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Biology Department

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PROCEEDINGS OF THE WEST VIRGINIA ACADEMY OF SCIENCE

Volume 4

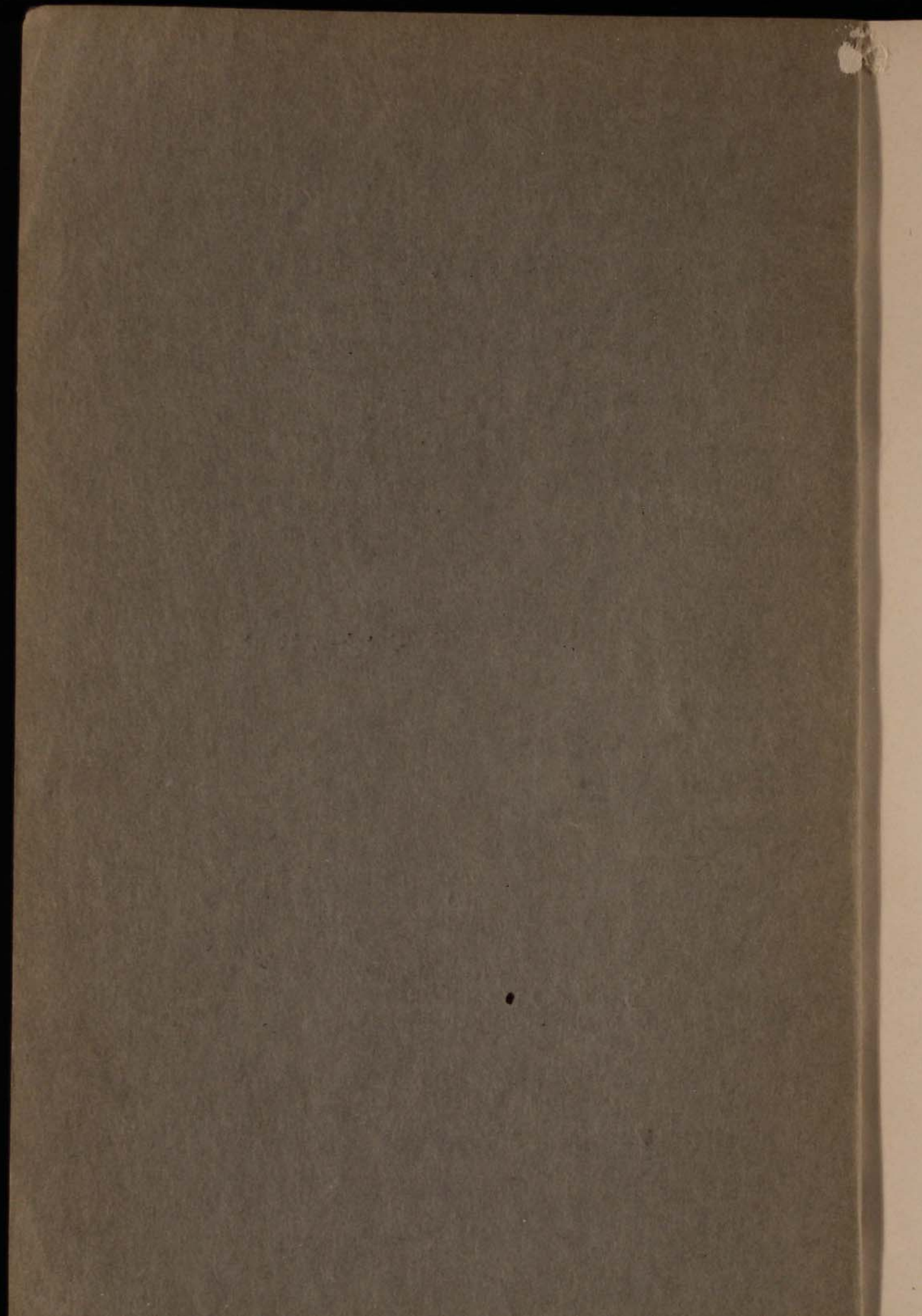


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PROCEEDINGS
OF THE WEST VIRGINIA
ACADEMY OF SCIENCE

Volume 4



October, 1930

Seventh Annual Session

33

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OFFICERS OF THE WEST VIRGINIA ACADEMY OF SCIENCE

Officers for 1929-1930.

President	H. F. Rogers, Fairmont
Vice President	A. B. Brooks, Wheeling
Secretary	P. D. Strausbaugh, Morgantown
Treasurer	H. T. McKinney, Bethany
Curator and Member of the Publica- tions Committee	John E. Winter, Morgantown

Chairmen of Sections.

Biology	B. R. Weimer, Bethany
Chemistry	E. C. H. Davies, Morgantown
Geology and Mining	C. E. Lawall, Morgantown
Mathematics and Physics	C. E. Albert, Elkins
Social Sciences	John E. Winter, Morgantown

Officers for 1930-1931.

President	A. B. Brooks, Wheeling
Vice President	P. D. Strausbaugh, Morgantown
Secretary	H. A. Davis, Morgantown
Treasurer	Carl G. Campbell, Huntington
Curator and Member of the Publica- tions Committee	John E. Winter, Morgantown

Chairmen of Sections.

Biology	Maurice Brooks, French Creek
Chemistry	W. W. Hodge, Morgantown
Geology and Mining	D. B. Reger, Morgantown
Mathematics and Physics	W. A. Hallam, Buckhannon
Social Sciences	C. E. Lauterbach, Buckhannon

MEMBERS OF THE WEST VIRGINIA ACADEMY
OF SCIENCE

- Albert, C. E., Dean of Davis and Elkins College, Elkins.
- *Ammons, Nellie P., Instructor in Botany, W. V. U., Morgantown.
- *Bancroft, George R., Professor of Chemistry, W. V. U., Morgantown.
- Beeler, Charles, Student, Fairmont Teachers' College, Fairmont.
- Bergy, Gordon A., Prof. Pharmacy, W. V. U., Morgantown.
- Bibbee, P. C., Prof. Biology, Concord State Teachers' College, Athens.
- Black, Amos, Instr. Mathematics, W. V. U., Morgantown.
- Blackwell, A. C., Prof. Chemistry, Morris-Harvey College, Barboursville.
- Bland, V. K., Weston.
- *Bleininger, A. V., Physician, Newell.
- Bloss, James R., Physician, 418 Eleventh Street, Huntington.
- Bond, H. D., Prof. Biology, Salem College, Salem.
- *Bourn, W. S., Boyce Thompson Institute for Plant Research, Yonkers, N. Y.
- Brock, Clarence, Teacher of Chemistry, East Side High School, Fairmont.
- *Brooks, A. B., Park Naturalist, Oglebay Park, Wheeling.
- *Brooks, Fred E., Entomologist, French Creek.
- *Brooks, Maurice, Teacher of Biology, French Creek.
- Brown, Russell G., Graduate Student, W. V. U., Morgantown.
- Burgess, Frances C., Prof. Geography, Marshall College, Huntington.
- Cameron, Hazel, Agr. Exp. Sta., W. V. U., Morgantown.
- *Campbell, Carl G., Prof. Chemistry, Marshall College, Huntington.
- Chapman, Daisy V., Teacher of Biology, Williamson.
- Chase, E. F., Philippi.
- *Chidester, F. E., Prof. Zoology, W. V. U., Morgantown.
- *Clark, Friend E., Prof. Chemistry, W. V. U., Morgantown.
- Collins, Berenice, 1215 Quarrier Street, Charleston.
- *Colwell, Rachel H., Prof. Home Economics, W. V. U., Morgantown.
- *Colwell, R. C., Prof. Physics, W. V. U., Morgantown.
- Conley, Phil, Editor West Virginia Review, Charleston.
- *Cook, Rollo V., Prof. Physics, Bethany College, Bethany.
- Cook, William A., State Superintendent of Education, Charleston.
- *Core, Earl L., Instr. Botany, W. V. U., Morgantown.
- *Cramblett, W. H., Prof. Mathematics, Bethany College, Bethany.
- *Cutright, Frank, Prof. Biology, Concord St. Teachers' College, Athens.
- Cutright, Paul R., Grad. Student, University of Pittsburgh, Pittsburgh, Pa.
- Dadisman, A. J., Prof. Farm Economics, W. V. U., Morgantown.
- *Davies, E. C. H., Prof. Chemistry, W. V. U., Morgantown.

- *Davis, Hannibal A., Prof. Mathematics, W. V. U., Morgantown.
*Dodds, G. S., Prof. Histology, W. V. U., Morgantown.
*Dustman, R. B., Prof. Chemistry, W. V. U., Morgantown.
Eddy, Zola M., High School, New Martinsville.
*Eiesland, John A., Prof. Mathematics, W. V. U., Morgantown.
Fenton, C. H., Prof. Pathology, W. V. U., Morgantown.
Forman, A. H., Prof. Electrical Engineering, W. V. U., Morgantown.
Frame, Nat T., Director of Agricultural Extension, W. V. U., Morgantown.
Franzheim, Charles Merts, Wheeling.
*Fromme, F. D., Dean College of Agriculture, W. V. U., Morgantown.
Frye, Wilbert M., Teacher, Capon Springs.
*Galbraith, F. D., Potomac State School, Keyser.
*Galpin, Sidney L., Prof. Geology, W. V. U., Morgantown.
*Garber, R. J., Prof. Agronomy, W. V. U., Morgantown.
Garrett, R. W., Prof. History, Bethany College, Bethany.
*Gilbert, Frank A., Prof. Botany, Marshall College, Huntington.
Green, Bayard, Elkins High School, Elkins.
*Greenleaf, William E., Dean College Arts and Sc., Marshall Col., Huntington.
Gwynn, C. W., Prof. Education, Davis and Elkins College, Elkins.
Hackney, Lillian, Prof. Mathematics, Marshall College, Huntington.
Hadden, Mildred, Teacher of Biology, Charleston.
Handlan, John W., Curator of Museum, Oglebay Park, Wheeling.
*Harris, T. L., Prof. Sociology, W. V. U., Morgantown.
*Harris, C. J., Prof. Biology, Morris-Harvey College, Barboursville.
Harshgarger, Jennie, Teacher Biology, Fairmont High School, Fairmont.
Haught, C. D., Prof. Physics, Fairmont St. Teachers' College, Fairmont.
Hearne, Julius G., Wheeling.
Hill, George H., Road Engineer, Charleston.
Hill, Canton N., Teacher Biology, East Side High School, Fairmont.
Hodge, W. W., Prof. Chemical Engineering, W. V. U., Morgantown.
Holland, Claude L., 400 Locust Avenue, Fairmont.
*H'ron, Ralph P., Prof. Physics, Marshall College, Huntington.
*Horner, R. R., Normal Gas Company, Clarksburg.
Hunter, J. Ross, Physician, 1013 Quarrier Street, Charleston.
Hussel, John, 1105 14th Street, Huntington.
*Jacobson, C. A., Prof. Chemistry, W. V. U., Morgantown.
*Johnson, R. W., Prof. Chemistry, Bethany College, Bethany.
*Jones, C. R., Dean College of Engineering, W. V. U., Morgantown.
Jones, Harris A., Meteorologist, Elkins.
*Judson, J. E., Prof. Biology, West Virginia Wesleyan, Buckhannon.
Judy, W. D., Teacher, Clarksburg.
Kaplan, D. B., Chemist, Morgantown.

- Kelly, Matthew J., Machinist, Elkins.
 Kerr, George, Student, Fairmont St. Teachers' College, Fairmont.
 *Knight, H. G., Chief Bureau of Soils and Chemistry, Washington, D. C.
 Lang, Thomas Simeon, City Engineer, Clarksburg.
 Lauterbach, C. E., Prof. Education, West Virginia Wesleyan, Buckhannon.
 Lawall, Charles E., Prof. Mining Engineering, W. V. U., Morgantown.
 *Leitch, Andrew, Prof. Psychology, Bethany College, Bethany.
 Lively, E. L., State Teachers' College, Fairmont.
 Long, Virginia Dare, Teacher, Weston High School, Weston.
 Loy, Melvin P., Prof. Zoology, Marshall College, Huntington.
 Martens, J. H. C., Prof. Geology, W. V. U., Morgantown.
 Maxwell, C. W., Attorney, Elkins.
 McClure, Iris,
 McGovran, E. R., Iowa State College, Ames, Iowa.
 *McKinney, H. T., Prof. Education, Bethany College, Bethany.
 McMillan, Teacher Chemistry, Morgantown High School, Morgantown.
 *McNeill, E. Meade, Prof. Biology, Concord St. Teachers' College, Athens
 Meharge, Laurence, Hazel Atlas Glass Company, Wheeling.
 Miller, Myrtle, Teacher Gen. Science, Fairmont Jr. High School, Fairmont.
 *Molby, F. A., Prof. Physics, W. V. U., Morgantown.
 Morgan, John J., Charleston Electrical Supply Company, Charleston.
 Montgomery, John G., Jr., 308 Seneca Street, Oil City, Pa.
 Moore, Laura B., Parkersburg.
 *Newins, H. S., State Forester, Charleston.
 Parrack, H. O., Grad. Student, Columbia University, New York, N. Y.
 Perkins, C. L., Forest Supervisor, Monongahela Nat'l Forest, Elkins.
 *Phelps, Edward, Prof. Chemistry, Marshall College, Huntington.
 Pond, R. S., Prof. Mathematics, Morris-Harvey College, Barboursville.
 Price, Paul H., Instructor in Geology, W. V. U., Morgantown.
 *Purdum, R. B., Prof. Physics, Davis and Elkins College, Elkins.
 Ramage, C. M., Physician, Fairmont.
 Raub, Leo G., Prof. Physics, New River St. College, Montgomery.
 *Reese, A. M., Prof. Zoology, W. V. U., Morgantown.
 *Reger, David B., State Geological Survey, Morgantown.
 *Reynolds, C. N., Prof. Mathematics, W. V. U., Morgantown.
 Rhodes, T. Thayer, Teacher of Science, Sandyville.
 Richards, Margaret, Teacher Biology, Morgantown High School, Morgantown.
 *Roberts, C. M., Prof. Biology, Fairmont St. Teachers' College, Fairmont.
 *Rogers, H. F., Prof. Chemistry, Fairmont St. Teachers' College, Fairmont.
 Rohr, H. D., Principal Weston High School, Weston.

- Saleski, R. E., Prof. German, Bethany College, Bethany.
Sargent, R. J., Dean Marshall College, Huntington.
Scott, S. A., Vice-President, New River State Coal Company, McDowell.
Sharp, Ward M., Graduate Student, W. V. U., Morgantown.
Shawkey, M. P., President, Marshall College, Huntington.
Shaw, D. A., Principal of High School, Gilbert.
Shouse, J. B., Dean Teachers' College, Marshall College, Huntington.
Simpson, John M., Dean Medical School, W. V. U., Morgantown.
Skuce, Thomas W., Extension Forester, Morgantown.
*Spangler, R. C., Prof. Botany, W. V. U., Morgantown.
Spray, Robert S., Prof. Bacteriology, W. V. U., Morgantown.
Staab, W. S., Prof. Mining Engineering, W. V. U., Morgantown.
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Stayman, Joseph W., President, Potomac State School, Keyser.
Stout, Wilbur, Geological Survey, Columbus, Ohio.
*Straley, H. W., III, Princeton.
*Strausbaugh, P. D., Prof. Botany, W. V. U., Morgantown.
Sumpstine, Wilbur J., Prof. Biology, Bethany College, Bethany.
Talbott, S. B., Prof. Biology, Davis and Elkins College, Elkins.
*Taylor, L. H., Prof. Zoology, W. V. U., Morgantown.
*Tilton, John L., Prof. Geology, W. V. U., Morgantown.
*Tucker, R. C., State Geological Survey, Box 265, Morgantown.
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*Vest, Lewis, 611 Randolph Ave., Elkins.
*Utterback, W. I., Prof. Zoology, Marshall College, Huntington.
Wade, S. S., Physician, Morgantown.
Wagner, John R., Glenville.
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*Weaver, J. B., 312 Buckhannon Ave., Clarksburg.
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*Weimer, B. R., Prof. Biology, Bethany College, Bethany.
Welch, George B., Prof. Physics, Marshall College, Huntington.
White, Bennett S., Prof. Drawing and Designing, W. V. U., Morgantown.
White, Frank S., Fairmont State Teachers' College, Fairmont.
White, Ryland, Fairmont State Teachers' College, Fairmont.
*Wilson, Dorothy, Potomac State School, Keyser.
*Winter, John E., Prof. Psychology, W. V. U., Morgantown.
*Woods, R. C., 1640 Sixth Avenue, Huntington.
Woolerly, W. K., Prof. History, Bethany College, Bethany.
*Workman, A. C., Dean, Bethany College, Bethany.
*Yeaton, Walter, Prof. Geology, W. V. U., Morgantown.

*Members of the American Association for the Advancement of Science.

CONSTITUTION OF THE WEST VIRGINIA
ACADEMY OF SCIENCE

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

ARTICLE II.—**Object.** The object of the Academy of Science shall be the encouragement of scientific work in the State of West Virginia.

ARTICLE III.—**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 candidates must have been nominated in writing by two members, one of whom must know the applicant personally; receive a majority 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. (As enacted by the Academy at the Elkins meeting, May 19, 1928).

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 officers 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. The term of the secretary shall be three years. (Provided for in amendment to constitution authorized by the Academy at West Virginia University meeting November 26, 1927).

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

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

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 members.

ARTICLE VIII—**Publications.** The Academy shall publish its transactions and papers which the Committee on Publications deems 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 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 meeting by a three-fourths vote of all active members present, provided a notice of said amendment has been sent to each member ten days in advance of the meeting.

BY-LAWS

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

1. Call to Order.
2. Reports of Officers.
3. Report of Executive Committee.
4. Reports of Standing Committees.
5. Election of Members.
6. Reports 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 for the Executive Committee.
- IV.—No bill against the Academy shall be paid without an order signed by the President and the Secretary.
- V.—Members who shall allow their dues to be unpaid for two years, having been annually notified of their arrearage by the 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.

The financial year shall end at 9 o'clock in the morning of the first day of the annual meeting after which time the books shall be available to the Auditing Committee. (Enacted by the Academy at the Charleston meeting, April 27, 1929).

In case a section adjourns without electing a chairman for the succeeding meeting, or 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. (By action of the Academy at West Virginia University meeting November 26, 1927).

- 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, Astronomy, Physics, Mechanical Engineering, Electrical Engineering.

Social Sciences. Philosophy, Psychology, Economics, Sociology, History.

MINUTES OF THE WEST VIRGINIA ACADEMY
OF SCIENCE

April 25 and 26, 1930.

The Seventh Annual Meeting of the West Virginia Academy of Science was held at the Potomac State School, Keyser, West Virginia, April 25 and 26, 1930.

On Friday at 1 o'clock the Academy convened in a business session with President H. F. Rogers in the chair. Dr. Joseph W. Stayman, President of Potomac State School, was introduced and, in a brief address, extended greetings and a welcome to the members of the Academy. He pointed out some of the industrial features of the region, and gave some information concerning the excursion to the Celanese Factory for which he had arranged as a part of the Academy programme. President Rogers responded for the Academy to this address of welcome.

The secretary was then asked to read the minutes of the previous meeting, and these were approved as read.

The report of the Treasurer was then called for, and was read by the Treasurer, Dr. H. T. McKinney. The text of the report follows:

Financial Statement of Treasurer, West Virginia Academy of Science
April 25, 1930.

Amount reported on hand, April, 1929, Charleston Meeting	\$272.15
Received from the secretary, refund from A. A. S.	23.00
Received as initiation and dues for year 1929-30	133.50
	<hr/>
	\$428.65
Less expense shown by cancelled checks	7.50
	<hr/>
Amount in Wellsburg National Bank, April 10	\$421.15
Additional fees received	2.00
	<hr/>
	\$423.15
Less checks No. 3, 4, 5 and 6	48.75
	<hr/>
Total on hand	\$374.40

Respectfully submitted,
H. T. MCKINNEY, Treasurer.

The secretary was then instructed to read the report of the Executive Committee, containing the following recommendations:

1. Your committee recommends that the West Virginia Academy of Science extend an invitation to the various, unaffiliated scientific societies of the state to become affiliated with the State Academy, and to submit for publication in the Proceedings of the Academy such papers as may be accepted by the Committee on Publications.

2. Your committee desires to recommend that May 15th, following the regular Annual Meeting of the Academy be designated as the final date for the submitting of papers to be published in the Proceedings, and that no papers be received after this time. This action seems necessary in order that the publication of the Proceedings may go forward to completion during the summer months.

3. Your committee recommends that the Academy accept the invitation of Dr. Homer E. Wark, President of West Virginia Wesleyan, to hold its Eighth Annual Meeting (1931) in Buckhannon.

4. Your committee has acted favorably upon the following applications for membership during the year. It is recommended that your immediate approval be given to the entire list in order that all may feel free to take part in the business of the session; and that such dues as have been paid in advance be considered payments due at this time for the coming year:

H. S. Newins, State Forester, Charleston.

Wilbert M. Frye, Teacher, Capon Springs.

J. E. Judson, Professor of Biology, West Virginia Wesleyan College, Buckhannon.

C. E. Lauterbach, Professor of Education, West Virginia Wesleyan College, Buckhannon.

C. M. Roberts, Professor of Biology, Fairmont State College, Fairmont.

J. H. C. Martens, Professor of Geology, West Virginia University, Morgantown.

C. J. Harris, Professor of Biology, Morris-Harvey College, Barboursville.

R. S. Pond, Professor Mathematics, Morris-Harvey College, Barboursville.

A. C. Blackwell, Professor of Chemistry, Morris-Harvey College, Barboursville.

H. D. Bond, Professor of Biology, Salem College, Salem.

C. L. Perkins, Forest Supervisor, Monongahela National Forest, Elkins.

H. W. Van Tromp, Physician, French Creek.

Wm. E. Greenleaf, Dean, College of Arts and Sciences, Marshall College, Huntington.

Phil Conley, Editor, West Virginia Review, Charleston.

John W. Handlan, Curator of Museum, Oglebay Park, Wheeling.

Caton N. Hill, Teacher of Biology, East Side High School, Fairmont.

5. Your committee recommends that the delegate of the Academy to the Annual Academy Conference be one of the following officers selected in the order mentioned: President, Vice-President, Secretary, Treasurer. In case none of these can be responsible for this duty, the President shall appoint a delegate to represent the Academy.

6. Your committee recommends the discontinuance of the policy of providing for a High School Essay Contest, and that the Executive Committee for the coming year be authorized to proceed at once with the organization and development of a Junior Academy of Science.

Signed:

H. F. ROGERS,

A. B. BROOKS,

P. D. STRAUSBAUGH,

H. T. MCKINNEY,

JOHN L. TILTON,

The various recommendations of the Executive Committee were considered separately and all of them were approved, without modification, by vote of the Academy.

The Secretary was then asked to read the report of the delegate of the Des Moines Academy Conference:

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE
THE ACADEMY CONFERENCE
REPORT OF THE DES MOINES SESSION

The Des Moines session of the Academy Conference occurred on Friday afternoon, December 27, immediately following the first council session at Des Moines and in the same room (room 331 of the Fort Des Moines Hotel). Fifteen members of the Conference and three invited guests were present.

The Conference consists of the council representatives of the affiliated academies (there being one representative from each academy) and three representatives of the Association council. The Conference is a special committee of the Association, organized for the purpose of furthering the work of the affiliated academies and improving the co-operation between them and the Association.

The Des Moines session was called to order at 4:30 with Dr. Howard

E. Enders, of the Indiana Academy, in the chair. The Secretary's report was read and accepted.

According to the action of the Conference at the New York session last year, the outgoing secretary automatically became chairman, and Dr. D. W. Morehouse, of the Iowa Academy, was declared chairman for 1930. As a result of a referendum vote taken by mail, Professor Chancey Juday, of the Wisconsin Academy, was elected secretary for 1930. In the absence of Professor Juday, Dr. Arthur C. Walton, of the Illinois Academy, was appointed secretary pro tem. Doctor Morehouse then assumed the chair.

A vote of thanks and appreciation was extended to Doctor Enders for his activity during the early days of the Academy Conference movement.

On motion, the privileges of the floor were extended to the invited guests of the Conference: Louise Astell, of the West Chicago High School; L. J. Thomas, of the Illinois Academy; Otis W. Caldwell, of Columbia University.

Doctor Livingston spoke briefly on the relations of the American Association to the affiliated state academies. Each academy has a representative in the Association council, who is a member of this conference. Each academy receives from the Association an annual allowance, for expenses, amounting to fifty cents for each academy member who is also a member of the Association. The Association wishes to carry out the academy arrangement by naming an Association representative named being an eminent scientist not resident in the state of the academy to which he is delegated. In view of the academy allowances, the Association is not in position to pay the expenses of these representatives and the aid of each academy is needed to enable this part of the plan to be carried out. If an academy secretary will inform Doctor Livingston as early as possible when arrangements are made for a speaker from outside of the state, that speaker may be named as the representative for the Association. The permanent secretary's office will aid in securing a representative from outside of the state if names of suggested persons are sent to Doctor Livingston early enough and if the representatives's expenses are to be care for by the academy. Discussion brought out the informal suggestion that part of the annual academy allowances might be used to meet the expenses of such representatives, who would presumably be invited speakers at the academy meetings. No definite action was taken.

The main subject for discussion at Des Moines was the question:- "How State Academies May Encourage Scientific Endeavor Among High School Students." Louis Astell, of the West Chicago Community High School, West Chicago, Illinois, led the discussion, by invitation. Mr. Astell has a very enviable reputation as a organizer of high-school science clubs and presented a very large number of profitable sugges-

tions in an excellent paper. This paper, or a summary of it, is to be made available through some form of publication, this matter being in charge of Dr. Otis W. Caldwell, of Columbia University, who is chairman of the Association's special committee on the place of science in education.

L. J. Thomas, former secretary of the Illinois Academy, and A. C. Walton, present secretary of the same Academy, presented a report on the methods used by the Illinois Academy in its very successful campaign among the high schools of the state, along lines similiar to those outlined by Mr. Astell.

Otis W. Caldwell, of Columbia University, suggested that the academies might offer a trip to the annual meeting of the American Association to certain high school students of their respective states, as a sort of prize for excellent junior academy work. He thought cash prizes were undesirable.

The session was followed by the Des Moines Academy dinner, given by the American Association to the Conference members who were present and the invited guests. While the dinner was in progress John T. McGill proposed the following resolution, which was unanimously adopted.

Resolved that the interchange of their publications by the affiliated state academies would be advantageous in promoting closer relationship with one another and in disseminating information about their activities; and

Resolved, that each academy is therefore requested to send to the other academies copies of its current publications and of back numbers as far as practicable.

At the close of the dinner a unanimous vote of appreciation was extended to Doctor Livingston, and through him, to the American Association, for the success of the Academy Conference and also for the courtesy of the Des Moines dinner.

(Signed) P. D. STRAUSBAUGH,

Delegate for the West Virginia Academy of Science.

Dr. C. A. Jacobson moved that the Scientific Society that becomes affiliated with the State Academy be allowed to appoint one member on the Publications Committee in charge of the publication of the Proceedings. This motion was passed.

President Rogers appointed the following committees:

Committee on Membership: Thomas Skuce, Chairman; A. M. Reese, Maurice Brooks.

Committee on Resolutions: David B. Reger, Chairman; Frank Cutright, B. R. Weimer.

Committee on Nominations: John L. Tilton, Chairman; C. D. Haught, Earl L. Core.

Auditing Committee: R. B. Purdum, Chairman; Walter A. Koehler, Frank S. White.

President H. F. Rogers then asked the Vice-President, Mr. A. B. Brooks, to take the chair while the President's Address was being given. Professor Rogers read a brief but inspiring paper on the subject, "The Scientist as Educator."

Following the address of the President the various sections convened separately for the reading of the papers announced in the sectional programs.

The complete program for the Seventh Annual Meeting of the Academy is as follows:

PROGRAM

Friday, April 25, 1930.

1:00 P. M.—Greeting, President Joseph W. Stayman, Potomac State School.

Reply, H. F. Rogers, President of the West Virginia Academy of Science.

Business of the Academy:—(This is an open session and all are invited to attend).

Reports of officers.

Report of Executive Committee.

Report of Standing Committee.

Election of Members.

Appointment of Special Committees.

Other Business.

1:30 P. M.—President's Address: The Scientist as Educator.

PAPERS

2:15 P. M.—Meetings by Sections.

Biology

(Botany, Zoology, Physiology, Medicine, Agriculture).

B. R. Weimer, Chairman.

Edwin Gould: The Biology of the Control of the Pistol Case Bearer in West Virginia.

Frank Cutright: The Teaching of Biology in Teacher Training Institutions.

Robert S. Spray: Some New Dehydrated Bacteriologic Diagnostic Mediums. 10 min.

D. R. Dodd: The effect of Soybeans on the yield of Succeeding Crops.

- Fred E. Brooks: A New Fossorial Wasp for West Virginia.
- B. R. Weimer: Comparative Length of the Alimentary Tract of the Male and Female Grass Frog. 4 min.
- L. H. Tiffany (Ohio State University): The Oedogoniaceae (lantern). 20 min.
- A. B. Brooks: Notes on Extinct and Living Mammals of West Virginia (lantern). 10 min.
- R. C. Spangler: Life History of Leathesia. 10 min.
- E. A. Livesay: Causes of Hybrid Vigor or Heterosis. 10 min.
- Thomas W. Skuce: Forest Types as Recognized and Used in West Virginia. 15 min.
- J. E. Judson: Some Old Plants of Florida. 10 min.
- P. D. Strausbaugh and Earl L. Core: Some Additions to the Millsbaugh Check List of West Virginia Spermatophytes. 10 min.

Chemistry

(Chemistry, Chemical Engineering, Pharmacy).

E. C. H. Davies, Chairman.

- Walter A. Koehler: The Whiteware Industry of West Virginia in Its Relation to Chemistry.
- B. B. Kaplan: Mineral Wastes.
- C. A. Jacobson: The Need of Standardizing Chemical Nomenclature. (It is hoped that this paper will start a general discussion in which others will participate).
- Earl C. H. Davies: Rythemic Evaporation of Orange II and Fast Red B. (Illustrated by samples, slides, and a home made movie).

Geology and Mining

(Geology, Coal and Oil Engineering, Road Commission, Building Material).

C. E. Lawall, Chairman.

- S. L. Galpin: Sedimentation Features of the Conemaugh at Morgantown. 10 min.
- L. V. Carpenter and A. H. Davidson: Progress in Treatment of Acid Mine Waters. 20-30 min.
- H. M. Fridley: The Physiography of the Appalachians.
- J. H. C. Martens: The Mineral Composition of Sand.
- J. L. Tilton: Animal and Plant Remains in the Rocks of Oglebay Park, West Virginia, and River Clays and the Pleistocene Problems in West Virginia (Two Papers).

Mathematics and Physics

(Mathematics, Astronomy, Physics, Mechanical Engineering, Electrical Engineering).

C. E. Albert, Chairman.

- R. C. Colwell: Some Lecture Demonstations in Introductory Physics.
 Mathew J. Kelly: Photographing the Moon.
 H. A. Davis: A Problem in Cremona Space Transformations.
 Amos Black: The Cremona Transformations Belonging to the Special Quadratic Complex of Lines Meeting a Conic.
 John Eiesland: An Analytic Treatment of Segre's V_3^3 in 4-space.
 R. P. H'ron: An Introduction to a course in General Physics Organized Around The Energy Concept.
 Discussion—The college curriculum in the light of present high school teaching.

Social Sciences

(Philosophy, Psychology, Education, Economics, Sociology, History).
 John E. Winter, Chairman.

- H. T. McKinney: A Study of the Religious Concepts of College Students. 15 min.
 T. L. Harris: Some Problems of Scientific Method in Sociology. 30 min.
 E. V. Bowers: Psychic Factors as a Cause of Misconduct in Problem Children. 25 min.
 C. E. Lauterbach: Lefthandedness. 25 min.
 E. M. Stalnaker: The Effect of $2\frac{1}{2}$ years of Town Influence on Scores of Standardized Tests Made on Rural Children. 10 min.
 F. S. White: What Type of Tests Should be Used in Rating College Students. 15 min.
 E. L. Lively: Ethics in Employment. 20 min.
 J. E. Winter: A Proposed Psycho-Clinic for the State of West Virginia. 10 min.
 6:30 P. M. Dinner, (No Speeches).

EVENING PROGRAM

- 8:00 P. M.—H. F. Rogers, President of the Academy, presiding.
 Introduction of winner of the essay contest.
 Reading of the Prize Essay: Out of Doors Where I Live.
 Award of Prize by H. F. Rogers.
 Address: Dr. E. N. Transeau, Ohio State University: The Original Vegetation of the North Central States, (Illustrated by lantern slides).
 Paper: W. C. Cook, State Superintendent of Free Schools: A Scientific Solution of West Virginia's Educational Problem.

Saturday, April 26

- 7:00 A. M.—Breakfast and Business Meeting.
 Remaining Papers.
 Business.
 Unfinished Business.

New Business.

Reports of Committees.

Auditing Committee.

Committee on Resolutions.

Committee on Nominations.

Election of Officers.

8:00 A. M.—Excursions to industrial plants and to other places, under the management of President Joseph W. Stayman, Potomac State School, and Local Committee.

Adjournment.

The winner in the Prize Essay Contest was Miss Lucille Stalnaker of the Uushur County High School. Owing to the absence of Miss Stalnaker, the prize essay was read by Mr. A. B. Brooks, Park Naturalist of Oglebay Park, Wheeling. The prize of \$25.00 was then awarded by President Rogers who gave the check to Mr. Maurice Brooks with instructions to deliver it to Miss Stalnaker as the award of the Academy in recognition of the superior merits of her essay.

Saturday Morning

At 8 o'clock the Academy was called to order by President Rogers. The report of the Membership Committee was called for and the following names were presented:-

J. B. Ward Jr., Student West Virginia University, Beverly.

Myrtle Miller, Teacher of General Science, Fairmont Junior High School, Fairmont.

Matthew J. Kelly, Elkins.

Dorothy Wilson, Department of Mathematics, Potomac State School, Keyser.

Amos Black, Department of Mathematics, West Virginia University, Morgantown.

The individual names were elected to membership by vote of the Academy.

The report of the Auditing Committee was then requested, and the report was as follows:

Treasurer's report audited by the committee April 25, 1930, and found to be correct.

(Signed)

R. B. PURDUM, Chairman

FRANK S. WHITE

W. A. KOEHLER

This report was approved.

The report of the Committee on Resolutions was called for and the following resolutions were presented:

We the members of the West Virginia Academy of Science, assembled in the Seventh Annual Meeting at Keyser, West Virginia, hereby resolve that:-

First, the thanks of the Academy are gratefully tendered to President Joseph W. Stayman and his associates of the Potomac State School for their cordial reception and entertainment.

Second, that in the death of Andrew Price of Marlinton, whose extraordinary love of nature throughout his whole life, and whose interest in the State of West Virginia has been a constant source of inspiration to his fellow citizens and especially to the youth of his home county, the State and the Academy have suffered an irreparable loss.

Respectfully submitted

DAVID B. REGER

B. R. WEIMER

FRANK CUTRIGHT

This report was accepted.

The reports of the section chairmen were given as follows:-

B. R. Weimer, Chairman of the Biology Section reported an attendance of thirty-two, and Mr. Maurice Brooks was elected chairman.

E. C. H. Davies, Chairman of the Chemistry Section reported an attendance of twenty, and W. W. Hodge was elected chairman.

C. E. Lawall, Chairman of the Section of Geology and Mining reported an attendance of eight, and D. B. Reger was elected chairman.

C. E. Albert, Chairman of the Section of Mathematics and Physics, reported an attendance of twelve, and no chairman was chosen.

J. E. Winter, Chairman of the Section of Social Sciences reported an attendance of twelve, and C. E. Lauterbach was elected chairman.

Dr. A. M. Reese, who is shortly to address the Kentucky Academy was instructed to extend to the members of that organization the greetings of the West Virginia Academy.

The President then called for the report of the Committee on Nominations:

Your Committee on Nomination of officers for the coming year reports as follows:

For President, A. B. Brooks.

For Vice-President, P. D. Strausbaugh.

Secretary, H. A. Davis.

For Treasurer, Carl G. Campbell.

For Curator and Member of the Committee on Publications,
J. E. Winter.

Committee

JOHN L. TILTON

C. D. HAUGHT

EARL L. CORE

This report was accepted and the Secretary was instructed to cast the ballot of the Academy for the names proposed.

The President then expressed his appreciation of the cooperation he had received during the course of the year. Following this, final announcements were made concerning the excursion to the Celanese Plant and the Geology trip under the direction of Mr. D. B. Reger, after which the meeting was adjourned.

P. D. STRAUSBAUGH, Secretary.

THE SCIENTIST AS EDUCATOR*

By

H. F. ROGERS,

Professor of Chemistry, Fairmont State Teachers' College.

