peerless) Coal . . (c)	325	. . .	450	475	. . .
Powellton Coal . . . . (d)	. . .	. . .	400	425	. . .
Eagle Coal . . . . (c)	275	325	375	375	375
Gilbert Coal . . . . (b)	200	250	275	225	250
Douglas Coal . . . . (d)	. . .	230	230	. . .	225
Lower Douglas Coal . . . . (c)	. . .	225	225	. . .	210
Upper Nuttall Sandstone (top)	175	220	220	200	200
Hughes Ferry Coal . . . . (a)	100	150	150	160	125
Lower Iaeger Coal . . . . (d)	. . .	125	125	125	100
Castle Coal . . . . (c)	50	75	75	100	75
Sewell "B" Coal . . . . (c)	. . .	40	40	50	40
SEWELL COAL . . . . (a)	0	0	0	0	0
Welch Coal . . . . (b)	(25)	(30)	30	40	40
Little Raleigh Coal . . . . (d)	. . .	(60)	60	(70)	. . .
Beckley Coal . . . . (d)	. . .	. . .	80	. . .	. . .
Fire Creek Coal . . . . (b)	110	(80)	100	100	115
Little Fire Creek Coal . . . . (d)	. . .	. . .	110	. . .	. . .
Base of Pottsville	110	100	110	100	115

a. Generally minable throughout region of outcrop.

b. Minable in limited areas.

c. Minable at a few points, extent unknown.

d. Thin, absent or worthless.

(Georges Creek) Syncline enters the territory from the north at the mouth of Otter Creek, passes southwestward to the extreme head of this creek, extends down Taylor Run and crosses Shavers Fork at the Chestnut Grove School east of Bowden. From this point southward, except in certain wide bends of the river, it lies generally on the west side of Shavers Fork, being 0.4 mile west of Flint, 1 mile west of Bemis, 1.4 miles west of Cheat Bridge, 0.5 mile west of Hopkins and about 1.1 miles west of Spruce. From this description it should be apparent that the greater amount of coal lies on the west side of Shavers Fork.

In the lower valley of Otter Creek, in the Shavers Fork valley from Faulkner and Bowden toward Flint and Bemis, and in the Upper Shavers Fork valley about Cheat Bridge the base of the coals is many hundreds of feet above drainage but along the upper half of Otter Creek and on Shavers Fork between Bemis and Cheat Bridge the Sewell Coal is seldom far above water level, being slightly below it for a short stretch on Otter.

DISCOVERY OF COAL AND START OF MINING

It has been known to geologists for perhaps a century that rocks of Carboniferous age covered portions of the valleys of Otter Creek and Shavers Fork but owing to isolation and rough topography no early attempts were made to study the coals. The surface generally of this whole region is covered with such a thick mantle of rock debris and so reinforced by vast thickets of rhododendron that natural outcrops of coal are extremely rare.

Probably the first use of any coal in the basin was during the Civil War of 1860-65 when the Federal troops entrenched along the Staunton and Parkersburg Pike on White Top Mountain west of Cheat Bridge opened a roadside outcrop of Gilbert Coal and used it for camp fuel. For nearly half a century no further mining was done and even during the construction of the Coal and Iron Railroad (now Western Maryland) from Elkins to Durbin in 1902-3 coal was laboriously hauled by wagon from the Hart Mine on Rich Mountain west of Beverly to Bemis, a trip of 15 miles over extremely rough roads and high mountains. Before completion of the road, however, exposures of the Sewell and Fire Creek Coals were found near the grade a mile above Bemis and these coals were then used. Following the completion of the railroad there was no attempt at commercial mining in the Shavers Fork Valley.

In 1905, or thereabouts, Mr. H. F. Cromer, land agent of the West Virginia Pulp and Paper Company, discovered and prospected the Gilbert Coal at the present location of the Hopkins Mine and at the same time the Sewell Coal was prospected by this company along the pike west of Cheat Bridge and at Stonecoal Run farther north and at the Clubhouse opening farther south. Concurrently the company bored seven test holes between Cheat Bridge and Hopkins.

In 1906, the late Dr. I. C. White, State Geologist, privately examined the lands of the West Virginia Pulp and Paper Company on Shavers Fork and advised that the coal at Hopkins be used for its logging operations and shortly afterward mining at Hopkins began. At the same time Dr. White examined and sampled other prospects and in 1908 published excerpts of his report in Volume II(A) of the West Virginia Geological Survey, thereby first calling public attention to these coals, which he generally classed in the New River Group.

In 1917, the writer made a private report on the West Virginia Pulp and Paper Company lands, supervised the drilling of 10 additional holes, identified the Fire Creek, Sewell, Hughes Ferry, Gilbert and other coals, and made a rough outcrop map of the same with an estimate of tonnages.

In 1918-20, the company opened for commercial mining the Fire Creek Coal at Deer Lick and the Sewell at Big John, Linan, Whitmeadow and Red Run. All these operations were abandoned a few years later during the slump in coal production and prices.

In 1925-26, the Thompson tract on Shavers Mountain northeast of Bemis was prospected by the owners and the Sewell Coal was found in good thickness and quality. At the same time the Camden property on Cheat Mountain southwest of Flint was prospected by Mr. J. D. Walker.

In 1926, the writer began a detailed study of the geology of the eastern three-fourths of Randolph County, and taking as a base on the south the knowledge previously acquired on the West Virginia Pulp and Paper Company lands and on the north the Tucker County Report of the West Virginia Geological Survey prepared by himself in 1923, was able to trace the Sewell and other coals from Flint to Bowden, Pond Lick Mountain, Bickle Knob and the head of Otter Creek. In the seasons of 1926-27, with the help of mountain guides and with labor furnished by the land owners the coals of this whole region from Flint to Otter Creek were opened and proved for the first time under his supervision.

In August, 1927, the Walkers New River Mining Company shipped its first car load of Sewell Coal from Montes and a few months thereafter the Monserrat Mining Company began commercial shipments of Sewell Coal from its mine on Fishinghawk Creek near Bemis. Under the stimulus of good reports on these pioneer shipments prospecting has gone rapidly forward and numerous new mines seem assured.

DESCRIPTION OF COALS

In a brief paper it is quite impossible to do more than barely review the characteristics of certain important minable coals. It may be said in general, however, that all these coals are soft in structure and high in fixed carbon, approaching but not reaching the qualities of a smokeless coal.

COALS OF ALLEGHENY AND KANAWHA GROUPS

The **Upper Freeport Coal** is believed to occur in the high plateau of Green Mountain and should be of minable thickness in view of its good development at Thomas and Davis.

The **Kittannings, Clarion,** and the **Mercers** are not known or believed to be of value. The **Quakertown (Winifrede)** has a fair thickness at one or two observed points and when fully prospected may produce a small tonnage.

The **Chilton, Cedar Grove,** and **Alma** are of doubtful value, there being little positive evidence of minable coal. The **Campbell Creek (Peerless)** makes a good showing on the old mountain road (Mine No. 2) west of Bemis and possibly elsewhere, and is worthy of serious attention.

The **Powellton** amounts to nothing but the **Eagle,** in the region south of Bemis has been found in fair thickness and quality in certain borings.

The **Gilbert** has been mined for many years at Hopkins and can usually be found in variable thickness as far north as Dry Fork River.

The **Douglas** makes no showing but at a few points the **Lower Douglas** has a fair thickness but does not appear persistent.

COALS OF NEW RIVER GROUP

The **Hughes Ferry,** under its protective mantle of Nuttall Sandstone, is usually present in fair thickness but is difficult to prospect owing to debris from the cliff. In future years it should afford a large tonnage of good coal. The **Castle** shows some very good coal in the region adjacent to Bemis and it should evidently prove minable over a considerable area.

The **Sewell "B"** is also very good at certain openings on Fishinghawk but elsewhere it has not been found in quantity.

The Sewell is by far the best and most important coal of the region, generally having a bony ply at the bottom but being otherwise mostly without impurities from Dry Fork as far south as Linan Mine. In the above territory the quality of this coal is equalled or excelled by few, if any, regions on earth. South of Linan it develops a bony cannel parting which greatly impairs its value although it is yet thick enough for the upper and lower benches to be recovered. The bony ply at the base, while worthless for fuel, affords a place for machine cutting and when removed gives head room.

Th **Welch** is nearly always thin or bony and offers little hope of commercial coal. The **Fire Creek** has been mined at Deer Lick and in the surrounding region, between Cheat Bridge and Bemis will eventually afford a considerable tonnage.

ESTIMATE OF TONNAGE

In making an estimate of tonnage it is thought best to omit for the present certain coals on which the evidence is not yet good enough to base an opinion and hence only the **Upper Freeport, Gilbert, Castle, Hughes Ferry, Sewell** and **Fire Creek** are figured, some of these even being judged of no importance in certain areas.

The following tables give the amount of supposed minable coal in each of the six coals above mentioned, as measured with planimeter from outcrops on the map, or as closely interpolated as in the case of the Castle and Fire Creek:

UPPER FREEPORT COAL
(Acreage computed from outcrop)

Counties by Districts	Thickness of Coal Assumed Feet	Square Miles	Acres	Cubic Feet of Coal	Short Tons of Coal. (2,000 Lbs.)
Tucker Co.:					
Dry Fork	3	1.55	992	129,634,560	5,185,382

GILBERT COAL
(Acreage computed from outcrop)

Counties by Districts	Thickness of Coal Assumed Feet	Square Miles	Acres	Cubic Feet of Coal	Short Tons of Coal. (2,000 Lbs.)
Randolph Co.:					
Beverly	1½	6.04	3,865.6	252,578,304	10,103,132
Valley Bend	1½	11.29	7,225.6	472,120,704	18,884,828
Huttonsville	2	10.08	6,451.2	562,028,544	22,481,142
Mingo	4	1.22	780.8	136,046,592	5,441,864
Dry Fork	...	.....	......	....	....
Totals		28.63	18,323.2	1,422,774,144	56,910,966
Pocahontas Co.:					
Greenbank	3	0.53	339.2	44,326,656	1,773,066
Edray	3	0.10	64.0	8,363,520	334,541
Totals		0.63	403.2	52,690,176	2,107,607
Grand Totals		29.26	18,726.4	1,475,464,320	59,018,573

HUGHES FERRY COAL
(Acreage computed from outcrop)

Counties by Districts	Thickness of Coal Assumed Feet	Square Miles	Acres	Cubic Feet of Coal	Short Tons of Coal. (2,000 Lbs.)
Tucker Co.:					
Black Fork	1	1.95	1,248	54,362,880	2,174,515
Dry Fork	1	5.44	3,481.6	151,658,496	6,066,340
Totals		7.39	4,729.6	206,021,376	8,240,855
Randolph Co.:					
New Interest	1	0.44	281.6	12,266,496	490,660
Leadsville	1	0.05	32.0	1,393,920	55,757
Beverly	1½	7.60	4,864.0	317,813,760	12,712,550
Valley Bend	1½	16.10	10,304.0	673,263,360	26,930,534
Huttonsville	1½	19.37	12,396.8	810,006,912	32,400,276
Mingo	1½	2.73	1,747.2	114,162,048	4,566,482
Dry Fork	1½	20.11	12,870.4	840,951,936	33,638,077
Totals		66.40	42,496.0	2,769,858,432	110,794,336
Pocahontas Co.:					
Greenbank	1½	1.69	1,081.6	70,671,744	2,826,870
Edray	1½	0.46	294.4	19,236,096	769,444
Totals		2.15	1,376.0	89,907,840	3,596,314
Grand Totals		75.94	48,601.6	3,065,787,648	122,631,505

CASTLE COAL
(Acreage estimated)

Counties by Districts	Thickness of Coal Assumed Feet	Square Miles	Acres	Cubic Feet of Coal	Short Tons of Coal. (2,000 Lbs.)
Randolph Co.:					
Beverley	1½	6.50	4,160	271,814,400	10,872,576
Valley Bend	1½	12.50	8,000	522,720,000	20,908,800
Huttonsville	1½	15.00	9,600	627,264,000	25,090,560
Mingo	1½	2.00	1,280	83,635,200	3,345,408
Totals		36.00	23,040	1,505,433,600	60,217,344

SEWELL COAL
(Acreage computed from outcrop)

Counties by Districts	Thickness of Coal Assumed Feet	Square Miles	Acres	Cubic Feet of Coal	Short Tons of Coal. (2,000 Lbs.)
Tucker Co.:					
Black Fork	2½	3.24	2,073.6	225,815,040	9,032,602
Dry Fork	2½	6.02	3,852.8	419,569,920	16,782,797
Totals		9.26	5,926.4	645,384,960	25,815,399
Randolph Co.:					
New Interest	2½	0.72	460.8	50,181,120	2,007,245
Leadsville	2½	0.11	70.4	7,666,560	306,662
Beverly	3	9.30	5,952.0	777,807,360	31,112,294
Valley Bend	3	21.67	13,868.8	1,812,374,784	72,494,991
Huttonsville	3	31.75	20,320.0	2,655,417,600	106,216,704
Mingo	3	5.48	3,507.2	458,320,896	18,332,836
Dry Fork	3	26.09	16,697.6	2,182,042,368	87,281,695
Totals		95.12	60,876.8	7,943,810,688	317,752,427
Pocahontas Co.:					
Greenbank	3	6.73	4,307.2	562,864,896	22,514,596
Edray	3	1.06	678.4	88,653,312	3,546,132
Totals		7.79	4,985.6	651,518,208	26,060,728
Grand Totals		112.17	71,788.8	9,240,713,856	369,628,554

FIRE CREEK COAL
(Acreage estimated)

Counties by Districts	Thickness of Coal Assumed Feet	Square Miles	Acres	Cubic Feet of Coal	Short Tons of Coal. (2,000 Lbs.)
Randolph Co.:					
Valley Bend	1½	24.00	15,360	1,003,622,400	40,144,896
Huttonsville (a)	1½	20.00	12,800	836,352,000	33,454,080
Dry Fork	1½	1.50	960	62,726,400	2,509,056
Totals		45.50	29,120	1,902,700,800	76,108,032

(a) North of Cheat Bridge only.

From the above tables the totals for all six coals amount to 692,-789,390 short tons. With 80 per cent of recovery it is evident that the final tonnage to be mined and shipped would be 554,231,512 short tons.*

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*For map of the territory and for tables of coal mines and exposures showing thickness, quality and results of analyses and tests and records of borings, see Bulletin No. 3 on the Cheat Mountain Coal Field of Randolph County; West Virginia Geological Survey.

OBSERVATIONS OF MINE TIMBERING IN THE SCOTTS RUN DISTRICT

By WM. A. STAAB

(Department of Mining, West Virginia University)

Roof control has always been an important factor in mining operations and has always demanded serious attention. Its importance is being accentuated by numerous statistics compiled in the interest of safety. Even with no loss of life a fall of roof is a very costly event and an operating mine subject to numerous falls is under a great handicap. The last published report of the West Virginia Department of Mines covering the period from July 1, 1924, to December 31, 1925, shows 34.58 per cent of the total serious mine accidents in West Virginia as being due to falls of roof, while 52.33 per cent of the fatal accidents are laid to that cause. This last figure is close to the average for the entire United States. These facts alone should cause the mining fraternity to focus its attention on ways and means of improvement in the support of underground excavations.

The various states in which mining is carried on recognize the need for rules and regulations as to roof support and accordingly we find on the statute books laws referring to timbering. A brief of the West Virginia laws in regard to timbering is as follows:

Operator.—To deliver timbers to such points as provided in mine rules; to adopt special rules for governing and operating mine; have rules printed and posted in conspicuous place about mine; and furnish copy of rules to any employee requesting it.

Superintendent.—No duties prescribed by law relating to timbering or roof conditions.

Mine Foreman.—To require roof and sides of refuge holes to be made secure; have all loose material overhead removed or secured; see that sufficient timber is available; examine timbering in every working place daily; direct that working places be made secure; if place is in dangerous condition, remain until it is made safe, or remove persons occupying place; give prompt attention to dangers reported to him; notify workmen to vacate place if danger can not be removed at once; and examine air courses and ways leading to old workings each week, recording conditions in a book for that purpose.

Fire boss.—No specific duties prescribed by law relating to timbering or roof conditions.

Machine men.—To make sure roof is safe before starting machinery.

Miners.—To examine thoroughly place before commencing work; to make safe any dangerous condition before commencing work or vacate place; when needing timber, to notify person delegated at least one day in advance (in emergency, timber may be ordered immediately); keep working place propped at all times; and examine roof carefully before resuming work after blasting.

(Abstract from Bureau of Mines Technical Paper No. 421.)

It will be noticed that the mine foreman is held responsible for safe operating conditions and nowhere in the mining law are these responsibilities nullified.

Unfortunately for the men engaged in mining, no definite rules or regulations can be made which will successfully cover all mining conditions. Coal beds are associated with other sedimentary rocks, these being strata of varying thickness with a wide difference in characteristics, varying from fire clay, soft shales and slates to sandstones and dense limestones. We find that after the removal of the coal the stronger strata may act as a beam and ride over the remaining coal, or that the softer strata may flake off due to the action of air and moisture, and gradually fall over the area from which coal has been removed with a tendency to arch and support itself.

If as coal is extracted from the earth it would be necessary to support the entire overlying rock mass, accurate calculations of the weight to be supported could be made, though such support would be impossible. The uncertainty which attends the actual weight that will come on any support, together with the uncertain way in which the roof may act due to weathering and previously existant cracks or fissures makes any exact calculation impossible. Successful timbering is dependent upon human judgment tempered with experience. These widely varying conditions of roof are illustrated by the fact that in one mine no timber was being used in the rooms at the time the inspection was made, but a few months later in a new section of the same mine props were not sufficient to hold the roof and cross bar timbering was being used.

The cost factor also must be considered. Mine timber is becoming increasingly scarce and therefore more costly so that now the cost of timber is a good sized item on the mine cost sheet, the actual setting of the timber in place costing in many cases more than the timber itself. No figures are available but using a rather low consumption per ton West Virginia as a whole should be using around 50,000,000 cubic feet of mine timber annually.

A good but difficult rule to follow is to use that amount of timber which will give proper support at least expense. The term timbering as used by coal miners refers to all types of underground support as well as to wood, the term steel timber being of common use.

The district under consideration known as Scotts Run is located in Monongalia County four miles northwest of Morgantown, West Virginia. In this locality the Waynesburg and Redstone seams have been worked to a very small extent, but major operations are confined to the Pittsburgh and Sewickley beds, observations of roof support being confined to the Pittsburgh and Sewickley seams.