As a large proportion of those composing the membership of the West Virginia Academy of Science are engaged in some form of educational work and as all scientists must be interested in spreading the gospel of science, some thoughts pertaining to the functions of the scientist as an educator will be appropriate here.

It is understood that the dominant interest of this gathering is science, not teaching. In the sectional meetings, reports of investigations in our various fields of science claim our attention: this is as it should be. Little will be said about education except by those who are scientific investigators of teaching and learning. That our emphasis is upon subject matter, the sciences pure and applied, is not an unhealthy sign; nor does it indicate lack of interest in matters educational. More and more it is clearly evident that it is of primary importance that teachers have a thorough knowledge of their own subjects and a keen interest in the latest developments and tendencies of their fields. Truly one must be a scientist, before he can be an effective teacher of any science. He must know at first hand its contents, methods, possibilities and applications and have a direct interest in its development.

To be sure, if one teaches a science, he should be convinced that his science has educative values. He should have a clearly defined conception of what these educative values are and know how to apply the materials of his field educationally. Furthermore he should become familiar with the findings of educational investigations applicable to his work as a teacher and cooperate with those who are seeking to establish educational practices on a sounder basis.

Superficially there may seem to be a necessary conflict of interests between scientific work and teaching. Devotion to research and scientific pursuits on the one hand and devotion to the work of instructing youth in the rudiments of science on the other may seem to be the impossible attempt to serve two masters; but not necessarily so. Indeed these two interests may be and should be supplementary. While there are many instances of instructors who are so wrapped up in their research work that they are neglectful of their teaching, and others who care little about science and research, but think they can teach better without it, there are those who make the happy adjustments of their interests wherein they may be real scientists and effective teachers at the same time. The fact is one cannot be an effective teacher of science, in the best sense, unless he is himself a scientist,—not just a book scien-

*President's Address.

tist or a theory scientist, but one who derives zeal and enthusiasm by actual participation in creative scientific work. The two interests are one: for a teacher cannot convey to his pupils the scientific spirit, genuine love of achievement in scientific work, nor can he train them adequately in scientific thinking and attitudes of mind unless he derives for himself these attributes and powers from direct scientific study and experience. True, one's time may be too limited to permit of extensive experimentation, but the spirit of experimentation, if one has it, should not be stifled, but some opportunity found for its expression. Thus one will enjoy the more, his place in the world of science; and as a teacher, he will be the more zealous, effective, vital and real.

For years as all know, productive scholarship has been a large factor entering into bases of judgment upon which professorial promotions and ranking are made. This fact naturally accentuates the evil, on the part of some, of neglecting teaching in order to devote more time to investigation, writing, etc. So, while urging the value of productive scholarship as a source of inspiration for better teaching and as necessary to effective science teaching, I lament the fact that in some quarters, promotion of teachers seems to be based wholly on the quantity of research work turned out and the amount of their extra-teaching activity. Productive scholarship should be regarded for the professor as a means toward the end of making him a more effective teacher and unless his devotion to teaching be somehow included in the judgment, an injustice may be done. Education should therefore seek to encourage productive scholarship, but see to it as well that those with research ability and who have the derived inspiration to transmit to their students should not be diverted entirely or too much from actual teaching. Educational administrators should so recognize the value of research when carried on by devoted teachers as a means to effective science teaching, that greater provision in time and facilities would be allowed.

The work of teaching science as to aims, results to be achieved, etc. will appeal to various teachers differently. There is a great diversity of pupil needs. We naturally think of our work in terms of the character and grade of the instruction which we are called upon to give: but it seems to me that we all have one dominant educational motive to actuate us as teachers of science, that is the desire to make people more scientific. That sounds trite, but who, blessed with scientific training, can contemplate how densely ignorant multitudes of people are of some of the simplest and most fundamental facts and principles of science, without being moved with a desire to banish the superstitions, errors, and prejudices which handicap and hamper so many. One of the greatest needs of the world is clearer thinking, and saner attitudes of mind. Science is often praised because of the inventions which add so much to human comfort, convenience, ease and pleasure, but a greater benefit by far she may confer in educating the rising generations to

think scientifically,—to use the common sense methods of science,—to be scientific in a scientific age. This I mean, not in the sense of making people chemists, biologists, geologists, psychologists in a limited specialized way (We shall have need to prepare the specialists it is true), but to give to all our pupils as far as possible enlightenment in such phases of these subjects as may have a significant bearing on everyday living and thinking. Does the subject matter we are giving our students obscure this objective? There is an educational doctrine which asserts: "Don't teach subjects, teach boys and girls." While this is a play on words to which one might retort: "How can you teach boys and girls unless you teach them something?" the dictum is sound in implying that subject-matter is not an end in itself, but a means to what should be a clearly defined educational end and that end for the teacher of science is as before stated to make our students more scientific:—in methods of thought and investigation, in background, mental perspective, in attitudes of mind, in precision, accuracy, fairness and intellectual honesty. The value of subject-matter *per se* depends on the pupils ability to use it as opportunities of using it arise. Since memorization of facts is not justifiable on the basis of discipline, some other value should be found for the mental pabulum we offer to our pupils. As regards the so called practical or useful information, how are we to know what may later prove to be useful? The real scientist who is also a devoted teacher will be the best judge of the relative value of his subject-matter. Often what superficially may seem to be practical information may not be really practical, while many an item of theory, a formula or an equation may be the most practical knowledge a student can acquire.

As to the scientist-teacher himself may I indulge in a few ideals? First, to safeguard his interests from being too narrow and restricted, his training should be broad. Of course we expect the thorough mastery of his specialty, but a broad training in his own science will be to his great advantage both in research and especially in teaching. And it is not enough to be broad in knowledge of the various subdivisions of one's own science. The sciences are so inter-related that one is every day feeling the need of certain phases of other sciences. As the chemists continually or often needs help from physics, mathematics, biology, etc. Also for the sake of effectiveness as a teacher his breadth of vision should include subjects which are not usually spoken of as science and he must be or should be broad in culture, scholarship and human understanding.

Another ideal I cherish for the scientist-teacher, and for all teachers, is that he be a human being,—a man with a social side, a sense of humor, some interest in the lighter more frivolous things as sports, games. Indeed one might even admit that he might forsake his profound pursuit of science for a game of bridge,—it has been done; but somehow the social side of his being ought to have a chance to function; laboratory

confinement and study sometimes make Jack a dull teacher, when it comes to the things in life which often count for the most.

The ideal science teacher is humble; for he realizes how small is his own knowledge in comparison with the whole of present day science, and how insignificant is this in comparison with the vastness of undiscovered truth.

The ideal scientist-teacher is honest; for fidelity to truth is the only basis for science.

The ideal scientist-teacher is reverent; for he must acknowledge how much our present scientific achievements depend upon the thinkers and workers of the past.

The ideal scientist-teacher is not profligate; for he knows the value of labor, of time, of energy, of natural resources and he knows the need of conservation.

The ideal scientist-teacher is sane in his thinking; his teaching will be constructive. He seeks the truth and proclaims the truth; for he believes the truth will make men free and make for the ultimate good.

As a scientist, it is not for him to deal with realms of religion, creeds, cults or philosophies, but the truth which he uncovers will dignify and enlarge human concepts as they take form in these other realms.

To summarize:

The teacher of a science should be himself a scientist.

The fundamental aim in science teaching is to make people more scientific,—with all that this implies.

The ideal scientist-teacher is broad, human, sane and constructive.

THE BIRDS AROUND MY HOME*

By

LUCILLE STALNAKER,
Student, Upshur County High School.

A Redbird sat on the edge of a feeding box and near her sat her mate. Occasionally he would extend to her a bit of bread or meat which she would take in her beak and proceed to devour. This happened within four feet of my eyes. However, I was concealed behind a curtain at a window which was near to one of my feeding boxes. It seems that some birds as well as some men choose to show their attentions and their affections in private rather than in public, for although I have watched by the hour since then within full sight of them, I have never seen the Redbirds do such an amusing thing again.

They are among the commonest birds which are around my home, but they are more timid than many of the other kinds. They are very noble in carriage and are beautiful of plumage. After a while they get to be very amiable and they are excellent songsters. Their loud clear warble and their little sharp metallic chirp can be heard all day long around my home when the ground is covered with snow.

On one side of my home I have a feeding box, open on all sides but with a roof to keep out the snow and rain. This box is suspended from the limb of a maple tree by a chain as a protection against a bird's greatest enemy—the cat. As long as feeding places for birds are within reach of a cat's greedy jaws it is better not to attempt feeding birds for one is doing them more harm than good.

On the other side of my home is a box made in much the same manner as the other but it is on top of a post which is about six feet high. About four feet above the ground I have nailed old pieces of tin (tin cans flattened out may be used) which are turned out at the bottom to resemble the shape of a washpan. This serves as a protection against cats for they are unable to climb over it.

In these boxes, and on the window sills which are far enough above the ground so that the cats cannot reach them, I keep different kinds of bread—biscuit, cornbread, and white bread. The birds invariably take cornbread and biscuit in preference to the white bread. I also keep chunks of fat meat in the boxes. The birds are very fond of this, but most of all they like nutmeats.

Some of the more common birds around my home in the winter are the Downy Woodpecker, the White-breasted Nuthatch, the Red-bellied Woodpecker, the Tufted Titmouse and the Chickadee.

Some of the birds which frequent my feeding boxes in the spring

*The winning essay in the High School Contest sponsored by the Academy.

and summer are the Robin, the American Goldfinch, the Carolina Wren and the Chipping Sparrow.

The Downy is the commonest of our Woodpeckers and if encouraged it will gradually get very tame. The Downies frequent my feeding boxes more than any other bird. It is amusing to watch them back down the tree trunks. I never saw one light on the feeding box without first rounding the tree trunk which is close by. The males have a bright red spot on the top of their heads but the females have none. I can get very close to them before they fly away.

The White-breasted Nuthatches can be seen at my feeding boxes every day. They have a short and square tail and are the only birds, in my knowledge, that can go down a tree head first. They prefer to eat meat instead of bread.

The Red-bellied Woodpeckers come rather often around my home but they are more shy and retiring than the other Woodpeckers. I have never been able to get very near one of them.

One morning last spring I was wakened by a loud, cheery song which came from the maple tree just outside my window. When I looked for the bird it was on a limb which was touching the house. It was a rich, rusty brown with a white stripe over the eye. The Carolina Wren had commenced its spring singing. Nearly every morning after that I could hear its pretty song which I can not describe.

The American Goldfinch is one of the most beautiful little creatures that I see in the spring and summer. Unlike other birds, Goldfinches do not nest in the spring but wait until June or July. Last summer I succeeded in getting within about two feet of one which was in a bed of many-colored flowers. I believe it thought, on account of its gay plumage, that I could not see it. And they really are hard to see, sometimes, for where it is possible they dwell among the flowers.

The Tufted Titmouse is one of my regular visitors and also one of my regular friends. When sitting on limbs of trees they can get themselves into the funniest positions imaginable! Their habits are almost identical with those of the Chickadee. I have had them eat from my hand a number of times.

I have had more fun and more experiences with the Chickadees than with any other bird. There are the cleverest little things in the world—in my opinion! They are by far the tamest of the local birds and they are the only birds which I have succeeded in getting to eat from my hands around my own home. They can cock their little black-capped heads in a way that will make anyone laugh. They have the most confiding disposition that one can imagine a bird having.

At my delight in finding one of my bird-loving friends had the birds eating from his hands he informed me that I could experience the same thing with but little work. I was told to stuff an old glove, fasten it to a stick and put it out one of the windows of my home. He

told me to put my best foods on it and that very soon I could expect results. I put the old glove out one evening and on rising the next morning I hurried to the window. On the limbs of the tree nearby were three or four Chickadees but none would venture to the glove. I had to go to school that day but when I returned home in the evening I found that all the nutmeats which I had placed on the glove were gone. I immediately put more on the glove and sat down behind the curtain to watch. Between four and five o'clock is one of the times, especially in the winter, when the birds like to eat. Soon they began to arrive at the feeding box which was near the window. Suddenly a Chickadee lit on the glove, cocked his little head sidewise, and then flew! As I watched two more came, acted in much the same manner, and were gone.

This kept occurring daily for about a week and each day I noticed that the birds seemed less frightened. Finally one evening I removed the glove and put out my own hand instead. To my delight they came promptly and since then there has not been a day but what they have eaten from my hand. Of course they have gradually become more tame. Now I can go out almost anywhere about my home and they will come to me. When it is cold I feed them from the windows and they have learned how to get their nutmeats when they want them. It is the idea of some people that birds do not reason. If they could see my Chickadees I'm sure they would change their minds. When they get hungry they simply fly against the windows of the room in which some one of the family is, or often they will light on the sill and sing. I can hear their little scolding or chuckling notes every morning when I am eating my breakfast. Neither my Mother nor I can refuse their entreating noises. When I put my hand out they will hop around for a while, singing their clear "chickadee-dee-dee" or "dee-dee-dee-dee" before lighting on my hand.

One day a piece of shriveled-up walnut was on my hand and when the Chickadee picked it up, immediately, with a jerk of his head he threw it down again. Shutting his mouth with determination he regarded me sternly with his round black eyes. His eyes clearly spoke his thoughts. I was being criticized for putting such a thing before him. Then he picked up another piece and hurried away.

These are only a few of my experiences with the Chickadees but I know that I shall always remember the funny little things which they have done to make me love them and to appreciate wild life.

FOREST TYPES AS RECOGNIZED AND USED IN WEST VIRGINIA

By

THOMAS W. SKUCE,

Extension Forester, West Virginia University.

The forest cover of West Virginia influenced as it is in difference in climate, elevation, and topography is composed of a large variety and combination of species. There are present three life zones or belts of forest vegetation. The lowest in elevation, the Carolinian, covers more than one-half the state with its southern extremity marked by the great Kanawha River. It is in this area that the best agricultural soils of the state are found. This belt is characterized by the presence of sassafras, yellow poplar, red birch, persimmon, and short leaf pine. The hickory, oak, chestnut, walnut, red gum, and maple are also found in abundance.

The Allegheny area or belt extends over the remaining part of the state with the exception of the higher mountains which is characterized by the coniferous species at 3000 feet or better in elevation. The characteristic species for the former are beech, birch, sugar maple, and hemlock of the north associated with the chestnut, walnut, oaks, butternut, beech, hazelnut, and hickory. In the latter we find that red spruce, hemlock and yellow birch are outstanding. A few scattered specimens of *Abies Fraseri* are scattered through this Canadian zone, but is not sufficient to designate the type as spruce fir. It should more be more properly called spruce hemlock.

These various zones are so inter-mingled in a way due to the varying topography it is very hard at times to type in West Virginia consistently with any established set of forest types.

There is difficulty encountered in type classification in a region in which changes and compositions occur with acre to acre. It may be well to note here that Buell's party working out from the Appalachian Station around Bluefield, in the extreme southern part of West Virginia confined their attention to what he called "cove hardwoods." They recognized forest types, all of which would probably fall under the Appalachian Section's embracive type of "cove hardwoods." He names his type as follows:

Cove Hardwoods

Yellow poplar	Beech
White oak	Sugar maple
Cucumber	Hemlock

Hemlock—Cove Hardwoods
(Cove-Hemlock)

Hemlock	Red oak
Yellow poplar	Beech
Chestnut	Basswood
Sugar maple	
Cove—Northern Hardwoods (Northern Hardwoods)	
Basswood	Beech
Sugar maple	Chestnut
Hemlock	White ash
Yellow poplar	

These combinations all occurred around elevations of 2,000 feet. The Appalachian Type Committee did not attempt to recognize cove types other than "cove hardwoods," except in the case of cove hemlock and yellow poplar, where these dominate the stand. It is realized that a further sub-division would be necessary from the point of view of silviculture and forest research at least, but such sub-division has been left for the future. The same thing is true of some of the types on the dry sites.

Much criticism has come from foresters engaged in acquisition work and general surveys against recognition of so many types since such work demands simplification of classes. As to this problem it may be interesting to note that some of the foresters in some sections of the state in which Buell's party worked is so very simplified that the classification fails to recognize silvicultural types from this standpoint, but rather in the land types and aspect types, that is the north and west slopes as compared with the south and east slopes. By slope is meant in the direction which the slope faces. This having been established for timber types as existing where the slope types are recognized. These are "cove," lower slope, upper slope and ridge. The stand composition all in one of the sub-types depend largely on which slope it falls in.

On adjacent properties still in the general Bluefield area, only three forest types are recognized. These are the "cove" type in which poplar, cucumber, basswood, walnut, beech, maple, white oak, hemlock predominates. Slope type in which chestnut, white oak, red and black oaks predominate. In the ridge type include chestnut oak, chestnut, hickory and black oak. These are for lands that are distinctly mountainous. All of these types, of course, include other species than those mentioned varying with topography. It is recognized that other types sometime occur, but for practical purposes it does not seem feasible to go into more detail. To meet such a demand for simplification of classes it might be necessary to conform to this requirement by establishing larger categories which might be termed "forests" under which the individual types might be placed. No doubt the hope for a general

forest classification for the East will lie in some such form of sub-classification.

Coming north of the Great Kanawha river we find that the question of forest types are only recognized as they influence the major logging units. In such cases the virgin type does not necessarily indicate at all times what the cut-over type is going to be, especially is this true in the mixed softwoods where spruce 40%, hemlock 40% and hardwoods 20% comprises the stand. The hardwood in this case is mostly yellow birch, black birch, hard and soft maple. When hardwoods are found mixed in this way they are of an inferior grade.

Clear spruce, this type is found on top of the ridges and in some cases is very good running from 30 to 40 thousand board feet per acre and saws a very good grade. As a sub-type there is recognized a pure spruce orchard 8 to 14 inches diameter. These are very old and make only pulp. This runs from 20 to 70 cords to the acre. These are found only on the high ridges.

Clear hemlock, very big stuff, found along the streams and once in a while we find pure stands on the slope, of a few acres. Why it is there, is some ecological factors that is hard to explain.

Mixed hardwoods, this is beech, birch, and maple about 66%. The rest is the other hardwoods, according to the soil and exposure. If the soil is dry it is chestnut and oak, if wet, poplar, cherry, basswood, etc.

Oak-Chestnut type, on Elk and lower Gauley and to the south and west is found this type almost all together. This is due to dry soil caused by slope of rock strata, the water is allowed to drain off. The soil is thin and poor, the better species just won't grow.

The cut-over lands is about the same with the exception of the softwoods. They don't come back, as a rule, and the ground is taken over by the hardwoods. This I think is due to the seed years coming so irregular.

In the region covered by the Monongahela National Forest where the Frothingham tables for upland hardwoods are used, we consider site qualities I and II as synonymous. Generally speaking, there is little site quality I in the Appalachians while site quality II comprises most of the "cove".

SITE QUALITY I AND II (COVE TYPES): Hardwood stands in which the mature dominant trees produce on an average three or more 16-foot logs or more and hemlock and white pine and other conifers producing an average of five or more logs per tree.

The stand classes are prevailing found close to the drainage lines, though they often extend well up on fertile slopes especially on soils which are derived from limestones, and sometimes even occur on benches and along the crests of ridges. The predominant species are usually yellow poplar, red oak, chestnut, hemlock and white pine in varying proportions; but often white oak and cucumber; sweet gum, spotted

oak, southern red oak and red maple, birches and hemlock; linn, cherry, buckeye, ash and silverbell, form characteristic stands; and less frequently yellow pine, black oak and hickory. Virgin cove stands yield from 7,500 to 25,000 feet b. m. of hardwoods or the equivalent. Second growth stands 100 per cent stocked should yield at maturity 35,000 feet b. m. Most of these stands in which chestnut or hemlock predominate have a heavy undergrowth of laurel.

SITE QUALITY III (LOWER SLOPE TYPES): Stands in which the mature dominant hardwood trees produce an average of two 16-foot logs per tree; yellow pine an average of three logs, and hemlock, white pine and other coniferous stands an average of four logs per tree.

SITE QUALITY IV (UPPER SLOPE TYPES): Stands in which the mature dominant hardwood trees produce an average of one 16-foot log per tree; yellow pine two logs, or other coniferous two and one-half logs.

The greater portion of the beech, birch, and maple mixtures lies within classes III and IV. These mixtures largely characterize the northern portion of the Allegheny Unit; they form the greater portion of the Monongahela Unit lying below the spruce belt and above 2000 feet elevation and constitute considerable areas at high altitude, particularly on north slopes in the Appalachians further southward.

Classes III and IV lie chiefly on the slopes but frequently cover the crests, especially the low and flattened summits or the ridges of the Alabama and Ozark Units. They embrace not only the species of the cover types as their stands become inferior, but include extensive stands of chestnut oak; Spanish oak and black pines, scrub pines, post oak and kalmia. The difference between upper slope and lower slope is usually more a matter of degree of site quality than of difference in composition.

SITE QUALITY V (RIDGE TYPES): In which most of the merchantable timber would consist of ties and cordwood, and in which the hardwood trees contain less than one 16-foot saw log per tree, yellow pine one 16-foot log, and white pine about one and a half saw logs per tree.

This class is largely limited to stands of the oaks, chestnut, the yellow pines or beech. They occupy the crests of ridges or the driest, most rocky slopes, or occasionally thin soiled flats. These sites produce virgin stands of hardwoods yielding less than 2500 board feet of saw timber per acre. Second growth stands 100% stocked might at maturity contain 5,000 b. m.

Spruce Types: In the Appalachians, south of Virginia, occur only above altitudes of 4,500 feet, in West Virginia above 2,500 feet and are composed largely of red spruce associated with hemlock, and with a small proportion of yellow and white birches, beech and maple.

Barren: Is land unsuited for grazing or farming and incapable of producing merchantable timber for industrial uses; e. g., the scrub oak lands of the sandstone mountains, lettuce beds and slicks of the Smoky Mountains; flat rocks of the Savannah Unit; and laurel and huckleberry thickets; and in the White Mountains, lands above timber line.

Burns: Consist (1) of spruce, hemlock and less often pine lands which have been so badly injured by fire that the trees have been entirely or largely killed, the soil destroyed or severely injured, and all young coniferous growth killed; (2) of hardwood lands on which the young growth hardwoods have been killed back so repeatedly that the value of the mature hardwood stands will be greatly reduced through suckers or by multi-caulin sprouting.

VALUES OF SITE QUALITIES: The site is expressed in terms of the quality of the stand which **now occupies** the soil, not that of a stand or species which has been eradicated and is replaced by a different species or mixture, and where replacement of valuable species is taking place through encroachment of some less desirable species, that should be reckoned with as a modifying element.

The following table shows the site qualities, virgin stand per acre on which the sites are based, and maximum price for each. This table is therefore one of base soil values.

It should be pointed out that this table is for the average virgin mature stands found in the Southern Appalachians. Such stands are, as a rule, not fully stocked and consequently are not indicative of the maximum capacities of the sites as is the case in the Frothingham tables.

STAND PER ACRE—BOARD FEET

Site Quality	Hardwoods	Yellow Pine	Hemlock and White Pine	Maximum Value per acre X (Soil Value only)
I-II	10,000 or more	15,000 or more	20,000 or more	\$5.00
	9,000	13,500	18,000	4.50
	8,000	12,000	16,000	5.00
III	7,000	10,500	14,000	3.75
	6,000	9,000	12,000	3.25
	5,000	7,500	10,000	2.75
IV	4,000	6,000	8,000	2.50
	3,000	4,500	6,000	2.00
V	2,000	3,000	4,000	1.75
	1,000	1,500	2,000	1.25
Spruce				3.00
Barren				.50
Burns				1.00

X—To arrive at stumpage values a regular timber appraisal the same as in case of a timber is made.

These major types are further subdivided into sub-types as follows:

SUB-TYPES

There are five forested sub-types.

Light Culled: In which some timber has been recently cut but less than 25 per cent of the stand has been removed.

Heavy Culled: In which from 25 to 75 per cent of the stand has been removed.

Cut-Over: In which more than 75 per cent of stand has been removed.

Burned: As described under Burns.

Second Growth: Consists of cut-over areas covered with young stands in large saplings and pole stages but not yet of saw log size.

Of fields or open lands, the following sub-types are recognized.

Cultivated land which is at present in cultivation or was in cultivation during the past season.

Grass land, including pasture, natural meadows, and abandoned fields which are in grass.

Re-stocking consisting of cultivated or grass lands which are re-stocking to forest trees which are below pole size and to such an extent that a forest cover would probably be formed within a period of 5 years. Older re-stocking stands are classed as second growth.

THE ECOLOGY OF THREE FATED GYMNOSPERMS

By

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(Abstract)

The cypresses (species of *Taxodium*), *zamia* and the stinking cedar (*Tumion taxifolium*) were plants that flourished extensively in ancient times. These plants have been restricted from a comparatively wide distribution in ancient times to a narrow region in modern times.

There are at present three species of cypress and they live naturally only in southeastern United States and Central America. The bald cypress (*Taxodium distichum*) is distinguished from the pond cypress (*Taxodium ascendens*) by its habitat and structural characteristics. In nature the bald cypress is found growing in rich swampy soils, while the pond cypress grows in clear pools with sandy bottoms. These trees grow very slowly and it is not unusual for a large tree to be seven hundred or more years old.

The *zamia* plants are at the present day restricted to the tropics. They are the modern representatives of the line that began with the Pteridosperms of the Paleozoic and were continued by the Bennettiales of the Mesozoic. Today these plants are conspicuous in southern and central Florida. *Tumion taxifolium* (stinking cedar) is even further restricted in its distribution and grows naturally only on the Appalachicola River bluffs of northern Florida. The stinking cedar and the cypress grow well farther north, if given an opportunity. The reasons these plants are confined to such narrow limits are that the climate has changed and the faster growing plants have evolved. In nature the cypresses were allowed to grow only in the swamps and in water, where the more rapid growing trees could not grow. Now they are being cut for lumber and in this way man is aiding in their destruction. If conditions continue at their present rate, these plants will become extinct as have their ancient relatives.

SOME ADDITIONS TO THE MILLSPAUGH CHECK LIST
OF WEST VIRGINIA SPERMATOPHYTES

By

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The flora of our state has always been of special interest and as early as 1793, Andre Michaux collected along the borders of West Virginia. During the 19th century the state was visited by the most celebrated botanists of the time; the list of collectors—a very long list—including such names as Pursh, Kin, Rafinesque, Gray, Sullivant, Canby, Merriam, Barnes, Coulter, Pringle, Small, Britton, Nuttall, and many others. While most of the primitive forest of West Virginia has been destroyed, the flora is still very interesting and deserving of the most profound study. It is hoped that all the present-day botanists of the state will unite in the effort to accumulate all possible information concerning our rich and abundant flora which inherently constitutes one of the greatest natural assets of the commonwealth.

A "Preliminary Catalogue of the Flora of West Virginia" was published in 1891, by the West Virginia Agricultural Experiment Station. This work was revised by Dr. Charles Frederick Millspaugh and the revision was published by him in 1896, under the caption, "West Virginia Flora." Finally, in 1913, Volume V (A) of the West Virginia Geological Survey appeared in which Dr. Millspaugh presented an entire revision of the "West Virginia Flora." Part I of this publication entitled "The Living Flora of West Virginia," and commonly known as the check list of the flora of our state, embodies in addition to the work of Dr. Millspaugh, the results of the studies of Dr. John L. Sheldon, and those of more than one hundred other individuals who had collected plants within the confines of our state.

This publication of 1913, presents a list of 1,586 spermatophyte species, and in most instances the name of the collector is given, and also stations where specimens were found. Unfortunately many of the herbarium specimens on which these records were based have been lost and consequently much of the work can not be verified. Doubtless most of the records are authentic but in a few instances there is some question as to the accuracy of identification; e. g., *Kalmia angustifolia* L., the narrow-leaved Sheep-Laurel, is reported from five counties of the state but recent attempts of a number of botanists to verify this record have failed to produce any evidence of its occurrence in the counties designated, or elsewhere in the state. There are also some errors apparent in the arrangement of species; e. g., *Andropogon scoparius* Michx., is designated as "Broom Sedge" and the notes concerning its distribution are clearly intended to apply in connection with *A. virginicus* L., which

is the species commonly known as "Broom Sedge," and which is much more widely distributed throughout the state.

Since 1913, many botanists have been interested in the flora of West Virginia and many specimens have been collected that are not mentioned in Dr. Millspaugh's check list. In 1924, the members of the staff of the Botany Department of West Virginia University outlined a plan to establish a State Herbarium which would eventually include all the available species represented in our state flora. Systematic work was begun and this has been continued ever since. Collectors in various parts of the state have assisted in this work and at the present time 1,500 species of seed plants have been catalogued and filed in the herbarium cabinets. The specimens are filed in such a way that any desired species or group can be found instantly and thus the herbarium material is made available to any one who may be seeking information concerning West Virginia plants. It is hoped that eventually sufficient information may be procured to make possible the publication of distribution maps for each species of seed plant represented in the state. To accomplish this end the cooperation of every botanist and every collector of plants within the state will be absolutely indispensable, and a prodigious amount of intensive work will be required.

Another objective arrived at in the course of the work is the revision of the Millspaugh check list. The demand for such a revision is insistent, and the material necessary is accumulating. However, any revision attempted should be based on careful and accurate identification of specimens that have been preserved in a herbarium where they may be available for examination at any future time. But here again, the cooperation of every botanist of the state is essential to the production of a complete and thoroughly dependable check list of West Virginia plants.

As some time must necessarily elapse before a complete revision of the Millspaugh check list can be effected, a preliminary list of all those species of spermatophytes not mentioned in the former publication has been prepared in order that information concerning the occurrence of such species within our flora may be more generally available. In presenting this list the authors have no selfish interests prompting a claim to priority in discovery, and they willingly and gladly acknowledge the fact that a great many of the species mentioned were first discovered by other botanists and publication of such discovery has already been made elsewhere. But this information is scattered through the literature and exceedingly difficult to find, and therefore it was thought that a check list of these additions would be helpful. Specimens of each of these species have been placed in the State Herbarium, and while most of these were collected in connection with the work of the University Botanical Expeditions, several specimens were donated by botanists collecting independently. For such kindly cooperation we are very grate-

ful to Mr. L. W. Nuttall of San Diego, California, and to Dr. Frank A. Gilbert of the Botany Department of Marshall College.

This preliminary check list contains 218 species and varieties distributed through forty-eight different families. Forty species of grasses are included in this list and this represents the largest number of additions in any single family. Mr. E. E. Berkley, one of our former students, now of the Department of Botany in Washington University, has made a thorough study of the Gramineae of the state, and we are largely indebted to this work for the species now in the State Herbarium, a collection containing practically all of the grass species occurring in the state. Thirty species have been added to the Compositae and twenty-four species to the Cyperaceae. Mr. Ward M. Sharp, a graduate student in the Department of Botany at West Virginia University, is making a thorough survey of the former group and the junior author is engaged in a similiar study of the Cyperaceae.

Some of the species mentioned, such as *Eleocharis quadrangulata*, *Glyceria pallida*, *Xyris arenicola*, *Hexalectris aphylla*, *Roubieva multifida*, *Paronychia argyrocoma*, *Amelanchier oligocarpa*, *Galactia volubilis*, *Hibiscus oculiroseus*, *Galium boreale*, etc., are very restricted in their distribution. Some species like *Verbena bracteosa*, and *Rumex pulcher* are very evidently recent introductions that have as yet only a local distribution. Other species mentioned have a considerable range and certainly have been growing in the state for a long time, but apparently were not observed by the earlier workers. In connection with each of the species listed, the station or stations where collections were made are noted. It is very likely that this list will be considerably extended when more intensive studies can be made of particularly favorable regions that have not yet received thorough study.

Sparganiaceae

- Sparganium americanum* Nutt.—Dunmore, Pocahontas.
Sparganium lucidum Fernald and Eames—Bretz, Preston.
Sparganium chlorocarpum Rydb.—Green Bank, Pocahontas.

Alismaceae

- Sagittaria longirostra* (M. Micheli) J. G. Sm.—Princeton, Mercer.
Sagittaria latifolia Willd.—Cass, Pocahontas.
Sagittaria latifolia var. *pubescens* (Muhl.) J. G. Sm.—Pineville, Wyoming.

Gramineae

- Sorghastrum halepense* (L.) Pers.—Wardensville, Hardy.
Digitaria filiformis (L.) Koeler—Morgantown, Monongalia.
Paspalum ciliatifolium Michx.—Wardensville, Hardy.
Paspalum pubescens Muhl.—Morgantown Country Club, Monongalia;
 Bluestone River, Near Shawnee Lake, Mercer; Princeton, Mercer;

- Keymann Memorial Farm, Hardy; Fair Grounds, Marlinton, Pocahontas.
- Paspalum circulare* Nash.—Hess Farm, Osage, Monongalia.
- Panicum wernerii* Scribn.—Burlington, Mineral.
- *Panicum xalapense* H. B. K.—Four H Camp, Mercer.
- Panicum huachucae* Ashe—Cass, Pocahontas; Terra Alta, Preston; Welch, McDowell; Morgantown, Monongalia; Core, Monongalia.
- *Panicum meridionale* Ashe—Princeton, Mercer; Athens, Mercer; Brown's Creek, McDowell.
- Panicum columbianum* Scribn.—Greenbank, Pocahontas.
- *Panicum boscii* Poir. var. *molle* (Vasey) Hitchc. and Chase—Bar Ford, Pocahontas; Near Athens, Mercer.
- Cenchrus carolinianus* Walt.—Hanging Rock, Hampshire.
- Zizania palustris* L.—Lake Terra Alta, Preston.
- Oryzopsis racemosa* (Sm.) Ricker—Smith Creek Gap, Pendleton.
- Aristida oligantha* Michx.—Core, Monongalia.
- Muhlenbergia tenuiflora* (Willd.) B S P.—Smith Creek Gap, Pendleton.
- Muhlenbergia foliosa* Trin.—Lake Terra Alta, Preston.
- Alopecurus pratensis*—Morgantown, Monongalia.
- Agrostis alba* L. var. *vulgaris* (With.) Thurb.—Morgantown, Monongalia; Allegheny Mountains, Pocahontas.
- Agrostis borealis* Hartm.—Cheat Mountain, on railroad track near Spruce, alt. 3800 ft. Pocahontas.
- Calamagrostis canadensis* (Michx.) Beauv.—Lake Terra Alta, Preston; Cranseville Glades, Preston; Lost River, Hardy.
- Sphenopholis pallens* (Spreng.) Scribn.—Morgantown, Monongalia; Core, Monongalia.
- Deschampsia flexuosa* (L.) Trin.—Burlington, Mineral; Ice Mountain, Hampshire.
- Spartina michauxiana* Hitchc.—Marlinton, Pocahontas; Lost River, Hardy.
- Melica striata* (Michx.) Hitchc.—Glady, Randolph.
- Poa triflora* Gilib.—Bald Knob, alt. 4842 ft., Pocahontas.
- Poa wolfii* Scribn.—Huntington, Cabell (F. A. Gilbert).
- *Glyceria laxa* Scribn.—Cranesville Glades, Preston; Athens, Mercer.
- Glyceria pallida* (Torr.) Trin.—Lake Terra Alta, Preston.
- Glyceria septentrionalis* Hitchc.—Cass, Pocahontas; Burlington, Mineral.
- Bromus commutatus* Schrad.—Top of Allegheny, alt. 4000 ft., Pocahontas.
- Bromus japonicus* Thunb.—Morgantown, Monongalia; Core, Monongalia.
- Bromus tectorum* L.—Morgantown, Monongalia.
- Bromus purgans* L.—Bar Ford, Near Cass, Pocahontas. Widespread.
- Bromus incanus* (Shear) Hitchc.—Blackwater Falls, Tucker.

Agropyron caninum (L.) Beauv.—Bar Ford, near Cass, Pocahontas; Frost, Pocahontas.

Hordeum jubatum L.—Tug Fork, near Farm, McDowell.

Elymus australis Scribn. and Ball—Coal River, near St. Albans, Kanawha.

Elymus canadensis L.—Greenland Gap, Grant; Spruce, alt. 3800 ft. Pocahontas; North Mill Creek, Grant; Coal River, near St. Albans, Kanawha; Pond Fork, Boone.

Elymus riparius Hitchc.—Morgantown, Monongalia.

Cyperaceae

Eleocharis quadrangulata (Michx.) R. & S.—Shawnee Lake, Mercer; "Rare" (Gray).

Eleocharis obtusa (Willd.) Schultes—Chenoweth Creek, Randolph; Leading Creek, near Camden, Lewis; Quinland, Boone.

Stenophyllus capillaris (L.) Britton—Reymann Farm, Hardy.

Rynchospora cymosa Ell.—Princeton, Mercer.

Rynchospora alba (L.) Vahl.—Cranberry Glades, Pocahontas. Common in Mountain Glades throughout the Alleghenies.

Scleria triglomerata Michx.—Near Alderson, Greenbrier.

- *Carex muskingumensis* Schwein.—Nuttallburg, Fayette (L. W. Nuttall).

- *Carex tribuloides* Wahlenb. var. *turbata* Bailey—Nuttallburg, Fayette. (L. W. Nuttall).

Carex cristata Schwein.—Sherrard, Marshall.

- *Carex festucacea* Schkuhr. var. *brevior* (Dewey) Fernald.—Nuttallburg, Fayette. (L. W. Nuttall).

Carex scirpoides Schkuhr.—Evergreen, Upshur. Common in Mountainous counties.

Carex trisperma Dewey—Cranesville Glades, Preston.

Carex cephaloidea Dewey—Core, Monongalia.

Carex gravida Bailey var. *laxifolia* Bailey—Oglebay Park, Ohio.

Carex setacea Dewey var. *ambigua* (Barratt.) Fernald.—Price Glade, Webster.

Carex conjuncta Boott.—Core, Monongalia.

Carex crinita Lam. var. *gynandra* (Schwein.) Schwein & Torr.—Cranberry Glades, Pocahontas, and elsewhere. Rather common.

Carex triceps Michx. var. *smithii* Porter—Harmon Creek, Brooke.

Carex willdenowii Schkuhr.—Allegheny Mountains, Mineral.

Carex pubescens Muhl.—Oglebay Park, Ohio.

Carex laxiculmis Schwein. var. *copulata* (Bailey) Fernald—Camp Caesar, Webster.

- *Carex debilis* Michx.—Evergreen, Upshur; Nuttallburg, Fayette. (L. W. Nuttall).

Carex hystericina Muhl.—Vandalia, Lewis.

- *Carex vesicaria* L.—Shawnee Lake, Mercer.

Araceae

Arisaema stewardsonii Britton—Dunmore, Pocahontas.

Xyridaceae

Xyris caroliniana Walt.—Near Oxley, along Route 21, Raleigh.

— *Xyris arenicola* Small—Cotton Hill Station, Fayette.

Commelinaceae

Commelina communis L.—Peterstown, Monroe; Elizabeth, Wirt.

Juncaceae

Juncus bufonius L.—Along Staunton and Parkersburg Turnpike, Allegheny Mt., Randolph.

Juncus diffusissimus Buckley.—Evergreen, Upshur; Uneeda, Boone.

Juncus aristulatus Michx.—Reymann Farm, Wardensville, Hardy; Hanging Rock, Hampshire.

— *Luzula campestris* (L.) D. C. var. *multiflora* (Ehrh.) Celak.—Core, Monongalia; Montgomery, Fayette.

Luzula campestris (L.) D. C. var. *bulbosa* A. Wood.—Morgantown, Monongalia.

Liliaceae

· *Melanthium latifolium* Desr.—Athens, Mercer.

Allium allegheniense Small.—Mill Point, Pocahontas. Common along the Alleghenies.

Agave virginica L.—Huntington, Cabell. (F. A. Gilbert).

Iridaceae

Belamcanda chinensis (L.) D. C.—Martinsburg, Berkeley.

Orchidaceae

Habenaria fimbriata (Ait.) R. Br.—Cranesville, Preston.

Spiranthes lucida (H. H. Eaton) Ames.—Oglebay Park, Ohio; Vandalia, Lewis.

Listera smallii Wiegand.—Droop Mountain, Pocahontas.

Liparis loeselii (L.) Richard.—Dunmore, Pocahontas.

Hexalectris aphylla (Nutt.) Raf.—Smoke Hole, Pendleton.

Santalaceae

Comandra umbellatum (L.) Nutt.—Berkley Springs, Morgan.

Polygonaceae

Rumex altissimus Wood.—Morgantown, Monongalia.

Rumex pulcher L.—Cass, Pocahontas.

Polygonum amphibium L.—Blennerhassett Island, Wood; Shawnee Lake, Mercer and elsewhere.

Polygonum acre H. B. K. var. *leptostachyum* Meisn.—French Creek, Upshur.

Polygonum cuspidatum Silb. and Zucc.—Escaped from cultivation in Oglebay Park, Ohio.

Chenopodiaceae

Roubieva multifida (L.) Moq.—Tug Fork, near Farm, McDowell.

Illecebraceae

Paronychia argyrocoma (Michx.) Nutt.—Harmon Rocks, Pendleton;
Seneca Rocks, Pendleton.

Caryophyllaceae

Arenaria stricta Michx.—Greenland Gap, Grant.
Stellaria graminea L.—Morgantown, Monongalia and elsewhere.
Stellaria holostea L.—Ice Mountain, Hampshire.
Stellaria pubera Michx. var. *sylvatica* (Beq.) Wby.—Huntington, Cabell.
(F. A. Gilbert).
Lychnis alba Mill.—State Farm, Morgantown, Monongalia.
Silene noctiflora L.—Star City, Monongalia.
Silene latifolia (Mill.) Britten & Rendle.—Lake Terra Alta, Preston.

Ranunculaceae

Ranunculus macounii Britton—Greer, Monongalia.
Anemone parviflora Michx.—Ice Mountain, Hampshire.
Nigella damascena L.—Pine Crest, Raleigh.
Delphinium exaltatum Ait.—Smoke Hole, Pendleton.
Aconitum vaccarum Rydb.—Spruce Knob, alt. 4800 ft., Pendleton;
Cheat Mountain, alt. 3800 ft., Pocahontas.

Cruciferae

Brassica juncea (L.) Cosson.—Roadsides, grain fields, etc., common.
Brassica campestris L.—Escaped from cultivation, French Creek, Upshur
and elsewhere.
Sisymbrium officinale (L.) Scop. var. *leiocarpum* D C. Common.
Sisymbrium canescens Nutt.—Morgantown, Monongalia.

Saxifragaceae

Heuchera macrorhiza Small.—Mouth of Second Creek, Greenbrier.

Rosaceae

Pyrus malus L.—Commonly escaped to woods and fields.
Amelanchier oligocarpa (Michx.) Roem.—Spruce, alt. 3800 ft., Pocahontas.
Fragaria vesca L., var. *alba* (Ehrh.) Rydb.—Camden, Lewis.
Fragaria vesca L., var. *americana* Porter.—Circleville, Pendleton.
Potentilla recta L.—Burlington, Mineral; Elk Garden, Mineral.
Potentilla tridentata Ait.—North Fork Mountain, Pendleton. (Fred and Maurice Brooks).
Rubus phoenicolasius Maxim.—Established several places near Pineville, Wyoming.
Prunus allegheniensis Porter.—Greenland Gap, Grant.

Leguminosae

Cassia depressa Pollard—Teays Valley, Putnam.

Trifolium incarnatum L.—Sleepy Creek Orchard, Near Berkeley Springs, Morgan.

Trifolium reflexum L.—Burlington, Mineral.

• *Desmodium viridiflorum* (L.) Beck.—Athens, Mercer.

— *Lespedeza procumbens* Michx.—Four H Camp, Nicholas.

Vicia villosa Roth.—Sparingly escaped near Morgantown, Monongalia; Wadestown, Monongalia; Whitmar Hills, Ohio; and elsewhere.

— *Clitoria mariana* L.—Teay's Valley, Putnam; Cotton Hill Station, Fayette.

Galactia volubilis (L.) Britton.—Burlington, Mineral.

Linaceae

Linum medium (Planch.) Britton—Reymann Memorial Farm, Hardy.

Geraniaceae

Geranium molle L.—Thorn Creek, Pendleton.

Geranium columbinum L.—Athens, Mercer; Elk Garden, Mineral; Sweet Springs, Monroe.

Erodium cicutarium (L.) L'Her.—Arcadia Orchard, Berkeley.

Polygalaceae

Polygala polygama Walt.—Deer Reserve, Allegheny Mountain, Mineral.

Euphorbiaceae

Euphorbia heterophylla L.—Wild Meadow Run, Mineral.

Malvaceae

— *Hibiscus moscheutos* L.—Nuttallsburg, Fayette (L. W. Nuttall).

Hibiscus oculiroseus Britton—Burlington, Mineral.

Hibiscus militaris Cav.—Bloomery, Jefferson.

Hypericaceae

Hypericum boreale (Britton) Bicknell—Cheat River, Monongalia.

Hypericum drummondii (Grev. & Hook.) T. & G.—Coal River, Kanawha.

Cistaceae

Lechea intermedia Leggett.—Muddy Creek Mountain, Greenbrier.

— *Lechea racemulosa* Lam.—Near Four H Camp, Nicholas.

Violaceae

Viola pedata L. var. *lineariloba* D C.—Slaty Mountain, Monroe.

Viola novae-angliae House—Star City, Monongalia.

Lythraceae

Lythrum salicaria L.—Salt Sulphur Springs, Monroe.

Onagraceae

Oenothera muricata L.—Marlinton, Pocahontas.

Oenothera laciniata Hill.—Cass, Pocahontas.

Circaea intermedia Ehrh.—Camp Caesar, Webster.

Haloragidaceae

Proserpinaca palustris L.—Burlington, Mineral.

Umbelliferae

- Hydrocotyle ranunculoides* L. f.—Reymann Farm, Hardy.
Conium maculatum L.—Ice Mountain, Hampshire; near Wellsburg, Brook, and elsewhere.
Bupleurum rotundifolium L.—North Mill Creek, Grant.
Anethum graveolens L.—Casual on waste ground, Pineville, Wyoming, etc.
Angelica atropurpurea L.—Cass, Pocahontas.

Ericaceae

- Andromeda glaucophylla* Link.—Cranberry Glades, Pocahontas.
Gaylussacia brachycera (Michx.) Gray—Mouth of Second Creek, Greenbrier.
Vaccinium ovalifolium Sm.—Allegheny Mountain, Mineral.

Primulaceae

- Steironema intermedium* Kearney—Pineville, Wyoming.
Steironema quadriflorum (Sims.) Hitchc.—Wardensville, Hardy.

Apocynaceae

- Vinca minor* L.—Escaped from cultivation, Core, Monongalia.

Asclepiadaceae

- Asclepias ovalifolia* Dcne.—Inwood, Berkeley.
Asclepias verticillata L.—Four Pole Creek, Cabell; Slaty Mountain, Monroe.

Polemoniaceae

- Phlox divaricata* L.—Morgantown, Monongalia; Mannington, Marion.
Phlox brittonii Small—Cass, Pocahontas.

Boraginaceae

- Lappula deflexa* (Wahlenb.) Garcke.—Chocolate Drop, Greenbrier.
Lappula echinata Gilibert—Cass, Pocahontas.
Onosmodium hispidissimum Mackenzie—Renick, Greenbrier; Roncerverte, Greenbrier.

Verbenaceae

- Verbena stricta* Vent.—Cass, Pocahontas.
Verbena bracteosa Michx.—Cass, Pocahontas.

Labiatae

- Stachys salvioides* Small—Cotton Hill Station, Fayette.
Mentha verticillata L. var. *peduncularis* (Boreau) Rouy.—Bloomery, Jefferson.

Solanaceae

- Petunia violacea* Lindl.—Stray from cultivation, Cheat River, Monongalia.
Physalis ixocarpa Brotero.—Mouth of Second Creek, Greenbrier, Common in alluvial soil elsewhere.
Physalis pruinosa L.—Pineville, Wyoming.

Scrophulariaceae

- Pentstemon laevigatus* Ait.—Star City, Monongalia.
Mimulus moschatus Dougl.—Thorn Creek, Pendleton; Smoke Hole, Pendleton.
Veronica chamaedrys L.—Morgantown, Monongalia.

Martyniaceae

- Martynia louisiana* Mill.—Casual in cultivated ground, Morgantown, Monongalia, etc.

Rubiaceae

- *Galium aparine* L. var. *vaillantii* (D C) Koch.—Athens, Mercer.
Galium parisiense L.—Dent's Run, Monongalia; Greer, Monongalia.
Galium boreale L.—Ice Mountain, Hampshire.
Galium mollugo L.—Bretz, Preston.
Diodia virginiana L.—Coal River, near St. Albans, Kanawha.

Caprifoliaceae

- Viburnum pubescens* (Ait.) Pursh.—Kate's Mountain, Greenbrier.
 • *Viburnum scabrellum* (T. & G.) Chapm.—Four H Camp, Mercer.

Campanulaceae

- Campanula rapunculoides* L.—Lewisburg, Greenbrier.

Compositae

- *Eupatorium album* L.—Four H Camp, Nicholas.
Eupatorium incarnatum Walt.—Guyandotte, Cabell. (F. A. Gilbert).
 — *Liatris squarrosa* Willd.—Summersville, Nicholas.
Liatris scariosa Willd.—Kate's Mountain, Greenbrier; Lake Terra Alta, Preston.
 — *Liatris graminifolia* (Walt.) Willd.—Slaty Mountain, Monroe; Nuttallsburg, Fayette.. (L. W. Nuttall).
Solidago aquarrosa Muhl.—Headsville, Mineral.
Solidago Randii (Porter) Britton—Vadis, Lewis. (William Conrad Hall).
Solidago altissima L.—Hurst, Lewis; Burlington, Mineral.
Aster furcatus Burgess—Reedsville, Preston.
Aster schreberi Nees.—Cold Run, near Cass, Pocahontas.
Aster radula Ait.—Greenbank, Pocahontas.
Aster oblongifolius Nutt.—Burlington, Mineral.
Xanthium pennsylvanicum Wallr.—Morgantown, Monongalia.
Xanthium chinense Mill.—Morgantown, Monongalia.
Xanthium italicum Mor.—Paw Paw Creek, Marion.
Rudbeckia spathulata Michx.—Reymann Farm, Hardy.
Rudbeckia amplexicaulis Vahl.—Cass, Pocahontas.
Helianthus annuus L.—Waste ground near Charles Town, Jefferson, and elsewhere.
Helianthus tuberosus L.—Morgantown, Monongalia.
Coreopsis verticillata L.—Hanging Rock, Hampshire.

- Bidens vulgata* Greene—Staggs Run, Mineral.
- Galinsoga parviflora* Cav. var. *hispida* D C.—Common throughout the state on waste ground; adventive from Tropical America.
- Helenium nudiflorum* Nutt.—Chenoweth Creek, Randolph; Masontown, Preston.
- Anthemis arvensis* L. var. *agrestis* (Wallr.) D C.—Robinson's Orchard, Berkeley.
- , *Centaurea cyanus* L.—Occasionally escaped, as at Four H Camp, Mercer.
- , *Centaurea maculosa* Lam.—Bluestone River, near Rock, Mercer.
- Krigia virginica* (L.) Willd.—Wardensville, Hardy.
- Sonchus arvensis* L. var. *glabrescens* Guenth, Grab & Wimm.—Morgantown, Monongalia.
- Lactuca saligna* L.—Peterstown, Monroe; Morgantown, Monongalia.
- Hieracium aurantiacum* L.—Cranberry Glades, Pocahontas.
- *Hieracium pratense* Tausch.—Marr Branch, Fayette.
- Hieracium greenii* Porter & Britton—Allegheny Mountain, Mineral.
- Hieracium marianum* Willd.—Ice Mountain, Hampshire.

THE ALGAL FAMILY OEDOGONIACEAE

By

L. H. TIFFANY

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(Abstract)

The algal family Oedogoniaceae was established in 1854 as a member of the Chlorophyceae by DeBary. It consists of three genera: Bulbochaete, established by C. A. Agardh in 1817; Oedocladium, established by Stahl in 1891; and Oedogonium, established by Link in 1820. Members of the three genera are readily separable from each other by rather evident characteristics. Oedogonium is unbranched, while the other two are branched filaments. Oedocladium is devoid of hairs, while the cells of Bulbochaete have laterally placed setae. A numerical recital of the composition of each gives some idea of their relative sizes. Bulbochaete has 48 species, 15 varieties, and 7 forms; Oedocladium has only 4 species so far recorded; Oedogonium has 195 species, 76 varieties, and 38 forms. In addition there are quite a number with incomplete descriptions, some of which may be good species.

Geographically, most forms are found in North America with Europe a close second. Then follow South America, Asia, Australia, and Africa, in the order named. Most North American species are found in permanent ponds. The species of Oedogonium found in the North Central States of the United States fruit largely in either May or July-August, and are thus characterized as either spring annuals or summer annuals.

A complete account of this algal family with keys to all species, varieties, and forms, completely described, illustrated and indexed, with a rather comprehensive bibliography occurs in a book published by the writer in April, 1930, entitled **The Oedogoniaceae, A Monograph Including All Known Species of the Genera Bulbochaete, Oedocladium, and Oedogonium.**

SOME NEW DEHYDRATED BACTERIOLOGIC DIAG-
NOSTIC MEDIUMS

By

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One of the greatest problems which the small bacteriologic laboratory faces is the preparing and keeping in stock the many necessary mediums for the cultivation and differentiation of the various microorganisms met in daily work. Many of these are complicated in formula, and time-consuming in their preparation. Bacteriologists are coming more and more to the use of special diagnostic mediums for the physiologic differentiation, rather than to rely upon morphologic distinctions. Mediums and methods are now available for the group differentiation of practically all of the bacteria. Of course, in the final analysis, such methods as complement fixation, agglutination and agglutinin absorption tests are called into play, but usually only as a last resort for exact identification of some uncertain strain.

In the small laboratory, with limited facilities, it is impracticable, if not impossible to keep in stock, available at all times, the variety of mediums necessary for even the most routine work. Also is it impracticable and wasteful to prepare individual lots of complicated media for only an occasional demand.

Again, it is difficult in preparing special mediums always to obtain a uniform product, since different lots of the necessary ingredients may vary widely from those used in the past.

For these, and other reasons, many laboratories are coming to realize the convenience of the dehydrated forms of mediums now available from several reliable sources. In this form media are prepared in bulk, accurately adjusted in reaction, and are then desiccated to a powder of uniform composition, requiring only the addition of the requisite amount of water and subsequent sterilization.

The idea was apparently first proposed by Dr. W. D. Frost in 1909, and it has been adapted to commercial production on a satisfactory scale. Practically all forms of the common, and many of the special mediums, are now available. These special mediums are prepared according to the formulae of the originators, and are approved by them before marketing. Many have been approved by the Society of American Bacteriologists as equivalent, or superior, to the usual hand-made preparation.

During the past nine years, for the reasons stated, we have made increasing use of these dehydrated preparations with complete satisfaction. Superficially it may appear that they are rather expensive, but when one considers the time, as well as the ingredients going into the hand-made product, the ultimate cost may be even less. Even admitting

a greater initial unit cost, the fact that small and yet uniform lots may be prepared and duplicated reduces the wastage by drying and ageing when prepared in bulk by the usual procedure.

In the course of the past five years I have had occasion to suggest several formulae which have met with approval at the hands of others who have tested them:

Lead Acetate Agar, useful in the differentiation of members of the Typhoid-Paratyphoid group, unless properly prepared according to the formula of Jordan and Victorson, may be decidedly inhibitive to growth, particularly of the Shiga dysentery bacillus. In the formula developed in our laboratory we selected Difco Peptone as the most satisfactory of five peptones tested, and balanced lead acetate ($\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 3\text{H}_2\text{O}$) in such fashion that the medium affords luxuriant growth with sharp reactivity and differentiation of those organisms which do or do not form hydrogen sulphide.

Kligler Lead Acetate Agar involves the addition of lead acetate to Russell's Double Sugar Agar. Thus incorporated, the medium serves to group-identify practically all members of the Gram-negative intestinal group. It forms one of the most valuable of routine media for the use of those interested in such organisms. All of the essential ingredients, dextrose, lactose, peptone, lead acetate and phenol red, are so balanced as to give sharp differential reactions with no trace of inhibition.

North's Gelatin Agar, while not a differential medium, is a recently developed formula serving the most general usefulness. It is prepared on the principle of the conservation of so-called "growth-accessory factors" by filtration through glass wool, or clarifying by centrifuging, to avoid the absorbing action inherent in ordinary filtration through cotton or filter paper.

This medium will support initial growth of the Gonococcus and Meningococcus without the addition of blood or serum, which are commonly regarded as essential to the isolation of organisms of this group. It is exceedingly satisfactory for the routine cultivation of the Streptococcus and similiar organisms which likewise grow well only in the presence of blood. It is superior for the cultivation of growths for preparation of autogenous vaccines, since all of the pyogenic bacteria commonly incorporated in vaccines grow luxuriantly in the first culture generation, and hence retain their presumed antigenic power, instead of losing it through repeated necessary sub-culturing.

Dehydrated Whole Blood and Hemoglobin,—In the course of studies on the Influenza-Pertussis group we devised a method of diluting whole blood or washed corpuscles to the point that such suspensions could be autoclaved, yet remain fluid. Such heated blood may then be added to the above North's Gelatin Agar to give a "chocolate-agar," which appears to be equal to the preparation from fresh sterile blood.

On this medium the *Streptococcus viridans* produces its customary greenish reaction, while the *Streptococcus hemolyticus* is entirely inactive. The *Pneumococcus* gives a broad zone of decolorization which usually differentiates it sharply from the closely allied *Streptococcus viridans*.

The particularly useful feature of these blood preparations, however, lies in the fact that they may be prepared from slaughter-house blood, with no necessary aseptic precautions, and that, when sterilized, the suspensions keep indefinitely and are available at any time for the preparation of large or small amounts of medium.

These two forms of dehydrated blood and corpuscles have been prepared, together with the other special media enumerated, in conjunction with the Digestive Ferments Company of Detroit. Their successful use here and elsewhere warrants a trial at the hands of all interested in routine bacteriologic work.

THE TEACHING OF BIOLOGY IN TEACHER TRAINING INSTITUTIONS

By

FRANK CUTRIGHT,

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The aim and purpose of this brief paper is to report as correctly as possible the present status of the teaching of biological subjects in the teacher-training institutions of the United States.

Since questionnaires have become a burden to school people the usual long list of questions were carefully avoided and the following questions were submitted to more than fifty of the leading teacher training institutions of the country. Thirty six of these colleges responded and, as these reports are from more than thirty states, it seems reasonable to suppose that they set forth with some accuracy the present practice of these institutions relating to the amount and character of biological instruction given to prospective teachers.

THE QUESTIONS ARE:

1. What subjects do you require of those who are preparing to teach biology in the high schools and how many hours of the subject?
2. What biological subjects do you require of those who are preparing to teach in the grades?
3. What methods courses do you require in biology?
4. Have you any liberty as to what you will offer in biology or is your work prescribed by a State Board of Education?

I have made an honest effort to tabulate the answers to these questions and have attempted to reduce all credits to semester hours but in a few instances the value of the credit has been hard to determine as to whether it is a quarter or semester hour, but I hope that I have arrived at a fair degree of accuracy.

In compiling this data I was surprised to learn that several teacher training institutions do not prepare high school teachers of biology, consequently the averages given are determined from fewer than thirty six institutions.

The data that I have, give an average of six and one-half semester hours required work in botany as a preparation for the prospective teacher of biology in the high school. The lowest requirement I find is two and two-thirds hours of botany and the highest sixteen hours.

Zoology is not quite as popular as botany because a high school teacher may qualify after having completed six and one ninth hours of zoology. The variation in this field is not quite so wide as that in botany varying from a minimum of two and two-third hours to a maximum of ten.

Regarding physiology presumably human, I find but few schools

requiring this subject for an average of four hours. One school of the thirty six reporting requires one hour of plant physiology.

Some schools report general biology and, as the requirements are high for this subject in some instances, twenty four hours at Peabody and Ypsilanti, it might be inferred that both botany and Zoology may be included under this general heading. An average of the figures reported gives a requirement of thirteen hours of general biology.

Only seven schools require methods courses in biology and two of this number failed to report the prescribed number of hours. An average for the five reporting gives slightly more than three semester hours of required methods.

Here and there an additional course is required, for example; one school requires four hours of bacteriology, another gives three hours of genetics, a third asks for four hours of histology, while history of biology is given by a school in Nevada.

Two and two-thirds hours of sex biology is given in South Dakota while a school in the middle west makes up its required hours from chemistry, physiology and nature study. One school in the west requires two thirds of an hour of bird study.

One of the most comprehensive courses noted comes from Arizona and is made up as follows: General botany eight hours, advanced botany eight hours, zoology eight hours, chemistry eight hours, practice teaching of Biology, eight hours. Opposing this strong course I have a report from a department of biology that is not sure as to whether is it preparing high school teachers or not as a major in biology is a prerequisite to a teacher's certificate in that particular state and the department has not had a major student in five years.

To summarize requirements for license to teach in high schools we find:

An average of six and one half hours required in botany, six and one-ninth hours in zoology, four hours in physiology—in the few schools prescribing it. Thirteen hours required in general biology also from a small number of schools, and an average of three hours in methods in biological subjects.

Requirements in other subjects are too scattering and meager to admit of a summary.

For students who are preparing to teach in the grades and will ordinarily remain in college but two years a tabulation of required subjects gives the following results:

General biology, sometimes called educational biology, five and six-tenths hours, nature study approximately four hours. Two or three schools require one year of general science, one school requires eight hours of botany, another five. In one or more instances physiology is prescribed and a school in the west requires eight hours of zoology. Nature study is required in several schools but the hours were not given

in several instances so that I did not have sufficient data to justify a tabulation.

Methods courses are provided in a few cases but, like the preceding there is not sufficient data upon which to base any conclusion.

Eight schools report that they are limited in their offering in biology while twenty-eight report freedom in regard to subjects offered. The difficulty that arises in teaching the two-year students seems to come from the limited number of hours that the biology department is permitted to offer rather than from the subjects to be offered.

This paper has now reached the point at which a summary or conclusion should be made but a heterogeneous mass of data removes the possibility of either.

After going over the reports from these thirty six institutions I have a feeling, perhaps not directly shown by the data, that the biology departments are handicapped by having to work under the supervision of another department.

In lieu of a conclusion I would like to propose several questions that I deem pertinent to the teaching of biology in West Virginia teacher training institutions.

1. Since a high school teacher is required to have but twenty hours of biology in college, is it necessary that he be required to take twenty hours of professional work, the present practice?

2. In the two-year curriculum for our so-called standard normal teacher six hours of biology and twenty hours of professional work is required. Does this arrangement suggest a well balanced course of study?

3. Should the biology department of Marshall College feel flattered or chagrined in that almost every other department in the school is permitted to offer methods courses except the department of biology?

4. Whose business is it to determine when a student is fitted to teach biology in a high school, the department of biology in the teacher training institution or some other department of the school?

5. Since twenty hours of professional work is required to prepare a high school teacher of biology, does it follow that the teacher of English should have professional work in the same proportion and be required to take thirty-four hours of professional work since he is required to have thirty-four hours of English?

6. Does our state requirement of thirty-four hours of preparation in social studies against twenty hours of biology indicate that the former is more important or that the biologist has more brains, and can teach his subject with less preparation than the expounder of sociology, history, and economics?

7. If five hours of psychology will balance twenty hours of biology,

how much psychology will it take to balance sixteen hours of chemistry, physics, or mathematics?

8. Finally, is a grade teacher a paying investment to the state if five-seventeenths of the effort of the commonwealth to produce a teacher is spent in training the young lady how to teach, leaving but twelve-seventeenths of the effort for learning something to teach? Would part of this five-seventeenths be better spent on biology or is this five-seventeenths of professional work an essential?

NOTES ON EXTINCT AND LIVING MAMMALS OF
WEST VIRGINIA

By

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Park Naturalist, Oglebay Park.

Of the mammals which lived in the West Virginia area during past ages we have one positive record from within our own territory, and a number of others from nearby points. In a limestone quarry, near the town of Renick, Greenbrier county, the fossil remains of a peccary were found in 1912. A single skull and a few other bones recovered here are in the national museum and have been referred to the species *Platygonus intermedius*, although possibly a new species is indicated, since there is a single pair of incisors in this case instead of two pairs in specimens of other members of the genus found.

The Cumberland Cave Deposit, uncovered when the Western Maryland railroad made a cut through a limestone ridge about four miles northwest of Cumberland, Maryland, in 1912, was found to contain the bones of 45 distinct species of mammals belonging to seven different orders. Incidentally, the deposit contained also remnants of two snakes and a crocodile. The mammals found here represent a strange assemblage, ranging in size from a small bat to a mastodon. Among them are shrews, bats, squirrels, porcupines, woodchucks, field mice, wood rats, beavers, rabbits and picas, bears, wolves, lynx, wolverines, badgers, minks, martens, horse, tapir, deer, peccaries and what appears to be a large antelope the size of an ox, possibly related to the eland of Africa. The only whole skeleton found is that of a large extinct peccary, *Platygonus Cumberlandensis*, Gidley. Several of the other species are extinct and some that are not extinct were far from their present ranges.

The fact that there is here a strange overlapping of mammals from all points of the compass is of interest to us and furnishes the basis for comparison with our present conditions. Into this Cumberland cave, which was a natural pitfall of the Pliocene Tertiary period fell the wolverine and marten of the north, the badger and the pica of the west and the peccary and tapir of the south.

If we could have restored before our eyes the conditions as they existed at the time the mammals referred to ranged in this region, we could better understand the presence of species with such diversified requirements of temperature. To a degree, however, we may understand the conditions and happenings of the remote past by studying the conditions with which we find ourselves surrounded here in the Appalachian mountains. J. W. Gidley, in his U. S. National Museum publication, "A Pleistocene Cave Deposit of Western Maryland," suggests the possibility of a higher temperature than at present in the lowlands of this

region, and more elevated mountains, so that tropical or sub-tropical and boreal conditions existed close together. This is, to my mind, a logical explanation, there being at that time a set of conditions similar to, though more pronounced, than those existing now.

My main reason for referring to the Cumberland Cave Deposit, which is located so near to where these meetings are being held, is that we may, perhaps, come to a fuller appreciation of the remarkable conditions that have for ages existed here, and of the exceptional opportunities for the study of creatures extinct and living. The mountain peaks were originally higher, and the temperatures of the lowlands lower, as stated, permitting a strikingly diversified fauna and flora; but after the lapse of 50 or 100,000 years we find the austral life zone in our warm valleys that lie less than 300 feet above sea level, and the Canadian zone of the ridges that tower in places more than four and one half thousand feet above them with their typical life forms.

As far as fossil remains of mammals are concerned practically all that have been brought to light in West Virginia and this region have been found by accident. Future deposits are likely to be uncovered in the same way. Yet here is an unworked field which has promise of even richer and more surprising revelations to the aggressive searcher.

Our knowledge of present day living forms is mostly an accumulation of miscellaneous, partially organized odds and ends, coming from the field of speculation and casual observation, often without basis in scientific fact. We have sufficient data to permit us to list some 56 species of native mammals, which is far from complete. Of the distribution of these species we know relatively little, and of their life histories and economic status we know less.

The records of mammals collected and positively identified and the field notes of responsible persons are such as to indicate not only the variety of species found at the extremes of altitude, but are the foreshadowing of that which will eventually be the reward of thorough and careful study.

Look at the distribution map of the gray, long-tailed shrew, *Sorex dispar*, Batchelder, which includes a triangular area embracing portions of Vermont, New York, Massachusetts and northern Pennsylvania and an isolated spot near Winding Gulf, W. Va., hundreds of miles to the south; or take the West Virginia range of another shrew, the masked shrew, *Sorex cinereus cinereus*, Kerr., which appears to be recorded only from high altitudes at Cranberry Glades and Job's Knob, in West Virginia, but which we found in 1928 at Oglebay Park near the Ohio river at a rather low altitude.

At White Sulphur Springs, Thaddeus Surber picked up the type specimen of the small-eared harvest mouse, *Reithrodontomys humulis impiger*, Bangs, and also collected the little short-tailed shrew, *Cryptotis parva*, Say.

Field naturalists of the U. S. Biological Survey, during occasional visits to West Virginia have secured such rare species as Merriam's harvest mouse, *Reithrontomys humulis merriami*, Allen., Stone's lemming mouse, *Synaptomys cooperi stonei*, Merriam, the Carolina red-backed mouse, *Evotomys carolinensis*, Merriam, and the Florida skunk, *Mephitis elongata*, Bangs, which appears to reach the Northern boundary line of its range in our mountains.

At Cranberry Glades, F. E. Brooks and, later, E. A. Preble, obtained specimens of the rock vole, *Microtus chrotorrhinus chrotorrhinus*, Miller, not known to exist south of the Catskill mountains of New York until this species was recently collected in northern Pennsylvania.

The rare Alleghenian least weasel, *Mustela allegheniensis*, Rhoades, which had two previous West Virginia records, one at Huttonsville, Randolph County, and another at Travellers' Repose, Pocahontas county, was collected on November 30, 1928, at Oglebay Park.

The ranges of the woodland jumping mouse, *Napaeozapus insignis insignis*, Miller, and the Hudson Bay jumping mouse, *Zapus hudsonius hudsonius*, Zimmerman, seems to join in the region of the upper Ohio Valley, where the latter was taken by E. A. Preble at Wheeling and the former taken recently at Oglebay Park in the same locality.

With the Virginia varying hare, *Lepus americanus virginianus*, Harlan, which ranges the deep forests and thickets of the Alleghenies, live also the cloudland white-footed mouse, *Peromyscus maniculatus nubiterrae*, Rhoads, and other forms that are found at high elevations. Here an occasional porcupine, *Erethizon dorsatum dorsatum*, Linn., is reported, and rumors of yet stranger mammals are sometimes heard.

From the south and west come the Alleghenian spotted skunk, *Spilogale putorius*, Linn., the western fox squirrel, *Sciurus niger rufiventer*, Geoffroy, and others.

The examples given are sufficient to indicate the wide extremes which are to be met with at the present time. There is urgent need for further study of West Virginia mammals, and it is my hope that the West Virginia Academy of Science will endeavor to encourage such a study by competent persons.

I have reason to believe that the U. S. Bureau of Biological Survey is interested in this territory as never before. Dr. Vernon Bailey, the chief field naturalist of this Federal bureau, devoted about two weeks in 1929 to the study of mammals at Oglebay Park and other members of the Survey have recently shown an active interest in this territory which promises so many interesting results. Such a biological survey in this state as has been made in others would be most desirable. I recall that the late Dr. I. C. White, the distinguished head of the West Virginia Geological Survey, had included in his program of field studies and publications a study of the mammal and bird life of the state. I hope my

friend, Mr. David B. Reger, who is so efficiently in charge of the Survey at this time, will be permitted to carry out this project.

The lantern slides which follow show some of the more interesting mammals now to be found in our region.

A NEW FOSSORIAL WASP FOR WEST VIRGINIA

By

FRED E. BROOKS,
Entomologist, French Creek.

In my boyhood days a white oak tree of stately dimensions stood on the bank of the road opposite the site of my present home. I recall distinctly the violent spring storm in which that tree went down. Its spreading top crashed into a piece of woodland which my father at the time was in the process of clearing for farm crops. A few days after the tree was uprooted I was sent with my brothers to clear away and burn the mangled tree.

The sweet air of that spring morning was fragrant with wild grape blossoms and musical with the songs of birds. Moreover, we boys had planned to visit that morning a deep hole at the forks of the creek where we knew the horney-chubs were waiting to be hooked.

As we approached the wrecked tree a great horned owl flew from among the broken branches and disappeared in the near woods. When we looked for the cause of its presence there we discovered that during the preceding night the owl had killed and partly devoured a skunk among these branches that we were to clear up. The animal had evidently resented the attack and had defended itself after the manner of its kind. Unfortunately, not all the skunk's defense had landed on its antagonist, but stupefying portions of it clung to the branches and drowned the odor of wild grape blossoms throughout that bosky dell. The waiting fish and the murmur of the waters at the forks of the creek seemed doubly dear to us as we tackled our task.

I may say that this is the only instance that has come to my notice of a raptorial bird killing and devouring a skunk. However I did one time find a crow's nest that was lined with a very odoriferous skunk's tail. The four young crows in the nest were apparently developing contentedly and happily in spite of the mephitic atmosphere surrounding them. I have always wondered just how this world impressed those young crows. If it a purely scientific premise that when those crows had grown up and were building nests of their own they inspected their completed structures and wondered why they were not like the nests that mother used to make.

The disintegrating forces of time have left of that fallen white oak only a grave-like mound to mark the spot where the root was upturned. This mound is composed of clay mixed in the upheavel with a disturbed stratum of dark shale overlying a thin vein of Brush Creek coal. The south slope of the mound is destitute of vegetation and lies bare to the full sunlight.

On July 19, 1925. I was passing the mound and noticed on the exposed slope a group of small openings in the ground scattered over

an area of about a square yard. The openings were forty in number and were of the diameter of a lead pencil. Around the entrance to each was a ring of fine, fresh earth which had evidently been carried out of the hole and pushed back by some insect. It was soon discovered that each opening was occupied by a single, female solitary wasp of unusual form and color. The wasps were about three-fourths of an inch in length, their brown bodies marked with spots and bands of yellow. Further study showed that they belonged to the genus *Cerceris*, a group of fossorial, or burrowing, wasps notable for their quiet manners and interesting habits about their nests. What eagles and hawks are among the birds, *Cerceris* wasps are among insects. They capture and store in their nests great numbers of beetles, selecting their prey with the finest distinctions as to species from among the Buprestidae or Curculionidae. I submitted specimens of my wasp to Mr. S. A. Rohwer, of the National Museum, and he found that they represented an undescribed species. My material is still in the museum, but the description and name of the new species have not yet been published.