The Pittsburgh seam in this district is comparatively flat but has a general dip of from one to two per cent to the northwest. It is very uniform in height, averaging eight to nine feet. Above the Pittsburgh coal proper we find draw slate and frequently a bony rooster coal, which means that if the entire height of Pittsburgh was mined, the roof would invariably come in with the coal. Therefore, it is the practice to leave up from one to two feet of roof coal which serves as a support to the draw slate, keeping the air away from it. This gives a mining thickness of from six to seven feet for the Pittsburgh coal.

The Sewickley seam dips in the same general direction, but the height of coal varies from thirty-nine inches at the mouth of Scotts Run where the seam crops along the Monongahela River to a little over six feet at other points. The roof is mainly slate which is overlaid by a sandstone which sometimes comes down to the coal. The slate will vary in thickness from nothing to twenty-five feet. This coal is mined clean at the roof and the slate top as a whole is very good. In some sections this slate top has a tendency to break along the rib and fall in, following the excavation.

The mines of this district are worked by the room and pillar system, or a variation thereof in the form of a block or panel system. In most cases the pillars are being robbed along with other room work and in one or two cases robbing old room pillars constitutes almost the entire source of output.

As would be expected the major amount of timber is used in room work, rooms in the various mines being driven from 12 to 25 feet in width. The majority of mines visited were inclined to be systematic in room posting. Variations in room posting were from no posts at all to one and two rows of props and occasionally a third row if room was wide and roof uncertain.

Rooms are generally driven face on the cleat which is very pronounced in both the Pittsburgh and Sewickley seams. Props are set square and well wedged with cap pieces which as a rule are driven parallel with the rib. One exception to this rule of wedging props was noticed in one Pittsburgh mine, all caps in this mine being driven at right angles to the rib, the officials claiming that this change enabled them to hold their roof much better. Spacing of props varies from 4 to 7 feet along the room and as a rule props where used are kept well up to the face leaving enough room for the machine to cut. Only one or two mines find it necessary to set safety props at the face while men are working. Where one row of props is used the track is run up one side of the room, where two rows are used, track is in the room center. In a few extreme cases three piece or cross bar timbering is used in rooms in which case regular mine props are used for legs and the cross bar may be either round or sawed timber. If round timber is used for the crossbar or collar it is hewed flat at the ends so as to give a good bearing on the legs and possibly the top is flattened off to give a better bearing against the roof and to assist proper wedging. The legs are set vertically and no other framing is done. Except in one or two cases where the regular mine timbermen are required to set the first four or five posts in a room all room props are set by the loaders.

The bulk of the mine props used in the district are purchased locally. Any hard wood is used with a preference for oak and the endeavor is made to secure straight props with a minimum diameter of 4 or 5 inches, depending on the length of prop. They being purchased from 4½ to 8 feet long according to the height of coal mined. Both split and round props are used and the split prop should have a cross section area equal to minimum diameter for a round prop. None of the mines purchase cap pieces, these being made by the timberman and loader from old ties and props or the waste from props cut to fit room height.

The entries are driven narrow, usually about 12 feet and no support is used unless the roof is bad. Support in such cases may be an occasional post or brick pier capped with wood, but is usually a three piece set. If the roof has fallen before supports were erected the space above the timber is cribbed to the present top if that top is still bad. If all loose material is down and the roof strata is solid no support is used.

Some very good examples of permanent entry timbering are to be found where a consistantly bad roof was encountered. One mine uses H beams for collars and sawed timber for the legs, legs being set vertical and no framing required. Another mine used heavy rails, cutting out the end of heavy round props to fit the inverted rail, thus obtaining a better bearing. Sets were spaced as experience dictated and lagging was only used as required and none was used along the rib.

While the percentage of fatal accidents due to falls of roof in this district is much less than for the state as a whole it does seem as though that rate could be lowered materially. Possibly a more general use of the safety post at the working face would help.

In closing I wish to quote in part from the American Mining Congress Proceedings for 1923, representing the report of a committee on timbering.

"Committee does not recommend a standard method of timbering working places, although some large operators are practicing this with more or less success. The roof conditions are too varied in the different fields and at times even in the same mine to permit such practice being economical and practical. Roof conditions should govern and sufficient timbers used to insure safety to both the miner and the working place—bearing in mind that timbering is not only intended to keep up a bad roof, but to prevent a good roof from getting bad."

HISTORY OF THE DEVELOPMENT OF THE DEPARTMENT OF GEOLOGY AT WEST VIRGINIA UNIVERSITY*

By JOHN L. TILTON

(Department of Geology, West Virginia University)

(Abstract)

THE PERSONEL

Samuel G. Stevens, Professor of Natural Sciences, taught Mineralogy in 1867-1869 and the latter half of 1870-1871.

John J. Stevenson, Professor of Geology, 1869-Christmas, 1871.

William M. Fontaine, Professor of Geology, 1872-1879.

I. C. White, with Fontaine 1877-1879; Professor of Geology, 1879-1892.

Samuel B. Brown (with Dr. White), Assistant in Geology, 1890-1893; Professor of Biology, 1893-1894; Professor of Geology, 1894-1926.

George P. Grimsley, Special Lecturer in Economic Geology, 1806-1909. (Student assistants are here omitted).

W. Armstrong Price, 1913-1919.

Earl R. Scheffel, 1919-1927.

John L. Tilton, 1920—present.

Walter J. Yeaton, 1825—present.

Sidney L. Galpin, 1927—present.

David White, Special Lecturer for one week, 1927.

EARLY REPORTS IN UNIVERSITY CATALOGUE

J. J. Stevenson, A Geological Examination of Monongalia County, 1869-1870.

I. C. White, Notes on the Geology of West Virginia, 1882-1883, 1883-1884, and 1884-1885.

THE CURRICULUM

The subject taught till 1877 by Professor S. J. Stevens was Mineralogy. When I. C. White began his work he introduced what was strictly Geology. Spring field work was inaugurated by him in 1881-2, continued throughout his work as professor, and through the first year of that of Professor Brown, 1893-1894, after which there were local field trips only till summer field work was re-introduced by John L. Tilton in 1924-5. During the time that Professor Brown was alone he taught the general courses in Physical and Historical Geology and

*The paper is to be published in full in a University Bulletin.

Mineralogy. W. Armstrong Price added Methods in Palaeontology and courses in Oil and Gas Geology. Earl R. Sheffield added two courses in Physical Geography and John L. Tilton added courses in Areal and Structural Geology, in Stratigraphic Palaeontology, and in the Microscopic Study of Minerals and Rocks, which latter and Structural Geology he transferred to Walter J. Yeaton in 1925-6. S. L. Galpin took the new course in Sedimentation, re-arranged the course on Building Materials, and has further adjustments in view.

LOCATION OF DEPARTMENT

Martin Hall, 1867-1911.

Science Hall, 1912-1913.

Library Building, 1913-1918.

Mechanical Hall, 1918-1926.

Chemistry Building, north end, first and second floors, 1926-.

THE COLLECTIONS

Samuel G. Stevens, 1867-1868. The collection consisted of 114 minerals.

John J. Stevenson, 1870, added 700 fossils.

Wm. M. Fontaine, 1872-1873, reports 2000 minerals and fossils and 2300 recent shells. These are repeatedly mentioned in the catalogues till 1886.

I. C. White, 1885-1886, mentions Henry A. Ward's College Collection of Rocks and Minerals. This is repeatedly mentionel till 1894.

Samuel B. Brown, 1893-1894, mentions obtaining the Julien Collection of Building Stones.

Samuel B. Brown, 1894-1895. This catalogue illustrates a number of maps and charts that had then recently been obtained.

Samuel B. Brown, 1896-1897. Ward's College Collection of Palaeontology is mentioned as 'very nearly complete."

Samuel B. Brown, 1897-1898. The Educational Series of Rocks was obtained from the U. S. Geological Survey (Bull. No. 150), and a collection of fossils from the Smithsonian Institution.

Samuel B. Brown. Numerous arrow-heads, etc., were obtained during 1894-1899.

John L. Tilton, with approval of S. B. Brown, 1921-1925. The following important additions were made to the collections: A complete series of Hand Specimens and Microscopic Slides of North American Rocks; selected sets of microscopic slides of minerals; collections of "Index Fossils;" Microscopic Slides of English "Coal Balls"; from the State Survey, fossils identified by John L. Tilton, and by others.

INVENTORIES

First Inventory: In a letter of S. B. Brown dated April 17, 1908, the total value is listed at $500, and the number of students registered in the department is given as 55.

In the 1917 inventory the total valuation is given as $4870. This includes a plane-table outfit, one microscope and a motor for use of W. Armstrong Price, and goniometer and crystal models for use of S. B. Brown.

In the 1921 inventory the total valuation is given as $5351. This includes a new explorer's alidade.

In the 1925 inventory the total valuation is given as $7504. This includes meterological instruments for use in classes of Earl R. Scheffel and two new petrographical microscopes for use in classes of John L. Tilton.

On June 28, 1926, Professor Brown reported to Dean Callahan that in 1924-1925 the students in the department numbered 315, that in 1925-1926 they numbered 378 and 60 in the summer school (a total of 438), and that the value of the equipment was approximately $10,-000, housed in "inadequite quarters."

The list of needs prepared for Professor Brown in 1920 by John L. Tilton is now supplied in full, except that two more microscopes (now ordered) are not yet here. The list included maps, outfit for preparation of microscopic sections, photographic and projection outfits, and illustrative material. The specimens obtained in recent years are now catalogued, and the work of cataloguing the older collections is proceeding as fast as needed help is obtainable. Information concerning a number of specimens obtained in former years has been lost because no record was kept. Space both for storage and for display is one of our needs, and we still await a Geological Building where what we have can be permanently located in a manner convenient for study, and where what is choice can be properly displayed for the benfit of the public. Give us a building for Geology suited to this wonderful geological field.

SCENIC GEOLOGY IN WEST VIRGINIA

(Illustrated by Lantern Slides)

By JOHN L. TILTON

(Department of Geology, West Virginia University)

West Virginia contains portions of four physiographic provinces. The first is along the eastern side of Jefferson county, where there is a narrow strip east of Shenandoah river that belongs to the west flank of the Blue Ridge area. The second lies between the Blue Ridge at Harpers Ferry and North Mountain. This is a portion of The Great Valley, or the Valley of Virginia. The third is between North Mountain and a series of ridges extending southwest from Briery Mountain to the southern boundary of the state. This is known as the Allegheny Ridge area. The fourth lies west of the Allegheny Ridge area. This is the Allegheny Plateau.*

The plan of the state highways gives access to the physiographic regions in a continuous manner. If one starts from Harpers Ferry it is at present advisable to go south to Winchester. From this place he can go west along the newly surfaced Northwestern Turnpike past Romney, New Creek, Mount Storm, Aurora, Grafton, Clarksburg, West Union and Harrisville to Parkersburg. Here he can turn south past Elizabeth and Spencer to Ripley, then west, and along the Ohio past Point Pleasant to Huntington. From Huntington he can turn east up Teays Valley and along the Kanawha to Charleston; then east to Gauley Bridge and Lewisburg to White Sulphur Springs. From here he may continue east to Lexington, and then northeast to Staunton, Harrisonburg, Winchester and Charles Town to Harpers Ferry; or, if he chooses to take the northeasterly course in West Virginia, he can turn northeast at Lewisburg and go via Marlinton, Bartow, Monterey, Franklin, Petersburg, Romney and Winchester to Harpers Ferry, thus making a complete circuit of scenic regions in West Virginia, varied by a trip through populous districts and always in reach of good hotels.

The general plan above outlined can be changed at several points. At Redhouse one can turn north to Oakland, then west to Terra Alta and along the newly surfaced road to Morgantown, then south to Fairmont and Parkersburg. Soon it will be possible to go up Scotts Run from Morgantown through a most recent and rapidly developed coal region to Cassville, then past Wadestown and Wileyville to New Martinsville, then south along the Ohio to Parkersburg.

*On the basis of classification followed by the Association of American Geographers "The Great Valley" is considered a part of "The Appalachian Valley Province," the western boundary of which is placed east of the Frostburg area.

At Grafton one can turn south to Philippi and Buckhannon, thence to Weston, Spencer and Charleston.

From Charleston one can go east along the south side of New River to Fayetteville, Beckley, Princeton and Glenlyn, then through The Narrows of New River. Having crossed the river at the town named Narrows he can turn north to Peterstown and then go on to Lewisburg.

At Franklin a detour west over the mountain by a good road leads to North Fork, then, with a few miles of dirt road, Seneca Rocks is reached. On return by the same route another good road turns east from Franklin to Brandywine, with a good dirt road from that point east across Shenandoah Mountain to Harrisonburg in the Valley of Virginia.

Later it will be possible to reach any county seat by surfaced roads, but at present one would encounter unimproved stretches on many of these side trips. In the itinerary outlined it is possible to enter the circuit at any point, as Harpers Ferry, Oakland, Morgantown, Parkersburg, Huntington, Bluefield, and complete the circuit to the starting point, reaching the scenic points in order. On the plan named one passes across valleys and through gorges in the northern part of the Allegheny Ridge area; then, after passing through the more populous western half of the state, turns eastward across the Allegheny Ridge area again, and may reach the most remarkable gorge of all, New River Gorge—The Narrows. The Allegheny Ridge area is full of remarkable mountain scenery from one end of the state to the other. The Plateau area as a whole does not have scenery that is so striking as that of the Allegheny Ridge area, but the roads lie along prosperous valleys in regions rich in coal, oil and gas.

Of the various remarkable views only a few of those used for lantern slide illustrations are here mentioned.* First of all the view west across the Potomac toward Harpers Ferry claims attention, for this place has been called the gateway to West Virginia. In the view the steep slopes along the western flanks of the Blue Ridge do not appear

*Of the lantern slides used all but the first are from negatives obtained during geological work in West Virginia either by the writer or by others, chiefly D. B. Reger, who is at present the Acting State Geologist. Fine illustrations of the scenery may be found in the various volumes of the West Virginia Geological Survey. These reports, with accompanying geologic maps may be obtained from the office of the survey at Morgantown. For the part of West Virginia that lies along the west flank of the Blue Ridge and in The Great Valley the descriptions are in one volume, that on Jefferson, Berkeley and Morgan counties. For the trip westward across the Allegheny Ridge area there are two reports available, one of Hampshire county, and one on Mineral and Grant counties. For the Allegheny Plateau area farther west there are reports on Preston, Marion-Monongalia-Taylor counties, and on Marshall-Tyler-Wetzel counties. For the trip along Kanawha and New River there are reports on Kanawha county, Fayette-Raleigh counties, and on Mercer-Monroe-Summers counties. For other regions reports are available on all counties except Greenbrier, and three others the reports on which are not yet through the press.

in the picture. In the foreground are two bridges across the Potomac just above the mouth of the Shenandoah; thus the Potomac is on the right and the Shenandoah in the left and center. At the curve of the railroad on the right is the site of the old arsenal, John Brown's Fort. In the center of the picture lies Harpers Ferry upon the Summerville Peneplain, with ground rising to the Harrisburg, or Shenandoah, Peneplain above the wooded slope just beyond. Along this slope and a little farther toward the background lies Jefferson Rock, affording a view down the valley that the early President considered the grandest in America. Above the Shenandoah Peneplain appears the even skyline of the Schooley Peneplain.

The second view here mentioned is that of Caudy's Castle, or Castle Rock. To reach this point a detour is necessary from Capon Bridge north to Good, Bloomery, and Forks of Cacapon, near which place a road turns south to Castle Rock. Here Oriskany sandstone in the west limb of an anticline rises almost vertically into the air, forming a tower where Caudy took refuge from the Indians during the French and Indian War. Across the river to the east may be seen another sheer cliff rising vertically along the river's margin. Between the two, and in this narrow valley, one would not expect to find the crest of an anticline, but there is one revealed along the river bed a little to the south, and along the narrow flat that lies so peacefully beside the turbulent stream. A view into this remote valley is well worth a trip from Capon Bridge to Caudy's Castle and back.

On the road from Capon Bridge to Romney a most artistic scene appears, as, rounding the various anticlines and synclines of the high ridges, the gap at Hanging Rock comes to view. Here, through this deep notch cut in Oriskany sandstone at North Mountain, may be seen distant farms on green hills and lowland, a serene picture in the rugged frame of the mountain.

A side trip from Romney to Moorefield and back would take one through another remarkable valley, "The Trough," where the Potomac flows for six miles through a valley as straight as an arrow where the river has cut the shale between steep mountain sides of Oriskany sandstone. The railway follows the river, but the highway avoids "The Trough."

To get west out of the fertile shale valley of South Branch one goes from Romney to Burlington, passing near the girlhood home of Nancy Hanks, then across Near Creek, then southwest up a five mile climb along a road cut diagonally up the Chemung strata of Fore Knobs to Allegheny Front. Here the resistant ledges are not of Oriskany sandstone but of Pottsville conglomerate, which is even more resistant to weathering than the Oriskany. The view eastward down into the deep valley of New Creek is one of the most striking views in the state.

If the course from Terra Alta west to Morgantown is the route pursued one first passes down the steep slopes of Briery anticline, the western margin of the Allegheny Ridge area, taking advantage of the long gentle slope of a tributary to Cheat River, the stream that foams along the valley to the west. Then, later, at Cascade, begins a descent along Deckers Creek. Here the great arch of Pottsville Conglomerate rises gradually to form the crest of Chestnut Ridge, and then bends down to reach the creek bed again five miles away. Over the exposed edges of this conglomerate the water of Deckers Creek first falls in a series of cascades; and later, when the descending limb of the anticline is crossed, it swirls and tumbles amid the massive bowlders of disintegration that lie in its path. All this is in plain view, close beside a good hard-surfaced road, above which rise the native ledges from which the boulders settled as the stream removed the weaker members and weathered products.

The valley of the Ohio and its tributaries are rich in early history of romance and endeavor. The high hills with their slopes of Permian shale, sandstone and limestone mark an ancient landscape far different from that of the steep valleys cut beneath their level. Along the valley sides may be seen the topworks of coal mines and the derricks of oil wells. Along the broader valleys are cities with their factories and trading centers. Here Wheeling and Huntington impress us with their manufacturing; and the events recorded in the history of Wheeling, New Martinsville and Point Pleasant, make it seem that the days of the pioneers who opened this country to civilization were but yesterday. Here is the region of the Burning Springs, and here is Old Greasy in the very region where seeking salt they found oil, and developed the methods of a great industry. At the junction of Elk River and the Kanawha lies the capital of the state, rich in early traditions, rich in the history of a great valley where progress accompanied and followed the early settlers, rich in present enterprise, and rich as the legal center of the state.