During the day following the discovery of the colony of wasps it was observed that they were provisioning their nests with weevils of the species *Curculio strictus*, which are commonly found attacking acorns of chestnut oak, *Quercus prinus*. The weevil confines itself closely to the fruit of the one host tree. When the wasps were watched at their nests, and the direction of their flight noted, it was evident that they were making their captures in a clump of chestnut oak trees which grew in the woods 1200 feet from the nests. The capture of the weevils could not be observed, but the inference is that the wasps found the weevils in the tree tops, pounced upon them, administered their stupefying sting, then, after waiting for the anaesthesia to take effect, clasped the victim in their second pair of legs and flew directly to the home colony.

The weight of the weevil averages two-thirds that of the wasp, the former weighing .4 grains and the latter .6 grains. The wasps frequently landed with their burden at the nests much exhausted. Each wasp knew its own door. They would usually come to the ground a foot or so from the nest, then, after a brief rest, would run straight to their holes. Occasionally one would try several openings before finding the right one.

The weevils were stored, three or four in a place, at the terminals of branches leading off from the main burrow. The burrows extended from eight inches to a foot into the ground. On one of the weevils an elongated, white egg is placed. The egg hatches within a few days and the wasp grub feeds on the weevils and grows rapidly. When full grown the larva spins itself a cocoon in which it rests over winter before pupating.

Late in June or early in July the wasps begin to issue from the ground, the males appearing a few days in advance of the females. The

males and females do not consort together around the nests but evidently meet and pair in the field. The females clean out the holes through which they escape and form of them their future nests. It thus comes about that successive generations of the wasps establish their villages in one spot for a number of years. The colony which I observed inhabited the roadside mound for at least five summers. After its discovery it grew weaker in the number of its inhabitants from year to year until it died out in 1929.

On July 25, 1925, when the village contained forty nests and when the activity of the wasps was at its apex, Miss Laura Moore and I kept the colony under continuous watch from sunup to sundown. The wasps brought in 77 weevils during the day. I estimated that the colony destroyed in its most populous year not less than 1400 weevils. Since the weevils are collected before their time of egg-laying begins, it is clear that the wasps in their activity reduce the number of weevil-infested acorns very considerably.

The wasp's nests were numbered and accounts kept with each occupant. One wasp left its nest and returned with a weevil in 7 minutes. Other journeys afield lasted for several hours. The various periods of time spent in securing weevils may be indicated as follows: 13, 15, 17, 35, 38, 90, 228, 294 minutes. The hour of greatest activity during the day was between one and two P. M., when 11 weevils were brought in, although between four and five P. M. 10 weevils arrived. The first weevil was brought in at 8:30 in the morning, and the last wasp arrived empty at 7:02 in the evening.

We never tired of watching the little creatures conduct the affairs of their city. On the whole, they seemed to do it about as wisely and well as do the average human citizens. There seemed to be no center of authority, nor any communal life. Each wasp occupied an independent place in the colony. There were no community enterprises, such as cooperative nest-building and brood-rearing and defense found in colonies of social wasps and bees. Some unseen bond of fellowship there certainly must have been. One wasp, which had in some way lost its nest, hovered about the site for days. Every now and then it would begin excavating for a nest, but would soon give it up and continue its monotonous work of hunting on foot and on wing for what seemed to be its dearest earthly possession. Finally, worn out and perhaps starved, it was found one morning in the center of the colony dead.

Relationships between individuals were friendly, except when some careless or meddlesome citizen entered or attempted to enter the wrong home. Unlawful entry seemed always to be resented. On one hot day a sudden shower caught most of the wasps afield. With the first drops they came hurrying home for shelter. One late comer approached a hole and found it already occupied, the possessor stationed at the entrance with its face to the door. The wasp on the outside attacked the

other and parried for an opening. Presently it saw a chance and seized the holder of the nest by the thorax, dragging it out into the rain. Both wasps were struggling to enter when a downpour of rain drove me away so that I did not see the outcome of the contest.

At night and during cool days the wasps remained in their nests usually keeping their doors closed with a covering of fine earth pushed up from within the burrow. The doors were kept closed in the same way, when, as often occurred, they rested for an hour or two during days of active work. When a wasp came with a weevil and entered its nest leaving the door uncovered it was pretty certain to reappear in a few minutes for another field trip, but when it closed the door promptly after entering we knew that it was likely to remain inside for a rest or nap. A single wasp would bring in from one to five weevils in a day. The more industrious individuals always showed signs of weariness at night and would retire early.

In fair weather activity began in the city by seven o'clock. The wasps first pushed the covering from their doors and moved the grains of earth back for half an inch or more to form a ring surrounding the entrance. They would often spend some time tidying up around their homes and would clean the dust from their own persons. They would then often watch from their doors for a while before taking flight. On the wing, they would circle several times around their doors and over the colony grounds, as if to familiarize themselves with objects, and then fly away to their hunting grounds.

The wasps possessed a very remarkable, although not unerring, instinct for identifying their favorite species of weevil. Not only were they able to confine their captures to one genus of weevil, but they almost invariably picked specimens of *Curculio strictus* from among several other species of the genus which were common in the locality. They did, however, make mistakes as is indicated by the fact that I found several specimens of two closely-related species which the wasps had brought in and abandoned at their doors. Whether they dropped these specimens because they learned they had made a mistake, I do not know. In twenty years of rather extensive collecting of nut weevils, I have secured but four specimens of *Curculio iowensis*. I submitted these to a specialist thinking myself that they were *strictus*, the favorite species of the wasps. Two of these four specimens were brought in by the wasps and dropped at the entrance to their nests. I also found several specimens of the lesser chestnut weevil, *Curculio auriger*, which the wasps had dropped outside their nests. Occasionally they similiarly abandoned specimens of *strictus*, and I do not know that they never carried the other weevils into their nests. I must admit, however, that there are evidences that these small wasps have greater skill than I in distinguishing between closely allied species of weevils.

My colony has now died out and I know of no others. It seems that only one other such colony has ever been discovered. This was in Illinois, where the wasps were found and specimens collected, but were mistaken for a more familiar species. Much remains to discover about these little weevil-catching wasps and I shall search for other colonies with unflagging interest.

A NEW GENUS OF FRESHWATER MUSSELS,
(NAIADES)

By

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To C. S. Rafinesque, the old German-French naturalist, we are indebted for the earliest studies of the Freshwater Mussels, or Naiades, in America. He came over from Europe when most of our forests were primeval and the soil was virgin; hence because of his priority in the nomenclature of the Naiades we have termed that delicate

Anodonta imbecillis of Say, (1829) the
Lastena ohioensis of Rafinesque, (1820).

This is one of the few species of Naiades which has not been buried in the maze of synonyms. This one synonym of Say would not have occurred if this species of Rafinesque had not been so grotesquely illustrated by the discoverer nine years before in all of his plates and figures for his "Monographie des Coquilles Bivalves Fluviales de la Riverie Ohio," (Ann. Gen. Sci. Phys. Brux., Vol. V, pp. 287-322).

When Thomas Say in 1829 discovered *Lastena ohioensis*, (now *Utterbackia ohioensis*), he thought he had found a new species since he did not recognize it from Rafinesque's crude figure of it in his Monograph of 1820. Thus it remained under Say's name of *A. imbecillis* until a few years ago when Dr. A. E. Ortman of the Carnegie Museum of Pittsburgh succeeded in convincing scholars of this group of Mollusks that the priority of Rafinesque should be recognized,—as was done in the nomenclature of many other species of Naiades, as well as that of many species which the old naturalist had discovered and first described for the fauna and flora of the Ohio Valley.

This early contribution to our biological science was mostly made by Rafinesque while a Professor of Biological Sciences in 1818 at Transylvania University, Lexington, Kentucky. We are indebted to the publishers, W. G. Binney and G. W. Tyron, for bringing to light "The Complete Writings of C. S. Rafinesque on Recent and Fossil Conchology" edited in 1864; and we are also grateful to R. E. Call on "The Life and Writings of Rafinesque," (Filson Club Publication, Louisville, 1895). Thus we have been enabled to eliminate much of the dead timber of synonyms for the different species of Naiades first described by this pioneer naturalist who has been overlooked by many subsequent conchologists, or ignored by others who may have considered his works as marred by frequent inaccuracies and by tendencies to multiply species.

Because of the discoveries and special studies made by the author of this paper Dr. Frank C. Baker, Curator of the Natural History Museum at the University of Illinois, has recently elevated *Lastena ohioensis*

(Rafinesque), to generic rank and has given the writer an honor by dedicating the New Genus to him under the name of,-

UTTERBACKIA, (Baker), with
Utterbackia ohiensis, (Rafinesque), as type.

This New Genus is presented in Dr. Baker's "Monograph of the Freshwater Mollusca of Wisconsin," published in two volumes by the The bestowal of a double honor upon the writer in the creation of a Wisconsin Geologic and Natural History Survey at Madison, (1929). The bestowal of a double honor upon the writer in the creation of a second namesake* and the claims for the creation of this New Genus are made for the following merited reasons:-

- 1.—The unusual vitality and rotary motion of the late embryos of *ohiensis*.
- 2.—Normal hermaphroditism of this species of Rafinesque's *Lastena*,—a rare occurrence among the Naiades.
- 3.—Its very peculiar shell characters,—especially as related to its delicate thinness, its bright green and olive color, prominent sculpturing and sub-cylindrical shape,—Say's chief reason for his supposedly new species,—*Anodonta imbecillis*.
- 4.—Its non-parasitic habit in the glochidial life,—the exception to the rule that mussels are parasitic on fish and salamanders in the post-embryonic life. This non-parasitism was verified by Dr. A. D. Howard, (*SCIENCE*, N. S., XL, pp. 353-355, Sept. 4, 1914).
- 5.—Its juvenile shell unusually light and buoyant for purpose of transportation by water currents as a compensatory provision for the loss of the usual means of geographic distribution in the larval life by means of fish hosts.
- 6.—Its continuous breeding season, or at least a very short interim of sterility,—the author having found its marsupia gravid with ripe glochidia every month of the year.
- 7.—Its rather distant removal from its former associate species, *Lastena suborbiculata*, (Say), to which it is only closely related as to its non-conglutinated glochidia which are of the unusually large size, (0.310 X 0.290mm.), and of the same sub-triangular form and beautiful golden russet color; yet it is physiologically different from *suborbiculata* in not clinging to

**Pleurobema Utterbackii*, (Frierson),—a New Species discovered by the writer of this paper and dedicated to him by Mr. L. S. Frierson who also verified the validity of the novelty of two other species of mussels found by the author and dedicated to his major Professors, Drs. Lefevre and Curtis of Missouri University while working as a graduate student on his Thesis,—"The Naiades of Missouri," (*Am. Midland Nat.*, Vol. IV, pp. 1-200, Plates 1-XXIX, 1916. See pp. 86-87, Pl. VI; also pp. 109-111 for full description of *L. ohiensis* for which the creation of the New Genus,—*Utterbackia*,—has been endorsed by the leading students of Naiadology).

the gills and fins of fish, but metamorphoses immediately into juvenile form upon leaving the marsupia,—a most extraordinary character!



FIG. 1.—*UTTERBACKIA OHIENSIS*,
(*RAFINESQUE*).—OUTER VIEW
OF THE RIGHT VALVE

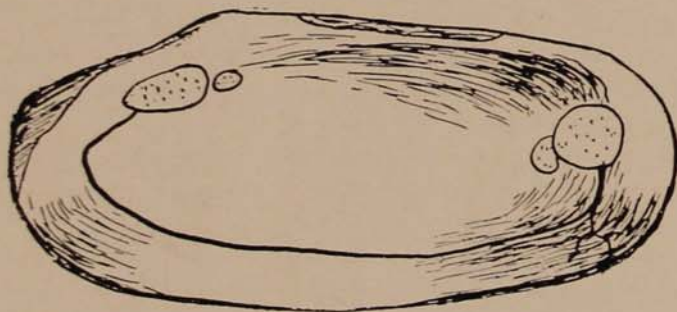


FIG. 2.—*UTTERBACKIA OHIENSIS*,
(*RAFINESQUE*).—INNER VIEW
OF THE LEFT VALVE

—W

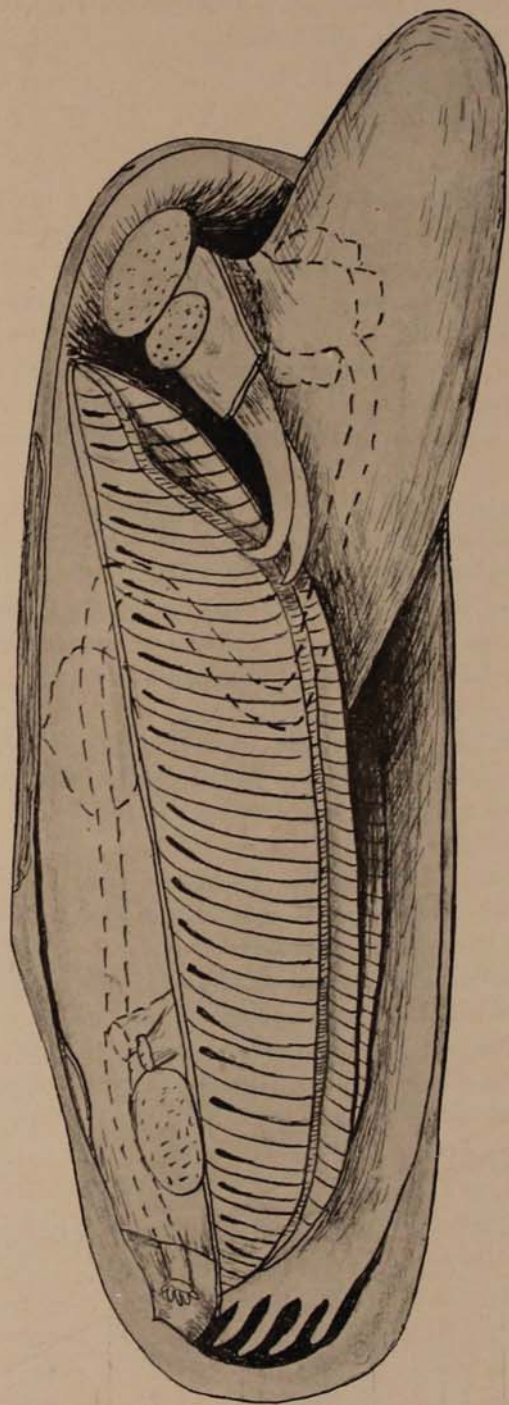


FIG. 3.-UTTERBACKIA OHIENSIS, (RAFINESQUE), WITH
RIGHT VALVE AND MANTLE REMOVED SHOWING
A GRAVID MARSUPIUM,—THAT IS, THE RIGHT
OUTER GILL ADAPTED FOR BROOD POUCHES. —~~W~~

COMPARATIVE LENGTH OF THE ALIMENTARY
TRACT OF THE MALE AND FEMALE COMMON FROG,
RANA PIPIENS, SCHREBER

By

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From general cursory observations made on frogs dissected in the laboratory by students over a period of years, the thought came that there might be some size variations in the alimentary tract of the male compared to the female frog. The more so since in the breeding season the female frog is much distended with eggs. Accordingly, dissections were so planned as to leave the digestive system intact in a number of these animals. After accumulating specimens for several years, definite measurements were made. The writer is indebted to Miss Cleo Mumper for making the measurements.

Due to the curves and convolutions of the parts of the alimentary tract being measured, it was necessary to use some flexible device which would closely conform. A fine piece of copper wire filled the requirements since it had the necessary flexibility and at the same time precluded any possibility of shrinkage or stretching. After a measurement was taken by the wire, the wire was straightened and applied to a solid metric ruler.

In order to compare frogs of uniform size, two groupings were made based on the length of the animal from the tip of the nose to the end of the tail. The groups thus set up were males and females whose measurements were below 7.5cm. and between 7.5 and 8.5cm.

Measurements were made of the esophagus from the oval cavity to the stomach; of the greater and lesser curvatures of the stomach to the pylorus; the small intestine from the pylorus to the rectum. The rectal and cloacal measurements were tabulated as follows: the rectum proper from the opening of the small intestine to the openings of the ureters; and the cloaca from the opening of the ureters to the anus. Measurements were made of 13 males and 39 females, a total of 52 frogs. These measurements are summarized in Tables I, II, III, and IV.

TABLE I.
Measurements of male frogs—7.5-8.5cm. long.

Frog No.	Esophagus	Stomach		Small Intestine	Rectum	Cloaca
		Gr. cur.	Less cur.			
1	0.9	3.05	2.3	11.1	2.0	0.6
2	0.6	2.9	1.9	9.2	2.2	0.6
3	0.5	2.7	2.0	10.3	1.5	0.7
4	0.7	2.8	1.7	10.5	1.7	0.6
Average	.67	2.7	2.0	10.3	1.9	0.6

TABLE II.
Measurements of male frogs less than 7.5cm. long.

Frog No.	Esophagus	Stomach		Small Intestine	Rectum	Cloaca
		Gr. cur.	Less cur.			
1	1.2	2.5	1.9	7.7	1.8	0.6
2	0.6	3.1	2.6	10.9		
3	0.08	3.3	2.2	11.0		
4	1.0	3.1	2.4	14.0	1.9	0.8
5	0.5	2.3	1.8	8.8	1.1	1.0
6	1.0	2.5	2.2	15.5	1.6	1.2
7		3.2	2.8	13.0	1.1	0.6
8	0.6	2.6	2.0	9.4	1.1	0.7
9	0.4	2.9	2.4	9.7	1.8	0.9
Average	.54	2.8	2.2	11.1	1.5	0.8

TABLE III.
Measurements of female frogs—7.5-8.5cm. long.

Frog No.	Esophagus	Stomach		Small Intestine	Rectum	Cloaca
		Gr. cur.	Less cur.			
1	0.6	3.1	2.3	8.8	1.5	0.9
2	0.8	3.7	2.9	11.9	1.9	0.8
3	0.5	3.5	2.5	8.6	2.0	0.8
4	1.0	2.7	2.1	13.6	1.7	1.4
5	0.7	2.7	1.7	9.8	1.5	1.4
6	1.1	3.2	2.2	13.0	2.5	0.6
7	1.1	4.3	2.8	16.0	2.2	0.9
8	1.1	3.0	2.1	12.1	1.8	1.2
9	1.3	2.2	1.9	10.4	1.6	1.1
10	1.0	2.6	1.9	8.1	1.7	0.9
11	1.1	2.3	2.0	9.7	1.1	1.7
12	1.1	3.2	2.1	13.7	2.6	1.5
13	0.9	3.1	2.0	14.2	1.6	0.8
14	0.8	3.2	2.4	14.1	1.7	1.2
15	0.6	3.3	2.5	15.6	1.9	1.6
16	0.3	2.8	2.1	9.0	1.6	1.2
17	0.7	3.2	2.3	12.8		
18	0.9	3.3	2.4	12.2	1.6	1.2
19	1.0	2.9	2.1	10.5	1.8	0.9
Average	0.87	3.7	2.2	12.3	1.7	1.0

TABLE IV.
Measurements of female frogs less than 7.5 cm. long.

Frog No.	Esophagus	Stomach		Small Intestine	Rectum	Cloaca
		Gr. cur.	Less cur.			
1	1.0	2.7	2.1	10.4	1.7	1.1
2	0.7	3.5	2.6	9.1	2.0	1.0
3	1.2	2.7	2.0	13.8	2.1	1.1
4	0.6	3.0	2.4	10.5	1.9	0.8
5	0.5	3.0	2.1	8.9	1.3	1.1
6	0.9	2.3	1.9	9.3	1.4	1.1
7	1.0	3.3	2.6	12.4	1.5	1.2
8	1.1	3.2	2.5	11.9	2.1	1.1
9	0.9	2.8	1.8	9.8	1.6	1.2
10	0.8	2.5	1.8	8.8	1.0	0.8
11	0.9	3.6	2.3	15.5	1.5	1.1
12	1.2	2.9	2.3	8.3	1.5	0.9
13	0.6	2.3	2.0	9.6	1.3	1.0
14	1.1	3.1	2.1	11.9	2.0	0.8
15	0.4	2.3	2.0	9.5	1.7	0.7
16	1.2	3.9	2.8	11.6	2.2	0.6
17	0.6	2.8	2.0	13.0	2.5	0.8
18	0.7	2.9	2.2	10.9	1.6	0.8
19	0.4	3.3	2.6	10.8	1.5	0.6
20	0.8	3.1	2.4	13.4	1.2	0.7
Average	0.83	2.9	2.2	10.9	1.6	0.9

Discussion.

When Table II is compared with Table IV there is noticed a remarkable uniformity in the average measurements for the males and females. The average length of the esophagus of the females is less than 3 millimeters longer than that of the males. Differences in the measurements of the other parts of the alimentary tract vary only from 0-2 millimeters, a difference which certainly must be considered negligible.

When Tables I and III are compared a somewhat greater difference appears, a difference which ranges from 2 millimeters to 2 centimeters. This may be due to the small number of male animals measured—only 4 being available, compared to 19 females. However, contrary to expectations, the tables show a higher average length for the female alimentary tract.

Conclusion.

From the data presented there appears to be no appreciable difference between the parts of the alimentary tracts of male and female frogs. This precludes the possibility of length of the digestive tract being a secondary sexual characteristic.

AN EXPERIMENTAL STUDY OF HYBRID VIGOR OR
HETEROSIS IN RATS

By

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(Abstract)

Hybrid vigor (measured by weight) was manifested in the F_1 rats of the two crosses studied. There was a distinct loss of vigor shown by the F_2 rats of each cross as compared to the F_1 rats. The F_1 rats of each cross were less variable in weight than the rats of the respective parent strains. The F_2 rats of each cross were more variable in weight than F_1 rats, although the difference in variability was not sufficient to be significant in the case of the crosses. The F_2 rats of each cross were less variable than the rats of the respective parent strains even though one of these strains (King Albinos) had been intensively inbred for more than fifty generations.

There was some evidence of size inheritance among F_2 rats, however, there was no evidence of size or growth genes being carried on the three pairs of chromosomes studied. There was no evidence that either a homozygous or heterozygous condition of the known allelomorphic genes had any influence upon the weight of F_2 rats, neither did the known dominant genes show any evidence of influence upon the size of rats.

THE NEED OF STANDARDIZING CHEMICAL SPEECH

By

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In the small country of Sweden, no larger than half the State of Texas, it is said the people speak in twenty-eight different tongues and that the language used in some provinces is unintelligible to the inhabitants of certain other provinces. Let me illustrate two of these dialects: No. 1. Å dä va en göös på en möös som had röa hööser å en pöös, å dä sak han ner å dä va dä it nöö mer. No. 2. I närke kan dum smi spiken å slå dit'n så han sitter der om dä kniper. In later years these dialects are slowly disappearing as intercommunication between the provinces is being more perfectly established. So also do we find that provincialisms are disappearing in this country, in proportion to the interchange of the written and spoken language.

When it comes to scientific, or more particularly, chemical terminology it appears to be equally difficult to use a new expression or a different pronunciation than that to which we have been accustomed, for the reason that most of us put the emphasis upon the facts and the subject matter of the discourse rather than upon the vehicle by which the thought is conveyed.

Nevertheless, accuracy in expression comes very nearly being as important as accuracy in manipulation and observation. Chemical speech like any other speech may be separated into three distinct divisions, namely, nomenclature, spelling, and pronunciation.

Not long ago the Chairman of the Committee on Nomenclature, Spelling, and Pronunciation of the American Chemical Society published notices in the Journal of Chemical Education and in the News Letter of the Journal of Industrial and Engineering Chemistry to the effect that the Committee proposed to send out a questionnaire containing a list of 250 or more words known to have different pronunciations, with a request that each recipient of the questionnaire shall check the words as he considers they should be pronounced.

A general response to this questionnaire would enable the Committee to fix the pronunciation of certain words according to present day usage, and it is needless to say that without cooperation the Committee could do nothing. It is of the greatest importance that teachers of chemistry should use correct expressions and proper pronunciation when instructing students, for it is first impressions that persist, and errors learned in youth are very hard to overcome.

When a student asks me how to pronounce *i o d i n e*, shall I tell him *iodine*, *iodine* or *iodine*? In the same institution we may have instructors lecturing to their students about *sulides*, *oxides* and *hyd-*

roxides while others say sulfides, oxides and hydroxides. One professor talks about am'ino acet'ic acid while another about am'in'o acet'ic acid. This one about calcium cyan'amide and that one about cyan am'ide. Who is right? Shall we say aurī or aurī bromide, ferrī or ferrī cyanide, hydrazine or hydrazine, iōdic or iōdic acid, hālite or hālite, mǎn'ganic or man gǎ'nic, ar'sine or arsine', cō'bal tite or co bal'tite, sulfōn or sulfōn, tī'-tānic of tītān'ic phenol-phthāl'ē-in or phenol-phthal'-ine or phenol-phthal'-ine, ar'a gō nite or a-rǎg'o nite, selēnic or selēnic acid, anilīne or anilīne, cholīne or cholīne, cystīne or cystīne, quī'nine, quī'nine' or kinīne', cěl' es tite or ce lēs'tite, bauxite or bō-zīte?

When we hear a chemist get up and tell about some āzo or hydrāzo compound we cannot blame him, for he was taught that way by his professor, but the chemist who speaks of these as āzo and hydrāzo at least has Webster on his side. Some of us report temperatures on the cēntigrade and others on the (çantigrade) scale. We measure lengths in both cēntimeters and (çantimeters). Which is the better reducing agent, nācent or nāscent hydrogen?

In this connection it would seem proper to give a list of words with the pronunciations as recorded in Hackh's Chemical Dictionary, which has recently been put upon the market, to see if there is complete agreement.

benzyl—(ben'-zil); (zil)
 ethyl—(eth'-il; e'thīl)
 butyl—(bu'-til; il)
 trimethyl—(tri-meth'-il; me'-thīl)
 quinine—(kwin'-ēn; kin'-ēn)
 chlorbutyryl—(bu'-tir-il)
 ephedrin—(ef'-e-drin)
 hydroquinone—(hi-dro-kwin'-ōn)
 phenol—(fe'-nol)
 brucine—(broo'-sin)
 fuchsine—(fook'-sin)
 convallarin—(kon-val-a'-rin)
 phenolate—(fe'-no lāt)
 phenolphthalein—(fe-nol-thā'-lin) (lin)
 hydrine—(hi'-drīn)
 catechin—(kat'-e-kin)
 catechol—(kat'-e-kol)
 pyro catechol—(kat'-e-kol)
 hexamine—(hex-am'-in)
 cyanamide—(si-an-am'-īd; si-an'-am-id)
 cyananilide—(si-an-an'-il-id)

cinnamyl—(sin'-am-īl)
 cyanbenzyl—(si-an-ben'-zil)
 nitrile—(ni'-tril; trīl)
 benzonitrile—(ben-zo-ni'-trīl)
 fluorine—(floo'-or-ēn)
 chlorine—(klo'-rēn)
 bromine—(bro'-min)
 iodine—(i'-o-din)
 alanine—(al'-an-in)
 cystine—(sis'-tēn)
 leucine—(lu'-sin)
 lysine—(li'-sēn)
 histidine—(his'-tid-in)
 lamine—(la'-mēn)
 pyridine—(pi'-rid-in)
 bismuthyl—(biz'-muth-īl)
 cinnamyl—(sin'-am-īl)
 fumaryl—(fu'-mar-īl)
 crotonyl—(kro'-ton-īl)
 Ångström—(ang-strem)
 aqua—(a'-kwah)
 aqueous—(a'-kwe-us) also ä or ā queous

How frequently do we not hear mōlecule pronounced mōlecule and bō'-zīte, bauxite, cēl'estite, ce-lēs'tite, sō'-lute, sōl'ūte, ācrō'lēin, acro'leīn, quaiacōl, quaiacōl; enzȳme, enzȳme, chlō'-rāl, chlōrāl', fur'-furāl, furfurāl', al'abaster, alabas'-ter, verdigrīs, verdigrīs and so on almost ad infinitum.

In view of such lack of uniformity in pronouncing chemical terms it would seem well worth the effort to attempt to fix certain standards of pronunciation.

Nomenclature

Of even greater importance to the science of chemistry is the subject of chemical nomenclature. Not long ago an article appeared in Science on "The Effect of Sodium Silicofluoride Sprays on the Peach" by Dr. H. W. Anderson. By silicofluoride he means fluosilicate, the sodium salt of fluosilicic acid. The former name is still used by many English and American chemists, and is so listed in various market price reports, although the magnesium salt is properly listed as magnesium fluosilicate and not silicofluoride. Another nomenclature instance; a man from New York wrote me, inquiring why I give the name arsenic trioxide to the substance whose formula is As_2O_3 when it has, since time immemorial, been manufactured and sold under the name arsenious acid.

The various names employed for acid salts are always confusing to beginners in the study of chemistry. We say sodium bi-carbonate or potassium bisulfite to show the acid character of the salts and sometimes insert the word acid instead of "bi." In tribasic acids we use either; nono, di, and tri acid, or mono-, di-, and tri metal; or we say primary, secondary and tertiary salt.

Sodium hyposulfite in the photographic world is a substance having the formula $\text{Na}_2\text{S}_2\text{O}_3$ with entirely different properties from the chemist's sodium hyposulfite, known by the formula $\text{Na}_2\text{S}_2\text{O}_4$. The chemists name for the former compound is sodium thiosulfate.

Ambiguity arises from the use of names that are pronounced alike but with different meaning, for example, benzene and benzine. The former is a single chemical entity, while the latter, a mixture of several substances. Fluorine is an element and fluorene a benzene derivative of methane. To some benzene and benzol are synonymous terms although the ending "ol" has been reserved to designate alcohols and phenols. The word ether means a very definite complex R-O-R yet the compound acetic ether does not possess this grouping. So also do we have phosgene without phosphorus and theobromine without bromine, lead pencils with no lead in them, isinglass with no trace of glass in it.

When sulfur replaces an oxygen atom in a salt from an "ic" acid many chemists still continue to speak of the salt as an "ide" with the prefix sulf or sulfo, for example $\text{Pb}(\text{CNS})_2$ they call lead sulfocyanide instead of thiocyanate, and $\text{Mg}(\text{CNS})_2$ magnesium sulfocyanide instead of thiocyanate. $(\text{NH}_4)_3\text{SbS}_4$ is often called ammonium sulfantimonate instead of thioantimonate.

More confusion still is observed in the naming of ammonia addition products. Many authors use the word ammine and others ammonio when one or more NH_3 radicals are joined to an inorganic compound. Dr. E. C. Franklin proposed the name ammonate while others prefer ammoniate. Some authors prefer just to add the word ammonia to the name of the compound, which system is illustrated in *Comey's Dictionary of Solubilities*. For example, under nickle chloride ammonia, the following compounds are listed: $\text{NiCl}_2 \cdot 2\text{NH}_3$, $\text{NiCl}_2 \cdot 3\text{NH}_3$, and $\text{NiCl}_2 \cdot 6\text{NH}_3$. More complex ammonia addition products are given individual names, such as the following taken from the above mentioned work: Bromo-, carbonato-, chloro-, iodo-, nitrato- and sulfo-tetramine cobaltic compounds; bromo-, chloro-, nitrato-, etc., purpureo-cobaltic compounds; croceo-cobaltic compounds; dichro-cobaltic compounds; flavo-cobaltic compounds; fusco-cobaltic compounds; luteo-cobaltic compounds; melano-cobaltic compounds; nitrito-cobaltic compounds; oxy-cobaltamine; praseo-cobaltic compounds; roseo-cobaltic compounds; xantho-cobaltic compounds, etc.

The foregoing discussion has been entered into with one purpose only, and that is an attempt to emphasize the need of standardizing chemical nomenclature as well as pronunciation.

Following are some of the changes in the nomenclature of organic compounds as recommended by the "Comité de Travail" on Nomenclature of the International Union at its session in 1928, Professor M. Holleman being Chairman of the Comité and Dr. A. M. Patterson the American representative.

1. Names of saturated open chain hydrocarbons, to end in **ane** and known as alkanes. Unsaturated open chain hydrocarbons end in **ene**, but if two double bonds are present the ending **diene**, three double bonds, **trienes**, etc. This class of hydrocarbons to be known as alkenes. Names of triple bond hydrocarbons end in **yne**, and when two triple bonds are present the ending is **diyne**, etc. The class to be known as alkynes. When both double and triple bond is present the ending is—**enyne**, **dienyne**, etc., and the class known by the name alkenynes.

2. The names of monocyclic saturated hydrocarbons end in—**ane** preceded by the word **cyclo-**, and the class to be known as cyclanes. Polycyclic saturated hydrocarbons will end in **-ane**. For example: naphthalane. Polycyclic unsaturated hydrocarbons end in **ene**, **diene**, **yne**, **dinyne**, **enyne**, **dienyne**, etc. as in the straight chain hydrocarbons depending upon the character of unsaturation. Partially saturated polycyclic hydrocarbons to be called **dihydro-** **tetrahydro-** etc. For example dihydroanthracene.

3. Progressive hydrogenation of heterocyclic nitrogenous compounds to be designated by the endings **-ine**, **idine**. For example: pyrrole, pyrroline, pyrrolidine, oxazole, oxazoline. The prefix used to designate hetero atoms is to end in **a**. For example: **oxa-** for oxygen as in oxadiazole and oxazine; **aza** for nitrogen as in diaza-quintadiene; and **thia-** for sulfur as in thiadiazole and thiazine.

4. In place of the suffix—mercaptan, the word **-thiol** is to be substituted. For example: benzyl mercaptan will be called phenylmethyl thiol.

5. The prefix to be used to designate an oxygen atom attached to two atoms in a chain of carbon atoms is **epoxy-**. For example: epoxyethane instead of ethylene oxide, and epoxy-1,4-butane instead of butylene oxide.

6. The name representing sulfur when not attached to oxygen in organic compounds is to be **thio-**; when attached to one oxygen, **sulfinyl**; and when attached to two oxygens, **sulfonyl**. For example CH_3SCH_3 is called methyl thiomethane, $\text{C}_3\text{H}_7\text{SCO}_2\text{H}$ propyl sulfinyl butane; and $\text{CH}_3\text{SO}_2\text{C}_2\text{H}_5$ methyl sulfonyl ethane.

7. Aldehydes are known by the suffix **al**, thioaldehydes by **thial**, and acetals named by the corresponding dialkoxyalkane. For example ordinary acetal, $\text{C}_2\text{H}_4(\text{OC}_2\text{H}_5)_2$ would be called diethoxy ethane. Names

of ketones terminate in **one**, **dione**, **trione**, etc., or **thione** when sulfur replaces oxygen.

8. When sulfur replaces oxygen in the carboxyl group of organic acids the name is to be **carbothioic**, or **carbothiolic**; and if it is known that the oxygen of the CO group is replaced by sulfur the name is to be **carbothionic**. If both oxygen atoms are replaced by sulfur the name is **carbodithioic**.

9. Names of nitrogenous bases shall end in **ine** with the proper prefix as **di-** **tri-** etc. Names of aliphatic compounds containing pentavalent nitrogen shall end in **-onium** instead of **ine**; and for similiar cyclic compounds the ending shall be **-inium**; and for those ending in ole the ending shall be **-olium**. For example: pyridinium, imidazolium.

10. The suffixes used to designate compounds derived from acids of arsenic, antimony and phosphorus by replacement of an OH by a univalent radical shall be **-arsonic**, **-stibonic** and **phosphonic**. For example: $C_2H_5PO(OH)_2$ is called ethyl phosphonic acid, and $(C_2H_5)_2PO(OH)$ is called diethyl phosphonic acid.

11. When an alkyl radical replaces hydrogen of the hydroxyl group in hydroxylamine, the compound is called an alkoxyamine, as $C_2H_5ONH_2$ ethoxyamine, while if it replaces the H of the amine group the resulting compound is an alkyhydroxylamine as C_2H_5HNOH is called ethyl hydroxylamine.

12. The name cyanate is reserved for true esters of cyanic acid. Esters corresponding to the formula $RNCO$ shall be called isocyanates, and those with formulas like $RNCS$ shall be called isothiocyanates.

A PHOTOGRAPHIC STUDY OF EVAPORATION RINGS

By

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Introduction

It has been previously shown¹ that under suitable conditions rhythmic bands of dyes may be formed upon filter paper, cotton cloth, and unglazed porcelain, when dilute solutions of certain dyes are allowed to evaporated at constant temperatures. In a later article² it was shown that rhythmic evaporation rings may be formed by allowing a suitable dye solution to evaporate from a watch glass. In September, 1929, a paper³ on evaporation rings was presented at the Minneapolis meeting of the American Chemical Society. It had been found that watch glasses are not sufficiently regular for making a quantitative study of evaporation rings. Therefore, optical lenses, about 4.5cm. in diameter, were obtained from Bausch and Lomb Optical Co. They were lenses such as used in eye glasses, were highly polished, and ground to uniform curvatures. The radii of curvature as measured by tripod spherometers ranged between 25mm. and 115.5mm. Following over 100,000 ring counts, the conclusions were as follows.