Leaving the Plateau Area going east, and entering the Allegheny Ridge area again, the gentle folds of the Allegheny Plateau are replaced by the great arches. At The Narrows one sees not only a great gorge cut by the master stream of the region, but a great overthrust where the White Medina on the east is pushed up and over Devonian on the west, and the Resistant White Medina sandstone now caps the mountain.

For ruggedness of scenery a trip past Marlinton, Monterey, Franklin, and Petersburg to Romney is well worth the endeavor. The main roads among the mountains are now well graded and many of them hard surfaced. The road along the valley from Franklin to Romney is partly a superb shale road and partly a hard surfaced road. Where the river crosses from one shale valley to another great arches of Oriskany sandstone and Helderberg limestone rise majestically like arches of titanic masonry. Side trips to the crests of mountain divides reveal the broad stretches of ridges and valleys as far as the eye can reach, and, if the trip includes Mouth of Seneca from Franklin and back, the endeavor is rewarded by a close view of results of vast erosion along a great anticline, with the white Medina along the west limb standing out like a jagged upturned ancient saw—Seneca Rocks.

By 1930 West Virginia will be ready to invite the travellers from afar to feast their eyes upon these charms of nature. Even now the main highways are open, and a hospitable people bids their visitors welcome.

TWO ILLUSTRATIONS OF WIND ACTION IN WEST VIRGINIA*

By JOHN L. TILTON

(Department of Geology, West Virginia University)

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Near Parkersburg, West Virginia, is a region of old sand duns now grassed over—"Wheeling Fine Sand."

Near Uffington, West Virginia, at Raven Rocks, is a superb illustration of present wind action in the processes of weathering. In the midst of the bluff is a zone of white sand bearing evidence of wind action in cross-bedding and curved bedding planes.

Near Parkersburg, West Virginia. It was my privilege in the summer of 1921 to be assigned by Dr. I. C. White to a study of the Permian of West Virginia with a view to locating fossil horizons. The study led me along the deposits at Parkersburg, Washington Bottom and Walkers Crossing, thence up Island Creek to Lubeck and back to Parkersburg. At North Parkersburg the low-lying rounded hills on the whole were grassed over and under cultivation, but they revealed the loose, fine sand wherever wheel ruts had been cut along the road. The topography was that of dissected low-lying dunes. The sand is loose, there being no silt binding it in horizontal bedding planes. At Washington Bottom the same characteristics were noted. Farther south along the bluff there were deposits of a fine texture. The peculiarities were such that the query immediately arose: Am I entering an area of loess banked in along the Ohio by southwest winds? It was because of this question that I followed the deposit east from Walkers Crossing and along the lower valley of Island Creek. The deposit proved too loose in texture for a loess, more like a silt, and near at hand where Island Creek comes from the bluff were beds of stratified rock that on weathering supplied a weathered product that seemed indistinguishable from the light gray silt-like deposit as seen along the bluff. It was therefore necessary to conclude that this material should not be considered a loess. I find it is recorded on the soil map as "Wheeling Silt Loam."

In the summer of 1925 I was again sent to this area, this time to accompany Professor Frank Leverett to contribute what I could with reference to Permian stratigraphy to aid in the problem on which he

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was at work and to gain what information I could of the problem on which he was engaged. Concerning his problem I need say little, leaving him to present results when he is ready to publish them; but with his consent I mention the following: We visited the area near North Parkersburg and then went to Washington Bottom, but did not go to Walkers Crossing. When I called his attention to the character of the sand he expressed his own judgment that the area was in reality that of old eroded dunes.

I had hoped to ascertain what the relation of such deposits might be farther southwest along the Ohio. As no opportunity for such a trip has presented itself I have consulted the state reports to see what is said under the head of soils. In the report on the classification of soils given in the geology of Pleasant, Wood and Ritchie Counties, West Virginia Geological Survey (p. 333), these deposits are called "Wheeling Fine Sand," and it is said "the Wheeling fine sand is derived from material deposited in early ages by the Ohio River and subsequently, in part at least, modified by the action of the wind."

In the report on Jackson and Mason Counties (p. 341), the report, while referring the origin to glacial material brought down the Ohio, distinctly recognizes "the dune-like surface" as "unquestionably due in part at least to the action of winds." In the report on Cabell and Wayne counties (p. 445) the single "dome-like area" is mentioned as "largely formed by wind-blown material derived from the other Wheeling terraces during dry seasons, and represents an old alluvium."

In the reports on counties farther north Wheeling Fine Sand is not distinctly recognized. The report on Wetzel county (p. 620) and the report on Ohio, Brooks and Hancock counties (p. 362) recognize a gravelly and a sandy phase of loam but do not recognize a distinct Wheeling Sand. In this region the southwesterly winds do not have so prolonged a sweep along the valley as they do farther south in the state. Though silt from the north supplied the material, the deposits are found in the area of broad valleys that in preglacial times drained northwest.

Near Uffington, West Virginia. At Raven Rock near Uffington is a superb illustration of present wind action in the processes of weathering. In the accompanying illustration* the entire upper part of the cliff is seen honey-combed by wind action. Numerous cracks have received deposits from solution, which deposits are now more resistant to weathering than the original beds. These deposits in the cracks stand out prominently, while between the ridges the softer rock is worn

*An excellent illustration of the cliff appears as Plate XX, opposite page 305, report on the Geology of Monongalia County, West Virginia Geological Survey.

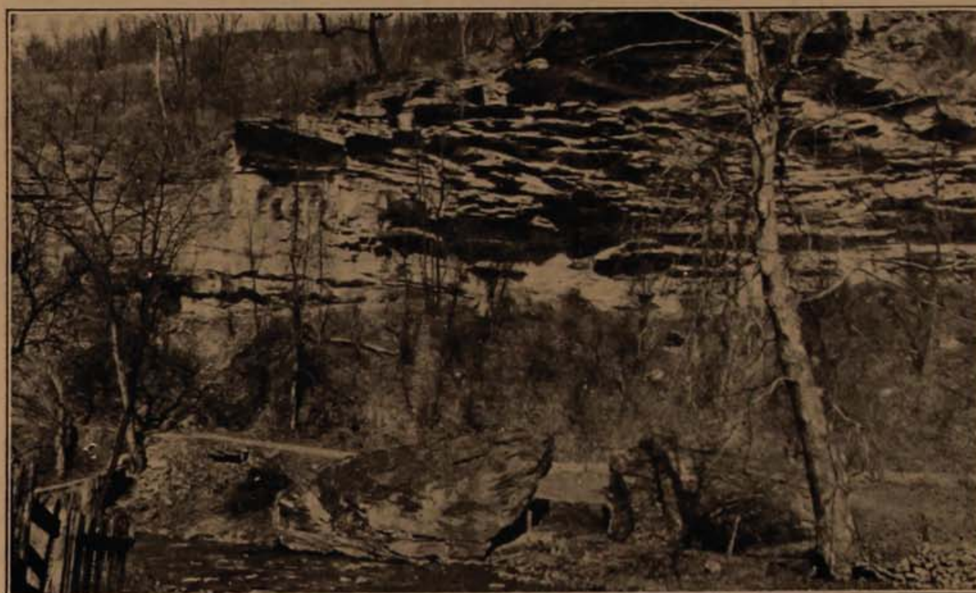

Fig. 1. At Raven Rocks the honey-combed face of the ledge rises to a height of 65 feet above the bed of Booth Creek. The lower portion close to the level of the talus is dotted with small concretions of hematite.

away. In numerous places eddying winds blow off the loosened material and whirl it around, enlarging the cavities, so that the "box-work" is varied by these numerous rounded cavities both large and small. In places the evaporation of water at the face of the cliff has so cemented the outermost portion that it has remained intact, hanging as a veil, while behind it the less cemented sand has been blown away. During strong gusts of wind these various cavities resound in a weird sort of way, emitting most startling moans.

In the lower portion just above the talus a fine white sand is in places horizontally bedded and in places cross-bedded, the lower horizontal beds containing numerous small but conspicuous concretions of hematite; and between the lowest portion with its hematite and the upper portion with its box-work and cavities are the cross-bedded sands and even thin seams of coal, varying in thickness up to five or six inches. In places amid this cross-bedded white sand there are beds with more clay and with darker color than the remainder at and above this horizon. Here the fine material reveals a distinct concentric structure. These portions amid the cross-bedded layers are undoubtedly due to deposition in water, as well as the parts both below and above the cross-bedding.

The cross-bedded portions presents a varied record. In general it dips to the northeast, as seen in the face of the bluff, the direction away from the shore of that time. The curvature and the repeated changes

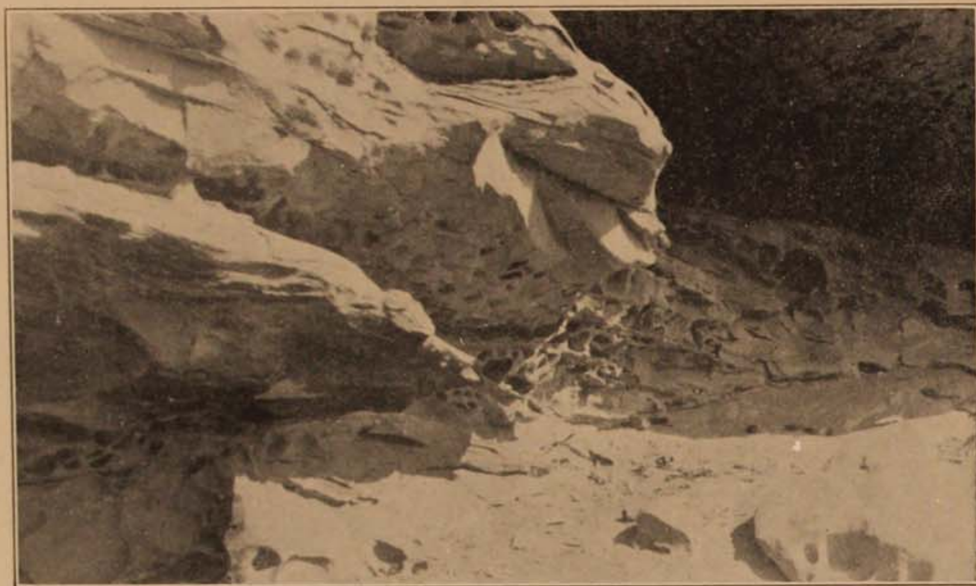

Fig. 2. Near the bottom of the box-work is a thin bed of coal, related to an old soil horizon.

in the bedding suggest action of wind from the southwest. While the cross-bedding thus has aeolian characteristics the deposits do not belong to a well-developed dune. The maximum dip of the cross-bedding

Fig. 3. The face of the bluff extends northeast-southwest. In the portion above that dotted with small concretions of hematite the white sandstone is variously bedded. Some of it is horizontally bedded, some of it is cross-bedded, and some of it lies in beds that are somewhat curved. Here also there are other layers of a concretionary darker clayey material in the fine sand.

is but 11° 45′ northeast, and the material is not of well-assorted rounded and pitted sand, but contains a mixture of other grains somewhat irregular in shape, interbedded with and surrounded by minute particles of quartz, traces of hematite and fine clay-like material. In this fine material is also considerable magnesium sulphate and traces of calcium carbonate, as revealed by the tests of Dr. B. B. Kaplan, Chemist of the Geological Survey. So far as has been observed these evidences of aeolian deposition are local, but the effect of wind on the box-work is noticed along the bluff northward for two miles to Traction Park, is seen near Valley Crossing east of Morgantown, and is to be observed at McKinneys Cave, eight miles east of Uffington.

While this evidence thus in a measure appears conflicting it in reality presents the sequence of events. The complete local series is as follows: A short distance below the beds above described, perhaps thirty feet, is one of the best seams of coal in the region, the Upper Freeport coal, the top of which can be seen in the bed of the creek close by when the water is low. Above this bed of coal lies the black Uffington shale* with its base crowded with fronds of Neuropteris and Pecopteris, and its upper portions locally with many iron concretions (hematite, or clay-iron stones) even six to ten inches in diameter lying along planes in the bedding. Above this shale comes the white sandstone (back of the talus in the lower part of the picture) with an abundance of small nodules of hematite. Next above is the cross-bedded portion of the white sandstone containing a few darker, more clayey beds with distinct concretionary structure. To the right of the picture, and in essentially the same horizon as these beds, may be seen the marks of an old soil horizon, which contains in places thin seams of coal, representing the Brush Creek coal horizon. Beginning in this horizon and extending clear to the top of the cliff is the box-work described. Accordingly we must recognize the portion of sandstone below the coal as Mahoning and that above the coal as Buffalo, though both are unlike the usual Mahoning and Buffalo of the region.

Thus, from the conditions of an extensive swamp (now Upper Freeport coal) there followed a deposition of mud, nicely stratified, now shale (Uffington). This on slight uplift became subject to erosion, so that in places the Uffington shale was completely eroded away. In the changes that followed there was a low sandy and swampy shore where sand was drifted inland by the wind, along and around hollows in which the vegetation was accumulating in places sufficiently to become coal later. Then for a long time the region as a whole became

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*J. J. Stevenson gives a list of marine fossils from the Uffington shale, a list that is reproduced on page 321 of the report on the Geology of Monongalia County. The fossils were found in the Brush Creek shale at another locality, as explained by Dr. W. Armstrong Price in "Science," Vol. 46, pp. 540-542 (1917).

the location of extensive water-laid sand, that later still became consolidated into Buffalo sandstone.

For present purposes the emphasis is on the peculiar aeolian-like cross-bedded portion of this sandstone, evidence of wind action in early Conemaugh time; and also upon the remarkable differential effects of wind action on the weathering face of a cliff with so varied a structure.

AMPERE'S RULE AND FARADAY TUBES

By R. C. COLWELL

(Professor of Physics, West Virginia University)

Magnetic circuits arise from fixed magnets and from electric currents. If it is postulated that all magnetic circuits arise from electric currents (real or fictive) it is possible to give one simple rule for the motions of conductors carrying currents and for the direction of induced currents. For instance if two fixed magnets AB and CD attract one another, their fields (Fig. 1) are analogous to the fields around

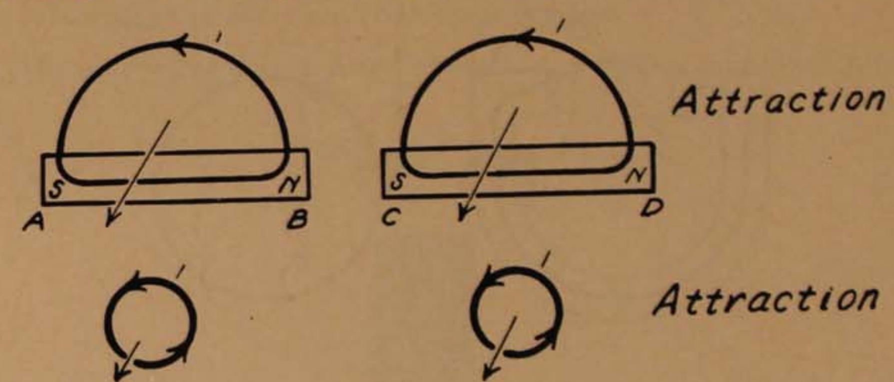

Fig. 1

The fictive currents and the magnets show attraction.

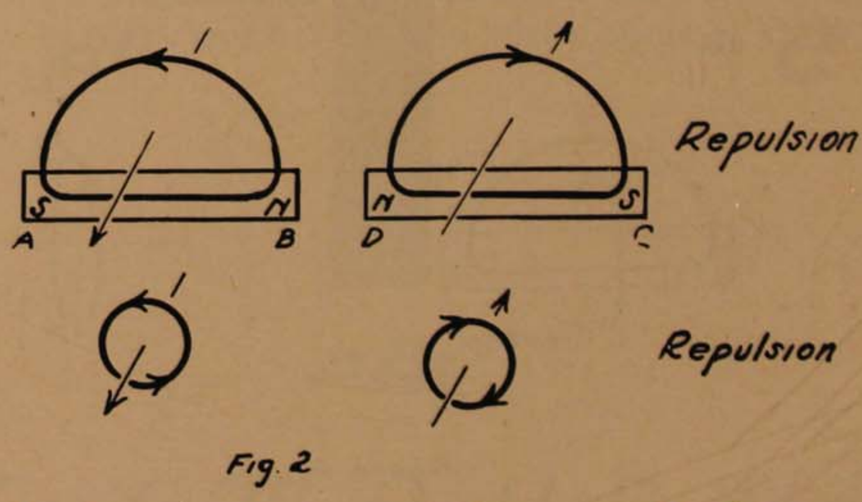

Fig. 2

The fictive currents and the magnets show repulsion two wires carrying currents. The fictive currents are both in the same direction; hence if it were not already known, it could be inferred that two currents in the same direction will attract one another (Ampere's Rule). If one of the magnets is reversed (Fig. 2), the fictive current is also reversed—accordingly two conductors carrying currents in opposite directions will repel one another.

It is obvious from these two examples that Ampere's rule applies to magnetic as well as electric circuits and that a general rule may be stated for all practical cases, namely, when two magnetic or electric circuits are in the same direction they will tend to superpose (i. e.,

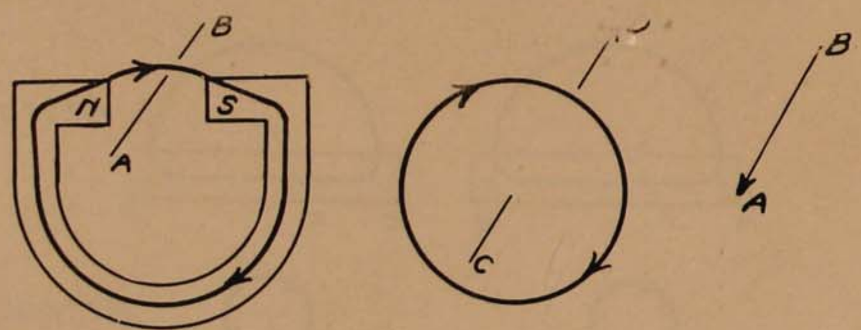

Fig. 3

When the wire AB is moved into the field, the induced current must be opposite to CD. (Fleming's right and left hand rules.)

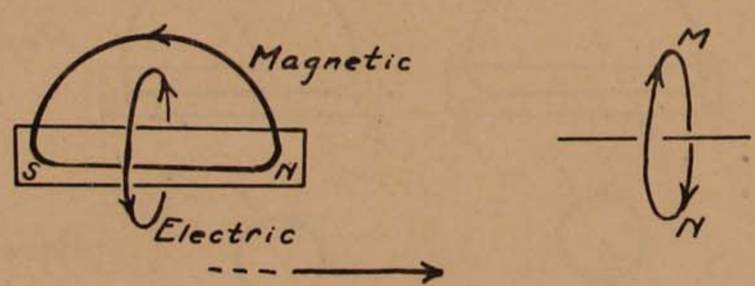

Figure 4.

The fictive current of the magnet induces an opposite current in MN. (Faraday's rule) they will attract one another); when they are in opposite directions they will repel one another. Further when a magnetic field is being induced the induced field must tend to leave the inducing field in its original state. If a wire is cutting into the field, the induced field must be opposite to the inducing field. If the wire is cutting out of the field, its field must be in the same direction as to oppose the motion of the wire. This will give an e.m.f. directed as shown in Fig. 3. If the wire is carrying a current directed from B to A, it will be thrown out of the field. Fig. 3 (Fleming's right and left hand rules). When a magnet is beign introduced into a loop, the current induced in the loop must be opposite to the fictive current. (Fig. 4) (Similar to Faraday's Rule). This rule applies to all cases of induced currents.

The general rule as outlined above may be given a physical inter-

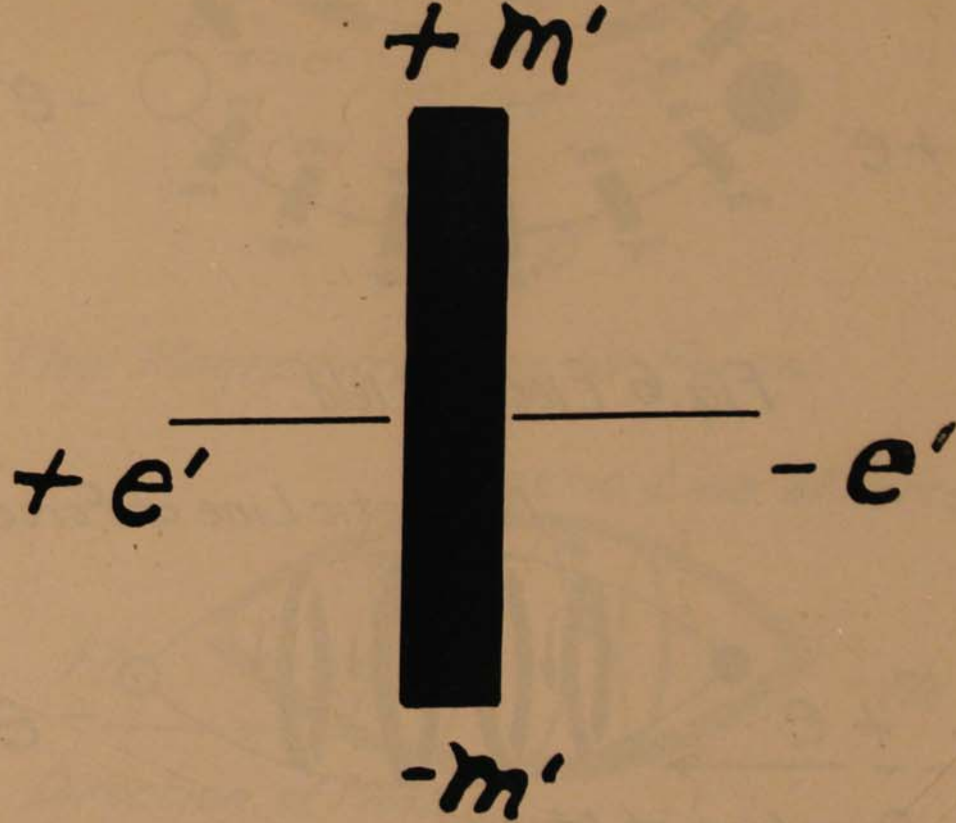

Fig. 5 The Double Doublet

pretation by the use of Faraday tubes. **It is supposed that a Faraday electric tube of force always extends from a positive to a negative charge; that it is made up of a great number of little particles which have both electric and magnetic polarity. These will be called double doublets.**

The electric field between two charges will then consist of Faraday tubes arranged with the negative magnetism inside and the positive magnetism on the outside. (Fig. 6). When e is moved toward —e the tubes shorten by the elision of double doublets. But the doublets are elided with a right hand twisting motion forming a magnetic line of

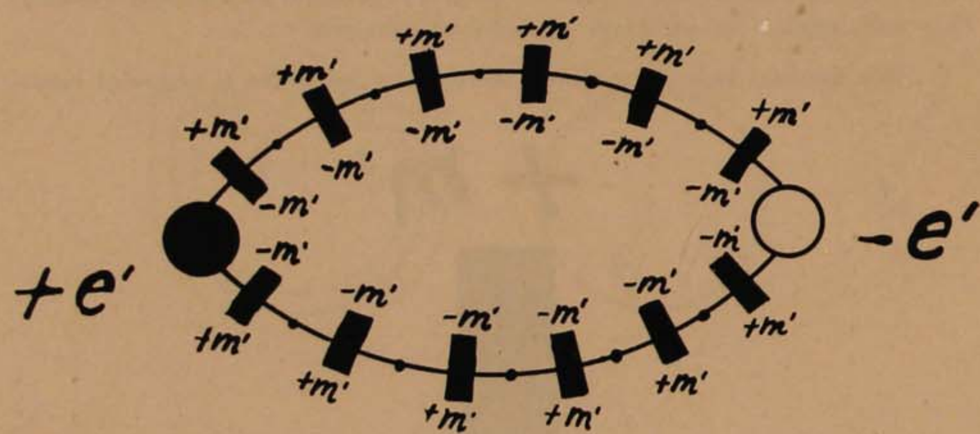

Fig. 6 Electric Field

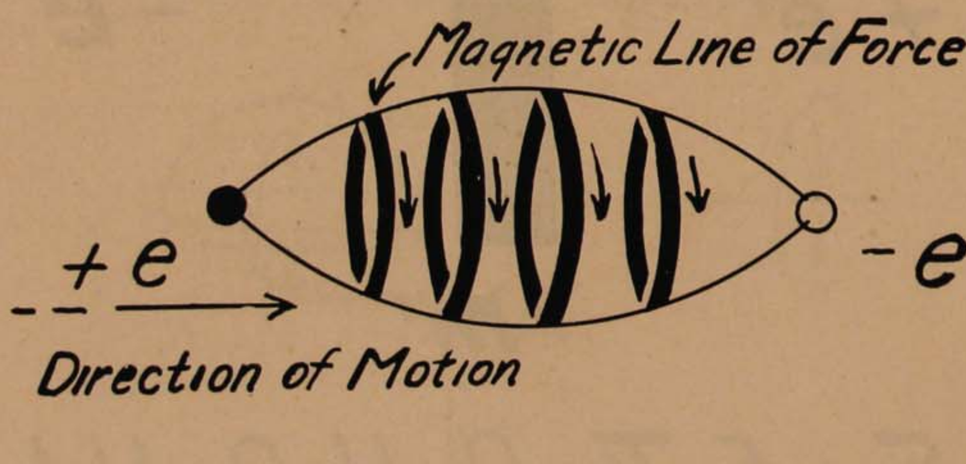

Fig. 7

force which follows Maxwell's right hand rule (Fig. 7). If the direction of motion of e is reversed, the twist of the double doublets is also reversed—i. e., **a shortening Faraday tube has a right hand twist, a lengthening tube a left hand twist.**

The magnetic field between two magnetic poles will resemble the electric field (Fig. 6) except that the electric and magnetic ends of the

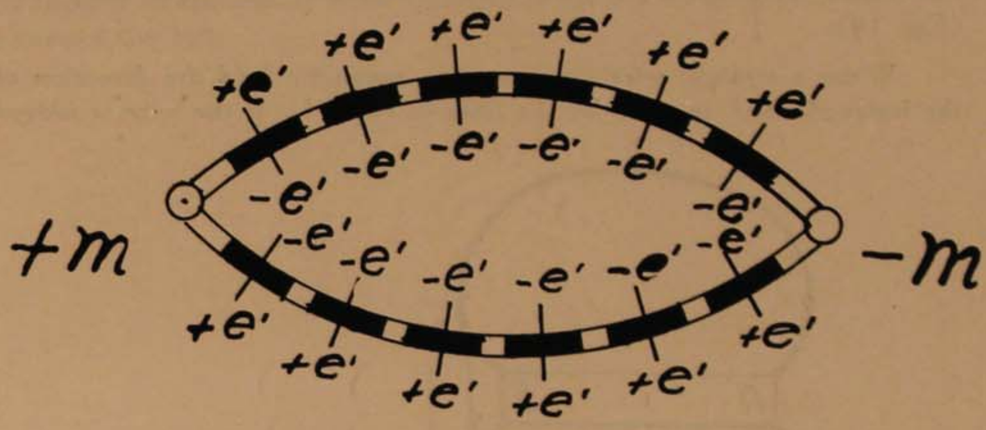

Fig. 8

The Magnetic Lines of Force.

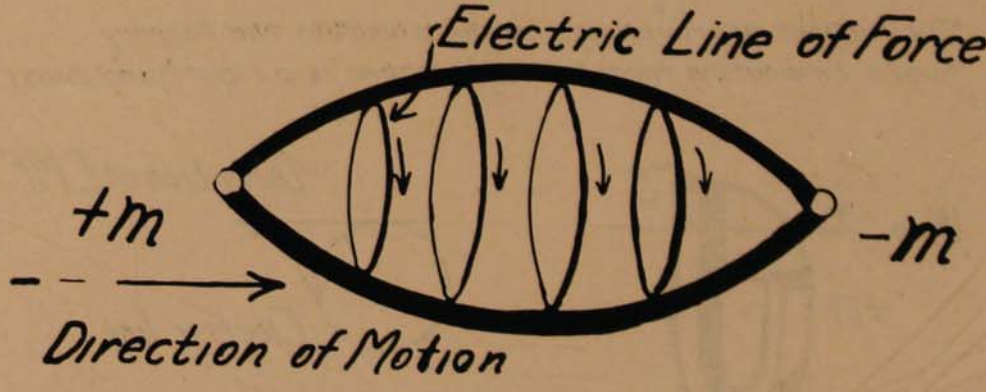

Fig. 9

doublets will change places (Fig. 8). A motion of m toward —m will then form an electric line of force similar to that of Fig. 7. (See Fig. 9.)

The case of a magnet inducing a current in a loop will now be discussed when the **south** pole of the magnet is toward the loop, the Faraday tubes from the **north** pole will be shortening at a greater rate than those from the south pole, hence there will be a right hand twist (Fig. 10).

When a straight wire cuts across a magnetic field the direction of the induced e.m.f. is given by the lines in Fig. 11. If the wire is moved

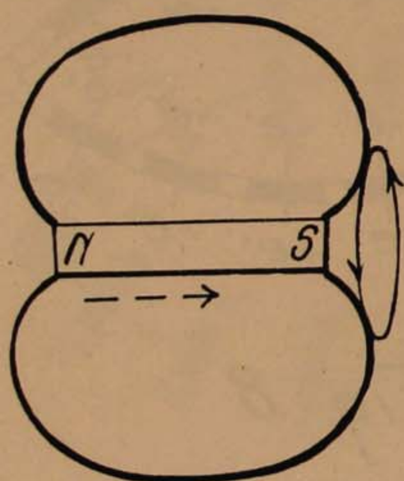

Fig. 10

The magnet approaching the coil shortens the Faraday tubes emanating from N—hence there is a right-hand twist.

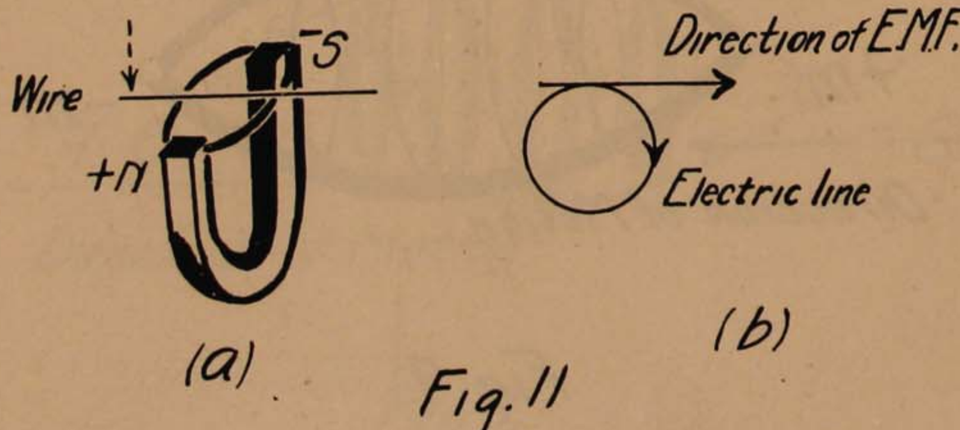

Fig. 11

downwards the magnetic lines are being shortened, hence the electric field twists right handed, so that the e.m.f. is directed toward the right. A reversal in the direction of motion, reverses the direction of the e.m.f.

All the so-called dynamo rules may then be reduced to a single statement: **When Faraday tubes (electric or magnetic) are shortening the twist is to the right; when Faraday tubes are lengthening the twist is toward the left.**

THE OSCILLATIONS OF A SPINNING TOP

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M. C. HOLMES
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The gyroscopic top is usually manufactured in two forms, in one of these it spins about its own axis like an ordinary conical wooden top, in the other form it turns about a fixed support and is balanced by a suitable weight. In the second form the precessions of the top are easily observed. In the new forms of tops which we have designed in our laboratory with the assistance of the mechanician, Mr. Lee Fullmer, many different couples can be applied to the gyroscope so as to produce rather unusual motions. In some of our tops, friction also plays an important part. The first top is mounted as shown in Figure 1. There

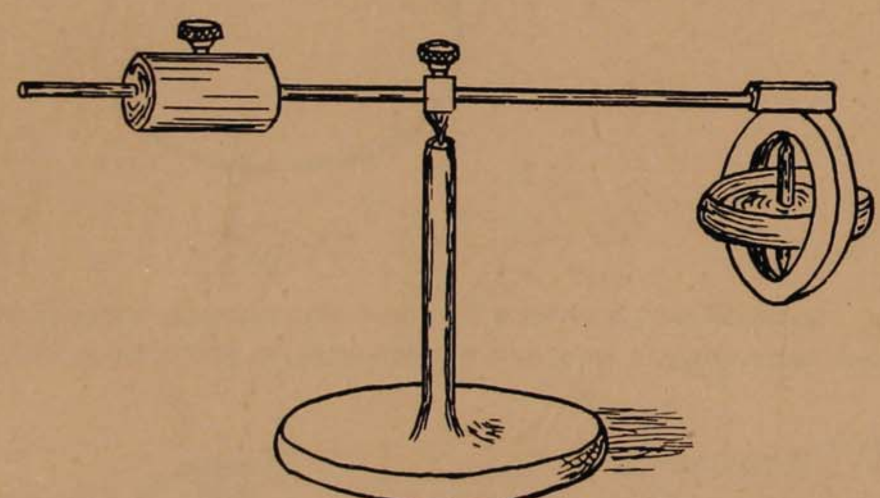

Fig. 1.

are two moments acting on the top one due to the weight W, and the other due to the mass of the top itself. These combine with the rotation of the top to produce a precessional motion. The couple due to the top, automatically changes sign so that the precession also changes sign, these changes cause the top to swing back and forth. Eventually the

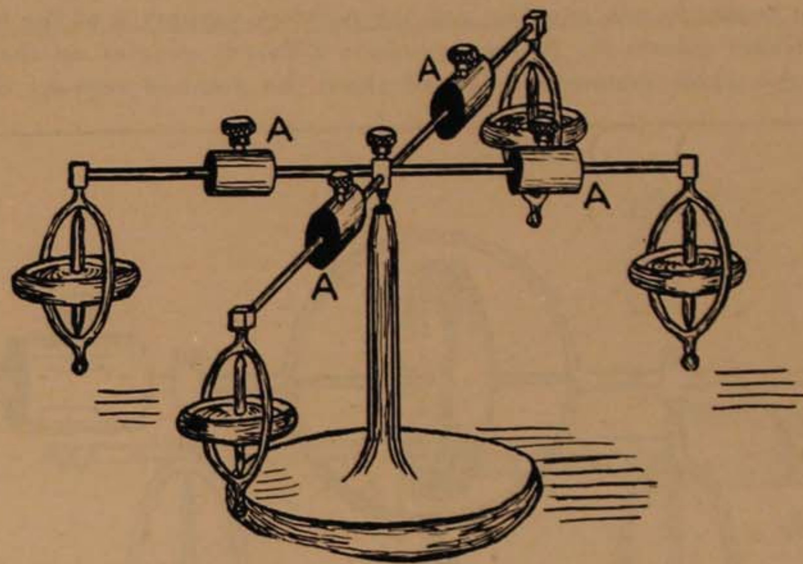

Fig. 2.

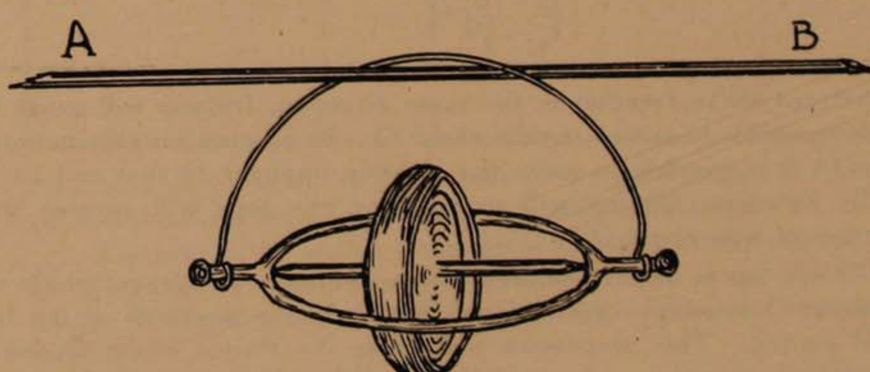

Fig. 3.

friction in the bearings will cause the gyroscope to rotate about its point of support in the direction of spin of the rotating member.