"Pure Orange II solutions give no rhythmic evaporation rings when evaporation containers are perfectly clean.

"Rhythmic evaporation rings of Orange II are not due to air or vapors absorbed from the laboratory by the evaporation containers.

"A surface skin of foreign substance may result in formation of rhythmic evaporation rings when the film is not too volatile and is capable of helping to cause the evaporation rings to stick to the surface of the container.

"A thin transparent film of abietic acid on the surface of the evaporation container is a satisfactory foundation film for the formation of rhythmic evaporation rings of Orange II.

"When such a foundation film of abietic acid is on the surface of the container the number of evaporation rings formed from a given volume of Orange II solution becomes greater (1) as the concentration of the solution decreases, (2) as the temperature of evaporation increases, and (3) as the radius of curvature of the evaporating container decreases.

"With Fast Red B no abietic acid or other foundation film is necessary and the number of evaporation rings becomes slightly less at higher

¹Earl C. H. Davies, J. Am. Chem. Soc., 44, 2705 (1922).

²Earl C. H. Davies, Proc. W. Va. Acad. of Science, 2 (1928).

³"Rhythmic Evaporation Rings of Orange II and Fast Red B," by Earl C. H. Davies, Kenneth Taylor, and E. W. Riblett, J. of Phys. Chem. 34, 842-854 (April 1930).

temperatures, whereas concentration and curvature effects are similar to those of Orange II.

"n-Butyric acid lowers the surface tension of Fast Red B and at the same time causes an increase in the number of evaporation rings."

Photographs of Evaporation Rings

The purpose of the present paper is to give a brief account of a few of the most interesting photographs of evaporation rings. As early as 1922, a number of photographs were made in this laboratory of evaporation rings of dyes on paper, but the photographic study of the

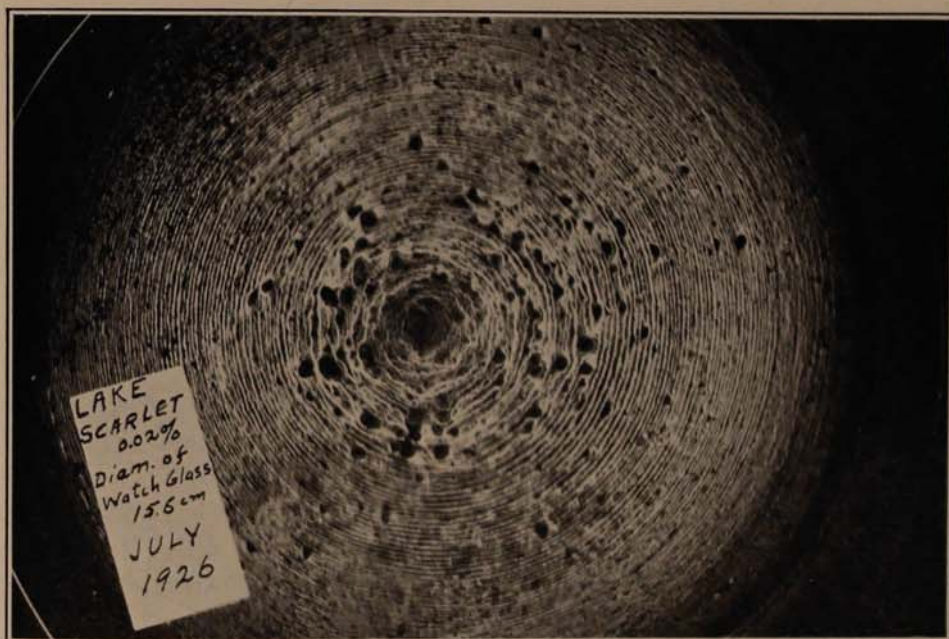


Figure 1. The cut is 67.3% as large as original photograph.

evaporation rings produced on watch glasses has been carried out periodically between 1926 and the present time.

Photographs Without a Camera.—In some of the earlier pictures (figure 1) the prints were made without a camera by simply putting the sensitive paper, face up, beneath the watch glass containing evaporation rings. At about 2 feet distance exposure to the light of a 100 Watt Mazda was 35 to 50 seconds depending upon the density of the specimen. This process produced "negatives" with the white portions appearing black. When this is objectionable the photograph may be made by firmly holding an unexposed film, emulsion side up, against the bottom of the watch glass. From such a negative prints may be made in the usual manner.

These direct photographs are, therefore, the exact sizes of the original rings. Several of these were made into slides by Homer Hoskins through the courtesy of Professor Fred A. Molby of the West Virginia University Physics Department. The idea was that the enlargement on the screen could be used to make a quantitative study of crystal sizes and distribution. Although this proposed study has not yet been completed, it is deemed best to include one of these original photographs (figure 1). This is a direct photograph of .02% Lake Scarlet R on a 15.6cm watch glass. The small irregular rings scattered over the dish are due to crystals of NaCl. These cubic crystals of sodium chloride may be seen even by the unaided eye.

Microphotographs.—Satisfactory microphotographs of some individual evaporation rings were made without any special equipment. The camera was a Premo Film Pack (3 by 5 $\frac{1}{4}$ inches). A black box was

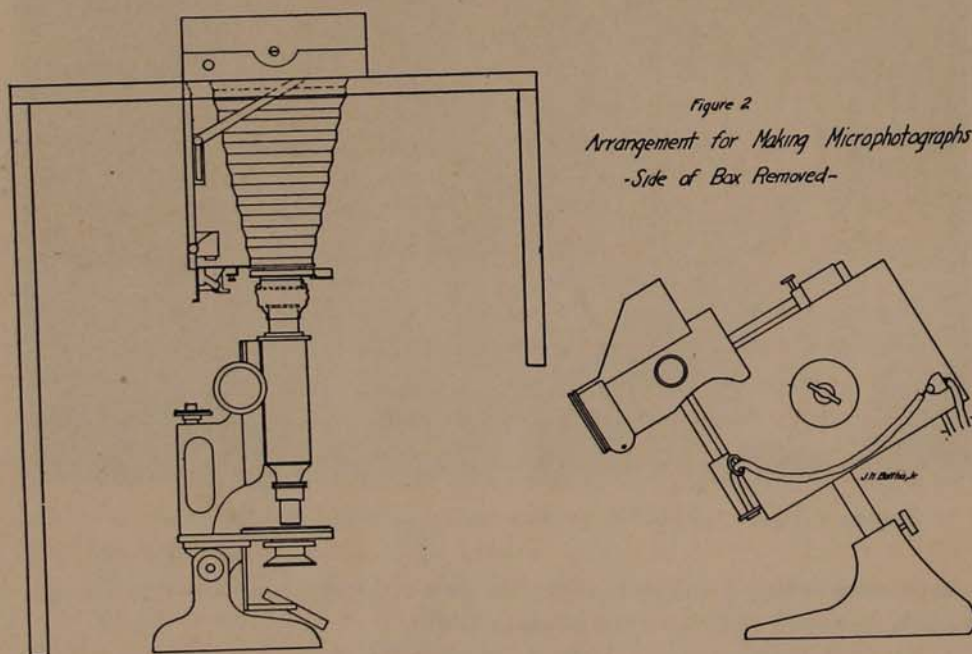


Figure 2
Arrangement for Making Microphotographs
-Side of Box Removed-

constructed as shown in figure 2. A wide rubber tubing was used as a sleeve to connect the top of the microscope with the camera. Sharp focus on the ground glass of the camera was easily obtained by adjusting the focus of the microscope and also of the camera. The time for exposure was 1 second.

In order to measure the amount of magnification, the diameter of a small wire was measured on a Gaertner sliding micrometer, carrying a microscope and reading to .001mm. Then this same wire was put under the microscope and camera. The width on the ground glass of

the camera of the image of the wire was measured, and the amount of magnification calculated as 88.5 times the original. Figures 3 and 4 are examples of this photography. Lantern slides were made of these microphotographs with the idea that the enlargement on the screen would be used to make a detailed, quantitative study of the rings. This proposed study is by no means completed, but a few facts are clear. Only 2 of these microphotographs will be here considered.

Figure 3 shows a portion of one evaporation ring of a .05% solution of $\text{Na}_2\text{CO}_3 \cdot 10 \text{H}_2\text{O}$ ("sal soda") at a magnification of 88.5 times the original taken October 28, 1928. This photograph indicates that

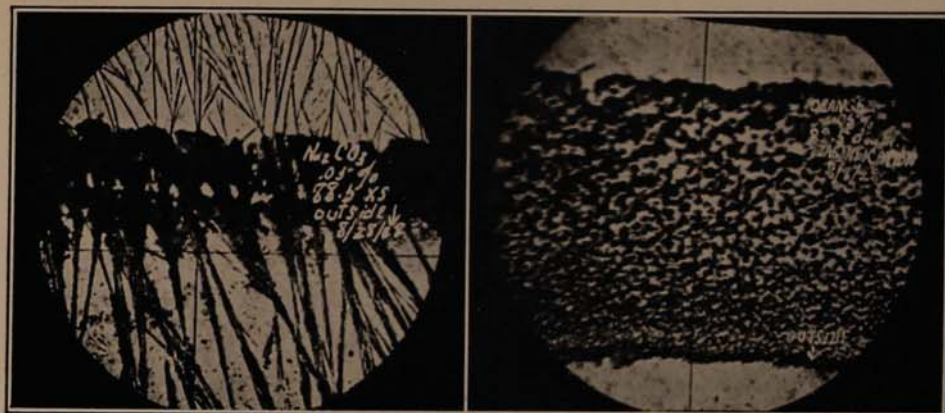


Fig. 3.

Fig. 4.

Figures 3 and 4 have been reduced to 56.6% of the size of the original photographs.

after the ring was attached to the glass some of the concentrated solution was isolated at the outer side of the ring, and rather large crystals were formed in this isolated solution. The crystals are oriented toward the center of the watch glass like the spokes of a wheel. As the solution pulled away from the ring to form the next innermost ring a thin film of solution remained on the glass. The evaporation of this film made the lighter crystals just inside the ring.

Figure 4 shows a portion of one evaporation ring of .05% Orange II at a magnification of 88.5 times the original. This ring is .565mm. wide. It contains the largest crystals on the inside. At its inside edge the ring is bordered by a nearly unbroken fence about .025mm. wide, consisting of crystals of about .012mm. diameter, while at the outer edge a .022mm. fence consisted of crystals of about .006mm. diameter. Between these fences was a fairly uniform deposit of crystals which gradually became smaller and more numerous toward the outer edge. This would indicate that crystallization was more rapid toward the outside of the ring, and that crystals forming the ring grew by evaporation of the concentrated liquid which adhered after the main body of the liquid had drawn away toward the center of the watch glass.

Movie Pictures.—During the several years in which we have been studying evaporation rings, we have frequently, during several continuous hours, observed rhythmic evaporation rings form on watch glasses. In order to record these observations more permanently, and to be able to study the actual formation in more detail, it was decided to make what is believed to be the first moving pictures of the formation of evaporation rings. This was made possible through the courtesy of Professor N. J. Giddings of the department of plant pathology at West Virginia University.

The evaporation lens containing the solution was placed on the stage of a compound microscope directly beneath the moving picture camera. An arc lamp not only furnished the light but also furnished heat necessary for evaporation. Proper adjustment of the focus, distance of arc, and other details, was not found especially easy for amateurs. However, we had "beginners luck" with the first roll. Kenneth Taylor and E. W. Riblett assisted the author in making these photographs.

When observation showed that a ring was about to form directly beneath the microscope, the camera crank was turned at the usual rate of 2 turns per second making 16 separate exposures per second on a strip of film 2 feet long by 1 inch wide. Thus, when these films are run through the projection machine at the same normal rate of 2 feet per second the rings will be seen to form at the actual speed. However, between the formation of each ring and that of the next there were several minutes when no pictures were taken, because it would have involved the considerable expense of many more feet of film. Nevertheless, a highly magnified movie of these intermediate quiescent states might have been quite instructive.

Although the moving picture includes a good view of ring formation of .1% Fast Red B, the .1% Orange II on a lens coated with abietic acid proved better. This picture emphasizes the importance of adhesion for ring formation. It is seen that the solution splits midway between the old and the new ring where it is thinnest. The split generally starts at one point and travels rapidly around the watch glass, while the remainder of the solution draws inward. The distance to which the solution will withdraw will depend upon the curvature of the lens and the surface tension of the solution.

Besides these moving pictures, we used the same arrangement to take 15 "still" pictures of lenses containing rhythmic evaporation rings of 9 different dyes. One of these of special interest was a lens containing rhythmic evaporation rings of a .05% solution of Lake Scarlet R which was .003 normal with sodium oleate. Although the sodium oleate does lower the surface tension of the dye solution, it seems that the rings are fewer and larger chiefly because the sodium oleate increases the

adhesion of the dye for the lens. The possibilities of what may be learned from these and other moving pictures have by no means been exhausted.

Summary.

Supplementing photographic studies with other quantitative methods, we believe that we are arriving at a clearer understanding of the underlying principles of the formation of rhythmic evaporation rings, including the fundamental importance of adhesion. Some of these conclusions have already been summarized in this paper and stated more fully elsewhere.

Directions are given for taking photographs (1) without a camera, (2) microphotographs, (3) and moving pictures.

These photographic methods make it possible to study the size and distribution of crystals in rhythmic evaporation rings and to watch the actual movements of the solution during ring formation.

In the case of Orange II, the solution "splits midway between the old and new ring where it is thinnest. The split generally starts at one point and travels rapidly around the watch glass, while the remainder of the solution draws inward. The distance to which the solution will withdraw will depend upon the curvature of the lens and the surface tension of the solution."

SOME ASPECTS OF THE POTTERY INDUSTRY OF WEST VIRGINIA II. MANUFACTURING PROCESSES

By

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DEFINITION OF WHITEWARE

The term "whiteware" comprises a large group of ceramic materials, composed of a white body material. The whiteness is due to the natural color of the raw materials, which in America consists essentially of clay, feldspar and flint. Whiteware manufacture includes the manufacture of china and porcelain as exemplified in West Virginia by vitrified hotel china, electrical porcelain, and high tension insulators and some sanitary ware; and the manufacture of earthenware, as exemplified by table ware, wall tile, and some sanitary ware. Whiteware is manufactured in West Virginia in 24 potteries, 19 of which are located in cities on the Ohio River. From the point of view of the value of the manufactured product, West Virginia ranks third in the United States. The manufacture of whiteware ranks eighth among the manufacturing industries of the state. Cheap natural gas and cheap high grade coal in this state make it attractive for all types of ceramic industries. The geographic location combined with good railway transportation also are assets which apply as well to other manufacturing industries.

China clay is an important ingredient in all whiteware. About a third of a million tons are imported annually from England, and almost half a million tons are produced in the United States in New Jersey, Georgia, North Carolina and Florida.¹ English china clays have been noted for their whiteness and uniformity since the days of Wedgewood. However, modern mining and washing methods have improved the quality and uniformity of domestic china clays so that manufacturers are using American china clays in increasing amounts. Of the 24 potteries in West Virginia, 21 use English china clays, but 13 of these also use in addition domestic china clays.

China clays are noted for their whiteness, both before and after firing. If, however, an attempt were made to use china only in the making of whiteware, three difficulties would be encountered: (1) The clay is so feebly plastic that it would be hard to shape the ware: (2) The shaped (but unfired) ware would be so weak that there would be great breakage in handling that the pieces must receive before they go to the kiln: (3) The ware would require an impractically high temperature to fire it properly. The first two difficulties can be overcome by adding

¹All china clay does not go into the manufacture of pottery. More china clay is used as a filler and coating for paper that is used in pottery manufacture.

a ball clay. Ball clays always burn nearly white, but in the unfired state they are dark in color due to organic material present. The organic material burns out in the kiln leaving a nearly white clay. Ball clays are clays that have been transported by water in such a way that the courser particles have dropped out enroute, and a very fine clay has been deposited in quiet waters—geologic ages ago. Fortunately, the deposition was such that impurities were added in but small amounts.

Ball clays are very plastic and are strong when dry but still unfired (in the green state). By the proper admixture of ball clay (about one-third to one-half as much ball clay as china clay) a suitably plastic blend is obtained. Ball clays are obtained from England and from western Kentucky and Tennessee. In order to reduce the high firing temperatures required, and also to increase the strength of the fired ware, a flux is added to supply a glassy bond in the fired ware. In the United States feldspar is used almost exclusively for this purpose. The feldspar melts at a relatively low temperature, it then dissolves some of the clay and a little of the flint and on cooling binds the mass into a firm whole. Feldspars are obtained from Maine, North Carolina, Tennessee, South Dakota, and Canada. The feldspars used are called potassium spars and contain from 9 to a little over 12% K_2O and 0.9 to 2.8% Na_2O .

In addition to clays and feldspars, flint is another important ingredient. It aids in the drying of the ware, but more important, it gives the body rigidity while it is being fired. The flint must be very pure, containing not less than 99.5% SiO_2 . Like the feldspars, it is ground to a very fine powder and must be perfectly white. Flint is obtained from Berkeley Springs, W. Va., Pennsylvania, Illinois, Ohio and Tennessee.

The usual procedure in preparing the body is to mix the clays, spar, and flint with water in a large tank containing a rotating gate or paddles. This process, called "blunging," mixes the ingredients and water to a creamy consistency, called a "slip." The slip is passed through a lawn or screen ranging from 100 to 180 meshes per inch, to remove any coarse particles. It also passes around the poles of magnets which remove any iron particles. To the uninitiated it is surprising how an almost invisible speck of iron may show up in the fired ware as an ugly brown spot several times the size of the original particle.

In order to get this clay slip into a workable plastic mass it must be partly dewatered; this is usually done with the conventional type of filter press, giving a filter cake of the plastic body material, containing from 22-25% moisture. This after being kneaded in a pug mill, is ready for the workmen who form the ware.

The forming of the ware is done by several methods, varying according to the shape and dimensions of the piece. The usual methods are jiggering, pressing, and casting, which will not be described here.

The finished ware must be dried before it is ready to be fired in the kiln. Small pieces present no special drying problems, but large pieces

of sanitary ware must be dried very carefully to prevent warping and cracking.

The old up-draft "bottle" kiln is gradually giving way to modern car-tunnel kilns. There are in West Virginia to-day 12 car tunnel kilns for firing bisque ware, 10 for firing glost ware and 6 for firing decorations. The sanitary ware and vitrified hotel china manufacturers of this state have not as yet taken to using tunnel kilns. In addition there are 134 periodic kilns for bisque ware and 92 for glost ware, besides one "Shore" compartment kiln used for firing sanitary ware. The temperature used for firing this bisque ranges from cones 8 to 12 (1225°-1310° C. or 2235°-2390° F.) depending upon the particular pottery and the type of ware produced.

Twenty-one of the 24 potteries use natural gas as a fuel. Of these four are equipped to use oil if necessary, and one uses natural gas and oil regularly with facilities for coal if necessary. One plant uses producer gas, one oil exclusively, and two coal. With the slowly waning supply of natural gas, and the abundant supply of high grade bituminous coal in the state, one can expect a gradual shifting to coal or producer gas as a fuel.

Whiteware is generally glazed, exceptions being refractory porcelain, floor tile and some electrical porcelain. The glaze is literally a glass although its composition is not exactly the same as window glass. For a glaze for semivitreous ware, for example, borax, boric acid, flint feldspar, whiting, china clay and white lead are melted together to form a frit. This frit when cool is mixed with more flint, feldspar, china clay, zinc oxide and white lead, and the mixture is ground in water to a powder. This insoluble powdered glaze is suspended in the water, and the glaze applied to the bisque ware by dipping the ware into the glaze, or by applying the glaze with a spray gun. When the powdered glaze has dried, the ware is placed in the kiln and fired to a high temperature. This melts the glaze and the surface tension pulls it smoothly over the surface. On cooling, the ware is covered with a thin sheet of clear glass. The temperature employed for this glost firing ranges from cones 1 to 8 (1125°-1225° C. or 2050°-2235° F.)

High tension electrical insulators, though not representing a large volume of the whiteware industry in the state, are interesting to the technical man for they represent the highest type of whiteware produced, from the mechanical point of view. High tension electrical insulators are made by two companies in this state, one makes these insulators only, another makes them along with standard electrical porcelain. In the manufacture of high tension insulators, vitrification is carried to its limit so that no pore spaces whatsoever are left in the ware. Samples of high tension insulators are subjected to rigid tests before the lot they represent are approved for shipment. The samples tested must show a puncture voltage of not less than 235,000 volts, a dry flash-over of

110,000 volts and a wet flash-over of 55,000 volts. In addition, the samples must show an ultimate tensile strength of 11,000 lbs. and must withstand 10 to 30 one-minute cycles of changes from boiling water to ice water.

Whiteware manufacturers are turning more each year to employing technical help and employing scientific instruments. There is still a great deal of information to be acquired before scientific instruments can be employed to their fullest advantage, so that years of practical experience in the whiteware industry is more important than it is in many other chemical engineering industries.

The body raw materials are given a firing test in nearly all potteries. The clay sample in the form of "pats" is placed in the kiln along with the regular ware, in order that its fired color may be observed. The flint may be placed in shallow dishes and placed in the kiln but the feldspar is usually made into the form of small blunt cones. The spar is tested not only for fired color, but also for "softness" which is observed by the slumping of the cones as it is exposed to the kiln temperatures.

THE RECOVERY OF MARKETABLE BY-PRODUCTS FROM ACID MINE WATER

By

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Stream purification from acid mine waters can not be affected by neutralization for two reasons. First, the effective neutralization of mine waters will involve an enormous expenditure of money which the bituminous industry can never supply; and secondly, because the neutralization of mine water with limestone merely changes one evil for another.

On the other hand, the economic solution of stream pollution due to acid mine water and industrial wastes of similar composition is limited, first, by the chemical and physical composition of the mine water and secondly, by the market for the products obtainable from this source.

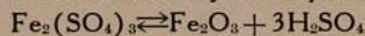
As to the first point, the chemical composition is iron sulphate and free sulphuric acid, and while a good many products are possible the products will still be compounds of either iron or sulphuric acid. Unfortunately, these products are cheap and in great abundance so that the industry can hardly be expected to turn to mine water as a source for its material unless the quality of the product so produced is of unusual merit.

At first glance the extreme dilution would seem to be an unsurmountable obstacle in the economic recovery of the chemicals from this source. On further study, however, it develops that the dilution is a great asset in that it makes it possible to recover products of unusual purity and of very desirable physical properties.

The Geological Survey is not concerning itself with stream pollution as such and is not making any attempts to purify mine water. What it is primarily trying to do, is to find a use for this water by converting some of its chemicals to marketable products. This, of course, would indirectly help to partially purify some of our streams. The more processes of this nature that are developed the nearer we would be to successful solution of stream pollution. For the purpose of this paper, we shall confine ourselves to the production of one product, viz., iron oxide or rouge.

This process is featured by the fact that the precipitation of basic iron sulphate is affected without the use of chemicals and the only agent used is one that is cheap and in great abundance in this State.

This process may be illustrated by the equation below:



This is an equilibrium reaction and goes on even in the cold. We can force this reaction to go to completion from left to right, either by

removing the sulphuric acid; or by reducing the acidity by dilution. To remove the acid would ordinarily mean neutralization by an alkali. The resulting oxide, however, would have no commercial value as a pigment.

The second procedure dilution has three disadvantages: first, it would increase the volume of water to be handled; second, it would require a pure water supply; third, the precipitate formed would be colloidal so that filtration would be impossible and settling long and tedious.

There is still another means available for increasing the speed of this reaction. It is a well known fact that the velocity of a given reaction is usually affected by temperature. The reaction rate is often doubled for every five or 10 degrees rise in temperature.

And so it is with this reaction. If the mine water is heated to the proper temperature, it is found that a basic precipitate settles out promptly. This precipitate gives a rouge of brilliant color, good tinting strength, large covering power, and contains no grit. It is silken to the touch and requires no further grinding.

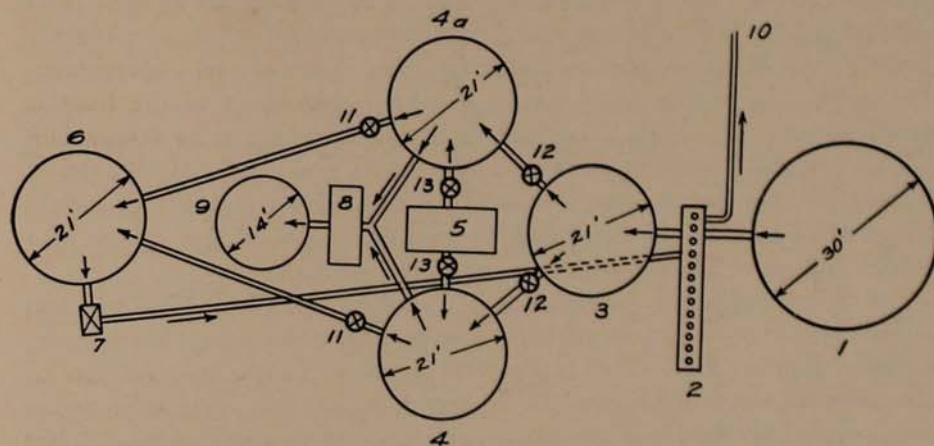


Fig. 1

Figure 1 illustrates the method of procedure.

Mine water enters tank 1 equipped with false bottom and is filtered into heat exchanger 2. From 2 the water empties into storage tank 3 by gravity. From tank 3 the water is run into reaction kettle 4. There the temperature is raised by heat supplied by furnace 5 until complete precipitation takes place. The amount of heat to be supplied depends on the free acid in the water, the higher the free acidity, the greater the temperature required for complete precipitation. While tank 4 is being heated tank 4a is being filled; and while the precipitate in tank 4 is settling the heat is applied to tank 4a.

At this point, two different procedures may be followed:

(1) The precipitate is allowed to settle for about 20 minutes and the clear liquor is run into tank 6 by opening valve 11. From tank 6 the hot water is continuously being pumped through the SW type T. R. heat exchanger where this water preheats the incoming mine water and is finally discharged at 10. The discharged water is at approximately 100° Fahrenheit.

(2) Tank 4 is made up of metal instead of wood as in 1 and is surrounded by a water jacket. The heat is abstracted from tank 4 by the incoming water which empties into 6 and is pumped from 6 to 2 as in the first case. The advantage of method 2 over 1 is that it makes it possible to use an iron heat exchanger which is coated with lead on the outside while in (1) the heat exchanger must be made up entirely of an acid resisting steel.

Tanks 4 and 4a are both cone shaped and are provided with discharge valves so that the precipitate is discharged from 4 and 4a on rotating dryer 8. From the rotary dryer 8 the dry powder is scraped into storage tank 9. If rotary vacuum dryer system is used it makes it possible to utilize the hot water discharged at 10 for drying the sludge. The sludge from tank 9 is next roasted at a temperature of approximately 1400° F. At this temperature a very brilliant shade of red is produced.

By the use of the heat exchanger about two-thirds of the heat is recovered and engineers have estimated that it would take about 1½ tons of coal for every ton of iron oxide sludge produced. With coal at about \$1.35 per ton the cost of manufacturing mine water sludge would be less than the freight now paid by manufacturers of this color, who import this material at the present time from abroad.

It is intended that the product is to sell from \$50 to \$200 per ton to compete with the imported products, and a product now made from so-called sulphur mud. This is distinctly superior in quality to either of the two products on the market. In every respect but one, mine water rouge resembles the highest grade rouge on the market selling from \$200 to \$300 per ton. Its tinting strength is not quite up to the product sold at 15 cents a pound.

Instead of roasting the product, the basic iron sulphate can also be used in sewage treatment.

This process is at the present time being carefully checked over by an industrial laboratory in New York City and it is hoped that when their report has been completed that a plant will be put up at Morgantown which will produce about 5 tons of this product per day.

DEVELOPMENTS IN THE TREATMENT OF ACID MINE
DRAINAGE

By

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Since the World War the State of West Virginia has forged ahead rapidly in the production of bituminous coal and at the present time the leadership in production is shared with Pennsylvania. West Virginia coal is a high grade coal and ranks with the best for steam purposes. Most of the veins are high in sulphur and the use of this coal for by-product purposes has been held back on account of the high sulphur content of the coke, making it unsuitable for blast furnace purposes.

ACID MINE WATER

The drainage from coal mines has become an acute problem in West Virginia due to the acidity of the water. The results of a number of weir measurements on the discharge from mines in Northern West Virginia and Western Pennsylvania indicate that the quantity of drainage will equal about twenty-five per cent. of the rainfall which is the estimated penetration. This figure is based on the area of coal exhausted. The quantity of drainage is dependent on the thickness of the coal vein, the character of the roof, thickness of the cover, character of surface topography, method of mining (pillars drawn), daily tonnage, and the area of coal exhausted. The last seems to be the best criterion of comparison and for the ordinary year in West Virginia (1) the average quantity of water will be about 1000 gallons per day per acre of coal exhausted. This is a permanent fact because the quantity of mine drainage is increasing directly with the mining of coal. The flow of water (2) does not fluctuate with the rainfall to any great extent as the majority of the deep mines will pump nearly as much water in the dry season as in the wet season.

ACIDITY OF MINE WASTE WATERS

Unfortunately it is not always possible to predict the acidity of the mine drainage from the vein of coal or even particular localities. Two mines within a few miles of each other may produce entirely different kinds of drainage from the same vein of coal. One of these mines which will be identified as mine A produces about 200,000 gallons per day of water which has an alkalinity of 170 p. p. m., while mine B, less than three miles away, mining from the same vein (Sewickley) produces 130,000 gallons of water with an acidity of about 30,000 p. p. m. The analysis of coal reported from Mine A showed 3.0% sulphur and Mine

B 2.6%. Numerous tests failed to reveal any direct relation between the sulphur in the coal and the acidity of the drainage. The same holds true of the coal veins. During a survey made during the summer of 1929 (3) the drainage from mines in the Freeport vein had a pH value from 2.1 to 6.8, the Pittsburgh vein from 1.8 to 6.8, and the Sewickley vein from 1.8 to 7.6. Analysis of the water showed that some drainage was distinctly alkaline while others were very acid. (One sample was 69,700 p. p. m.) Table I is the partial analysis of the water from several mines.

TABLE I

Determination	No. 1	No. 2	No. 3	No. 4	No. 5
Total Residue	13,600	69,560	5,262	33,600	10,692
Acidity	6,980	47,800	1,375	22,700	+154
Sulphates	7,400	41,700	3,560	19,300	990
Total Iron	1,530	12,270	460	5,900	14
Calcium	590	412	477	682	780
Magnesium	6	13	12	20	32
pH value	2.6	1.4	2.9	2.0	7.2

EFFECTS OF ACID MINE WATERS

Acid mine water is very detrimental to our streams. It makes the water corrosive, unpalatable and unsuitable for domestic, commercial or recreational purposes. It is felt that it has a very marked effect on fish life, but this subject needs a large amount of investigation to work out just what concentration of mine water will permit propagation of fish life.

TREATMENT OF ACID MINE WATERS

The largest installation for the treatment of mine drainage was built by the H. C. Frick Company at its Calumet Mine (4). The water is pumped from the mine by wooden lined pumps to concrete towers which are at an elevation sufficient to let the water pass through the plant by gravity. The water leaves the towers through baffles into a mixing chamber where it is mixed with lime that will pass a No. 200 mesh screen. The lime and water are thoroughly mixed and then run into a Dorr thickener. The thickener has a retention period of four hours and the settled water flows over a weir and thence to a storage tank where it is again settled and the settled sludge is pumped on a revolving steam heated drum which evaporates a large part of the water and leaves a deposit of ferric hydrate. Ferric hydrate has a limited use in removing hydrogen sulphide from artificial gas and as a base for paints. This company has discontinued the process because of the inability to market the ferric hydrate.

Collins (5) shows the design of a treatment plant where lime is added to the acid mine water in a baffled chamber and then given

a 2 to 4 hour retention period in a settling chamber. This process gives a sludge containing about 75% water and the remainder ferric hydrate. The ferric sludge is dried by splashing against a heated drum. Collins says that about one hundred pounds of lime is required for each 1000 gallons of water. This plant was not built.

A Travers Marl clay (6) filter was installed on Elk Creek in Harrison County, West Virginia. A limy marl was added to the water after which it was allowed to settle. Press dispatches state that after this plant was installed that fish life was abundant and the stream was very much improved. This plant has since been abandoned.

A number of patents have been granted for the treatment of polluted acid waters (6). One of these processes is based on treatment by passing the liquid waste through porous calcium carbonate and maintaining a period of contact between two and five minutes. The writer does not know of a plant of this type that has been installed on a commercial scale.

About one year ago the West Virginia Geological Survey released a press dispatch (7) in which they announced the Kaplan-Reger process for treating mine waste waters. According to the dispatch, "it consists in adding to the sulphate waters a complex organo-metallic compound which combines with the chemical compounds of the water and forms a blue pigment to be known as Monongahela blue at the same time removing the acid." In conclusion the dispatch states that, "in the Kaplan-Reger process, the added chemicals combine completely with the chemicals in the water to form an insoluble, marketable product, leaving the water practically free from acid and mineral substances." This process has not been tried on a large scale and not enough technical data have been reported to properly interpret the possible results from the process.

One article (8) suggests the use of magnesite for the neutralization of mine waters. The author states that it takes about one-third as much magnesite as lime and that the magnesite can be used as a substitute for lime in a majority of the processes of neutralization of mine waters. Magnesite costs more than lime.

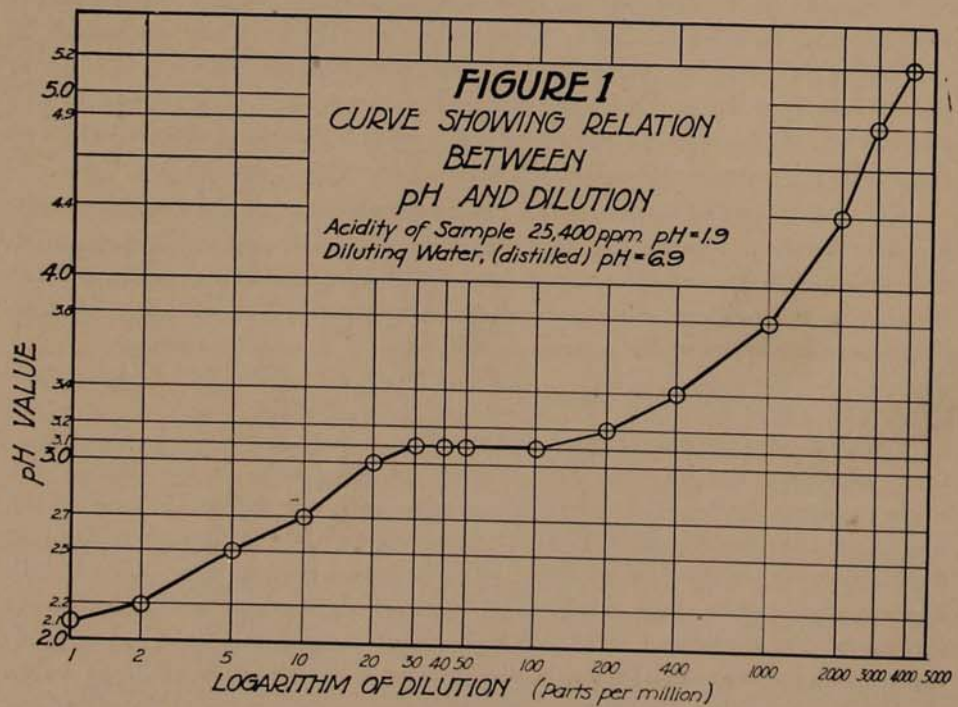
SEALING ABANDONED MINES

Unfortunately abandoned mines offer a real problem in the treatment of acid mine waters. The gobbed material both in and out of the mine causes a lot of acid water. One mine in Monongalia County which has been abandoned since 1922 is discharging over 100,000 gallons of drainage with an acidity of over 10,000 grains per gallon. (9) Leitch has suggested that most mines lend themselves readily to sealing inside the mine. He suggests a concrete slab about three feet thick and extending into the rib about the same distance as a satisfactory seal. A valve should be provided to relieve excessive pressure. Several installations

in Pennsylvania have been successful in the prevention of the formation of the acid water.