The second top consists of four tops rigidly attached to two arms at right angles to one another, and the point of support is at the center, the movable masses A, A, etc., produce different couples on the tops. When the whole system is balanced about the point of support O, and

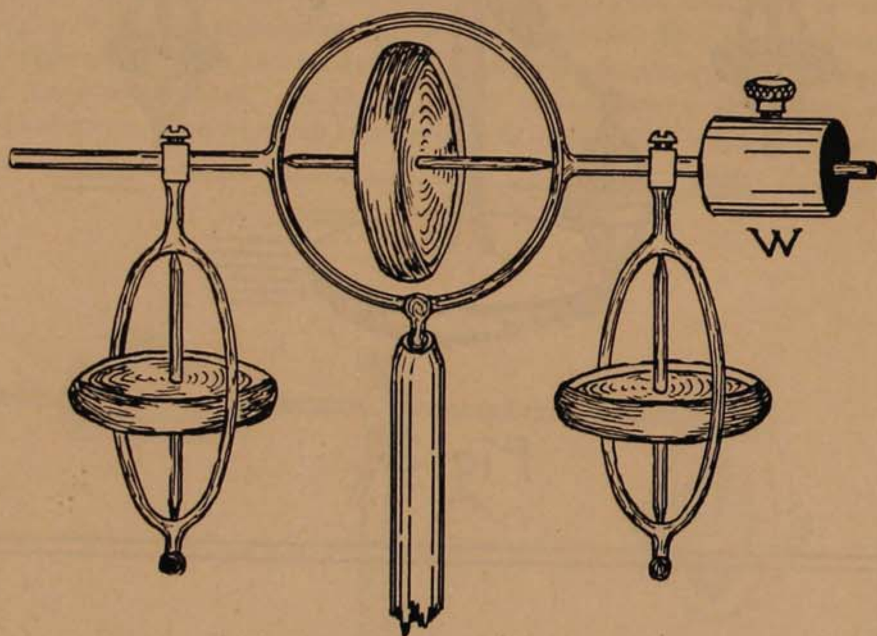

Fig. 4.

all the tops set in rotation in the same direction, friction will cause the whole ensemble to rotate rapidly about O. By placing suitable moments about O, it is possible to make the rotation opposite to that of friction. Finally however, friction will prevail and the tops will reverse their direction of spin about O.

If one top is unscrewed from those of Figure 2, a large couple will act about O causing a precessional motion in the direction of the frictional torque. This precession will cause the torque about O due to the tops to change sign so that the whole rotation starts and stops in noticeable jerks.

The top of Figure 3 is supported by a wire frame not rigidly connected to the ends of the gyroscope. The rotation of the top will cause the wire frame to rotate lengthwise about AB. The friction between the wire frame and the supporting rod AB will make the top turn over sev-

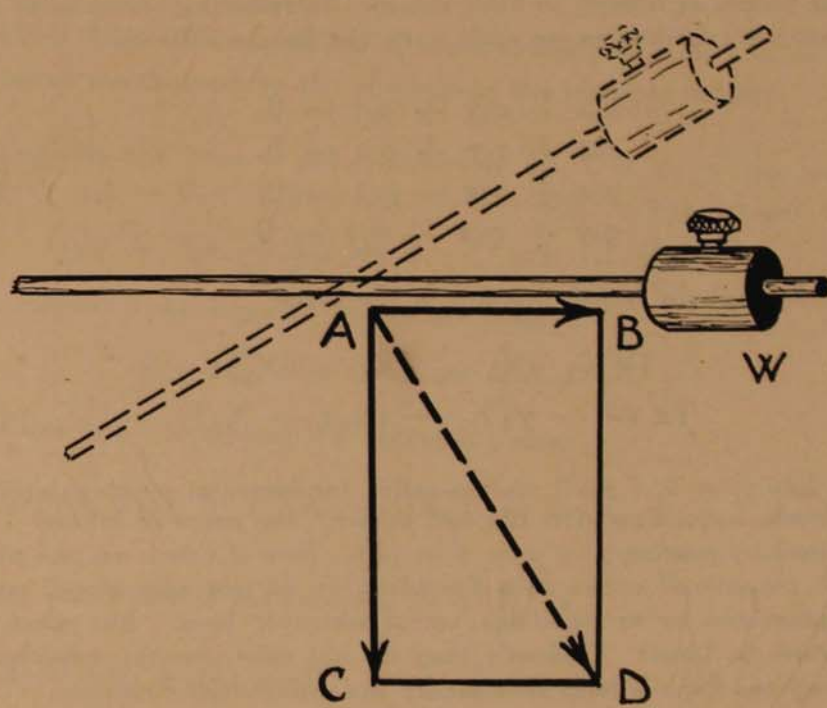

Fig. 5.

eral times on its axis. A great deal of energy is required for this operation, so the top must be rotating at a very high speed.

The fourth top of this series gives a combination between two spins at right angles to one another. The resultant couple lifts the heavy weight W far above the position it occupies when the tops are not in rotation.

The two spins indicated by AB and AC in Figure 5, cause the axis to tilt along the resultant diagonal AD, and this motion lifts the mass W as shown in Figure 5.

SINGULARITIES OF THE LINE-SPHERE TRANSFORMATIONS

By JOHN A. EIESLAND

(Professor of Mathematics, West Virginia University)

A serious difficulty in Line-Sphere Geometry arises when we consider the points at infinity in both spaces. Introducing rectangular and homogeneous coordinates we shall write the line as follows:

$$\begin{aligned} \sigma_0 x - \sigma_2 y + \varrho_1 t &= 0, \\ \sigma_0 z + \sigma_1 y + \varrho_2 t &= 0, \\ \sigma_2 z + \sigma_1 x - \varrho_0 t &= 0, \\ \varrho_0 y + \varrho_2 x - \varrho_1 z &= 0 \end{aligned} \qquad (1)$$

and the line-sphere transformation in the form

$$\begin{aligned} Tx &= yX_3 - (X_1 + iX_2)t \\ Tz &= -y(X_1 - iX_2) - X_3 T. \end{aligned} \qquad (2)$$

To the line $y = 0$, $t = 0$, the so-called fundamental or singular line, corresponds, according to S. Lie and others,* the plane at infinity $T = 0$, obtained by putting $y = t = 0$ in (2). Now if this is so, the plane $T = 0$, considered either as a Euclidean or an isotropic plane, ought to be generated by at least one set of isotropic lines. But what are these isotropic lines? Evidently they do not exist, for the complex of isotropic lines, that is lines that satisfy the differential equation

$$dX_1^2 + dX_2^2 + dX_3^2 = 0\,,$$

has no representative in the plane at infinity. If we write a line in $\bar{S}_3$,

$$\bar{\sigma}_0 X_1 - \bar{\sigma}_2 X_2 + \bar{\varrho}_1 T = 0, \qquad \bar{\sigma}_2 X_3 + \bar{\sigma}_1 X_1 - \bar{\varrho}_0 T = 0\,,$$
$$\bar{\sigma}_0 X_3 + \bar{\sigma}_1 X_2 + \bar{\varrho}_2 T = 0, \qquad \bar{\sigma}_0 X_2 + \bar{\varrho}_2 X_1 - \bar{\varrho}_1 X_3 = 0\,,$$

the isotropic lines are lines of the quadratic complex $\bar{\sigma}_0^2 + \bar{\sigma}_1^2 + \bar{\sigma}_2^2 = 0$, where all the σ's do not vanish.

If however all the $\bar{\sigma}$'s vanish we have $T = 0$, $\bar{\varrho}_0 X_1 + \bar{\varrho}_2 X_1 - \bar{\varrho}_1 X_3 = 0$, that is, any line in the plane at infinity. Since an isotropic

L. J. Coolidge, "A Treatise on the Circle and the Sphere," p. 485.

line has the property of meeting the absolute in a single point, it is a reasonable guess that the lines represented by the points of the notable line are the ∞^1 tangents to the absolute in $T = 0$, that is, they are the intersection of the isotropic planes $\bar{\varrho}_0 X_2 + \bar{\varrho}_2 X_1 - \bar{\varrho}_1 X_3 = 0$, $(\bar{\varrho}_0^2 + \bar{\varrho}_1^2 + \bar{\varrho}_2^2 = 0)$ with the plane at infinity. At any rate, however that may be we shall add these lines to the complex of isotropic lines, the resulting aggregate being known as the extended isotropic complex.* We shall now prove the following

THEOREM. **To the points of the singular line $y = t = 0$, in S_3 correspond the tangents to the absolute in the plane at infinity.**

Consider the lines of the congruence $\sigma_0 = 0$, $\varrho_2 = \sigma_2$, namely

$$-\sigma_2 y + \varrho_1 t = 0, \quad \sigma_1 y + \sigma_2 t = 0, \quad \sigma_2 z + \sigma_1 x - \varrho_0 t = 0,$$

$$\varrho_0 y + \sigma_2 x - \varrho_1 z = 0, \qquad \varrho_1 \sigma_1 + \sigma_2^2 = 0,$$

which intersects the singular line in the point

$$y = 0,\ t = 0,\ \frac{x}{z} = \frac{\varrho_1}{\sigma_2} = \frac{-\sigma_2}{\sigma_1};$$

to this line will correspond the isotropic plane

$$\sigma_1(X_1 + iX_2) + \varrho_1(X_1 - iX_2) + 2\sigma_2 X_3 + \varrho_0 T = 0. \tag{4}$$

Consider also a line of the complex $\bar{\varrho}_2 = \bar{\sigma}_2$, or

$$\bar{\sigma}_0 x - \bar{\sigma}_2 y + \bar{\varrho}_1 t = 0, \qquad \bar{\sigma}_0 z + \bar{\sigma}_1 x - \bar{\varrho}_0 t = 0,$$

$$\bar{\sigma}_0 z + \bar{\sigma}_1 y + \bar{\sigma}_2 t = 0, \qquad \bar{\varrho}_0 y + \bar{\sigma}_2 x - \bar{\varrho}_1 z = 0, \tag{5}$$

to which corresponds the isotropic cone

$$\bar{\sigma}_0 (X_1^2 + X_2^2 + X_3^2) + \bar{\sigma}_1(X_1 + iX_2)T + \bar{\varrho}_1(X_1 - iX_2)T$$
$$+ 2\bar{\sigma}_0 T X_3 + \bar{\varrho}_0 T^2 = 0. \tag{6}$$

If a line of the congruence (3) intersects one of the complex (5) we must have

*The lines of the extended isotropic complex are called minimal circles in a paper by H. Beck entitled "Fundamentalsatz der Lieschen Kugelgeometric in Euclidischen Raum." Math. Zeitschrif't, B. 15, pp. 160-167.

$$\varrho_0\bar{\sigma}_0 + \varrho_1\bar{\sigma}_1 + \sigma_1\bar{\varrho}_1 + 2\sigma_2\bar{\sigma}_2 = 0$$

with the Plücker relations

$$\sigma_2^2 + \varrho_1\sigma_1 = 0, \quad \bar{\sigma}_2^2 + \bar{\sigma}_0\bar{\varrho}_0 + \bar{\sigma}_1\bar{\varrho}_1 = 0.$$

The lines (3) and (5) intersect in a point P whose coordinates are

$$y = \frac{\varrho_1}{\sigma_2}t, \quad x = \frac{\varrho_1\bar{\sigma}_2 - \bar{\varrho}_1\sigma_2}{\bar{\sigma}_0\sigma_2} \quad z = \frac{\varrho_0\bar{\sigma}_0 + \sigma_2\bar{\sigma}_2 + \sigma_1\bar{\varrho}_1}{\bar{\sigma}_0\sigma_2}t, \tag{7}$$

and to this point will correspond an isotropic line which is common to the isotropic plane and the null-sphere.. The equations of this line are

$$\text{(a)} \quad T\,\frac{\varrho_1\bar{\sigma}_2 - \bar{\varrho}_1\sigma_2}{\bar{\sigma}_0\sigma_2} = \frac{\sigma}{\sigma_2}X_3 - (X_1 + iX_2),$$

$$\text{(b)} \quad T\,\frac{\varrho_0\bar{\sigma}_0 - \varrho_1\bar{\sigma}_1 + \sigma_2\bar{\sigma}_2}{\bar{\sigma}_0\sigma_2} = -\frac{\varrho_1}{\sigma_2}(X_3 - iX_2) - X_3. \tag{8}$$

If now we let $\bar{\varrho}_1 \longrightarrow \varrho_1$, $\bar{\sigma}_1 \longrightarrow \sigma_1$, and $\bar{\sigma}_0 \longrightarrow 0$, the two lines (3) and (5) tend to coincide and the null-sphere (6) will in the limit break up into two planes T = 0 and the plane (4). The point P will approach indefinitely to the point $y = t = 0, \frac{x}{z} = \frac{\varrho_1}{\sigma_2} = -\frac{\sigma}{\sigma_1}$, In fact we have from (7)

$$y = \frac{\varrho_1}{\sigma_1}t, \quad \frac{x}{z} = \frac{\varrho_1(\bar{\sigma}_2 - \sigma_2)}{\sigma_2(\bar{\sigma}_2 - \sigma_2)} = \frac{\varrho_1}{\sigma_2}.$$

Putting $t = 0$ we have $y = 0$, $x : z = \varrho_1 : \sigma_2$, that is, a point on the singular line. In order to find what happens to the isotropic line (8) we eliminate T from one of the equations and we obtain the equation

$$\frac{\varrho_1\bar{\sigma}_2 - \bar{\varrho}_1\sigma_2}{\varrho_0\bar{\sigma}_0 + \sigma_2\bar{\sigma}_2 + \sigma_1\bar{\varrho}_1} = \frac{\frac{\varrho_1}{\sigma_2}X_3 - (X_1 + iX_2)}{-\frac{\varrho_1}{\sigma_2}(X_1 - iX_2) - X_3} \tag{9}$$

Multiplying (8a) by σ_1 and (8,b) by σ_2 and adding we have

$$T\varrho_0 = 2\sigma_2 X_3 - \sigma_1(X_1 + iX_2) - \varrho_1(X_1 - iX_2) \quad (10)$$

and (9) and (10) now take the place of (8,a) and (8,b). If $\bar{\varrho}_1 \longrightarrow \varrho_1$ and $\bar{\sigma}_0 \longrightarrow 0$, we get

$$\frac{\varrho_1}{\sigma_2} = \frac{\frac{\varrho_1}{\sigma_2}X_3 - (X_1 + iX_2)}{-\frac{\varrho_1}{\sigma_2}(X_1 - iX_2) - X_3} \quad (11)$$

$$T\varrho_0 + \varrho_1(X_1 - iX_2) + \sigma_1(X_1 - iX_2) + 2\sigma_2 X_3 = 0. \quad (12)$$

Multiplying (11) by σ_1 we get

$$\varrho_1(X_1 - iX_2) + \sigma_1(X_1 + iX_2) + 2\sigma_2 X_3 = 0. \quad (13)$$

Combining (13) and (10) we have

$$T = 0,\ \sigma_1(X_1 + iX_2) + \varrho_1(X_1 + iX_2) + 2\sigma_2 X_3 = 0, \quad (14)$$

which is a tangent to the absolute, since $(\varrho_1 + \sigma_1)^2 - (\varrho_1 - \sigma_1)^2 + 4\sigma_2^2 = O$, hence, **to the points of the singular line correspond the tangents to the absolute, g e. d.**

We may also proceed as follows: Consider the regulus of null-lines

$$\varrho_0 = 0,\ \sigma_0 = 0,\ \varrho_2 = \sigma_2 . \quad (15)$$

which together with the complementary regulus $\varrho_1 = \sigma_1 = 0$, $\varrho_2 + \sigma_2 = 0$ belong to the quadric

$$yz = xt . \quad (15^1)$$

The complementary regulus contains two null-lines, the singular line $y = 0$, $t = 0$, and $x = 0$, $z = 0$. To the regulus of null-lines corresponds the ∞^1 isotropic planes

$$\sigma_1(X_1 + iX_2) + \varrho_1(X_1 - iX_2) + 2\sigma_2 X_3 = 0,\ \sigma_2^2 + \varrho_1\sigma_1 = 0. \quad (16)$$

which have for envelope the null-sphere

$$X_1^2 + X_2^2 + X_3^2 = 0. \tag{17}$$

To the complementary regulus corresponds the ∞^1 concentric spheres,

$$\varrho_0^2(X_1^2 + X_2^2 + X_3^2) + \sigma_2^2 T^2 = 0, \ \varrho_0\sigma_0 + \sigma_2^2 = 0. \tag{18}$$

The asymptotic cone of these concentric spheres, which pass through the absolute, is the null-sphere (17) which represents the line $x = 0$, $z = 0$, and the line $t = 0$, $y = 0$ is represented by the plane at infinity, $T = 0$ **considered as ruled by the intersections of the isotropic planes (16) with $T = 0$.** Two points P and Q on the lines $x = 0$, $z = 0$; $y = 0$, $t = 0$, respectively, which are joined by a null-line of the regulus (15) have the coordinates

$$P: \ x : y : z : t = 0 : \varrho_1 : 0 : \sigma_2,$$
$$Q: \ x : y : z : t = \varrho_1 : 0 : \sigma_2 : 0.$$

To the point P corresponds the generator of the null-sphere (17), namely

$$\frac{\varrho_1}{\sigma_2}X_3 - (X_1 + iX_2) = 0, \ -\frac{\varrho_1}{\sigma_2}(X_1 - iX_2) - X_3 = 0, \tag{19}$$

and to Q corresponds the line

$$T = 0, \ (\sigma_1 + \varrho_1)X_1 + i(\sigma_1 - \varrho_1)X_2 + 2\sigma_2X_3 = 0,$$
$$\sigma_2^2 = -\varrho_1\sigma_1. \tag{20}$$

The quadric $yz = xt$ is thus transformed into a configuration generated by the **line-cross*** (19) and (20).

We know that a quadric, one set of whose generators are null-lines, is carried into a reducible quadric which, in the case before us, is represented by the equation

$$T^2(X_1^2 + X_2^2 + X_3^2) = 0. \tag{21}$$

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*For definition of line-cross see E. Study, Geometric der Dynamen, p. 4. TThis line-cross here obtained is improper, (uneigentlich).

In fact, the projective transformation

$$x = -x' + t',\ y = y' + z',\ z = -z' + y',\ t = t' + x' \qquad (22)$$

converts the quadric (41′) into the quadric

$$y'^2 - z'^2 + x'^2 = t'^2$$

to which corresponds, as we have seen, the reducible quartic

$$[X_2'^2 + X_3'^2 + (X_1' - T')^2]\ [X_2'^2 + X_3'^2 + (X_1' - T')^2] = 0. \qquad (23)$$

To the transformation (22) corresponds the inversion

$$\frac{X'_1}{T'} = \frac{X^2 - T^2}{\sum X_i^2 + T^2 - 2X_1T}$$

$$\frac{X'_2}{T'} = \frac{-2Z_2T}{\sum X_i^2 + T^2 - 2X_1T}$$

$$\frac{X'_3}{T'} = \frac{-2X_3T}{\sum X_i^2 + T^2 - 2X_1T}$$

whose fundamental sphere is $\sum X_i^2 + T^2 - 2X_1T = 2T^2$. It carries (23) into the reducible quartic

$$T^2\,(X_1^2 + X_2^2 + X_3^2) = 0\,.$$

The null-spheres having their vertices on the imaginary circle $X'_1 = 0$, $X_2'^2 + X_3'^2 + 1 = 0$, are converted into the tangent flats to the null-sphere (17), and the spheres having their centers on the X_1'-axis become concentric spheres (18).

In S_{n-1} we have a similar result. To the singular flat $y_i = 0$, $t = 0$, corresponds a ruling in $T = 0$, which has the equations

$$T = 0, \frac{\varrho_i}{\sigma_{\frac{n}{2}}} = \frac{\frac{\sigma_i}{\sigma_{\frac{n}{2}}} X_{n-1} - (X_{2i-1} + iX_{2i})}{-\sum \frac{\varrho_K}{\sigma_{\frac{n}{2}}}(X_{2K-1} - iX_{2K}) - X_{-1n}},$$

$$i = 1, 2, \ldots \frac{n-1}{2}, \quad \sigma_{\frac{n}{2}}^2 + \sum \varrho\, \sigma = 0. \qquad (24)$$

A flat of this "ruling" has contact with the absolute along a generator

$$X_{2i-1} + iX_{2i} = \frac{\varrho_i}{\sigma_n} X_{n-1}, \qquad (25)$$

$$\sum \frac{\varrho_K}{\sigma_{\frac{n}{2}}}(X_{2K-1} - iX_{2K}) + X_{n-2}$$

(This generator reduces to a point on the absolute in 3-space and (24) becomes the tangent line to the absolute.) The flat (24) is imbedded in the tangent (n-3)-space

$$T = 0, \quad \sum\sigma_i (X_{2i-1} + iX_{2i}) + \sum\varrho_i (X_{2i-1} - iX_{2i}) + 2\sigma_{\frac{n}{2}} X_{n-1} = 0, \quad \sigma_{\frac{n}{2}}^2 + \sum\sigma_i\varrho_i = 0.$$

Hence, **To the singular flat corresponds a "ruling" in T = 0 of the $\infty^{\frac{n-2}{2}}$ the tangent flats (24) to the absolute having contact with it along one set (25) of generators of the absolute.**

THE METHOD OF SCIENCE AND PHILOSOPHY IN THE FIELD OF PEDAGOGICS

By H. T. McKINNEY
(Professor of Education, Bethany College)

Modern education is characterized as both scientific and philosophic. In such practices as setting up definite aims or outcomes to be realized in teaching—for instance, the social aim or the Cardinal Principles—we have unquestionably followed the method of philosophy in the field of pedagogics. The tendency in philosophy of education is to follow this same method but to explain the learning process in the terms of synapses, change or growth. More and more the tendency in this field is to build a philosophy of education on facts scientifically derived in the field of psychology and sociology.

The object of this paper is to call attention to a trend of progress which is changing pedagogics—by this term is meant "Principles and Rules of Teaching"—from the broad realm of opinion over into the more restricted field of scientific fact and to indicate some of the advantages to our schools from this change. We have said that modern education is scientific, that is to say, the method of science is the dominant method of present day pedagogics. This indicates a significant change from conditions of a generation ago when the Normal Schools offered courses in semi-scientific psychology and theoretical, distinctly theoretical, classes in "How to Teach." This professional training was offered to Elementary grade teachers, only. Today, all is changed. In place of such work being confined to the Normal Schools, much improved as they are, departments of education in every standardized college, and Colleges of Education in many of the Universities, offer four years of similar training. In addition, the last named institutions usually offer graduate work in this field, which leads to the advanced degrees, Master of Arts or Doctor of Philosophy. This fact in itself is ample evidence that Education as pedagogics are called now, is fully committed to the method of science and it is recognized on that assumption.

WHAT CONSTITUTES THE METHOD OF SCIENCE?

At this point, it may clarify matters if we make plain what we mean by the method of science. We do not claim for Education that it is a science like Psychology or Biology is a science. But we are content to point out that the trend in Education during the last decade, especially, has been to distinguish between science and opinion and to adopt the criteria of science in determining the value of an article, a book, a bit of research or a procedure. The criteria set up by Pofessor E. L. Thorndike,* so familiar to many of you, are clear and defendable.

*Thorndike, E. L. Principles of Teaching, pp. 265-266. A. G. Seiler, 1916.

Education is as free to adopt these standards as guides, as any recognized science is. Hence, we speak of the method of science in the field of education. The criteria we speak of are the following:

"**Mathematical Precision.** That is to say, Science implies a precise measure of quantitative facts by which changes and correspondencies may be properly weighed; opinion is content to guess at amounts of differences and likeness, to talk in vague terms of more or less, much and little, to rate a method as better or worse without taking the pains to find out just how much better or worse it is.

"**Objectivity.** Science pays no heed to anything but the facts which it has already made sure of; it puts nothing in the scale but objective evidence. Opinion trusts its personal impression.

"**Verifiability.** Science reveals the course of its evidence and the course of its arguments, so that any properly equipped thinker can verify for himself the facts asserted to be true. Opinion offers itself to be accepted or rejected, but not to be verified.

"**Expertness.** Science is the work of minds specialized to search after truth. . . . Opinion is the occasional thought of those who, though important and capable people, are yet only amateurs in the work of getting truth.

"**Impartiality.** Science knows or should know no favorites and cares for nothing in its conclusions but the truth. Opinion is often misled by the 'unconscious logic of its hopes and fears' by prepossessions for or against this or that book, method or result."

STATISTICAL METHOD AS SCIENTIFIC METHOD.

Statistical method as applied to education has done much to bring us to where we are in this field. Prior to the movement in tests and measurements which motivated the application of statistical method in the field of educational research, we had but little scientific literature that could be classed as Education. We lacked in nearly all of the above points. It seems that our chief development is an extension of Psychology to applied fields; from the Psychology of Education came the whole group of experiments in experimental education which have dignified education by pointing the way to make its literature more objective. But nothing has popularized and forced upon us the scientific method quite so much as Standardized Achievement Tests and Intelligence Tests. The result is that practically all of the recent literature in the field of education has been colored with terminology from statistical method and readers now expect to find data in terms of mathematical precision.

The outstanding example of lack of scientific method prior to the present century is the case of Dr. Rice who is credited with starting the movement in experimental education with a study based on one of the elementary subjects. His study was suggestive and stimulating, but it could not be verified because he failed to report the details of his method. Over against this, in 1907, or about 15 years later than Dr. Rice made his study, Dr. Thorndike reported his famous study, "Elimination of Pupils From School," (U. S. Bulletin No. 4, 1907) which is regarded quite generally as the first study of real scientific worth in the literature of Education. Following this, 1911, Dr. L. P. Ayers, working for the Russell Sage Foundation, brought out his "Laggards in Our Schools." The method of these two studies did much to set the pattern for studies that have appeared since. When one investigates the number and the range of scientific studies that have appeared within the last two decades, he finds that research in Education compares favorably with many fields. In fact, the number of studies recently runs up into many scores each year. In addition to graduate study in connection with institutions of learning, practically all cities of approximately 75,000 inhabitants or more have their own research in connection with the public schools. In many instances the results are published and made available in a limited way to the public, at large. Baltimore, Jackson (Mich.), St. Louis, and Los Angeles are among the cities in various sections doing this type of research. Moreover, the same scientific spirit is found in cities of smaller population where it is not uncommon to find a superintendent leading his faculty in some experimental project, or probably the school is working in cooperation with some outside agency on a larger problem.

EVIDENCE THAT WE FOLLOW THE FINDINGS IN SCIENTIFIC RESEARCH.

For evidence that we have experienced a spread in scientific spirit in education and that we are following the lead of the method of research, one need not go far. Examine the texts used in the common schools during the last decade. The arithmetics have been rewritten to include only the problems of known worth in realizing our accepted aim in education. Spelling books have been limited to words that people actually use as determined by scientific experimentation. Penmanship is criticised in the light of a diagnostic scale that assigns objective values for each sample. In fact, the content of every subject and every type of curriculum has been scientifically scrutinized and evaluated. Our reference books, professional books, pamphlet materials and all types of apparatus such as visual aids, show the same line of evidence and bear the imprint of research.

The administrator today echoes the same truth. He talks of his work in terms of percentile, age—grade—progress, central tendency, I. Q's or A. Q's. Likewise, his classroom teacher must speak a new technical language. She knows or may know, by diagnostic tests what is the expectancy of each and every pupil, what are the individual weaknesses in each and every subject, and she knows the technique of measuring the achievement of her grade in the various subjects so that she could compare the median of given scores with the corresponding scores of pupils of that grade in general, and can say whether her own pupils are low or high by two, three or any other number of points as the case may be.

It is amazing how scientific this classroom teacher may be. She has been taught that experimentation shows that to provide ample light in a schoolroom, the window surface must be as much as one-third the surface of the floor when the light is from the North and one-fourth the floor surface when the light is from other directions. She knows what the volume of circulating air must be for every pupil of the room; what advantages may accrue from vaccination; what a child of a given height should weigh and what to recommend for children who are under weight, anemic, or nervous. Every teacher knows, also, the significance of individual differences in mental traits and when the right solution comes, as it must come, to the problem of individualized instruction and promotions at a rate natural and proper for each child, the teachers will receive such findings with a joy known only to those who habitually search for truth.

In this connection, we should not fail to observe that educators have developed a technical terminology which is a significant trend. For example, course, course of study, junior high school, junior college, retard, accelerate, semester hour, and unit of credit has a connotation as technical as terms like moron, dual personality, and subject (in Psychology) or specie, mutation, atom, and ductless gland in other mature science. In this period, especially since the appearance of the Modern High School, by Charles Hughes Johnson a decade ago, education has made commendable stride in this direction.

WHAT MAY WE CONCLUDE?

In conclusion, there is convincing evidence that during the past twenty years which date back to Thorndike's study which was probably the initiation of the method of science applied to the solution of problems in education, there has been a gradual increase in the number of adherents to this scientific procedure until the present time. Today, scientific method is the mode throughout the field of education.

Some of the noteworthy results are increased thoroughness of instruction and resulting scholarship due to methods of diagnosis of weakness and remedial instruction. This result, we should add, is not general. Neither is the use of the method general. This situation prompts us to say that the greatest weakness of educators at present is probably the fact that they do not work into their habits and procedures, the best tested theory of which they have knowledge . Our best ideas as individuals or as a group must find expression as habits and procedures if our schools and other institutional life are to reach heights of which we are capable.

RESEARCH, A MEANS OF IMPROVING COLLEGE TEACHING

By H. T. McKINNEY
(Professor of Education, Bethany College)

"The modern university looks forward and is a factory of new knowledge; its professors have to be at the top of the wave of progress. Research and criticism must be in the breath of their nostrils." —Huxley.

"It is a truism of trade that our manufacturers owe a large measure of their supremacy to their readiness to abandon old machinery and substitute new."—Henry Fairfield Osborne, "Creative Education."

OUTLINE

I. It is assumed that the college teachers, themselves, are quite generally agreed that instruction on the college level must be progressively improved in keeping with other means of progress so as to obtain and maintain quality colleges.

II. College teaching might be improved by three or more means, as follows:

1. By means of professional training of the faculty. To this there are several objections such as traditional adverse attitude and having no institution above the college to train its teachers as the college (and university) trains the teachers of secondary schools.

2. By means of personal experience in trial and error methods. This is too wasteful.

3. By means of cooperative and individual research in the field of college methods. The paper which follows is concerned with showing the desirability and feasibility of this means of improving college methods.

Ours is a generation of research. Evidence of this fact may be seen in any important occupation such as agriculture, aeronautics, engineering, big industry, and medicine, all of which must look to the truths of science as the chief means of progress. In ascertaining the extent to which research methods may be applied to improve economy of method and quality of output, should we not include teaching on the college level just as we include administration and teaching in secondary education? To discuss the desirability and the feasibility of improving college instruction by this means, is the purpose of this short paper.

That research pays in other occupations, is not questioned. In the industrial world where the method is oldest, the results are most evident. In 1925 (a) "We (were) spending approximately $100,000,000 a year for industrial research in the United States. The government was spending one-third that amount, while industry (was) matching dollars for research two to one for the government's expenditures. The federal government at that time was engaged in "1100 cooperative undertakings." Industry, on the other hand, had nearly 600 industrial research laboratories in the United States. Add to all this the university research and that done by other agencies and one gets some idea of the extent to which this generation is committed to this method of progress. "Research in the universities, institutes and technical colleges," says Holland, "has assumed considerable proportions especially in such well-known ones as Carnegie Institution, Massachusetts Institute of Technology, University of Illinois, Purdue, Mellon Institute, Cornell, and others."

A considerable portion of the research of institutions of higher learning has been concerned with problems of teaching and learning in the schools below the college level.. What we know about the nature and extent of individual differences in students; means of measuring intelligence and applying the results to simplify the problem of proper classification; the nature and limitations of the learning process; the degree and method of transfer of training; methods of thinking and teaching to think; failures and probable results (b) of repetition of grades; and all else that pertain to proper understanding the nurture of the mental life of students, may be traced to collegiate research. In recent years, every public school tends more and more to become a laboratory in which such findings may be applied experimentally to life situations.

Such advancement as this reflects credit upon Colleges of Education, Bureaus of Educational Research and other agencies concerned with experimentation of this sort. But those engaged in college teaching have been comparatively slow to utilize the findings of research of this kind. Gradually, it seems, this situation is changing. A recent bibliography (c) including 245 "best references on college teaching from educational literature of the past ten years" shows about 200 of these texts, studies, and the like, have appeared since 1923. This can be taken to mean that not much interest in the improvement of college teaching has been evident until within the past five years.

We should be interested in the status of college teaching for various reasons. Because the colleges are at the top of our so-called educational ladder, the high schools must look to them for teachers

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(a) Holland, Maurice, "Research the Prime Mover of Industry," Scientific Monthly, April, 1926, 297-98.

and the methods of these high schools will reflect the status of teaching in the colleges Also, the college itself is effected indirectly by having to accept poorly prepared freshmen when the high school teachers are not effective, as well as directly when the faculty fails to give the college students the type of instruction that they supposedly pay for. The reputation of any school is closely associated with the type and quality of teaching that prevails, and this in turn rests on ability of students to comprehend.

To ascertain the pupils' point of view as to what constitutes good college teaching, different questionnaire studies have been made recently. One (d) was directed to 460 juniors and seniors in Kansas University and among other things asked for was this: "Recall the teacher of whom you can say, 'he (or she) is the best college teacher I ever had', or if no teacher stands out that (prominently) strongly then choose one of your best teachers. In what department did he (or she) teach?"

The ranking of subjects mentioned based on the frequency, is as follows: Economics, history, English, biological sciences, modern and ancient languages, physical sciences, education, sociology, psychology, mathematics, philosophy, home economics, physical education. At first thought this might be taken to signify that the status of teaching in the department of economics and history is most satisfacory to the upper-classmen while psychology, mathematics, home economics and physical education are not as effectively taught. Closer study of the situation, however, shows that many of these departments had practically the same frequency, the difference being too slight to be significant. There is evidence, also, that the replies are somewhat biased or confused with imaginary replies to a supposed question, "What materials are most interesting because you think they may be more closely related to life-problems?" The replies to other questions asked show this. The returns from a similar study by Dean Kelly of Minnessota, show that alumni of his school set the same standard of "Not related to life," "Not practical," when asked to say why they did not like certain subjects. Thus we are led to believe that when pupils try to recall their "best teachers" they tend to confuse the idea of good teaching as such with interest in subject based on a supposed value as being closely related to life-problems.

(b) Buckingham, B. R., "Research for Teachers," 1926, Ch. I and VIII. Silver, Burdett & Co., Chicago.

(c) Good, Carter, V., "Bibliography on College Teaching with Special Emphasis on Methods of Teaching." Studies in Education Yearbook No. XVI of the National Society of College Teachers of Education." 1928. The U. of Chicago Press.

(d) Obrien, F. P., "The College Student's Viewpoint." Studies in Education. Yearbook XVI, 1928.

Granted that opinions like these gathered from former students may be in a way misleading, as when pupils who never expected to teach voted that "Fundamentals of Education" was extremely boresome (i. e., uninteresting because not related to life-problems). Data of this sort are valuable at least in giving college teachers a picture of their teaching as students' reactions portray the situation. The picture should signify that teachers ought to be concerned with measuring their efforts in terms of reactions in individual pupils. It may signify, too, that we do not sufficiently regard teaching as an artful practice and we rely on mere presentation of subject matter by an acknowledged erudite instructor as the only necessary element in the teaching act. Learning is measured in terms of changed reaction and, of course, when there is no learning, there is no teaching. One way to improve the status of college teaching is, therefore, to be continually concerned with what the matter presented means to the students taught.

Our almost exclusive emphasis on scholarship as preparation for college teaching is at present meeting some interesting opposition that has been expressed in certain proposals. Among these it is said that men whose chief interest is productive scholarship (research) should not teach; that, as a rule, the Ph.D 's do not make good teachers; and that what we need most in the interest of college teaching, is a **Ph. D. in teaching.** This suggestion (f) of an additional doctorate grows out of the fact the Ph. D., while representing unquestioned scholarship is conferred on evidence of ability (dissertation) to do independent research and often the required training has no reference to ability to teach. The suggestion has been made, consequently, that ideally those who obtain the Ph. D. as at present, should not teach and that as better qualification for college teaching, the Ph. D. **in teaching** ought to substitute a year of internment for the dissertation.