DISPOSAL BY DILUTION

One writer makes the statement that the dilution required for mine water should be about 1 in 120. Fig. 1 shows the relation between acidity and pH of a sample of mine water diluted with distilled water (pH=6.9). A dilution of 1:20 increased the pH value from 1.9 to 3.0. 1:30, 1:40, 1:50, and 1:100 dilutions all had a pH value of 3.1. In other words, an acidity of 850 p. p. m. gave the same pH value as the sample with an acidity of 254 p.p.m. A dilution of 1:4000 brought the pH value up to 5.2. These results have been checked and bring out a point that is very important in stream pollution work, i. e., there is a range of dilutions for practically every mine water which gives the same pH value. pH values offer better criterion for the aggressiveness of the water but in working out the assimilating power of a stream it is necessary to try diluting samples collected to see if the pH value is for the higher or lower acidity. This set of experiments partially explains some discrepancies which occurred last summer during the pollution survey of the Cheat River. Very frequently samples of water which have been diluted by alkaline streams showed the same pH value as the stream before the addition of the diluting water.

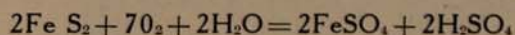


In studying the diluting power of a stream for acid waste waters, it is necessary to develop standards. Should the stream be able to support major forms of aquatic life? If so, what pH value of water and what acidity will be the lower limit? This offers a real research problem as unfortunately nothing has been done on the resistance of fish life to mine waters. One of the authors has found black bass spawn living in sections of Lake Lynn where the pH value was less than 3.0. It is hoped to conduct some experiments during the coming summer on the effects of various concentrations of mine waste water on fish life.

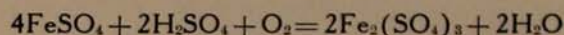
A large amount of work is necessary to work out the exact relation which exists between the acidity of the mine water and the proper dilution to avoid undesirable conditions.

ORIGIN OF ACID MINE WASTE WATER

It is generally agreed that after coal has been mined that the water passing through the coal and slate beds oxidizes the pyrites into ferrous sulphates and free sulphuric acid. These acids oxidize to hydrates which give the familiar brownish-yellow color to the bottoms of streams that carry sulphur water. The following reactions indicate what is assumed to take place:



and this reaction continues as follows:



The oxidation of the pyrites is a very slow process. Winchell (10) found that on treating pyrites with aerated water for one month that neither the iron nor sulphur had gone into solution. It has also been found that alkaline waters decompose pyrites and marcasites to ferric oxide. All of these changes are rather slow and it is difficult to explain the rapid formation of acid waters in mines by chemical theory alone.

Anaerobic bacterial action by some of the sulphur producing organisms might possibly explain some of the high acidities found in mine waste waters. The authors have started a rather exhaustive series of tests to determine whether this acid production is due to bacterial action. (II) Powell and Parr found that at the end of 88 days an inoculated coal showed a decided increase in soluble sulphur over that found in a sterilized sample. It is a well established fact that the sulphur in the coal is not soluble enough to account for the amount of sulphates found.

LABORATORY EXPERIMENTS

A series of laboratory tests were made to determine the feasibility of using various neutralizing agents for the treatment of acid mine waters. A sample of waters with an acidity of 22,700 p. p. m. and a pH of 2.0 was selected for the tests. The neutralizing agent was added in

varying amounts until the pH value had reached 5.6. This value is high when the volume of diluting water available is appreciable but it is about the lowest limit for the support of major fish and plant life. The quantity of sludge formed was measured, and its water content determined.

TABLE III

Data on the neutralization of 1000 gallons of acid mine water and the resultant sludge.

Neutralizing Agent	Lbs. per 1000 gal.	Approximate volume of Sludge %	Weight Dry
Lime (90% CaO)	172.5	35	424
Pulverized limestone	434.6	35	621
Sodium hydroxide	130.0	25	188
Calcium carbonate	161.5	40	352
Sodium carbonate	200.0	40	194
Ammonium hydroxide	160.0	20	130
Sodium carbonate plus lime	80.0 66.3	25	...
Lime + NaOH	61.9		
	60.0	35	183
Potassium ferrocyanide*	142.3	..	264
Lime + Potas. Ferro- cyanide	60. 103.5	..	389
Sodium Cyanide	140.	..	188

*This quantity of potassium ferrocyanide brought the pH value to 3.0 only as compared to 5.6 for the other processes.

From a cost comparison basis it was figured that the limestone treatment was the cheaper, principally because a cheap source of limestone is available locally. In other localities, it is probable that the lime treatment would be cheaper. On the basis of capitalized cost of plant drying of sludge and no return for the sale of sludge it was figured that the total cost per 1000 gallons would be \$0.90. This treatment would neutralize the water but would make it unsuitable either for domestic or industrial use on account of its hardness. It does seem to remove the majority of the iron from the water. These laboratory tests clearly indicate (as many other results have already shown) that the success of treating mine waters will not be assured until some method of utilizing by-products has been developed that will help pay the operation costs.

Conclusions:

1. That the present status of mine waste water is very uncertain and that much fundamental research is needed on the origin of the water and the formation of the acid.

2. The laws governing the amount of diluting water should be worked out.
3. Research work should be done on the effects of high sulphate waters on aquatic and animal life.

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Limestone (2) just above the horizon of the Redstone Coal lies in the bed of Waddles Run 0.8 mile above the cross-roads at Greggs and one mile southwest of the mansion (7). About a quarter of a mile east, up the run, the black shales in the roof of the Upper Sewickley Coal (3) appear beside the run. At another quarter of a mile the Benwood Limestone (4) is seen in an old quarry close to the road. The Waynesburg Coal (5) appears in the side of a branch to the run at a point 0.65 mile southeast of the mansion (7). The Upper Washington Limestone (6) appears in the road cut just to the west of the mansion (7).

A columnar section of the region has been prepared by Mr. David B. Reger of the State Geological Survey, which, through his kindness, is here reproduced.

A mile southwest along the road toward Greggs and close to the north edge of Waddles Run is a thin exposure of the roof of the Upper Sewickley seam of coal containing the spreading roots of a tree that grew on the spot while the strata were being laid down. The plant is of a *Lepidodendron* or sigillarid type, but no evidence is left to indicate which of the two it is. If it is a *Lepidodendron*, or "Scale Tree," the leaf impressions that covered the trunk lay in oblique succession, each



Fig. 2. Close to the north edge of Waddles Run is a thin exposure of the roof of the Upper Sewickley seam of coal containing the spreading roots of a *Lepidodendron* or Sigillarid tree. The hammer is resting on the roots. Photo by John L. Tilton.

GENERAL STRATIGRAPHIC SECTION, OGLEBAY PARK, OHIO
COUNTY, W. VA.

PALEOZOIC ERA	Permain System Dunkard Series (Washington Group) 275 Feet +	Limestone, Upper Washington	10-20	20
		Shale, calcareous	50	70
		Sandstone, Hundred	0- 5	75
		Coal, Hundred, not found		75
		Shales	40	115
		Sandstone, Upper Marietta	5-10	125
		Coal, Washington "A," streak		125
		Limestone, Middle Washington	10-18	143
		Sandstone, Lower Marietta	5-10	153
		Limestone, Lower Washington (6)	10-20	173
		Coal, Washington (8)	0- 2	175
		Fire Clay Shale, Washington	10-25	200
		Limestone, Bristol	5	205
		Sandstone, Washington, absent		205
		Coal, Little Washington, absent		205
		Sandstone, Mannington	2-20	225
		Coal, Waynesburg "A," streak		225
	Limestone, Mt. Morris, absent		225	
	Sandstone, Waynesburg	5-30	255	
	Limestone, Elm Grove, dark (5)	5	260	
	Shale, Cassville (5)	5-15	275	
	Coal, Waynesburg (5)	2	277	
	Limestone, Waynesburg	5	282	
	Sandstone, Gilboy	5-10	292	
	Limestone and shales	22	314	
	Sandstone, Uniontown, shaly	10	324	
	Coal, Uniontown	0- 1	325	
	Limestone, Uniontown	8	333	
	Sandstone, Arnoldsburg	5-15	348	
	Shale, calcareous	5	353	
	Limestone, Arnoldsburg (new), buff	7	360	
	Shale, Fulton Green	5	365	
	Limestone, Benwood, shaly (4)	50-67	432	
	Sandstone, Sewickley	5- 0	432	
	Coal, Upper Sewickley (3)	2- 3	435	
Shale, calcareous	10-19	454		
Coal, Lower Sewickley	1	455		
Limestone, Sewickley (2)	30-43	498		
Coal, Redstone	1- 2	500		
Limestone, Redstone	10-15	515		
Sandstone, Upper Pittsburgh	0- 5	520		
Coal, Pittsburgh (1)	5	525		
Pennsylvanian System Monongahela Series 250 Feet				

diamond-shaped impression bearing three markings, one of the fibrovascular bundle that went to the leaf, and on each side of this impression another impression or pit where ducts passed to the breathing pores in the narrow leaf. Trees of this type may reach a height of forty to sixty feet, branching but few times and bearing spore-producing cones. If the tree is of the Sigillarid type the leaf markings were hexagonal in outline, arranged in vertical rows along grooves that gave the trunk the appearance of a fluted column. Both of these types of trees had spreading roots but no tap root.

The shale above the Waynesburg Coal, known as the Cassville Shale is here but 26 inches thick. It is exposed together with the Waynesburg Coal in a branch about half a mile southeast of the mansion (5 of Figure 1). It grades upward into a black shaly Elm Grove Limestone that weathers into a calcareous black shaly mass easily to be mistaken

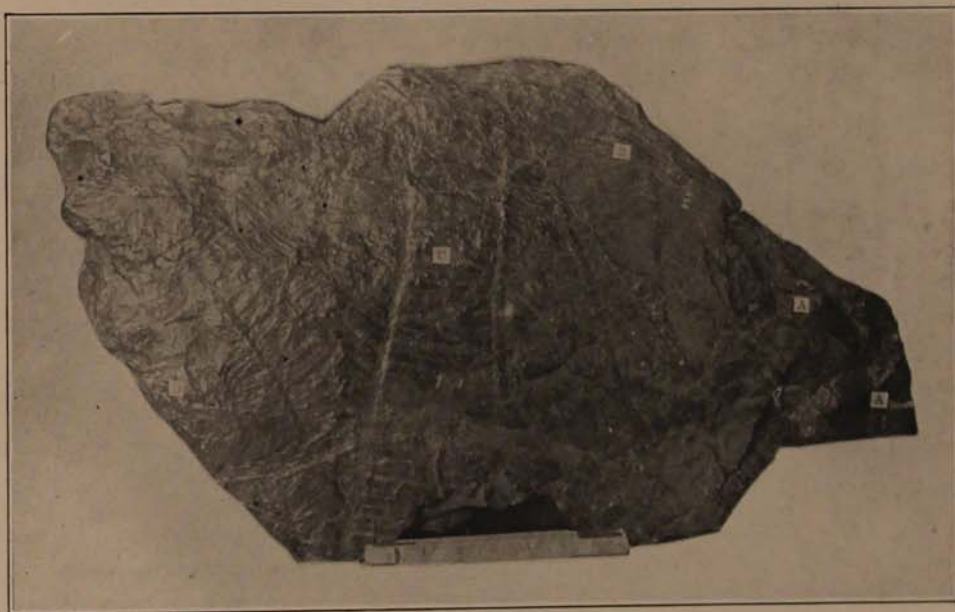


Fig. 3. Shale from immediately below the Sewickley seam of coal. Purs-glove Mine No. 2, Scotts Run. The specimen was donated to West Virginia University by Mr. H. C. Brumbaugh in 1927 and the plants were identified by Dr. David White in 1928. A. *Neuropteris hirsuta*. B. *Pecopteris pteroides*. C. *Pecopteris tenuifolium* (?). D. *Annularia stellata* (?). Photo by John L. Tilton.

for Cassville Shale. In the Cassville Shale and extending up into the black shaly carbonaceous base of the Elm Grove Limestone are to be found numerous fragments of leaves and twigs belonging to fern-like plants or rather to Cycado-filices, plants some of which (Pteridosperms) produce seeds and some (Filices) produce spores. When such plants are known to produce seeds they are recognized as Cycado-filices. When

they are known to produce spores like a fern they are classed as Filices. Fragments that show the fruiting are especially choice. Here also may be found impressions of Calamites. Forms that have been found in other localities at this horizon not far away are as follows:

Neuropteris
 Allethopteris
 Pecopteris
 Sphenophyllum
 Sphenopteris
 Annularia
 Asterophyllites
 Nematophyllum.

The same genera of plants are also found in the black shales near the Washington Coal, where thin fragments are responsible for the carbonaceous material that darkens the shale.

Scott¹, whose descriptions are here followed, classes Neuropteris, Allethopteris and some of the Pecopteris species under the Pteridosperms.

Neuropteris

"The leaves of Neuropteris are of a very large size, bipinnate, tripinnate, or even quadripinnate in composition, with ovate or oblong leaflets somewhat cordate at the base and usually attached to the rachis by a short stalk. The median nerve of the pinnule is distinct till near the end, where it breaks up into smaller dichotomous nervules; similar nervules are given off from the sides of the median nerve throughout its length; they leave the latter at an acute angle, and bend outwards to the margin." The smoothness of the surface of these large leaflets and the fineness of the nervules are such that this leaf is not likely to be confused with that of any other plant.

Allethopteris

"In the genus Allethopteris the leaves are likewise large, and bi- to tripinnate, but here the thick, usually oblong pinnules are inserted on the rachis by a broad, decurrent base and are in some cases confluent with one another. The edges of each leaflet are incurved on the lower side. The median nerve extends the whole length of the pinnule, and is prominent on its under surface; the secondary nerves leave the median one at a wide angle and pass directly, with or without dichotomy, to the margin."

Pecopteris

It is found that some of the species of Pecopteris are seed-bearing and some are true ferns. The most important part of Scott's² description is as follows:

¹D. H. Scott: Studies in Fossil Botany, Part II, pp. 426-427.

²Idem. Vol. I. p. 247.

"Pinnules attached to the rachis by their whole breadth—contiguous—with parallel or slightly convergent margins, usually entire, more rarely lobed or dentate; apex usually obtuse, sometimes acute. Median nerve distinct, extending almost to the apex of the pinnule; secondary nerves pinnately arranged, always springing from the median nerve, with which they make a wide angle, and not directly from the rachis; sometimes simple, sometimes dichotomous."

The main points of distinction between *Pecopteris* and *Allethopteris* relate to the shape of the base of the pinnule.



Fig. 4. The fruit of the Cycadofilices is known as *Trigonocarpus*, referring to the three longitudinal ridges that appear along the sides of the fruit. Photo by John L. Tilton. These particular specimens are Pennsylvanian in age, but they serve to illustrate what may be looked for in the Permian.

Sphenopteris

Sphenopteris is a fern. The characteristics are as follows: "Fronds generally tripinnate or quadripinnate, more rarely bipinnate; pinnules usually small, contracted at base, with a more or less narrow pedicel, habitually divided into acute or rounded lobes which are themselves

contracted into a wedge towards their base. Nervules simple or branched, forming acute angles both with the median nerve and with their own branches."³

Sphenophyllum

Sphenophyllum is in a group by itself. It is not a calamite nor a Cycado-filices, nor a fern. "The slender stems of Sphenophyllum were ribbed; the ribs did not alternate in successive internodes, but ran straight on through the nodes; in like manner the leaves of successive whorls were not alternate, but superimposed, a point of great importance among the distinctive characters of Sphenophyllum."⁴ The leaves forming a whorl are sometimes wedge-shaped, with entire or toothed margins, and sometimes dichotomously divided into narrow lobes, even forming a whorl of simple narrow leaves. In the middle of the stem is a solid strand of primary wood, triangular in section and without pith. The lateral branches spring from the nodes.

Annularia, Asterophyllites and Nematophyllum are calamites. In these the upright aerial stem rises from a stem creeping along the ground (rhizome) and the impressions of the fibrovascular bundles are continuous at the nodes, not alternate as in Sphenophyllum.

Annularia

"The leaves are linear, lanceolate or spatulate, and more or less united into a sheath at the base of each whorl, though this feature is often scarcely noticeable. As found in the form of flattened impressions, the whorls are usually spread out in the same plane as the axis. Two opposite branches are borne on a node."⁵

Asterophyllites⁶

As recognized by Scott the other of the two main types of Calamites is known as Asterophyllites. In this form the leaves are not spread out in one plane and are not united at the base. The stem is ridged and each leaf has a mid rib. Each twig bears linear leaves arranged in circles or whorls, the numerous whorls being closely compacted together.

Nematophyllum⁷

Wm. M. Fontaine and I. C. White recognize this as a separate genus and define it as follows: "Stem covered with thick, very finely striate epidermis; internodes rather remote, swollen, leaves verticillate, numerous, very long and thread-like, of equal width throughout, finely striate, without nerves, united at the base, in a narrow annular band."

³Zeiller, quoted by Scott, *Idem.* p. 248.

⁴*Idem.* pp. 76, 78.

⁵*Idem.* p. 67.

⁶*Idem.* pp. 67-68.

⁷The Permian or Upper Carboniferous Flora of West Virginia and S. W. Pennsylvania. PP. of the Second Geological Survey of Pennsylvania, p. 35.

Psaronius. A number of tree ferns have been found in the midst of Permian strata, marking an horizon where temperature and other conditions were favorable to their growth in early Permian time.

Cordaitales. This gymnospermous tree thrived in the uplands when the Pittsburgh and Sewickley seams of coal were forming. Great logs

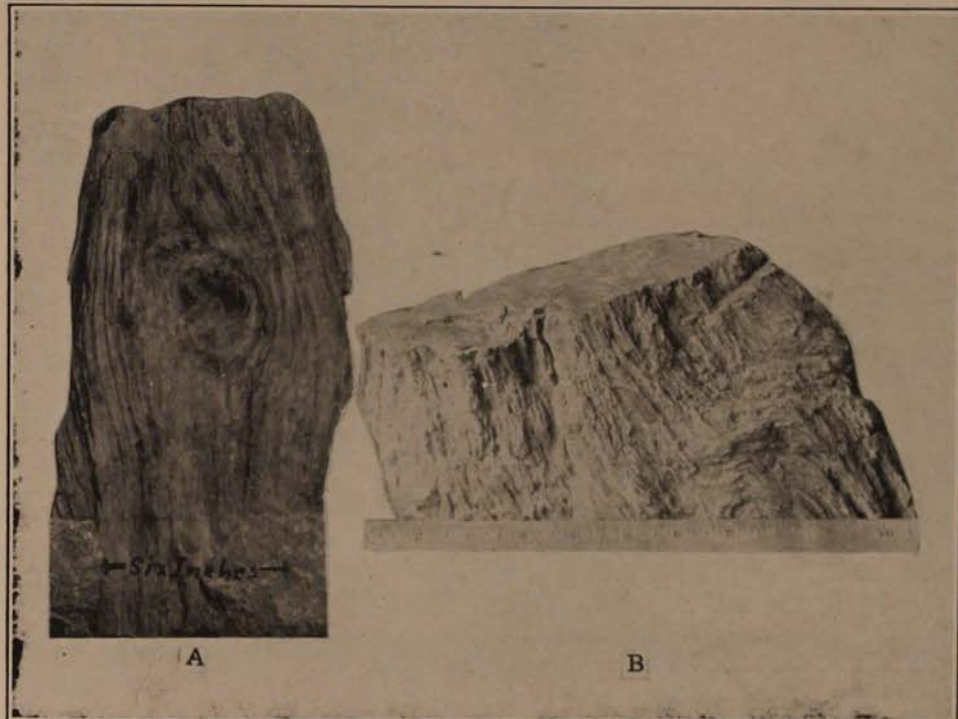


Fig. 5 A and B. A. Cordaitales. This fine specimen set in cement was an ornament in the front yard of Mr. and Mrs. A. A. Huntsberry, Ohio County. Recognizing the value of such a specimen for illustration in teaching they have donated it to the University. It may now be seen near the entrance to room 201 of the Department of Geology.

B. Psaronius. Several tree ferns have been found in the field where the White family holds its reunions. Photo by John L. Tilton.

of it are in the sand and shale above the coal and fragments of it occur in both this seam and the Sewickley seam.

West Virginia forms of both Psaronius and Cordaitales are to be studied further in the future.

Fossil Animals.

The animal remains that may be expected in the rocks at Oglebay Park, West Virginia, are best indicated by a list of those found June 24-26, 1929, by the writer assisted by Miss Ella K. Wemple and students at The Nature Training School then in session. In addition to these

there are three forms (Plate III, Fig. 1-3) previously collected by Mr. David B. Reger and Miss Wemple.

The Sewickley Limestone is crossed by Waddles Run at 0.8 mile



Fig. 6. Sewickley Limestone (2 of Fig. 1) outcropping in Waddles Run, near Oglebay Park. *Spirobis* in abundance was obtained at the top of the heavy ledge in the front center. A mine entrance is close at hand on the right. Photo by John L. Tilton.

east from the corner of the road at Greggs, and 0.45 mile west from the point where the "Nature Trail" south from the mansion reaches the road along Waddles Run. Here a surface of the limestone is coated with an abundance of *Spirobis anthracisia*. These are flat-coiled, generally somewhat mashed, diameter 1.9 mm., and have a surface bearing undulations parallel to the margin of the aperture.



Fig. 7. *Spirobis anthracisia* Whitfield, X 10; Sewickley Limestone.

Along with fragments of *Spirorbis* are many ostracods of different genera, some of them 1.6 millimeters in diameter, most of them much smaller. These are minute shells of crustacea, illustrated on Plate I.

Cytharella sp. Figure I of Plate I gives a somewhat inclined left valve of a form in which the narrow left is the anterior end and the broader rounded right is the portion where the abdomen of the animal curved down and then forward to the

left. Apparently the right valve overlaps the left valve all the way around, though in the photograph it looks as if the overlap were ventral only. The shell is inclined slightly to expose this overlap. The shell is smooth, length 1.3 mm., height 0.8 mm., greatest thickness and height about three-fourths way from the anterior end.

Such a description fits *Cytharella*. No description of species is found that applies; and it is not thought best to propose a specific name at this time, either for this species or for other species mentioned later in this paper.

Amphissites sp. In figures 2 and 3 are two views of the right valves of two specimens, oval in outline but with a slight angle noticeable at the upper anterior margin. In figure 3 this projection is concealed but it is present in the specimen. A slight median sulcus is noticeable with a faint median node just above and to the left, beyond which posteriorly is the rounded portion of the shell, with the thickest portion just back of the middle of the shell. Under a magnifier the yellowish-brown surface appears somewhat rough, rather than pitted. In figure 2 the length is 2 mm., height 0.75 mm. In figure 3 the length is 1.5 mm., height 1.0 mm.

Amphissites sp. In figure 4 the object appears a little distorted by the presence of foreign material and by concentrated illumination. The general outline is much like that of figure 5. Apparently figure 4 gives the left valve, the posterior lobe extending below forward and upward, with a depression before it (on the left). Figure 5 gives a right valve and figure 6 a left valve. The surface of each is irregular, the anterior lobe extends downward, and the margins meet without overlap. The posterior lobe especially is thick—swollen, as shown by the dimensions given for figure 4. The anterior part is not swollen. In figure 7 there is but a single valve, which is more regular in surface and outline than figures 5 and 6.

		Length	Height	Thickness.
Fig.	4	0.84	0.42	0.21 mm.
	5	1.19	0.6	
	6	1.25	0.6	
	7	1.6	1.1	

In figure 8 there is an extension downward on the right of the circular area and upward on the left, and the center of the area is raised—embossed in a conical manner. The length is 1.197 mm., the height 0.84 mm. and the thickness (height of the embossed surface) 0.1 mm. While on one side this thin irregular plate suggests the form of a shell the plate does not correspond to any described form.

Denticles. Along with the ostracods two denticles were found (Fig. 9). These are conical in shape with rounded and transparent points and smooth surfaces, lengths 0.860 and 0.970 mm., diameters 0.581 and 0.602 mm.

Bairdia sp. The Benwood Limestone has yielded a complete specimen of what appears to be the same species as found in the Sewickley Limestone. The Benwood specimen, here figured as number 10 of Plate I, is a right valve nearly circular in shape. The left valve, which is slightly larger than the right, overlaps it along all margins. The anterior margin is slightly frilled, the posterior is well rounded, and contains but a slight extension. The surface is smooth, length 1.247 mm., height 0.86 mm., thickness of the two valves combined 0.642 mm. The valves are about equally convex.

Elsewhere the Benwood Limestone has been found to contain minute gastropods, but none were seen in this locality (location number 4).

With the exception of the Benwood Limestone, as just stated, the various shales and sandstones found farther up stream along Waddles Run did not yield fossils till the Cassville Shale was reached. Here numer-



Fig. 8. Where the contour for 1100 feet is crossed by a branch of Waddles Run at a point 0.7 mile nearly straight east from the mansion, the water falling over the Elm Grove Limestone has washed away the Cassville Shale beneath and also a portion of the black, shaly base of the Elm Grove Limestone. On the west side of the run the top of the Waynesburg coal is exposed. On the east side of the run the limestone has been undercut and a portion of the black shaly limestone removed.

ous fragments of the plants already mentioned were noted, but no insects. It is commonly supposed that the Cassville Shale is rich in the remains of insects. This is because one who searched for a long time in a favored locality near Cassville found fragments the description of which by Samuel H. Scudder made the Cassville Shale famous as an horizon for insects. One would be fortunate indeed to find such another locality. Near Oglebay Hall at location number 5, 0.7 mile nearly straight east from the mansion, the Cassville Shale above the coal is but 26 inches thick. It grades upward into a black, shaly Elm Grove Limestone that weathers into a black calcareous shaly mass easily to be mistaken for Cassville Shale. In this black, shaly, basal portion of the Elm Grove Limestone there is a veritable bone bed.

One horizon especially in the basal portion of the Elm Grove Limestone is rich in fossil remains, particularly fish, as is evident in plates II, III and IV. In plate II figures 1, 2, 3, 4, 5 and 6 are photographs of scales of *Palaeoniscus*. Other scales of the same type of fish can be seen in figures 1 and 3 and in the right side of figure 6 of plate III, and at the lower edge of A in plate IV. It will be noticed that there are at least five variations in the types of scales. Fig. 1 of plate II is essentially ovate, smooth on one side and with coarse longitudinal corrugations on the other side. The other scales are essentially rhombic, and all, unless it be figures 4 and 5 of Plate II, have irregular oblique furrows. In figures 3 and 5 of plate III there are oblique furrows but the exact shapes of the scales are not evident. Such enamel-coated scales, rhombic in shape, sometimes cycloid, are characteristic of a large group of fish belonging to the family *Palaeoniscidae*, a group related to the gar-pike.

Two of the illustrations reveal the sharp serrated edges of selachian teeth, the sharks teeth in figures 1 and 2 of plate III. In figure 4 of plate III is a form that is judged to be that of a small plate tooth. There are also fragments of bone, most noticeable in figure 7 of plate II and in the upper portion of A, plate IV. In figure 6 of plate III is part of a rod-like portion of a spine 19 mm. long with evidence of lateral extensions. This seems to be portion of a spine of *Edaphosaurus*, a reptile of wide areal distribution, being reported from Germany and Texas.

Among the fragments found is a fish coprolite. This is a mass of solidified material cylindrical in shape with rounded ends, length 2.2 mm., diameter 0.86 mm. Across a portion of the form are three faint, somewhat diagonal impressions that are referred to a spiral valve, because of which the coprolite is thought to be from a fish rather than from an amphibian (stegcephalian). The surface contains markings of fragments of teeth and scales, undigested fragments.



Fig. 9. Fish coprolite, natural size.

The collection includes a single valve of a delicate brachiopod shell (plate II, Fig. 8), *Lingula*

sp., perfect when discovered but broken when moved into position to

photograph it. It is decidedly quadrate in shape, has faint lines of growth and a sharp umbo. Its length is 2.15 mm., its width 1.72 mm. This is the first time that a brachiopod shell has been reported from this part of the Permian though *Lingula permiana*⁸ has been reported from Washington Limestone in Ohio. The presence of *Lingula* and the serrate sharks teeth combine to give evidence that the locality had marine connections, brackish-water conditions for the deposition of the basal portion of the Elm Grove Limestone, the carbonaceous character of the limestone emphasizing the presence of adjoining swampy regions. Thus this relation of the Elm Grove Limestone to marine conditions is now added to similar relations heretofore noted for the Washington Limestone in Ohio.

In one layer there was an abundance of pelecypods of two different kinds (plate IV). The forms marked 1 present a relation of length to height of 1: 0.65 or 0.7. The posterior portion is somewhat elongated, the posterior curvature less broadly rounded than in the specimen marked 2. The lines of growth are very distinct. The teeth are not observed. This form corresponds to *Glossites* (?) *belmontensis* S. and S. The forms marked 2 present a relation of length to height of 1: 0.56. In this form the surface in front of the umbo is only slightly concave, that posterior to the umbo is slightly convex with broadly rounded posterior curvature to the ventral margin. The lines of growth are evident but not prominent. The teeth are not observed. This form corresponds to *Pleurophorus* (?) *ohioensis* S. and S.

In the lower right hand corner of A, plate IV, may be seen the sole representative of gastropods; *Naticopsis* (?) *diminuta* S. and S., a minute form but a millimeter high and a millimeter wide with but three whorls. *Pleurophorus*, *Glossites* and *Naticopsis* are all three reported from the Elm Grove Limestone of Ohio.

Amphissites sp. A single black ostracod was found (plate II, fig. 2). The view is that of a right valve, dorsal portion rounded, lower posterior end curving forward and upward. The left lobe is the larger but the two valves meet without apparent overlap. The surface is smooth or slightly granular. The length is 0.546 mm., the breadth 0.336 mm., the thickness 0.231 mm., greatest height just posterior to the center.

It may be seen that the ground material in which the above mentioned forms are located is a perfect mass of fragments the exact character of which it is impossible to name.

In the road cut located a mile and a half northeast of the mansion and in another road cut located a quarter of a mile southwest of the mansion are exposures of Upper Washington Limestone and associated strata. In the cut west of the mansion small ostracods were found of two types, as illustrated in plate VI.

Cythereella sp. Figures 1, 2, and 3 are of the same type. They are all oval in shape, dorsal margin slightly curved, right valve overlapping the left both dorsally and ventrally, right valve the larger, greatest

⁸The shell here illustrated is not *L. permiana*, neither is it *L. umbonata*.

thickness two-thirds back from the anterior end. The surface is smooth though granular in appearance. The dimensions found are as follows:

	Length	Height	Thickness.
Fig. 1	0.714 mm.	0.441 mm.	0.357 mm.
Fig. 2	0.777	0.483	0.441
Fig. 3	0.609	0.441	0.420

Figure 4 is oval in shape, dorsal margin slightly curved, right valve overlapping the left both dorsally and ventrally, right valve the larger, with thickness fairly uniform throughout the length, thus presenting the shape of an elongated oval: length 0.483 mm., height 0.252 mm., thickness 0.168 mm. All four specimens are classed as *Cytharella*. Figure 5 appears to be but a portion of a shell similar to figures 1, 2 and 3, the anterior end having been broken off.

Cypridina sp. Figure 6 is of a very different type than the others. It is of the left valve, with no evidence of overlap. The irregularly circular outline (oval ?) with an anterodorsal projection refers the shell to *Cypridina*. The dimensions are as follows: length 0.525 mm., height 0.399 mm., thickness 0.399 mm.

PLATES

(For explanation of plates see text.)

Plate I.

Fig. 1.	<i>Cytharella</i> sp.	X 20.	Sewickley Limestone.
Figs. 2-7.	<i>Amphissites</i> sp.	X 20.	Sewickley Limestone.
Fig. 8.	?	X 20.	Sewickley Limestone.
Fig. 9.	Denticles.	X 20.	Sewickley Limestone.
Fig. 10.	<i>Bairdia</i> sp.,	X 20.	Benwood Limestone.

Plate II.

(All specimens are from the base of the Elm Grove Limestone.)

Fig. 1.	Scale of <i>Palaeoniscus</i> .	X 20.
Fig. 2.	<i>Amphissites</i> sp.	X 20.
Figs. 3-6.	Scales of <i>Palaeoniscus</i> ,	X 20.
Fig. 7.	Fragments of bone.	X 20.
Fig. 8.	<i>Lingula</i> sp.	X 20.

Plate III.

(All specimens are from the base of the Elm Grove Limestone.)

Fig. 1.	Selachian tooth and scale of <i>Paleoniscus</i> ,	X 5.
Fig. 2.	Selachian tooth,	X 5.
Fig. 3.	Scale of <i>Palaeoniscus</i> ,	X 5.
Fig. 4.	Plate tooth and conical tooth,	X 5.
Fig. 5.	Scale of <i>Palaeoniscus</i> ,	X 21.
Fig. 6.	Part of a spine of <i>Edaphosaurus</i> and two scales of <i>Palaeoniscus</i> ,	X 5.

Plate IV.

(All specimens are from the base of the Elm Grove Limestone.)

A.	Fragment of bone,	X 5.
	Scale of <i>Palaeoniscus</i> ,	X 5.
	<i>Naticopsis</i> (?) <i>diminuta</i> S. and S.,	X 5.
B.	1. <i>Pleurophorus</i> (?) <i>ohioensis</i> S. and S.,	X 5.
	2. <i>Glossites</i> (?) <i>belmontensis</i> S. and S.	X 5.

Plate V.

Figs. 1-5.	<i>Cytharella</i> sp.,	X 20.	Upper Washington Limestone.
Fig. 6.	<i>Cypridina</i> sp.,	X 20.	Upper Washington Limestone.

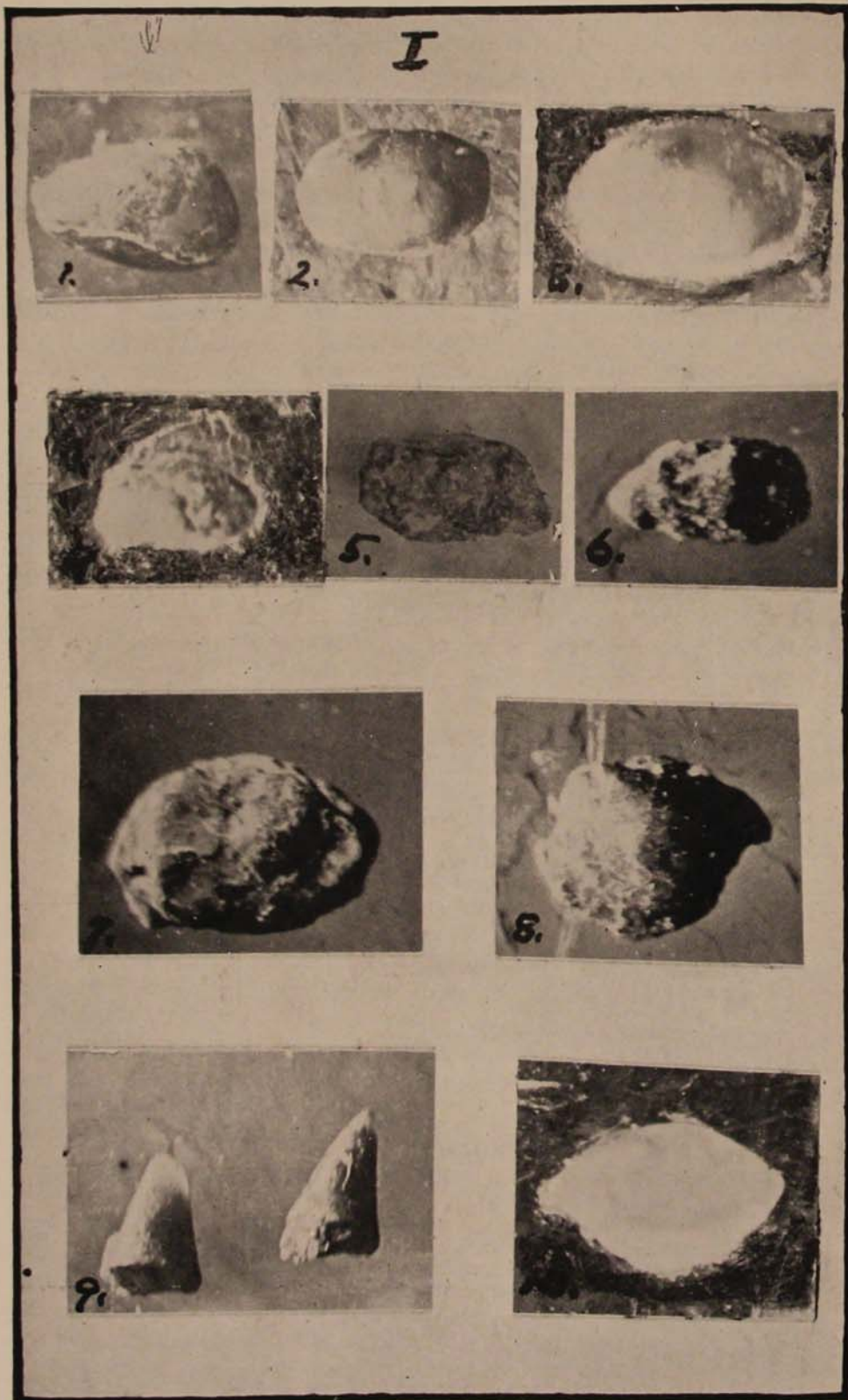


Plate I

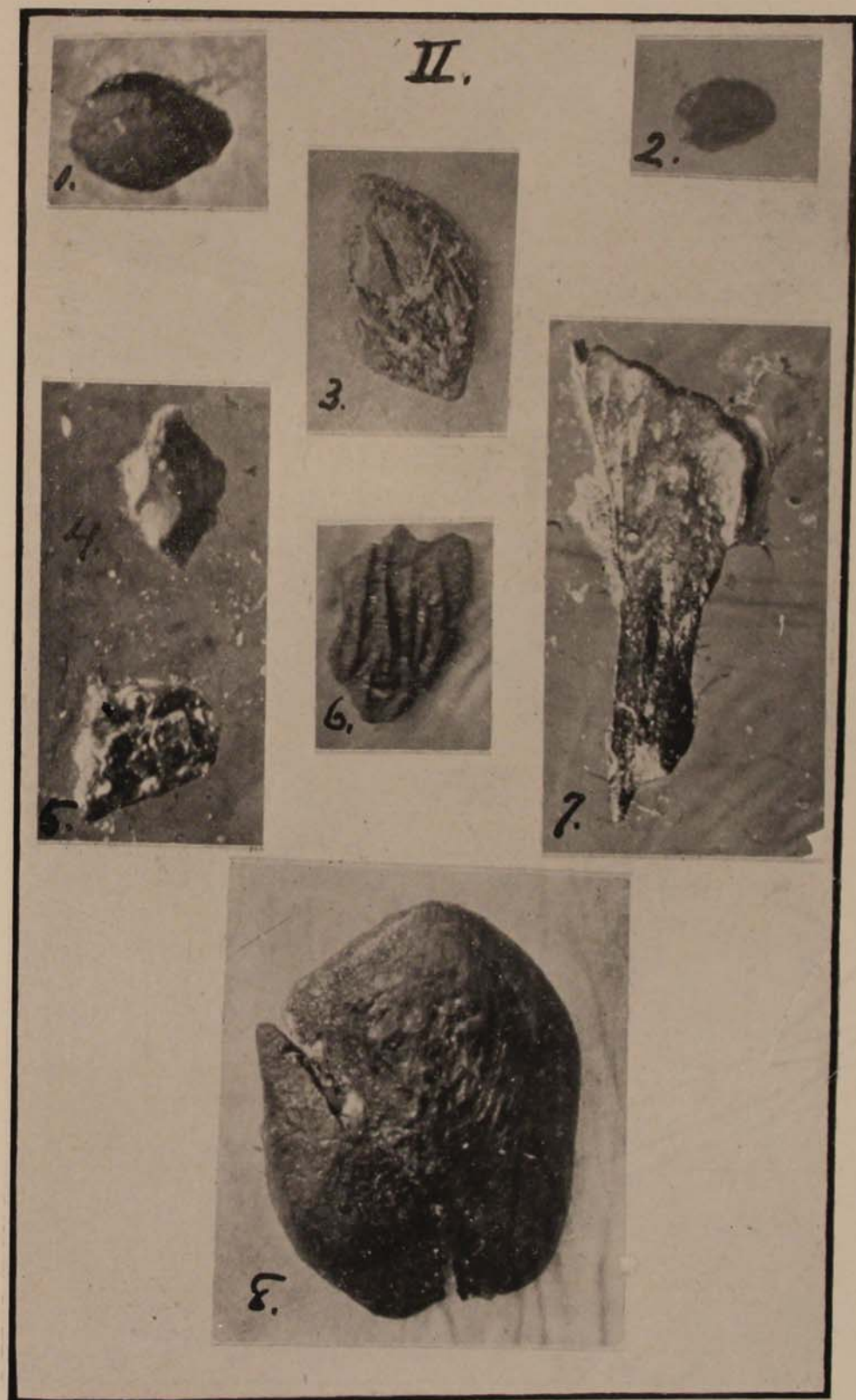
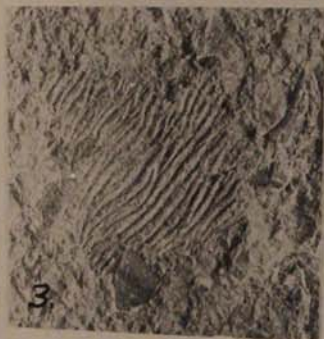


Plate II

III.



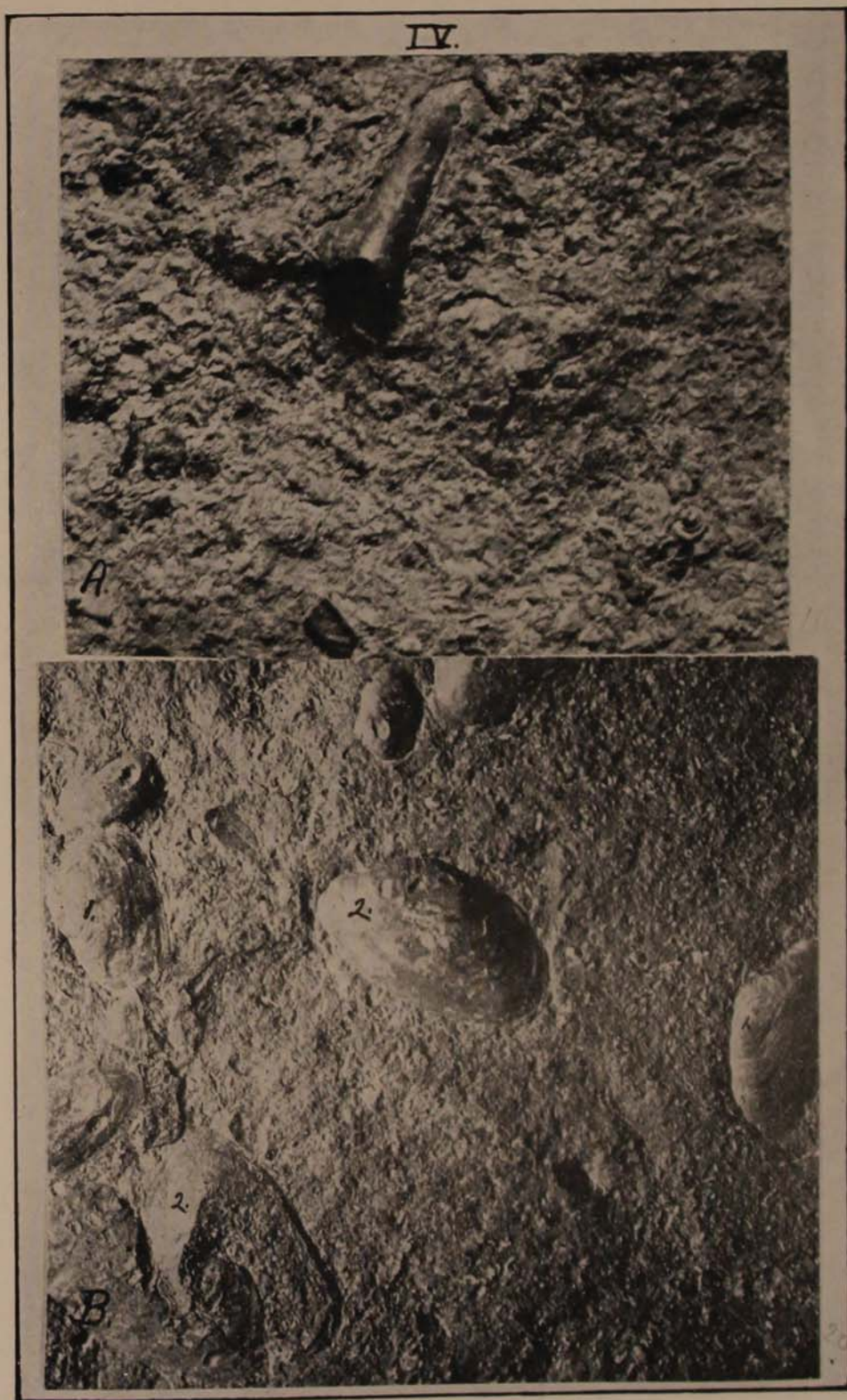


Plate IV

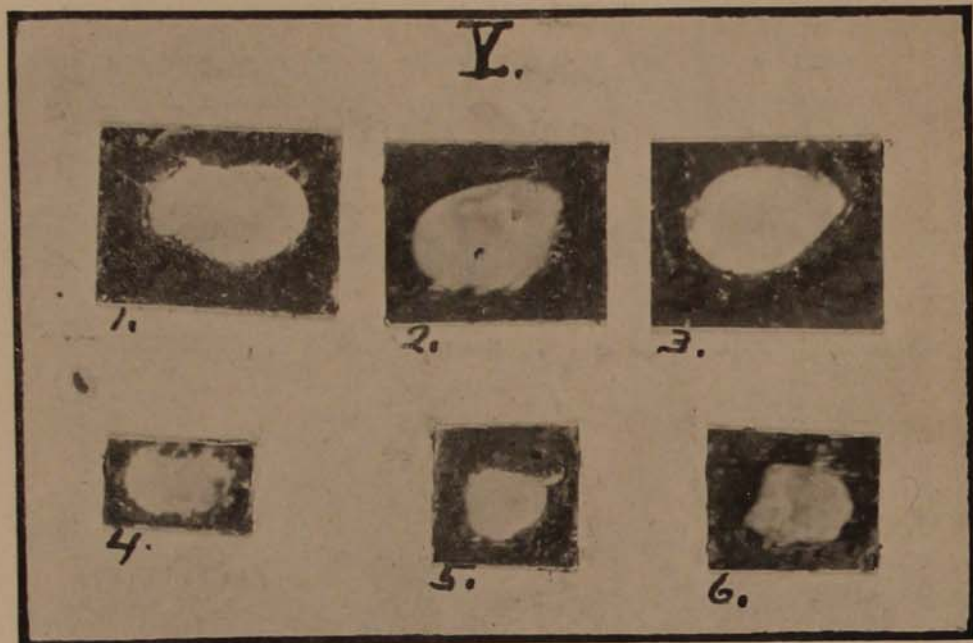


Plate V

RIVER CLAYS AND THE PLEISTOCENE PROBLEMS OF
WEST VIRGINIA

By

JOHN L. TILTON,

Professor of Geology, West Virginia University.

(Abstract)

The presence of Pleistocene clays along the Monongalia have long been known. This paper calls attention to lamination and reviews the literature in which the relation of the Pleistocene clays along the Kanawha, the Ohio and the Monongalia is discussed, and gives reference to the literature on the subject. It thus traces the development of our knowledge with reference to the Pleistocene so far as it relates to West Virginia.

SEDIMENTATION FEATURES IN THE CONERNAUGH
NEAR MORGANTOWN

S. L. GALPIN,

Professor of Geology, West Virginia University.

(Abstract)

This is a progress report on sedimentation features exhibited in recent road and railroad excavations in and near Morgantown, West Virginia. An attempt is made to list all sedimentation units from the Buffalo, to the Saltsburg Sandstone. Mention is made of the erosion surface below the Buffalo Sandstone; of ridges in the top of the same sandstone suggesting barrier beaches; of marine fossils in the red shale next above the Pine Creek Limestone, and in the gray calcareous shale directly above the Bakerstown Coal horizon.

THE PENEPLANES OF THE ALLEGHENY PLATEAU

By

H. M. FRIDLEY,

Assistant Professor of Geology, West Virginia University.

(Abstract)

Identification, dating, and correlation of peneplanes is of great importance in the correct interpretation of geological history. In the present paper no attempt is made to date erosion surfaces. The main purpose is to show evidence of two distinct erosion surfaces where heretofore only one has been generally accepted.

The first area studied is the tier of fifteen-minute quadrangles along the boundary lines of Pennsylvania-West Virginia and Pennsylvania-Maryland extending from Frostburg, Maryland westward to the Ohio River. The second area includes the fifteen-minute quadrangles of Waynesburg, Amity, and Carnegie, in Pennsylvania.

In the detailed study of these sections use was made of the method of projected profiles, perfected by the late Dr. Joseph Barrell. Since the verticle in the profiles is exaggerated about 26 times over the horizontal, any discordance in the elevation of hilltops shows up clearly. In the first section, from Frostburg to the Ohio River two levels are distinctly shown. The lower level is evident in the Morgantown quadrangle and from there westward to the Ohio, at an elevation of about 1500 feet. This surface has been developed on the Permian and upper Pennsylvanian rocks of western West Virginia. This level is here termed the Schooley peneplane.

The upper level can be observed extending across the Appalachian ridges from Maryland to chestnut ridge in West Virginia. Folding in the eastern part of the section has brought up the stronger formations which accounts for the fact that this part was not reduced at the time when the region to the west was completely penelaped. This peneplane is here called the Kittatinny.

The lower level, or Schooley peneplane, is traced through the Waynesburg, Amity, and Carnegie quadrangles to the vicinity of Pittsburg, where it has been described as the Harrisburg peneplane by M. R. Campbell, H. Leighton and others.

PROCEEDINGS OF THE
PHOTOGRAPHING THE MOON

By

MATHEW J. KELLY

The writers experiments in lunar photography have all been made with the 10 inch Newtohian reflector of 90 inches focal length, clock driven equatorially mounted, at the Davis and Elkins College Observatory. The reflector is more suitable for astronomical photography than the visual refractor, owing to the difference of the focal point for visual and chemical rays in the refractor. In the reflector they both fall at the same point. Two methods are available, magnified images and primary focus images. For magnified images a camera or dark box is used and an eyepiece substituted for the camera lens. The plate holder is put a suitable distance from the eyepiece and focussing to suit, as in a magic lantern. The practical limits for magnified images is small, and I have found that for satisfactory results 3 or 4 diameters of the primary focus image is about the limit. Moreover this gain in size is accompanied is the same whether magnified or unmagnified. For primary focus images a dark slide carrier and some form of shutter for attaching to the eye piece adaptor is used. The image at the primary focus of a telescope is formed just the same as the image in a camera, and when used without an eyepiece is to all purposes an ordinary camera, though of much longer focus than usual. Thus it forms an inverted image which can be focussed on a ground glass, and the point at which this image is sharpest is known as the primary focus of the object glass. The size of the image formed depends on the focal length of the object glass, increasing or diminishing in the same ratio and depends upon the apparent angular diameter of the object and the distance of the image from the object glass, the object and its image will subtend equal angles. For a telescope of 90 inches, the diameter of the moon at mean distance will be about $\frac{7}{8}$ inches. The accesories I use for magnified images are a 4×5 folding camera, a cable release shutter of $1\frac{3}{4}$ inch opening and a $1\frac{1}{2}$ inch negative eyepiece. The plate or film holder is placed about 5 inches from the eyepiece and images about 3 inches in diameter are obtained. For primary focus images, I use $2\frac{1}{4} \times 3\frac{1}{4}$ inch graflex film holders with an attachment to fit in the main eyepiece tube and the shutter mentioned above. Eastman super speed cut films were used in making the photographs submitted.

Owing to the earth's rotation, all astronomical photography deals with objects which are in constant motion with regard to the telescope, and the amount of movement on the plate or film, even in a short period, is a good deal more than might be expected. With the telescope stationary, the earth's rotation carries the image of the moon across the plate by the amount of her own diameter in about two minutes. For an image

of say two inches in diameter, this would mean a movement of $1/60$ inch in one second, from which it is apparent that with a fixed telescope to get reasonably sharpness, exposures must not exceed one second even at the primary focus. A clock rated to follow the stars, while cancelling the effects of the earth's rotation, will not give a motionless image, as the moon's proper motion in right ascension and declination soon make their presence felt. The moon's motion in right ascension eastwards among the stars amounts at maximum to about $1/44$ th of her diameter per minute, or $1/266$ th of her diameter every ten seconds, and she will lag by that amount behind a telescope adjusted to follow the stars. This movement can be practically eliminated by slightly retarding the rate of the clock. The motion in declination at maximum is about $1/650$ th of the moon's diameter in ten seconds, diminishing to zero and then rising again to maximum. This takes place twice every lunation, the minimum occurs at the time the moon attains her greatest north or south declination, and about these periods her motion in declination may be counted as being eliminated altogether.

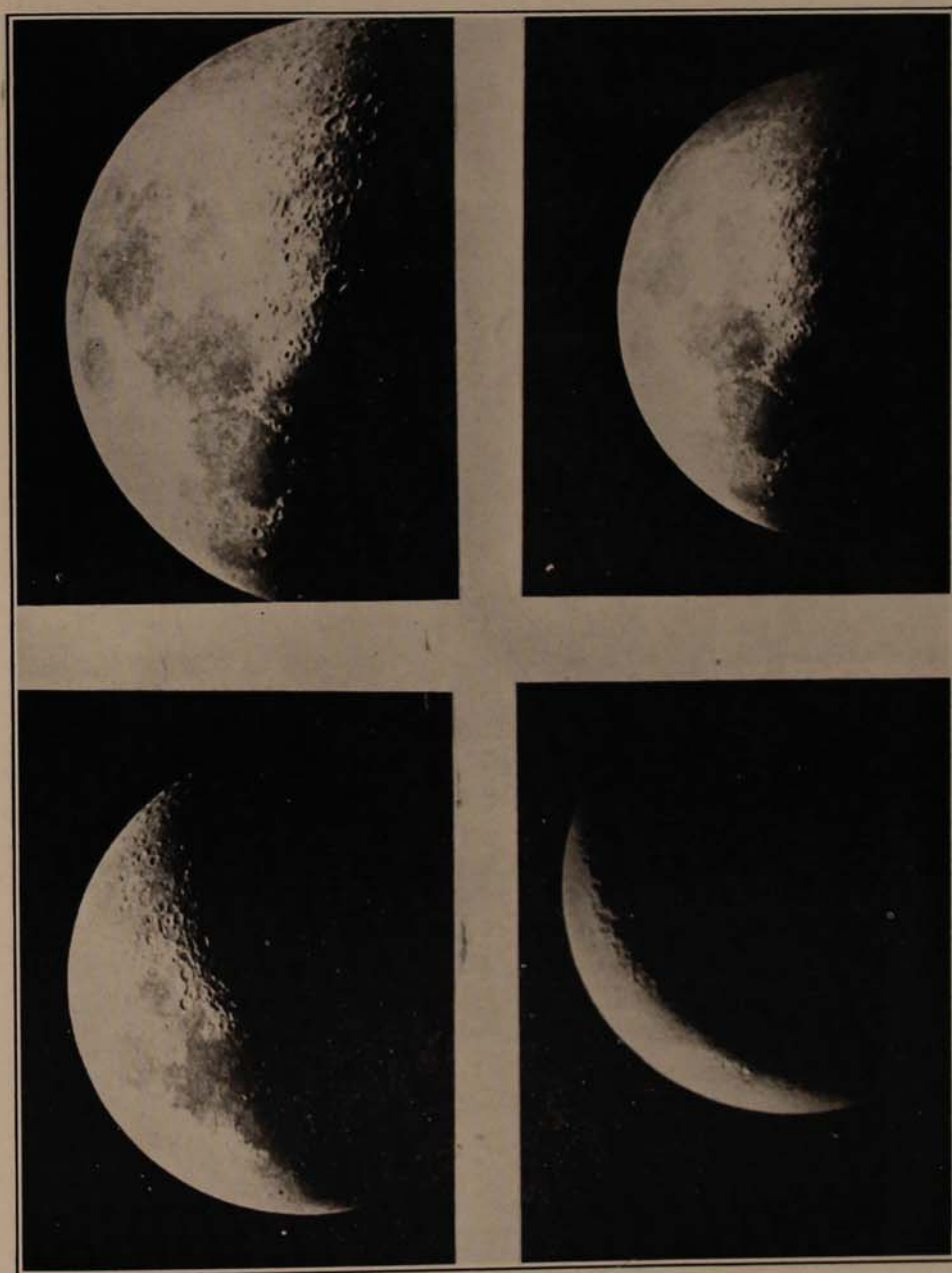
In arriving at the correct exposure time the state of the atmosphere has to be considered and also the altitude of the moon. When the sun is low every photographer knows that exposures have to be lengthened, because a considerable portion of the actinic rays is absorbed while traveling the increased depth of the atmosphere. The same cause affects exposures in astronomical photography, and consequently objects at a low altitude require a much longer exposure than those at the zenith. The moon therefore should be photographed at as high an altitude as possible to obtain the shortest exposure and least atmospheric disturbance. In addition to these there are three special factors which have to be taken into account. The first has to do with the phase of the moon. When full, her illuminated area is exactly twice what it is at either first or last quarter, and her total light should therefore be twice as bright. But observation shows that instead of being twice as bright, at full she is actually 9 times brighter than at first quarter, and 10 times brighter than at last quarter, so that at these phases, exposures must be four or five times longer, in order to obtain a negative of equal density and detail with one taken at full. For lesser phases the increase of exposure is still greater. For a phase about three days before or after new moon the exposure being 12 or 13 times longer than for full. The decrease in brightness is due to the shadows of the rough surface of the moon, which are seen most prominently from the earth in the young or old moon. The illumination being more or less at right angles to the earth, but which gradually become less visible or disappear altogether, as the sun and the earth come into the same line about full. The second factor is the position of the moon in her orbit. When in apogee, or farthest from the earth, exposures should be one-third longer than when in perigee. When in perigee one-fourth shorter. The reason being

that at these two points in her orbit, the light intensity is in the ratio of 3 to 4 as the result of her different distance from the earth. The third factor has to do with the region of the moon which it is desired should come out best on the negative. Only about full is the brightness approximately the same at both limb and center, at other times, the region towards the terminator is much less bright than the limb, especially photographically. The seas also come out darker on the photograph than their relative visual brightness, being much less actinic than their surroundings. Owing to this unequal illumination of the moon's surface, it is impossible to bring out the maximum detail over the whole disc on one negative. The terminator usually comes out under-exposed and this has the effect of giving the moon an age which does not correspond to the real age at the time of the exposure. When detail is required near the terminator, or the seas, exposures must be lengthened, but care must be taken not to over-expose or halation will be caused.

The exposure times as I have found them are as follows. For the full moon, one tenth second, at first quarter, one second, about three or four days old, two seconds, for the earth-lit moon one minute. These are for the primary focus, and under average conditions. For magnified images the exposure times can be found from the following. Doubling the focal length of the object glass doubles the diameter of the primary image but increases its area four times, so that four times the exposure is required when the area of the lens is not increased. Therefore, with the eyepiece image, as the aperture remains the same, magnifying the primary focus image two diameters requires four times the exposure. If magnified three diameters, nine times the exposure and so on, the time of the exposure being the square of the number of times the primary focus image is magnified. Some light is also lost in the eyepiece, which adds to the length of exposure over the exposure required by the magnification.

It must be borne in mind that the greater the magnification, the quicker the image travels across the plate, and any vibrations or imperfections in the instrument will be magnified by the same amount. As the image formed at the primary focus in medium sized instruments is small, it is necessary to enlarge the negatives, this is best accomplished by making an enlarged positive on a lantern plate and taken off a negative by contact, or the positive can be further enlarged and prints made from the final negative. This is done to minimize the granulation on the original negative. Each enlargement should not exceed 3 diameters.

For part of this information I am indebted to Astronomical Photography by H. H. Waters, and I understand that this is the only information in book form on this subject.





AN INTRODUCTION TO AN OUTLINE OF A COURSE IN GENERAL PHYSICS ORGANIZED AROUND THE ENERGY CONCEPT

By

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The writer believes that the chief objective of physics is the energy concept, that this should be impressed on the students in the beginning, and that it should be emphasized throughout the course as the central theme through all of the work. He believes that all the subject matter of the course should be organized around this central theme and be made to point toward it. The subject matter he believes, should consist of the products of analysis of this chief objective, which are to be used for class exercises. One or more of these lesser objectives should be made the central theme or themes for each exercise. However, the "Big Idea" of physics (the energy concept) should be kept before the students at all times; also, a system of values that should result from the study of science, such as that stated by Ingalls, Powers, Downing, or the National Education Association. The following list of aims taken from Downing's "The Teaching of Science" appeared only about four years ago: First—Knowledge, embracing (a) Acquisition of habits of healthful personal and community living; (b) Acquisition of scientific knowledge, ideas, and ideals that make for worthy home membership and citizenship; (c) Acquisition of the principles and ideas of the science on which they are based; (d) Discovery and direction of aptitudes; (e) Intelligent choice of a vocation; (f) Wise use of leisure. Second—Skill in thinking, embracing (a) Establishment of the habit of thinking to correct conclusions from observed facts; (b) Formation of the habit of carrying the conclusions over into action; (c) Development of the habit of scientific thinking that will function in (1) The solution of life's problems, (2) The formation of independent opinions, (3) The securing of wise action. Third—Appreciation, embracing, (a) Acquisition of the moral import of the orderliness of nature and the student's obligation to adjust himself to her laws; (b) Acquisition of an appreciation of the great achievements in science, and of the devoted labors of the great scientists; (c) Acquisition of the aesthetic and intellectual appreciation of the commonplace environment.

With the exception of the small amount of energy liberated by the disintegration of the atoms of radioactive substances and the small amounts received from meteors and heavenly bodies other than our sun, all of the energy on the earth can be traced to the sun which radiated this energy as electromagnetic waves of many frequencies and wave lengths. We may tap this energy directly as it comes to us, or indirectly

through its storage reservoirs—the deposits of coal, oil, and gas, the forests, and the waterfalls. Our interest in physics lies chiefly in the efficient transformation of this energy in producing greater happiness for the race.

The study of the solar electromagnetic wave band of fifty-five octaves should be introduced at frequent intervals throughout the course to show how the different sections take their departure more or less directly from this wave band, so that the students will develop as clear concepts as possible of the significance of the solar spectrum. The central theme of the course is energy—its nature, its various forms, and its transformations in the service of man. The instructor should keep this clearly in mind, and each item discussed should be presented from this point of view.

The writer is interested in this problem because he believes its solution will so systematize the work in general physics that a great deal more valuable information concerning modern physics can be taught the students than is possible when closely following a text-book; and, too, without omitting any of the fundamentals included in the course as it is usually given.

For the successful teaching of general physics in accordance with this or any similar outline, a sufficient number of reference books on modern physics will be needed in addition to the usual general physics texts and laboratory manuals that are commonly used as references. As examples of the books on modern physics that are suitable for this work we may mention the following: *New Physics* by Haas; *Fundamental Concepts of Physics* by Heyl; *Nature of the World and of Man* by several members of the Faculty of the University of Chicago; *Rise of Modern Physics* by Crew; *History of Physics* by Cajori; *Nature of the Physical World* by Eddington; *Elements of Physics* by Smith; *Introduction to Modern Physics* by Richtmyer; *Common Sense of the Theory of Relativity* by Heyl; and *Relativity and Space* by Steinmetz. The reference books used should be chosen with due regard to the maturity and ability of the students.

In 1901 it was shown experimentally that the mass of an electron increases rapidly as its speed approaches the velocity of light. According to this experiment mass is a variable, and thus the great principle of the conservation of mass was overthrown as a general law. According to the view of Einstein, Jeans, and others, the radiation of heat and light waves is accomplished at the expense of the mass of the incandescent body. The writer believes that the outstanding characteristic of the universe is motion—and motion implies energy. He believes that energy is the most important physical quantity with which we deal.

The writer does not lay claim to any originality in the construction of the outline, and it is by no means complete. It is but a remodeling of some of the work on this problem that has been done by others—yet

he hopes that some improvement has been accomplished. In its present form the outline is but an introduction to a course in general physics which he hopes to be able to develop in sufficient detail so that it will be suitable to use with his class of pre-medical students within the next year.

The outline is rather long and, therefore, attention will be called to but a few of its many items, all of which are to be used for class instruction. Each item should be studied and discussed as fully as the time devoted to the course will permit.

ITEMS FOR CLASS INSTRUCTION SELECTED FROM THE OUTLINE

All energy on the earth can be traced to the sun which radiated this energy as electromagnetic waves. Interest in Physics is centered in efficient transformation of this energy.

Heat and Light are forms of Energy derived directly from the Sun's Spectrum.

- I. Light and Radiant Heat are similiar in many ways; wave form, velocity, etc.
 - A. Both are radiated from incandescent bodies.
 - a. This occurs at the expense of the mass of the body.
 - b. The sun is loosing mass at the rate of about four million tons per second in the emission of energy.
 - c. Incandescent bodies radiate energy in the same manner as does the sun.
 - x. A gas or candle flame contains incandescent particles of carbon.
 - y. The incandescent filament of a lamp converts electrical energy into light energy. However, the efficiency is very low.
 - z. Incandescent gases are used for the production of light in Neon tubes and Cooper-Hewitt lamps.
 - B. The medium usually considered involved in the transmission of heat and light energy is the imponderable luminiferous ether.
 - a. Some theories of light and radiant heat deny the existance of the ether. These theories will be discussed later.
 - C. Radiant heat and light travel through interstellar space at a speed of approximately 186000 miles per second.
 - a. Light travels in approximately straight lines which explains shadow formation and eclipses.
 - b. The velocity of light was determined by
 - w. Roemer's astronomical observations on one of Jupiter's satellites.
 - x. Bradley's astronomical observations on stellar abberation.
 - y. Foucault's experimental method.
 - z. Michelson's improvements on Foucault's method.

- D. Light and radiant heat travel as transverse ether waves (electromagnetic waves).
- a. An early theory of light was the Emission or Corpuscular theory which was supported by Newton.
 - b. The wave theory of light offers the best explanation of the nature of radiant heat and light for most optical phenomena. Contributions to it were made by Huygens, Young, Fresnel, and Maxwell.
 - x. Diffraction of light is the slight bending of light around corners.
 - y. Refraction of light occurs when light enters a medium of different density. It consists of a bending of the light toward or away from the normal to the plane of contact between the two media, and occurs in accordance with the First (Snell's law) and Second Laws of refraction. It may be Single or Double.
 - z. Polarization of light occurs when, by refraction, reflection, etc., light is made to exhibit different properties in different directions at right angles to the line of propagation.
 - c. The Quantum theory of Planck, Einstein and others offers the best explanation of such optical phenomena as the photo-electric effect which are not explained satisfactorily by the wave theory.
- E. Light and radiant heat spectra comprise only a portion of the solar family of electromagnetic waves consisting of some fifty-five octaves.
- a. Only a very small part of the solar spectrum affects the eye or the photographic plate.
 - y. The prism disperses colorless light into its component wave lengths.
 - z. The eye is unable to respond to radiations of greater wave length than those of red light (infra-red waves) or shorter than those of violet (ultra-violet waves).
 - b. Slightly greater wave lengths than those of red (the infra-red) produce the sensation of heat. This is determined by taking a sensitive bolometer or thermopile beyond the red of the visible spectrum.
 - c. Waves slightly shorter than those which arouse the sensation of violet (ultra-violet) cause chemical and biological reactions, and may be studied with the photographic plate or the fluoroscope.
 - d. Hertzian (radio) waves are all longer than the infra-red waves and range in length from hundreds of meters to a

fraction of a centimeter.

- e. X-rays (Roentgen rays) are of various lengths, but are all shorter than the ultra-violet waves. They differ considerably as to method of production, properties and uses.
 - f. Gamma waves are shorter than X-rays and are probably produced by the sudden emission of beta particles (electrons) from the atoms of radioactive substances.
 - g. Cosmic rays are very short waves of high penetrating power that are now generally considered to be evidence for atomic synthesis from electrons and protons in interstellar space.
2. Light and radiant heat, because of their difference in wave length and frequency, are different in many respects.
- A. When radiant heat is absorbed by a body on which it impinges, a change in the kinetic energy of its molecules results. The effect in the case of light waves is small although absorption does take place—by the soil under the glass of a hot-bed, for instance.
- a. An absorbing body is required if radiant heat is to be transformed into molecular or sensible heat. Once absorbed the resulting heat energy may be conveyed from one point to another by convection, conduction, and radiation.
 - x. An older theory of heat was the caloric theory, according to which heat was a material substance—an imponderable fluid.
 - y. Closely associated with the caloric theory was the old phlogiston theory of combustion according to which a burning body gave off an imponderable fluid which was called phlogiston.
 - z. The kinetic theory of heat offers the most reasonable explanation of the production and phenomena of sensible heat.
 - b. The earth warms up and cools off by radiation; a form of heat transfer by means of electromagnetic waves.
 - x. The rate of cooling by radiation is proportional to the difference in temperature between the radiator and its surroundings.
 - y. Good absorbers of heat are, also, good radiators of heat. Generally rough black surfaces radiate best.
 - z. Good reflectors of heat waves are poor absorbers and poor radiators of heat.
 - c. Radiant energy is stored on earth chiefly in the form of fuel—coal, oil, gas, wood, etc. Also, a great deal is stored in water which has been lifted above the surface of the sea by evaporation.

- d. Heat is transferred from one point to another in gases, liquids, and solids by Conduction. This is accomplished by the liberation of energy from electrons as they flow away from the warmer part of the medium toward the colder part.
 - y. The function and design of clothing involves consideration of conduction.
 - z. Building materials are usually poor conductors of heat.
- e. Convection is a means of transferring heat through gases and liquids by means of currents—made possible by the greater molecular freedom of fluids.
 - y. Ventilation and chimney drafts are convection phenomena.
 - z. Convection is applied in heating and in refrigeration.
- f. Light travels through material bodies only by a process of radiation similiar to its progress through interstellar space in general.

In its present form the outline consists of some fifty pages—too long to permit all of it being included in this paper. However, enough of it has been included to give one an idea of its nature. It covers all of the major divisions of physics—mechanics, heat, magnetism and electricity, sound and light; also, the electron theory of matter.

SOME LECTURE DEMONSTRATIONS IN PHYSICS

By

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The usual torsional apparatus for laboratory use consists of a wheel into whose center the rod is clamped. A string passes around the periphery of the wheel and weights attached to this string distort the elastic rod. If large wooden clamps are attached to the rod at equal intervals (A, B, C, D, E, Fig 1) each clamp will be rotated a different amount, but the upper ends will stay in a straight line as the torsion is increased and decreased. This shows that Hooke's law is true for torsional elasticity.

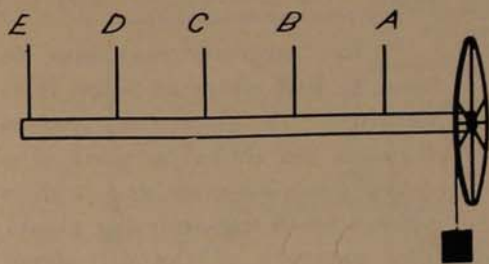


FIG. 1

A wire twenty feet long stretched across the lecture room table and passing over the wheel of the apparatus mentioned above will demonstrate Young's Modulus of stretch. A long cardboard needle attached to the wheel will indicate the amount of stretch as weights are added to the scale pan attached to the wire.

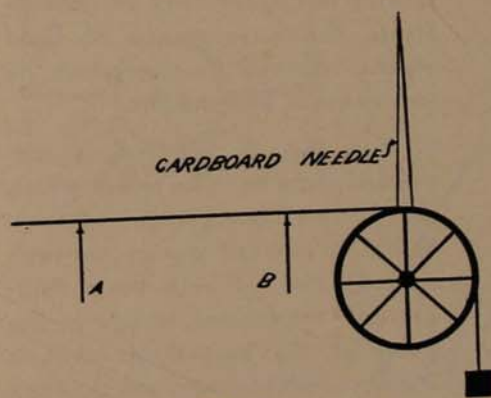


FIG. 2

An electric current passed through the wire from A. to B. will cause an expansion due to heat—this will be indicated by the cardboard needle (linear coefficient of expansion).

If a gas enclosed in a vessel is suddenly compressed or expanded, the change is adiabatic so that the temperature of the gas increases or decreases. This may be shown by means of a Wheatstone Bridge. The vessel which contains the air (Fig. 3)

is of metal and is itself the fourth resistance in the arm of a Wheatstone Bridge.

The bridge is first balanced and the air compressed in A—this causes a deflection of the galvanometer in one direction. When the compressed gas is allowed to expand suddenly by the opening of a stopcock, the container is cooled and the galvanometer is deflected in the opposite direction.