There is an important distinction displayed in such a proposal in that it points out the desirability of specific training for college teaching. It being just as important to train HOW to teach as HOW to do research, a degree of similar rank should be granted, we believe, in each field. But we fail to see the necessity of an additional degree or a bifurcation of that sort. Research and teaching are in no sense inimicable. They must be closely associated in a way that one may, particularly in the field of education, be strengthened by the other. It is unquestionably true that some of our most talented research workers are not excellent teachers. They do not claim to be. The interests of all concerned would be best served probably if these would be assigned to positions of full

(e) Kelly, F. J., "Questionnaire study of opinions of alumni of the University of Minnesota concerning courses and methods used with freshmen and sophomores." Yearbook XVI, I, National Society of College Teachers of Education. 1928.

(f) Wyckoff, Geo. S., "On Revision of Ph.D. Requirements." The English Journal, March, 1928.

time research Another type of research worker, however, is very effective in his methods of teaching. More and more his problems for investigation are selected from the field of Education, particularly the field of methods. Instead of trying to separate college professors into two distinct camps, our most urgent endeavor should be to imbue every college teacher with the spirit of research and to train teachers in service through experimentation with their own problems.

Just as professional training seems to be somewhat overdone in the field of secondary education, it is evidently under-estimated in the college field. On this point a recent questionnaire study (g) limited to Land-Grant Colleges indicates that but two of the "46 out of 47 other such schools" reported professional training or experience as a requirement of applicants. Tennessee requires 12 semester hours for full professors and 6 hours education for positions of lower rank; and Rhode Island expects 15 hours professional training of all new teachers. Experience is expected in the five states, Colorado, Florida, Maine, Pennsylvania, and Tennessee.

Allowing, as we should, some time for full professors to do research in their own departments, we are still apparently committed to the practice of employing on the basis of the degree held. Such a practice is all the more evidence that we must train teachers in service. This is the ground of our claims that the most logical means for improving college methods of teaching is research. Defined as we are using the term, research is any "diligent and protracted seeking after truth, facts or principles." Applied to training in service, the teacher takes his or her own problems and attempts to solve them by means of experimentation under controlled conditions.

This practice among college teachers is already in use, but we have just begun to base our investigations on ourselves and the everyday problems that challenge solutions. When we read the statement from one college or university, for example, that the per cent of Freshmen dropped for poor scholarship this year was only about 5 per cent., which is within 1 per cent of what it has been annually for a term of years, we get one impression of the quality of students that are entering the colleges from high schools. But in another report, again from a large university of the same section of the country, we are told that more than half the Freshmen who entered the class in September were not permitted to continue after the first semester because of poor work. This condition reflects on the preparatory schools of that section and leaves us in uncertainty about the thing that the first report had so well settled for us. In the last situation, the typical problems are: What causes of failure were most evident? What special efforts were put

(g(Bohannan, C. D., "Improvement of college instruction." Phi Delta Kappan, April, 1928, 161-63.

forth by the faculty to prevent what happened? To what extent are the pupils with low grades in freshmen college work the ones with poor marks in high school? To what extent may we rely on the record made in first year college subjects in making a prognosis of individual success as upper-classmen?

Assuming that there is no one cause that of itself explains poor work in college, we ought experimentally to determine the value of such proposals as the following: Poor work may result when strong as well as weak students are not properly orientated. (2) Pupils earn better marks when the teaching is in the direction of the pupil-interest rather than when ignoring this factor. (3) Formal recitations should be replaced by methods that are more individual. (4) Method must be adapted in the light of the subject matter and outcome expected.

The University of Pittsburgh is experimenting on the first of these proposals by having the teachers become better acquainted with the pupils through interviews of 15 minutes duration weekly with each pupil alone.

Bethany College is experimenting on the second and third proposals. In the classes taking German, three groups are recognized according to the purpose which prompted students to study this language: One group consists of pupils who may become teachers of the subject. They are given more grammar and technical points than some others. A second merely wants a reading knowledge for further study of some science or as part requirement for some higher degree. A third, is interested from the point of conventional and economic value of German as a spoken language. A different method is used with each group and soon we will have data for evaluation of this procedure.

Likewise, experimentation on a plan for reducing the number of group recitation-hours and increasing individual assignments and individual conferences with teachers, is being tried out by different members of this faculty.

On the fourth proposal listed here, the writer found (j) decided gain in the promotive rate in Freshman English in college when the subject was taught as a modern language and the principle of habit-formation was consciously followed as a criterion for judging knowledge of the subject. The experimental study ran through four semesters, that is, it was concerned with two different classes and the results were compared with marks of former years in the same institution The method was: (1) To select a minimum number of principles most evidently operative in teaching a language and (2) to adopt and strictly

(h) American School Digest, March, 1928.
(i) The American Magazine, April, 1928.
(j) McKinney, H. T., "Selected Principles a Guide in College Methods." 1925 (unpublished).

follow procedures necessary to carry out the principles agreed on as a basis of method.

PRINCIPLES

1. Teaching by its very nature is chiefly concerned with what pupils **do not know** or what they **cannot do well.**
2. The unlearned matter for each pupil, severally, listed in some order of value, is the defined field of endeavor.
3. Most effective teaching results from a maximum pupil-participation.
4. Habitual response in correct english is the ideal to approximate.
5. Verb-forms, sentence-structure and the like are learned only when recognition and use are automatic.
6. Correct expression as an ideal tends to crowd out less desirable expression.

PROCEDURES

1. **Assignments** were by topics and adjustable to the demands of each pupil. A notebook was kept by each individual in which were listed "things to be learned." These items became the basis of drills and reviews.
2. **Recitations** of the old type were rare. The period was usually spent in discussions by three or more groups arranged at the beginning of the hour on the basis of common difficulties. The teacher passed from one to another and spoke only when needed to direct the pupils in their participation. Hard places were reported by leaders for general class instruction later.
3. **Reviews** were made a conscious part of each meeting. These were supplemented by drills.
4. **Readings** were for the purpose (Prin. 6) of emphasizing ideal expression. Pupils were encouraged in private conferences with the instructor as well as in class lectures, to look for the manner of expression in the selected readings.
5. **Tests** were used as teaching devices. Pupils were encouraged to test themselves and to record their deficiences. A few well-written themes, the lesson assignments read with the view of ascertaining what was known already, and questions for pupils to answer orally before the class for criticism, were the favorite tests. A comprehensive examination was given at the close of each semester as a basis of determination of a term grade.

On the basis of such research (experimentation) progressively carried on by the teachers themselves we may improve college method. The value of such procedure is enhanced through reports such as we have illustrated in a limited way here.

THE SOCIAL VALUE OF FOREIGN LANGUAGE STUDY

By R. E. SALESKI
(Professor of German, Bethany College)

Possibly all of you have been afflicted at some time or another with the study of some foreign language which was as far as you have ever been able to determine has not been worth an iota to you nor is in any danger of acquiring such value. And you all have heard the question: Why punish the 85 per cent of high school students who never go to college with the study of foreign languages for the sake of the 15 per cent who go, of whom again only a small per cent ever get beyond the academic requirements of **points** and **credit hours.** The state of West Virginia stands particularly low in this respect, I believe; or from the other point of view, particularly high, for having lagged behind in these requirements. The whole question about the value of foreign language instruction is a perfectly proper question and should be asked, and if possible, impartially answered. That is to say: The answer must not come from the one-sided opinion of partisans, that is, from us, instructors of foreign languages, but from students of education, society, psychology, etc., from just such a body as this. Of course your answer will not be worth much either, unless you try to be just; if it proceeds from an ignorance of the subject or, as has been the case with a few of your loud-mouthed colleagues elsewhere, from an unwillingness to study their language lessons in their own school-days. However, as a group you can never go so far astray as we, the teachers of language, in this matter, for self-preservation is still the first law of nature. But perhaps we can be of some assistance to you by supplying on the one hand details of the process of language study, and on the other hand, information on the social and psychic relationship of various languages to each other and particularly to the one language we happen to speak.

And this, in a very limited and fragmentary way, is what I shall try to do. Please, however, remember that I am not arguing for the present state of things: college and high school requirements, hours, methods and standards, I am concerned now only with the problem of the social value of foreign language instruction, assuming that when you have decided on the worth of such study in the abstract, you will be able to judge the requirements, standards, and methods in the light of your findings, and advocate such changes afterwards as may seem desirable.

Public instruction can be concerned with the individual only as far as the life of the individual redounds to the benefit or detriment of the community. I cannot expect the state to supply me with cigarettes or moonshine, unless somehow the community may be expected to profit by the reaction. So let us consider briefly: 1st, the benefit the individual student may derive from a foreign language, that may redound to the benefit of the community, and 2nd, the benefit the community may derive as a whole, possibly without any benefit to the individual.

1st. To the individual the discipline of the studying may be a benefit. This discipline will depend on the method of study. The old method of learning paradigmatic grammar and piecing the parts together like building-blocks seems to me was much the same as the method of natural science and especially mathematics, where things get taken apart and put together again, analyzed and synthesized according to given rules, with the exception that natural science is based on the logic of Nature, while language study is based on the logic and illogicalness of the particular people whose language we have in hand. "It ought to be so," the student figures, but it isn't always. It isn't logic; it is life. The student learns that he is dealing with men; there is something besides reason and law, viz, feeling and habit, to be counted with. He learns this also in the social sciences, but differently. In the social sciences, history, economics, education, government, etc., he sees where feeling and habit have interfered with reason in the big things; in language he sees where they interfere in the very minutiae of thought. Different people have different habits of putting their ideas together; they have different habits of dividing the natural and the psychic world in their every-day thought, from which result the differences in the big things that are taught in the social sciences.

The newer or direct method avoids logical snytheses and analyses as much as possible and is based on imitation and habit. "Logic," its advocates say, "is better learned where it is thorough-going, in mathematics for instance; the important thing in language-study is that the student learns to feel and look at things—whether reasonably or unreasonably—as people of that language do, i. e., the student learns to sympathize with them, thereby broadening his own outlook and widening his understanding." This is quite the opposite goal to that of natural science, which must foster always the cold facts and ceases to be natural science as soon as it indulges in sympathies and feelings. But the benefits of seeing the same things in a different light due to the difference in feeling and habit of the other people, are not lost by this method. They are rather heightened, for the student as far as he has made actual progress in his language study according to standards of this method, becomes himself habituated to the points of view and feelings of the other people. He can react the way they would, if he wants to, and the fact that it is a foreign, i. e., a second or third language, makes him conscious naturally of one or more possibilities of reacting otherwise. This the one-language person is not aware of. Of course, the advocates of the direct method have not always been quite clear about this, and academic tradition has usually stood in the way of any fundamental proposals in this direction.

The benefit the student derives from the accomplishment of his study, will, of course, vary greatly. Reading knowledge for doctors' dissertations and further researches, foreign trade and diplomacy, pleasures of travel, reading for pleasure you have all heard enough about, and these things apply only to the small percent of the 15 percent going to college that under the present system continue their studies beyond collegiate requirements. But there is one possibility that you may allow me to mention of extending also to the 85 percent the benefit of the accomplishment of this study. The language of the United States is, to be sure, English, but there are many other languages spoken—some in one place, some in others. The theory of superior and inferior languages is a survival of the Renaissance or earlier times, when Latin was the language of the infallible Church, Greek the language of the blessed Apostles; and Hebrew the language of God Himself. Today scholars, if they admit a better and a worse among languages at all, admit also that they do not know which are the better and which the worse. The criterion of literature is often resorted to, but I fear that in doing so we are too prone to regard as greater the literature that we happen to know and as lesser the one we do not, and if an unprejudiced judgment based on an equal knowledge of the world's literature could be found, Sanskrit and Chinese among others would have to be added in conspicuous places to our present offering. At any rate, the study of a language for the sake of its literature applies only to a very small percent of our students, the students of literature; for all others there is more than they will ever read in original English and in translations made more carefully than these students will ever study a text either in the original or translation.

The fact is, nearly every resident in the United States has daily opportunity to exchange a few words in a language other than English. But today hardly any one avails himself of this opportunity; because in the days of his youth when his courage is good, he does not appreciate it, and in the days of his age, when wisdom is rife, his heart is sunk. Most valuable to a student are those accomplishments which he may continue to practice after his studies are over. If we can persuade him to this, the school need do only one thing: fit him out with that minimum of material necessary to make practise possible; then as he continues his practice outside the school, his vocabulary will grow, his precision will increase much as our English vocabulary has grown and become more precise. He will work out for himself if he has only slight ambition in this direction, all the advantages of thorough school training. But he must be started in this direction in the days of his youth.

Now we come to the second question: What benefits will society derive from such a study? I can answer in a few words. Discounting all the indirect benefits of accomplishment: reading knowledge for research, trade, diplomacy, literature, etc., the greatest I think still remains. A society in which all the half-educated people, i. e., high school graduates, use, however falteringly, two languages, will live in greater sympathy with the foreigners within its borders and in a better understanding with other nations. This in turn will afford a safer and more effective foundation for all those whom as students of foreign civilization, of art, literature, language, economics, government, we send abroad in increasing numbers every year. When the 85 per cent of high school students have gained a sympathetic understanding of at least one other language and a personal acquaintance with some of the people who speak it, they will be able to appreciate better the value to their own immediate society that the studies of the few who devote their lives to international understanding in one way or another, can have. Though the individual student should acquire nothing but a vague feeling that others by disposition and habit think, feel, and act in a way different from his, are reasonable and unreasonable in places where he is not; society as a whole, even though every one speaks the same language natively, will run smoother in its every-day intercourse and be less irritated and obstinate when the greater questions arise. It will be more tolerant of others' opinions and more open to the consideration of new ideas. The chief benefit from the study of foreign languages, properly conducted, is a moral one; and morality—that is human sympathy—is the greatest end of education.

THE SPIRITUAL VALUE OF SCIENTIFIC METHOD

By JOHN E. WINTER

(Professor of Phychology, West Virginia University)

The present year (1928) marks the 300th anniversary of Harvey's classical research. The suggestion has been broadcasted by the executive secretary of the American Association for Medical Progress to the various Academies of Science throughout the United States that they take advantage of this occasion to stress the spiritual values of scientific method. The subject offered such allurement to the writer that he undertook to follow up the suggestion, particularly in so far as the general subject is pertinent to his own special science, psychology.

At first thought the spiritual value of scientific method is so self-evident as to make superfluous any discussion of the subject. A little reflection, however, will reveal two tendencies in the thinking of men, either of which leads inevitably to colossal error either by openly opposing scientific method on the ground that it is destructive of spiritual values, or by siezing upon some of the genuine fruits of scientific method and attempting to rear upon those a pseudo-science with the avowed intention of reaping ill-earned gain. The first tendency is represented by many devotees of art and religion. The religious group, for example, contend that the great mysteries of religion are a sacred realm toward which man should not only assume an attitude of reverence, but into the workings of which he should not enquire lest his insight into the mysteries lead him to abandon his interest and destroy his reverence. That this fear of loss of interest in religion is not altogether without ground is attested by the familiar experience of students who upon obtraining a mere smattering of the history or philosophy of religion assume an attitude of revolt against, and contempt for, their earlier beliefs and practices altogether out of proportion to the value of their discoveries. The harrowing experience of a Galileo, a Newton, a Descartes, a Darwin, and a Braid, indicate the avidity with which the religious thinkers pursued their convictions.

The second tendency is represented by those who, profiting by the plausible hypothesis of localized areas for special mental functions, formulated an elaborate phrenology with an attendant system of supposedly scientific character analysis; or by those who base upon certain facts brought to light by the development of psycho-analysis an elaborate system of psychotherapy. In view of these tendencies, therefore, either to misunderstand the import of scientific method, or to abuse its legitimate results, it may not be out of place to call attention to the wealth of spiritual value inherent in it. In order to avoid ambiguity in our discussion we shall begin with a definition of terms.

Science is essentially descriptive. Its object is a complete and consistent description of experience in the simplest possible terms. Its method is (1) the discovery of facts, (2) the arrangement of these facts in systematic form, (3) the discovery of the conditions of their occurrence, and (4) development from these of a general formula or law.

The subject matter of science includes the whole knowable universe. It is not confined to physical facts alone, but covers psychological, aesthetic, and moral facts as well. In short, it deals with everything to which its methods can be applied. What makes a study scientific is not the nature of the material studied, but the method of dealing with it. According to Karl Pearson "The unity of all science consists alone in its method, not in its material."* The man who classifies facts of any kind whatever, who sees their mutual relations and describes their sequences, is applying the scientific method and is a man of science. In the words of Thomson, "The facts may belong to the past history of mankind, to the social statistics of our great cities, to the atmosphere of the most distant stars, to the digestive organs of a worm, or to the life of a scarcely visible bacillus. . . . . . . The smallest group of facts, if properly classified and logically dealt with, will form a stone which has its proper place in the great building of knowledge, wholly independent of the workman who has shaped it."** Science reveals unvarnished facts, and must always be disinterested and impersonal in its attitude. As Thorndike says, "science knows or should know no favorites, and cares for nothing in its conclusions but the truth." It represents knowledge rather than opinion. Opinion trusts its personal impressions, bows to authority and follows the crowd. Science does none of these. It "reveals the sources of its evidence, and the course of its arguments, so that any properly equipped thinker can verify for himself the facts asserted to be true."***

The method of science may be summed up in a single term,—analysis. Inherent in analysis are the more specific methods of observation, experiment, measurement or correct registration, induction and deduction. The methods employed in science are unique, and their use requires a specific attitude of mind or mood. Thomson draws a clear distinction between the scientific mood and what he calls the practical and emotional moods. "The practical man," he says, "tends toward doing, not knowing. He must have facts and social feelings if he is to be effective. He does not care, however, for the descriptive formulae of science, nor yet is he interested in aesthetics. The practical mood has much inherent good and leads to science, as the history of

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**Thomson, A., Introduction to Science.
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***Thorndike, E. L., The Principles of Teaching.

mathematics demonstrates. It is apt, however, to become tyrannous. Things are apt to overide ideals and ideas. The practical man is apt only to grub for edible roots, and not see the stars and the flowers."

"The emotional and artistic mood sees beauty and finds enjoyment in the heavens and the earth, in music, dancing, song, painting, carving and religious rites. This mood helps us to remain aware of the inner harmony of things. But, uncurbed by science, and unrelated to practice, it may become morbid, even mad. The scientific worker, on the other hand, elects primarily to know, not to do or feel. He does not try to exploit nature and control life, though he makes this more possible. He tries to describe nature's sequences in the simplest possible formulae. He tries to make the world translucent, not for the sake of emotion, but because of an inborn inquisitiveness, a dislike for obscurity, and a love of system."*

The specific characteristics of the scientific mood, which may very legitimately be called spiritual values, are, according to Sir Michael Foster (as quoted above by Thomson), as follows:

First, his nature must be one which vibrates in unison with that of which he is in search. The seeker after truth must be truthful with the truthfulness of nature; second, he must be alert of mind, alert to nature's secrets; third, scientific inquiry needs normal courage, especially the courage of endurance.

Thomson's own characteristics of the scientific mood are as follows:

First, a passion for facts, based upon accuracy of observation and precision of statement. To accomplish this is a hard task, even in simple occurrences, due in part to artistic rather than scientific interests, to lack of training or to wrong preconceptions. Second, cautiousness of statement. In other words, withholding judgment when data are incomplete, doubting conclusions quickly reached, hesitating to accept what is peculiarly attractive. Third, clearness of vision. Ascertained facts become clear to the scientist. The botanist, for example, sees clearly the sap, the water, the salts and the sugar in the tree. Fourth, a sense of the interrelatedness of things. Nature is a vibrating interconnected system. Darwin had this in mind when he said that "cats have to do with clover crops, and earthworms with the world's bread supply."

The application of scientific method to the study of human experience has produced results of stupendous importance. Evolution of thought has sometimes been tantamount to revolution. From astrology to astronomy; from Ptolomy to Copernicus, La Place and his successors; from alchemy to chemistry; from humours as an explanation of disease

*Thomson, A., Introduction to Science.

to the bacillus; from phlogiston or caloric to the molecular theory of heat; from the divining rod to the magnet; from special creation to the doctrine of evolution; from crude mesmerism to present day hypnotism; from phrenology to physiological psychology; from a world subject to the caprice of the gods to a world governed by universal law; the history of science reveals increasingly man's undaunted ambition to know the truth of the universe.

Within the field of psychology the application of scientific method to the solution of that most difficult problem—the mind-body problem—has yielded certain definite results. I quote them from Thomson, who is a scientist, but not a psychologist:

"1. While we do not know of any transition between the non-living and the living, we have a long series of steps connecting the simple reactions of unicellular animals with the intelligent behavior of dogs, horses and rational man.

"2. The genetic psychologist has much to tell us of individual developments of behavior, and of the gradual emergence of capacities, whether instinctive or rational.

"3. Science has much to say in regard to actual correlations between the static and dynamic of our organism, or between structure and function. It has been demonstrated, for example, that increase in the complexity of the brain correlates with increasing complexity of behavior."

To these advances in the science of psychology may be properly added the development of psycho-physics and certain aspects of psychotherapy.

The term "spiritual value" as here used is intended to cover all those values or characters that do not strictly belong to the material world. It is not limited to those values that are placed in the category of religion, although it will include the latter. It will also embrace all values that may be denoted as intellectual, moral and aesthetic in so far as these are distinguished from one another. Among the spiritual values of scientific method I would give imagination a conspicuous place. Scientists like Faraday, Kelvin, Darwin, Newton, Kepler, Boyle, and many others attained tremendous heights of imagination in formulating their hypotheses and in testing them out. "It is only ignorance," says Hering, "that fails to see in the scientist the richest facility of imagination, and it is a mistake to think he deals only with assured fact. He dreams dreams and sees visions, not at all to his discredit if he is not thrown off his balance by them." In the field of spiritual disciplines, such as art and literature, imagination is also legitimate but is apt to be subject to abuse through lack of checking up. "The fantasies of a story teller are likely to be woven when the author is in a dreamy mathematics demonstrates. It is apt, however, to become tyrannous. Things are apt to overide ideals and ideas. The practical man is apt only to grub for edible roots, and not see the stars and the flowers."

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The next spiritual value of scientific method is truthfulness or veracity. 'Man,' says Thomson, 'is too often content with "nearly" and "almost." Nature never is.' And Huxley said, "There is no alleviation for the suffering of mankind except veracity of thought and action, and the resolute facing of the world as it is, when the garment of make-believe by which pious hands have hidden its uglier features is stripped off." To quote Thomson again, "The scientist will use his imagination and make his hypotheses or guesses at the truth, but he will avoid giving to the ignorant as a gospel in the name of science, the rough guesses of yesterday that tomorrow should forget." "The world," said Faraday, "little knows how many of the thoughts and theories which have passed through the mind of a scientific investigator have been crushed in silence and secrecy by his own severe criticism and adverse examination."**

When Elliotson, the great English physician, in 1846 was called upon to deliver the Harveian lecture for that year he was savagely attacked by his fellow physicians because of his researches in the growing science of mesmerism. He was called a professional pariah and was told that his oration would be a black infamy. Undaunted by this Elliotson spoke on the subject of his researches, reminding his audience never to allow authority, conceit, habit or fear of ridicule to make them hostile to truth. In confirmation of his statement he quoted the following remarkable passage from Harvey's work: "True philosophers, compelled by the love of truth and wisdom, never fancy themselves so wise and full of sense as not to yield to truth from any source and at all times; nor are they so narrow minded as to believe any art or science has been handed down in such a state of perfection to us by our predecessors that nothing remains for future industry."

The cold reception accorded Elliotson by his fellow physicians, similar to the reception Harvey received at the hands of his contemporaries, suggests certain moral values that are essential in the scientists. Courage in the face of temporary defeat, patience under ridicule and false accusation, self control and intellectual honesty in withholding judgment in the face of insufficient evidence. No one really wants to be fooled in his judgments and beliefs, yet many people are unwilling to subject their beliefs to analysis for fear they may have to give them up. An overpowering wish supplants the love of truth. Not so the scientist. To quote from Thomson, "There is one thing I feel strongly," said Lord Kelvin, "in respect to investigations in physical and chemical laboratories, it leaves no room for shady, doubtful distinctions between

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To say that science contributes spiritual value to art would seem to be more difficult to demonstrate than its contribution to the moral life. Art has to do with beauty, harmony, enjoyment, wonder, admiration, symmetry. Its appeal is largely to the emotional aspect of our nature, while science belongs more strictly to the intellectual. Yet art would be much impoverished but for science. To know nature is essential to enjoying her. As we know nature better, everything becomes equally wonderful, if we know enough about it. A tiny grain of sand, a raindrop, a flower, a bird, a human infant inspires us with awe as much as does the majestic movement of the spheres, or the glory of the sunset. The discovery of the ceaseless bounding of the electrons or the capturing of ether waves affords an enjoyment fully equal to the ecstasy with which we listen to a virtuoso. The prevailing sense of order in the universe which began when man first noticed the regularity of day and night, the seasons, and the constellations, and which dispelled forever the old notion of arbitrary deities, afforded an experience in harmony comparable to the best that music and harmony have to offer. Far from interfering with art, science enlarges its borders and opens up new and wonderful vistas for its development.

There is a notion always present that to explain a wonder is to destroy it. It was Keats who said that "Newton had robbed mankind of the wonder of the rainbow," but as Thomson says "with the clearing up of minor mysteries, greater and grander mysteries appear, and there will always be plenty of mystery."

Religion, more than ethics or aesthetics, has for centuries been the arch enemy of science. Every advance in science has been sure to be interpreted as a blow to religion. The roster of scientists who became martyrs to their cause at the hands of an infuriated clergy is impressive. Galileo, Newton, Descartes, Bruno, Darwin and Braid are but a few of the more conspicuous of this group. Yet the advance of science has fostered the development of religious ideas and experiences. Despite this seemingly unrasonable antagonism on the part of religion, it is hardly possible to exaggerate the role of religion in human development. In view of this it behooves us always to treat the subject with reverence and sympathy. This attitude automatically dismisses as unscientific the viewpoint of those who deny or scout the validity of religion on the ground that it is a mere expression of fear or camouflaged sex. Although the respective fields of science and religion are largely incommensurable, they frequently meet, with the result that the transition from the one to the other is easy. Religion and science must inevitably clash when religious doctrine denies well-demonstrated facts of science, as in the case of Galileo. In the case of the doctrine of state with eyes closed; those of science are the product of the weaver whose eyes are open and who is very wide awake."*

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To understand more fully the spiritual value of science to religion we must note the specific field and the limitations of scientific method, for these limitations have a tendency to alter the conclusions of the scientist from the absoluteness, which they are apt to assume, to relativity.

In the first place every science, such as physics, chemistry and psychology, is based upon certain definite presuppositions such as the existence of matter, energy, life, mind and the uniformity of the laws of nature. For the most part the scientist does not deal with the veracity of these concepts, he assumes them. Whenever the scientist attacks the fundamental problem of his hypotheses he leaves the field of science and becomes a philosopher.

In the second place, science confines itself to the discovery of secondary causes and not first causes. Aristotle recognized four definite causes to account for the existence of phenomena,—the material cause, the efficient, the formal and the final causes. Science deals only with the first two of these, the material and the efficient causes. Science is satisfied if it can show a sequence in events under definitely known conditions. **How** things happen is a legitimate question for science, **why** they happen is not. Science thus makes no pretense to exhaustive explanation. The explanation of ultimate reality is beyond its realm, and all its presuppositions remain for it profoundly mysterious.

In the third place, the scientist knows that his measurements which form the basis for his conclusions are only approximate, that there is great difference among individual measurers, and that his conclusions must be accepted with reserve.

It is in the light of these limitations of science that the significance of religion appears. Religion begins where science ends. Science rests on unexplained presuppositions. The mystery of these is unsatisfactory to the inquiring mind which demands an explanation in terms of beginnings, ends, values and meanings. Religion offers a transcendental explanation to supplement the work of science. "Happy are they," says Thomson, "who, at the end of their intellectual tethers, can get a glimpse of incomprehensibles."

The attitude of worship and reverence may be strengthened by science, as we appreciate more fully the wonder, beauty and harmony of the universe, the immensities that tax our imagination, and the beneficence of nature toward those who learn its secrets and obey its laws. There is a certain wonder, born of ignorance, that is apt to disappear with the advance of knowledge. Such has frequently been the case as a result of the application of psycho-analysis to the emotions. Enlightenment is followed by a peculiar selfconsciousness that inhibits genuine feeling, and may even create contempt toward one's earlier attitudes. The latter attitude may be due, however, to a lack of appreciation of the values that sophistication affords.

Thus we see that science far from being hostile to spiritual values not only employs some of these in the very foundation of its method, but in the course of its procedure opens up new vistas without which our spiritual experience would be greatly impoverished.

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The attitude of worship and reverence may be strengthened by science, as we appreciate more fully the wonder, beauty and harmony

Literature and everyday speech are replete with references to instinct, most of which range in meaning from ordinary nature in the broadest sense, to aptitude. I quote here a few cases taken from McDougall's Social Psychology. "Ancestor worship has survived among western peoples as mere tradition and instinct." "A medical journal asserts that if a drunkard is fed on fruits, he will become instinctively a teetotaler." "The Russian people are rapidly acquiring a political instinct." "The notion that blood demands blood is an inveterate instinct of primitive humanity."

Stage 2.

These quotations will suffice to indicate a use of the term that is still popular, but uncritical. However, the early psychologists themselves used the term undiscriminatingly. Wundt, for example, the greatest psychologist of the past generation, applies the term instinct to the very strongly fixed acquired habits as well as to innate experiences.

Even the psychologist James makes no clear distinction between instinct and habit. To quote: "There can be no doubt that the instinct to seek a sheltered nook, open only on one side, into which he may retire and be safe, is in man quite as specific as the instinct of birds to build a nest. It is not necessarily in the shape of a shelter from wet and cold that the need comes before him, but he feels less exposed and more at home when not altogether unenclosed than when lying all abroad——We feign a shelter by backing our beds in rooms with their heads against the wall, and never lying in them the other way."* This for James is blind instinct.

Stage 3.

This loose and improperly defined use of the term demanded attention, and the psychologists of the last twenty-five years lost no time in formulating more or less clear-cut definitions of instinct. The task was in reality more difficult than it appeared to be. The result was that while there appeared to be a fair concensus of opinion as to the main trend of meaning of instinct, great and vital differences developed in working out details. We shall quote from a few of the outstanding authors, such as Watson, Woodworth, Angell, McDougall and Pillsbury, so as to bring out these differences.

Woodworth: "Instinct is innate behavior. It has a persisting tendency and is directed toward a result that cannot be instantly accomplished. It is not just a reaction, but an inner adjustment or tendency to reaction."**

Angell: "Instincts represent structurally preformed pathways in

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*James, Wm., Principles of Psychology.
**Wordworth, R. S., Psychology.

the nervous system, and stand functionally for effective coordinations made in response to environmental demands. The activity involves a series of acts, each one of which, considered singly, is relatively useless, but all of which taken together lead up to some adaptive consequence."*

McDougall: "Instinct is an inherited psycho-physical disposition which determines its possessor to perceive, and to pay attention to, objects of a certain class, to experience an emotional excitement of a particular quality upon receiving such an object, and to act in regard to it, or at least to experience an impulse to such action."**

Pillsbury: "The term instinct is used to indicate all acts whose conditions are inherited. It matters not whether these acts may be referred to specific inherited connections in the nervous system, or whether the act is the result of striving for an end which some innate predisposition compels the individual to strive for.*** In many cases the **desire** that an end shall be attained is all that is instinctive. The attainment of the end may be reached by various methods.

Watson: "Instinct is an hereditary pattern reaction, the separate elements of which are movements principally of the striped muscles. Or it may be called a combination of explicit congenital responses unfolding serially under appropriate stimulation.****

The quotations reveal five main divergences in the conception of instincts, each of which presents a distinct problem that demands solution.

1. The relation of instinct to consciousness. Does an instinct require consciousness in order to function?
2. The universality of instinct. Just how widespread must an act be in order to merit the term "instinct"?
3. The relation of instinct to reflex. Are they identical or divergent?
4. The problem of innate versus acquired characteristics. What is the relation between instinct and habit?
5. As a corollary to the problem of innateness there arises the question as to where innateness begins, and at what stage of the individuals development, if any, it ceases to function.

When once these problems have been settled, it will be a simple matter to solve the minor and subsidiary problems, such as actual number of instincts and their grouping into types.

Stage 4.

*Angell, R., Psychology.
**McDougall, Wm., Social Psychology.
***Pillsbury, W. B., Psychology.
****Watson, J. B., Psychology from the standpoint of a behaviorist.

The recent criticism of instinct which we have designated stage 4 in the development of this concept has gathered largely around the fourth of the major problems, namely, the relation between instinct and habit. All the psychologists referred to in stages 3 and 4 are agreed that instinct, if it exists and where it exists, is a form of innate behavior, that it represents an unlearned skill in its possessor. The question at issue is whether human beings possess such characters at all, and if they do, how long they persist. Kantor, for example, holds that the adult human being has no instincts. Kuo holds that the unlearned organism of the nervous system, that is, the nervous system previous to birth, is an uncharted sea (so far as innateness is concerned). He says that the reason for similarity of actions in large groups is not innateness, but because (1) all have the same sense organs; (2) all have the same reaction systems, hence responses must be of the same general kind; and (3) all the members of the group are subject to the same environment. For Kuo all responses are originally random, while certain ones soon get learned. These are what others call instincts. We shall refer to this latter point later on.

The psychologists whose definitions we have quoted—McDougall, Watson, Pillsbury, Woodworth—along with many others hold in general to the view that there are certain innate forms of behavior, but that they are soon modified by experience, and so develop into habits. The chief question at issue here is whether an act, in order to develop into a habit, must renounce or repudiate all relationship to the sources from which it sprang. The extreme environmentalists insist on the absolute separation of the terms and the two types of behavior. The majority of the psychologists recognize the organic relationship between the innate mechanism or disposition (or both) and the behavior that develops on this basis.

Most of the recent criticism of instinct arises from a partial apprehension or misapprehension as to the factors that are fundamental to the development of any habit. There are, in fact, four fairly well-defined forms of behavior, all of which are innate, and three of which furnish the sources from which habits arise.

These four modes of behavior are autonomic activity, reflex, instinct and random activity. The autonomic activities, such as digestion, circulation, and various forms of glandular activity are, as their name indicates, a law unto themselves and quite independent of environmental influences, so far as neural connections are concerned.

As to reflex and instinct, some authors use the two terms interchangeably, thus practically identifying them; others refuse to consider instinct as a valid form of experience, and use the term "reflex" to designate all innate behavior; while still others find a fairly well-defined line of demarcation between them. In the case of the third view reflex acts would indicate the more simple, innate behavior involving a prompt reaction of some restructed part of the body. Instinct, on the other hand, would be complex and would involve, according to Woodworth "a persisting tendency directed toward a result which cannot be instantly accomplished." It is not only a reaction but a tendency. Walking would be a case of instinct, while winking, smiling and the knee-jerk would be reflexes.

As to random activities, we can discern large numbers of these. In fact it is seldom that the body is not in some form of random movement. The fingers twitch, facial muscles are drawn, etc., with no particular purpose and in no coordinated direction.

Now it is these last three forms of behavior, reflex, instinct and random movements, that lie at the basis of all habit formation. Every habit is a development of one or more of these three forms of behavior. Learning the habit of typewriting or playing the piano would involve the coordination of large numbers of random innate activities. Learning to walk on a slack wire would require the development of the walking instinct (or reflex, if you prefer that term). Learning to keep the eye open while firing a gun would require a development of the winking reflex. Learning to fight would require the development of innate activities, more or less random, that form the experience of struggle.

In view of these facts my answer to those who claim that there are no instincts, or that many of the forms of behavior, such as aquisitiveness, hunting, collecting, fighting, rivalry, etc., are not instincts but habits, is this: (1) the particular direction that these activities take are undoubtedly influenced by environment, and may legitimately be called habits, but that each of these activities is an outgrowth of an innate form of behavior, which we may call instinct or reflex or random movement; (2) that although the outward form of behavior may suffer a change in the course of its development, the innate basis upon which the developed behavior rests persists as a tendency, urge or drive; (3) that this organic relation between innate behavior and habit cannot be ignored without doing violence to well-established facts.

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