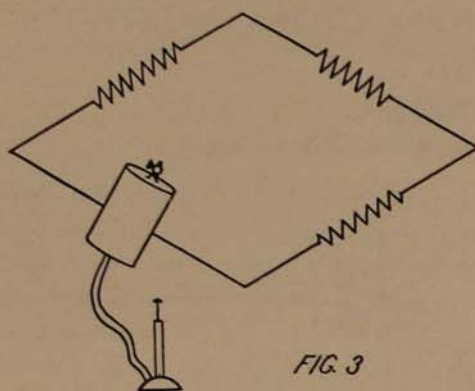


FIG. 3

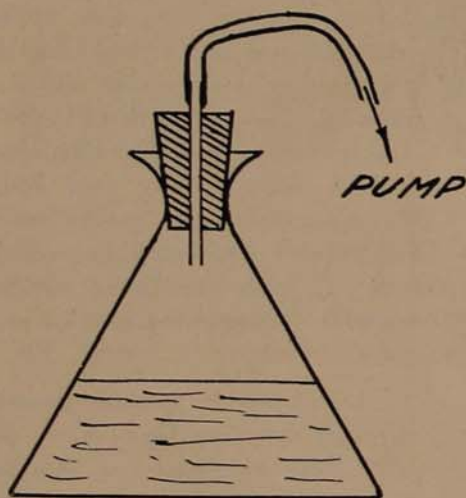


FIG. 4

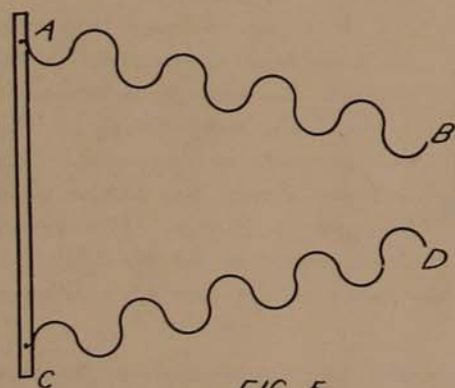


FIG. 5

The aspirator pump is a satisfactory instrument for the rapid production of a vacuum before a large class. A partially inflated balloon placed under the bell jar may be thus expanded to fill the whole jar—when air is allowed to enter, the balloon collapses suddenly to its original size.

The aspirator may also be used to boil water at room temperature. A glass tube passes through the rubber stopper of a vessel containing air and is then connected to the aspirator pump. The pressure of the air above the water is rapidly reduced and the water boils violently although the flask is held in the hand of the operator.

The apparatus shown in Fig. 5 was invented by Mr. Lee Fullmer of our laboratory to demonstrate the interference of light waves. A and C represent the two sources of the light.

In Fig. 6, the coil is suspended from the two wires which carry the energizing current. When a current passes through the coil, the coil acts like a magnet and is attracted to one of the poles of the horseshoe magnet. If the current is reversed through the coil by means of the switch, the coil immediately flies off the one arm of the magnet and over to the other. If two coils are suspended instead of one, the magnetic action of the coils upon one another may also be shown. With the current in the same direction

through the coils, the coils attract; if one current is reversed the coils are repelled.

rapid production of a vacuum before a large class. A partially inflated balloon placed under the bell jar may be thus expanded to fill the whole jar—when air is allowed to enter, the balloon collapses suddenly to its original size.

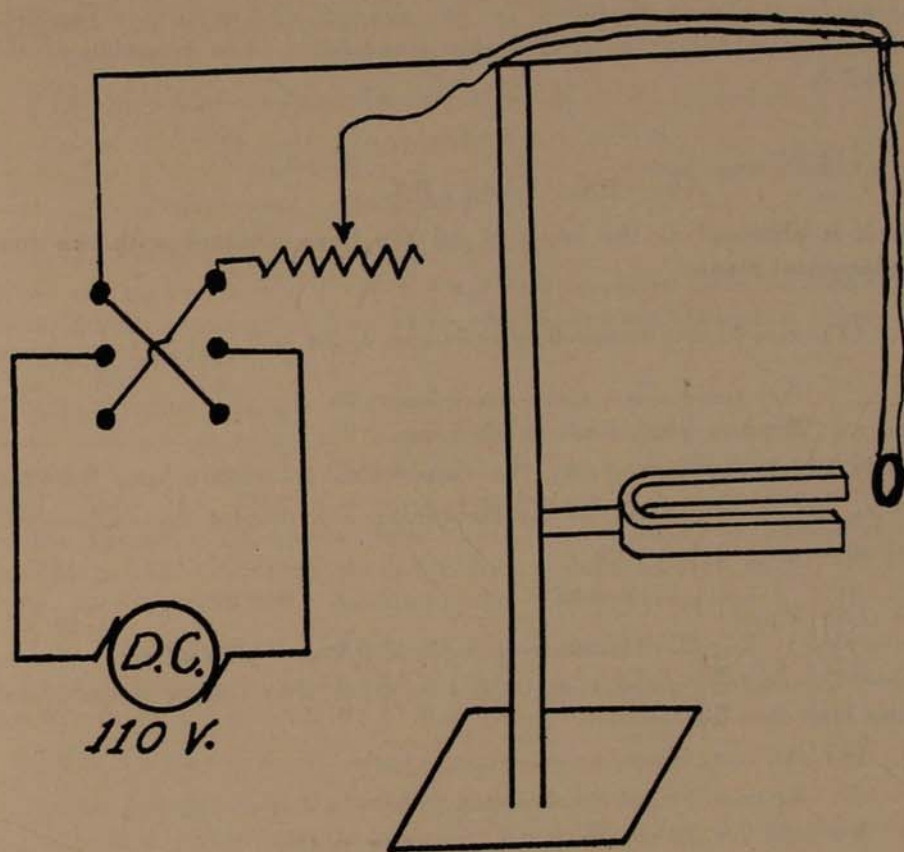


FIG. 6

ON SEGRE'S VARIETY V_3^3 IN S_4

By

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1. It is the purpose of this paper to treat SEGRE'S variety* in S_4 by the analytic method developed for the general V_{n-1}^{n-1} in S_n in a paper by the author published in the Palermo Rendiconti. The equation of this spread is

$$(1) V_3^3 \left| \begin{array}{cc} x_1 + x_2 & x_3 + x_4 \\ AB_{12} - BA_{12} & AB_{34} - BA_{34} \end{array} \right| = 0,$$

which is obtained as the locus of all the lines incident with the four fundamental planes

$$(2) x_1 = 0, x_2 = 0; x_3 = 0, x_4 = 0; x_5 = 0, \sum_1^4 x_i = 0$$

$$A = a_1x_1 + a_2x_2 + a_3x_3 + a_4x_4 + a_5x_5 = 0,$$

$$B = b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 = 0,$$

and in which $A_{12} = a_1x_1 + a_2x_2$, $A_{34} = a_3x_3 + a_4x_4$, $B_{12} = b_1x_1 + b_2x_2$, $B_{34} = b_3x_3 + b_4x_4$. If we introduce the Grassmannian coordinates $\alpha_{ik} = a_i b_k - a_k b_i$ the equation (1) becomes

$$(3) V_3^3 \equiv \left| \begin{array}{cc} x_1 + x_2 & x_3 + x_4 \\ -C + (\alpha_{51}x_1 + \alpha_{52}x_2)x_5 & C + (\alpha_{53}x_3 + \alpha_{54}x_4)x_5 \end{array} \right| = 0,$$

where $C = (\alpha_{13}x_1 + \alpha_{23}x_2)x_3 + (\alpha_{14}x_1 + \alpha_{24}x_2)x_4$. The fourth fundamental plane may then be written:

$$(4) A: \alpha_{21}x_1 + \alpha_{23}x_3 + \alpha_{24}x_4 + \alpha_{25}x_5 = 0,$$

$$B: \alpha_{12}x_2 + \alpha_{13}x_3 + \alpha_{14}x_4 + \alpha_{15}x_5 = 0.$$

We now set up the projective transformation

$$(5) x_1 = p_1x'_1 + q_1x'_2, \quad x_3 = p_3x'_3 + q_3x'_4,$$

$$x_2 = p_2x'_1 + q_2x'_2, \quad x_4 = p_4x'_3 + q_4x'_4,$$

$$x_5 = p_5x_5 + q_5 \sum_1^4 x_i,$$

where $p_1 + p_2 = q_1 + q_2 = p_3 + p_4 = q_3 + q_4 = r$, $r \neq 0$;

this transformation leaves invariant the first three fundamental planes

(2). The fourth plane may now be transformed into the plane

*Palermo Rendiconti, Vol. LIV, 1930. The analytical treatment of CASTELNUOVO (see E. BERTINI, Einführung in die Projective Geometrie Mehrdimensionaler Raume pp. 201-203) while very elegant, seems to take us by surprise, moreover, it does not shed any light on the various degenerate cases of the V_3^3 , all the coefficients of the equation having been fixed ab initio.

$$(6) \quad x_2 + x_5 = 0, \quad x_1 + x_4 = 0.$$

This can be done in one and only one way. We find the following values for the parameters p_1 and q_1 :

$$p_1 = \frac{(\alpha_{34} + \alpha_{42} + \alpha_{23})r}{D}, \quad q_1 = \frac{\alpha_{25}r}{\alpha_{25} + \alpha_{51}}, \quad p_3 = \frac{\alpha_{45}r}{\alpha_{53} + \alpha_{45}}, \quad q_3 = \frac{(\alpha_{21} + \alpha_{14} + \alpha_{42})r}{D},$$

$$q_5 = \frac{\alpha_{34}r}{\alpha_{53} + \alpha_{45}}, \quad p_5 = \frac{[\alpha_{12}(\alpha_{35} + \alpha_{54}) + \alpha_{34}(\alpha_{25} + \alpha_{51})]r}{(\alpha_{53} + \alpha_{45})(\alpha_{25} + \alpha_{51})}.$$

$D = \alpha_{31} + \alpha_{14} + \alpha_{42} + \alpha_{23}$. The equation (3) now becomes

$$V_3^3 = \begin{vmatrix} x_1 + x_2 & x_3 + x_4 \\ x_1x_5 - x_2x_4 & x_4x_5 + x_2x_1 \end{vmatrix} = 0, \text{ or, when expanded,}$$

$$(9) \quad x_1x_3x_5 = x_2x_4(x_1 + x_2 + x_3 + x_4 + x_5).$$

If we set $x_6 = -(x_1 + x_2 + x_3 + x_4 + x_5)$ and consider x_6 as an additional superfluous coordinate, we have the following two-term form of SEGRE'S variety:

$$(10) \quad x_1x_3x_5 + x_2x_4x_6 = 0.$$

If we interpret x_6 as a sixth homogeneous coordinate in an S_5 , we have here a V_3^4 studied by U. PERAZZO.* It has 9 double-lines and is self-dual. Since the 4-flat $x_1 + x_2 + x_3 + x_4 + x_5 + x_6 = 0$ is a tangent space to the spread (10) at the point $(-1, 1, -1, 1, -1, 1)$ it intersects the spread in the V_3^3 which therefore has a double-point at $(1, -1, 1, -1, 1)$, that is, V_3^3 has 10 double-points. These points are:

0: $(0, 0, 0, 0, 1)$, 1: $(0, 0, 0, -1, 1)$, 2: $(0, 0, 1, 0, 0)$, 3: $(1, -1, 1, -1, 1)$, 4: $(1, 0, 0, -1, 0)$, 5: $(0, 1, -1, 0, 0)$, 6: $(0, 0, 1, -1, 0)$, 7: $(1, -1, 0, 0, 0)$, 8: $(0, 1, 0, 0, -1)$, 9: $(1, 0, 0, 0, 0)$.

The 15 planes on V_3^3 are:

The five associated planes, $x_1 = x_2 = 0$; $x_3 = x_4 = 0$; $x_5 = 0$, $\Sigma x_1 = 0$, $x_2 + x_5 = 0$, $x_1 + x_4 = 0$; $x_2 + x_3 = 0$, $x_4 + x_5 = 0$. Moreover 10 planes whose equations are:

$$x_1 = x_4 = 0; \quad x_2 = x_3 = 0; \quad x_4 = x_5 = 0; \quad x_2 = x_5 = 0; \quad x_1 + x_4 = 0, \\ x_1 + x_2 = 0, \quad x_4 + x_5 = 0; \quad x_2 + x_5 = 0, \quad x_3 + x_4 = 0; \quad x_1 + x_2 = 0, \quad x_3 + x_4 = 0; \\ x_1 = 0, \quad \sum_1^5 x_1 = 0; \quad x_3 = 0, \quad \sum_1^5 x_1 = 0.$$

Each plane passes through four double-points of which any three are not colinear, and through each double-point pass 6 planes. We may now, following CASTELNUOVO,† arrange the 15 planes in 6 quintuples, viz.:

*Atti. Acc. Torino 36 (1921) p. 891. See also Encyclopedie der Math. Wiss. III, C, 7, p. 953.

†E. BERTINI, Loc. cit. p. 196.

- I. (0126): $x_1 = x_2 = 0$; (0789): $x_3 = x_4 = 0$; (4567): $x_5 = 0$, $\sum_1^5 x_1 = 0$;
 (2348): $x_2 + x_5 = 0$, $x_1 + x_4 = 0$; (1359): $x_2 + x_3 = 0$, $x_2 + x_5 = 0$;
- II. (0348): $x_1 + x_4 = 0$, $x_2 + x_3 = 0$; (0789): $x_3 = x_4 = 0$; (1237): $x_1 + x_2 = 0$, $x_4 + x_5 = 0$; (1568): $x_1 = 0$, $\sum_1^5 x_1 = 0$; (2469): $x_2 = x_5 = 0$.
- III. (0258): $x_1 = x_4 = 0$; (0149): $x_2 = x_3 = 0$; (1237): $x_1 + x_2 = 0$, $x_4 + x_5 = 0$, (4567): $x_1 = 0$, $\sum_1^5 x_1 = 0$; (3689): $x_3 + x_4 = 0$, $x_2 + x_5 = 0$.
- IV. (0367): $x_1 + x_2 = 0$, $x_3 + x_4 = 0$; (0149): $x_2 = x_3 = 0$; (1568): $x_3 = 0$, $\sum_1^5 x_1 = 0$, (2348): $x_2 + x_5 = 0$, $x_3 + x_4 = 0$, (2579): $x_4 = x_5 = 0$.
- V. (0367): $x_1 + x_2 = 0$, $x_3 + x_4 = 0$; (0258): $x_1 = x_4 = 0$; (2469): $x_2 = 0$, $\sum_1^5 x_1 = 0$, (1359): $x_2 + x_3 = 0$, $x_4 + x_5 = 0$; (1478): $x_3 = 0$, $\sum_1^5 x_1 = 0$.
- VI. (0345): $x_1 + x_4 = 0$, $x_2 + x_3 = 0$; (0126): $x_1 = x_2 = 0$; (1478): $x_3 = 0$, $\sum_1^5 x_1 = 0$, (2579): $x_4 = x_5 = 0$; (3689): $x_2 + x_5 = 0$, $x_3 + x_4 = 0$.

Through any generic point of V_3^3 will pass 6 of the ∞^2 lines that generate the spread. Let the point be $(\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5)$; the equations of the six lines are then

$$\begin{aligned} \text{I. } x_1 &= \frac{\alpha_1}{\alpha_2} x_2, \quad x_3 = \frac{\alpha_3}{\alpha_4} x_4, \quad x_5 = \frac{(\alpha_1 + \alpha_2) \alpha_1 x_2 + (\alpha_3 + \alpha_4) \alpha_2 x_4}{\alpha_1 \alpha_3 - \alpha_2 \alpha_4}, \\ \text{II. } x_1 &= \frac{(\alpha_2 + \alpha_5) \alpha_2 x_2 + (\alpha_3 + \alpha_4) \alpha_2 x_4}{\alpha_3 \alpha_5 - \alpha_2 \alpha_4}, \quad x_3 = \frac{\alpha_3}{\alpha_4} x_4, \quad x_5 = \frac{\alpha_5}{\alpha_2} x_2, \\ \text{III. } x_1 &= \frac{\alpha_1}{\alpha_4} x_4, \quad x_3 = \frac{\alpha_3}{\alpha_2} x_2, \quad x_5 = \frac{(\alpha_3 + \alpha_2) \alpha_1 x_2 + (\alpha_1 + \alpha_4) \alpha_2 x_4}{\alpha_1 \alpha_5 - \alpha_2 \alpha_4}, \\ \text{IV. } x_1 &= \frac{(\alpha_2 + \alpha_3) \alpha_1 x_2 + (\alpha_4 + \alpha_5) \alpha_2 x_4}{\alpha_3 \alpha_5 - \alpha_2 \alpha_4}, \quad x_3 = \frac{\alpha_3}{\alpha_2} x_2, \quad x_5 = \frac{\alpha_5}{\alpha_4} x_4, \\ \text{V. } x_1 &= \frac{\alpha_1}{\alpha_4} x_4, \quad x_5 = \frac{(\alpha_3 + \alpha_5) \alpha_4 x_2 + (\alpha_1 + \alpha_4) \alpha_2 x_4}{\alpha_1 \alpha_5 - \alpha_2 \alpha_4}, \quad x_3 = \frac{\alpha_3}{\alpha_2} x_2, \\ \text{VI. } x_1 &= \frac{\alpha_1}{\alpha_2} x_2, \quad x_3 = \frac{(\alpha_1 + \alpha_2) \alpha_4 x_2 + (\alpha_4 + \alpha_5) \alpha_2 x_4}{\alpha_1 \alpha_5 - \alpha_2 \alpha_4}, \quad x_5 = \frac{\alpha_5}{\alpha_4} x_4. \end{aligned}$$

We have here six systems of ∞^2 lines. Each system meets the corresponding quintuple of planes (the correspondence indicated by the numerals I, II, III, IV, V, VI). It will also be noted that each of

the 15 planes is incident with the lines of two different systems, since any two quintuples have a plane in common.

If the point (α_1) is not generic, let us suppose that it lies in any one of the 15 planes and does not coincide with any of the 10 double-points. Thus, let the plane be $x_1 = x_2 = 0$, and the point $(0, 0, \alpha_3, \alpha_4, \alpha_5)$. We write the equations of a line through this point as follows:

$$x_1 = p_1 x_2, \quad x_3 = p_3 x_2 + \frac{\alpha_3}{\alpha_4} x_4, \quad x_5 = p_5 x_2 + \frac{\alpha_5}{\alpha_4} x_4. \quad \text{If it shall lie on the}$$

surface we must have

$$p_1 p_5 p_3 = 0, \quad p_1 \frac{\alpha_4^2}{\alpha_3 \alpha_5} + \frac{\alpha_4}{\alpha_3 + \alpha_4 + \alpha_5}, \quad p_1 p_3 \frac{\alpha_4}{\alpha_5} + p_1 p_5 \frac{\alpha_4}{\alpha_5} = 1 + p_1 + p_3 + p_5,$$

that is, we must have $p_3 = 0$, or $p_5 = 0$. Solving we find two lines whose equations are

$$x_1 = \frac{\alpha_4 (\alpha_3 + \alpha_4 + \alpha_5)}{\alpha_3 \alpha_5} x_2, \quad x_3 = \frac{\alpha_3}{\alpha_4} x_4, \quad x_5 = \frac{\alpha_4 + \alpha_5}{\alpha_3} x_2 + \frac{\alpha_5}{\alpha_4} x_4$$

$$x_1 = \frac{\alpha_4 (\alpha_3 + \alpha_4 + \alpha_5)}{\alpha_3 \alpha_5} x_2, \quad x_3 = \frac{\alpha_4 + \alpha_3}{\alpha_5} x_2 + \frac{\alpha_3}{\alpha_4} x_4, \quad x_5 = \frac{\alpha_5}{\alpha_4} x_4.$$

In general, through any point on one of the 15 planes, which is not a double-point, will pass two lines which belong to two different systems corresponding to the two different quintuples in which the plane is found.

2. The apparent contour of the V_3^3 may be obtained thus: Let the point (α_1) be a generic point in S_4 . The contour will then be the intersection of the cone having its vertex at (α_1) and an arbitrary 3-flat S_3 . A line through (α_1) may be written

$$(15) \quad x_1 = p_1 x_2 + \frac{\alpha_1 - p_1 \alpha_2}{\alpha_3} x_4, \quad x_3 = p_3 x_2 + \frac{\alpha_3 - p_3 \alpha_2}{\alpha_4} x_4, \quad x_5 = p_5 x_2 +$$

$\frac{\alpha_5 - p_5 \alpha_2}{\alpha_4} x_4$. Substituting in (10) we have the cubic equation

$$(16) \quad C x_2^3 + \frac{A - 3\alpha_2 C - \alpha_4 D}{\alpha_4} x_2^2 x_4 + \frac{B + 3\alpha_2^2 C - 2\alpha_2 \alpha_4 D - \alpha_4 \Sigma \alpha_1}{\alpha_4^2} x_1 x_2^2 x_4$$

$$+ \frac{(\alpha_1 \alpha_3 \alpha_5 - \alpha_2^3 C + \alpha_2^2 A - \alpha_2 B)}{\alpha_4^3} x_4^3 = 0, \quad \text{where } C = p_1 p_3 p_5, \quad A = \alpha_1 p_3 p_5 +$$

$\alpha_3 p_1 p_5 + \alpha_5 p_1 p_3, \quad B = \alpha_3 \alpha_5 p_1 + \alpha_1 \alpha_5 p_3 + \alpha_1 \alpha_3 p_5$ and $D = 1 + p_1 + p_3 + p_5$. A rather lengthy calculation which we shall not reproduce here gives the discriminant of this cubic in the form

$$(17) \quad (3CM - KL)^2 + 4(K^2 - ML)(3CK - L^3) = 0, \quad \text{where}$$

$$M = 3 \frac{(\alpha_1 \alpha_2 \alpha_5 - \alpha_2 \alpha_4 \sum \alpha_1)^{1-5}}{\alpha_4^2}, \quad C = p_1 p_3 p_5, \quad L = \frac{A - \alpha_4 D}{\alpha_4}, \quad K = \frac{B - \alpha_2 \alpha_4 D - \alpha_4 \sum \alpha_1^{1-5}}{\alpha_4^2}$$

Solving the equations (15) for p_1 , p_3 and p_5 we have

$$p_1 = \frac{\alpha_4 x_1 - \alpha_1 x_4}{\alpha_4 x_2 - \alpha_2 x_4}, \quad p_3 = \frac{\alpha_4 x_3 - \alpha_3 x_4}{\alpha_4 x_2 - \alpha_2 x_4}, \quad p_5 = \frac{\alpha_4 x_5 - \alpha_5 x_4}{\alpha_4 x_2 - \alpha_2 x_4},$$

and substituting in (16) we have the tangent cone required. If now we let the space S_3 be the coordinate space $x_4 = 0$, which can be done without loss of generality, we have the equation of the apparent contour:

$$(18) \quad (3C_1 M_1 - K_1 L_1)^2 + (K_1^2 - M_1 L_1) (3C_1 L_1 - L_1^2),$$

where $M_1 = 3 (\alpha_1 \alpha_3 \alpha_5 - \alpha_2 \alpha_4 \sum \alpha_1)$, $C_1 = x_1 x_3 x_5$, $L_1 = \alpha_1 x_3 x_5 + \alpha_5 x_1 x_5 + \alpha_5 x_1 x_3 - \alpha_4 x_2 (x_1 + x_2 + x_3 + x_5)$. $K_1 = \alpha_1 \alpha_5 x_5 + \alpha_5 \alpha_3 x_1 + \alpha_1 \alpha_5 x_3 - \alpha_2 \alpha_4 (x_1 + x_2 + x_3 + x_5) - \alpha_4 \sum \alpha_1 x_2$. This is a sextic surface having 10 double-points and 15 tropes. The 10 double-points are:

$$(19) \quad (0, 0, 0, 1), (1, 0, 0, 0), (0, 0, 1, 0), (0, 1, -1, 0), (0, -1, 0, 1), (1, -1, 0, 0) (\alpha_1 + \alpha_2, \alpha_2, \alpha_3, \alpha_5), (\alpha_1, \alpha_2, \alpha_3 + \alpha_4, \alpha_5), (\alpha_1, \alpha_2, \alpha_3, \alpha_4 + \alpha_5), (\alpha_1 + \alpha_4, \alpha_2 - \alpha_4, \alpha_3 + \alpha_4, \alpha_4 + \alpha_5).$$

The 15 trope-planes are:

$$x_1 = 0, \quad x_3 = 0, \quad x_5 = 0, \quad \alpha_2 x_1 - \alpha_1 x_2 = 0, \quad \alpha_5 x_2 - \alpha_2 x_5 = 0, \quad \alpha_2 x_3 - \alpha_3 x_2 = 0, \\ \sum_1^5 \alpha_1 x_5 - \alpha_5 \sum_1^{3+5} x_1 = 0, \quad \sum_1^5 \alpha_1 x_1 - \alpha_1 \sum_1^{3+5} x_1 = 0, \quad \sum_1^5 \alpha_1 x_3 - \alpha_3 \sum_1^{3+5} x_1 = 0, \quad (\alpha_2 + \alpha_5) x_1 - \\ (\alpha_1 + \alpha_4) (x_2 + x_5) = 0, \quad (\alpha_1 + \alpha_3) x_1 - (\alpha_1 + \alpha_4) (x_2 + x_3) = 0, \quad (\alpha_1 + \alpha_2) x_3 - \\ (\alpha_3 + \alpha_5) (x_1 + x_5) = 0, \quad (\alpha_3 + \alpha_5) x_3 - (\alpha_3 + \alpha_4) (x_2 + x_5) = 0, \quad (\alpha_1 + \alpha_2) x_5 - \\ (\alpha_4 + \alpha_5) (x_1 + x_2) = 0, \quad (\alpha_2 + \alpha_3) x_5 - (\alpha_4 + \alpha_5) (x_2 + x_3) = 0.$$

The surface has also a cuspidal edge of the 6th order. In fact, the conditions that the equation (16) shall have a triple-root are obtained by adding to (17) the condition $3CK - L^2 = 0$, as an easy calculation will show. We have then the curve $3C_1 M_1 - L_1 K_1 = 0$, $3C_1 K_1 - L_1^2 = 0$, which is of the 12th order. But the sextic curve $C_1 = 0$, $L_1 = 0$, which is a partial intersection of the cubic and the quartic must be deducted, since it corresponds to no triple-root of (16). The cuspidal edge is therefore the residual intersection of the two surfaces.

$$(21) \quad 3C_1 M_1 - K_1 L_1 = 0, \quad K_1^2 - M_1 L_1 = 0,$$

which is of the sixth order. We also find rank $r = 2.3 (2 + 3 - 2) = 18$,

$$\text{number of apparent double-points } h = 6, \quad \text{genus } p = \frac{5.4}{2} - 6 = 4.$$

3. If the point (a_1) is on V_3^3 , but not on any one of the 15 planes, we have to set $M_1 = \alpha_1 \alpha_3 \alpha_5 - \alpha_2 \alpha_4 \sum_1^5 \alpha_1 = 0$ in (18). The equation then

reduces to the following:

$$L_1^2 - 4K_1C_1 = 0,$$

or,

$$[\alpha_1 x_2 x_5 + \alpha_3 x_1 x_5 + \alpha_5 x_1 x_3 - \alpha_4 x_2 (x_1 + x_2 + x_3 + x_5)]^2$$

$$- 4x_1 x_3 x_5 (\alpha_3 \alpha_5 - \alpha_2 \alpha_4) x_1 + (\alpha_1 \alpha_5 - \alpha_2 \alpha_4) x_3 + (\alpha_1 \alpha_3 - \alpha_2 \alpha_4) x_5 - \alpha_4 \left(\sum_1^5 \alpha_i + \right.$$

α_2) $x_2 = 0$, which is a Kummer surface having the following double-points:

1°. The 10 double-points (19), the α 's satisfying the relation $M_1 = 0$.

2°. Six additional double-points obtained by intersecting the 6 lines (14) which proceed from any generic point of V_3^3 by the space $x_4 = 0$. These double points are:

1. $(\alpha_1(\alpha_1\alpha_5 - \alpha_2\alpha_4), \alpha_2(\alpha_1\alpha_3 - \alpha_2\alpha_4), 0, \alpha_2\alpha_4(\alpha_1 + \alpha_2))$,
2. $(\alpha_2\alpha_4(\alpha_2 + \alpha_5), \alpha_2(\alpha_3\alpha_5 - \alpha_2\alpha_4), 0, \alpha_5(\alpha_3\alpha_5 - \alpha_2\alpha_4))$,
3. $(0, \alpha_2(\alpha_1\alpha_3 - \alpha_2\alpha_4), \alpha_3(\alpha_1\alpha_3 - \alpha_2\alpha_4), \alpha_2\alpha_4(\alpha_2 + \alpha_3))$,
4. $(\alpha_2\alpha_4(\alpha_2 + \alpha_3), \alpha_2(\alpha_3\alpha_5 - \alpha_2\alpha_4), \alpha_3(\alpha_3\alpha_5 - \alpha_2\alpha_4), 0)$,
5. $(0, \alpha_2(\alpha_1\alpha_5 - \alpha_2\alpha_4), \alpha_3\alpha_4(\alpha_2 + \alpha_5), \alpha_5(\alpha_1\alpha_5 - \alpha_2\alpha_4))$,
6. $(\alpha_1(\alpha_1\alpha_5 - \alpha_2\alpha_4), \alpha_2(\alpha_1\alpha_5 - \alpha_2\alpha_4), \alpha_2\alpha_4(\alpha_1 + \alpha_2), 0)$,

The trope-planes are:

1°. The 15 trope-planes (20), the α 's satisfying the relation $M_1 = 0$,

2°. The trope-plane whose equation is,

$$(\alpha_3\alpha_5 - \alpha_2\alpha_4) x_1 + (\alpha_1\alpha_5 - \alpha_2\alpha_4) x_3 + (\alpha_1\alpha_3 - \alpha_2\alpha_4) x_5 - \alpha_4(\alpha_1 + \alpha_3 + \alpha_4 + \alpha_5 + 2\alpha_2) x_2 = 0,$$

which is the intersection of the tangent space to V_3^3 at the point (α_1) by the coordinate space $x_4 = 0$. This plane passes through the six double-points (23).

4. It remains to consider the case when the point (α_1) lies in any one of the 15 planes (12). The three planes $x_1 = x_4 = 0$; $x_3 = x_4 = 0$; $x_4 = x_5 = 0$, must be excluded since the contour becomes reducible when the view-point is on any one of them. Let the point be $(\alpha_1, 0, 0, \alpha_4, \alpha_5)$ which lies on the plane $x_2 = x_3 = 0$. The equation of the contour is then

$$(24) [\alpha_5 x_1 x_3 + \alpha_1 x_3 x_5 - \alpha_4 x_2 (x_1 + x_2 + x_3 + x_5)]^2 - 4x_1 x_3 x_5 [\alpha_1 \alpha_5 x_3 - \alpha_4 (\alpha_1 + \alpha_4 + \alpha_5) x_2] = 0,$$

which is Plücker's Complex Surface having $x_2 = x_3 = 0$ as double-line. The eight double-points outside of this line are:

1°. The six double-points $(1, -1, 0, 0)$, $(0, -1, 0, 1)$, $(0, 0, 1, 0)$, $(\alpha_1, 0, \alpha_4, \alpha_5)$, $(\alpha_1 + \alpha_4, -\alpha_4, \alpha_4, \alpha_4 + \alpha_5)$, $(0, 1, -1, 0)$.

2°. Two additional double-points obtained by intersecting the two lines that issue from the point $(\alpha_1, 0, 0, \alpha_4, \alpha_5)$ by the space $x_4 = 0$. These two lines are easily found by the method explained on p. 139. The equations are:

$$(a) \quad x_1 = \frac{\alpha_1}{\alpha_4} x_4, \quad x_3 = \frac{(\alpha_1 + \alpha_4 + \alpha_5)}{\alpha_1 \alpha_5} x_2, \quad x_5 = \frac{\alpha_4 + \alpha_5}{\alpha_1} x_2 + \frac{\alpha_5}{\alpha_4} x_4,$$

$$(b) \quad x_1 = \frac{(\alpha_1 + \alpha_4)}{\alpha_5} x_2 + \frac{\alpha_1}{\alpha_4} x_4, \quad x_3 = \frac{(\alpha_1 + \alpha_4 + \alpha_5) \alpha_4}{\alpha_1 \alpha_5} x_2, \quad x_5 = \frac{\alpha_5}{\alpha_4} x_4.$$

The additional double-points are therefore, $(\alpha_1(\alpha_1 + \alpha_4), \alpha_1 \alpha_5, \alpha_4(\alpha_1 + \alpha_4 + \alpha_5), 0)$, $(0, \alpha_1 \alpha_5, \alpha_4(\alpha_1 + \alpha_4 + \alpha_5), \alpha_5(\alpha_4 + \alpha_5))$. The eight double-points lie in pairs on the four dorsal lines. $x_3 = 0$, $x_1 + x_2 + x_5 = 0$; $x_2 = 0$, $\alpha_5 x_1 - \alpha_1 x_5 = 0$; $x_2 + x_3 = 0$, $(\alpha_1 + \alpha_5) x_1 - (\alpha_1 + \alpha_4) x_5 = 0$, $\alpha_1 \alpha_5 x_3 - \alpha_4(\alpha_1 + \alpha_4 + \alpha_5) x_2 = 0$, $\alpha_1(\alpha_1 + \alpha_4) x_5 + \alpha_5(\alpha_4 + \alpha_5) x_1 + \alpha_4 \alpha_5(x_2 + x_3) = 0$. Every point on the double-line is bispatial except two, namely $(0, 0, 0, 1)$ and $(1, 0, 0, 0)$, which are unispatial.

5. We shall now consider the cases where the V_3^3 degenerates without becoming reducible. To do this we must return to the original equation (1). The transformation (5) fails in the following four cases:*

1°. $\alpha_{15} = \alpha_{25}$; 2°. $\alpha_{35} = \alpha_{45}$; 3°. $D = 0$; 4°. $\alpha_{12}(\alpha_{35} + \alpha_{54}) + \alpha_{34}(\alpha_{25} + \alpha_{51}) = 0$. In order to show what happens in each of these cases we shall find the plane associated with the four fundamental planes (2). All the lines that meet the four planes (2) also meet a fifth plane whose equations are:

$$(25) \quad D \alpha_{34} (\alpha_{51} + \alpha_{25}) x_1 = D (\alpha_{53} + \alpha_{45}) (\alpha_{23} x_3 + \alpha_{24} x_4) + (\alpha_{53} + \alpha_{45}) (\alpha_{51} + \alpha_{25}) (\alpha_{23} + \alpha_{34} + \alpha_{42}) x_5,$$

$$\alpha_{34} (\alpha_{51} + \alpha_{25}) (x_1 + x_2) = (\alpha_{53} + \alpha_{45}) [(\alpha_{23} + \alpha_{31} \alpha) x_3 + (\alpha_{21} + \alpha_{41}) x_4] + (\alpha_{51} + \alpha_{52}) (\alpha_{53} + \alpha_{45}) x_5.$$

The five plane (2) and (25) are the so-called associated planes. If $\alpha_{15} = \alpha_{25}$, this fifth plane coincides with the fundamental plane $x_3 = x_4 = 0$. If $\alpha_{35} = \alpha_{45}$ it coincides with the fundamental plane $x_1 = x_2 = 0$. In the third case, $D = 0$, it is identical with the plane $x_5 = 0$, $\sum_{1}^5 x_i = 0$. Finally in the

fourth case it coincides with the plane $A = B = 0$. In each of these four cases the V_3^3 will have a double-line which passes through three bispatial double-points. Outside of this double-line the V_3^3 has four double-points.

We shall consider the first case, $\alpha_{15} = \alpha_{25}$. A projective transformation may be found which will leave invariant the three fundamental

planes $x_1 = x_2 = 0$; $x_3 = x_4 = 0$; $x_5 = 0$, $\sum_{1}^5 x_i = 0$, and which will carry the

fourth plane $A = B = 0$ into the plane

$$(26) \quad x'_1 + x'_2 + x'_3 - x'_4 = 0, \quad x'_2 + x'_4 - x'_5 = 0.$$

Such a transformation is the following:

*The case $\alpha_{12} = \alpha_{34} = 0$ is not considered since then the space $A = 0$ would coincide with the space $B = 0$ and the V_3^3 would become reducible.

$$(27) \quad \begin{aligned} x_1 &= \frac{\alpha_{32}}{\alpha_{13} + \alpha_{32}} x'_1 + \frac{\alpha_{42} (\alpha_{35} + \alpha_{15}) + \alpha_{32} (\alpha_{35} + \alpha_{54})}{(\alpha_{35} + \alpha_{54}) (\alpha_{13} + \alpha_{32})} x'_2 \\ x_2 &= \frac{\alpha_{13}}{\alpha_{13} + \alpha_{32}} x'_1 + \frac{\alpha_{13} (\alpha_{35} + \alpha_{54}) + \alpha_{34} (\alpha_{35} + \alpha_{15})}{(\alpha_{35} + \alpha_{54}) (\alpha_{13} + \alpha_{32})} x'_2 \\ x_3 &= x'_3 + \frac{\alpha_{51} + \alpha_{54}}{\alpha_{35} + \alpha_{54}} x'_4, \quad x_4 = \frac{\alpha_{35} + \alpha_{16}}{\alpha_{35} + \alpha_{54}} x'_4, \quad x_5 = \frac{\alpha_{34} (\alpha_{35} + \alpha_{15})}{\alpha_{53} (\alpha_{35} + \alpha_{54})} x'_5 \end{aligned}$$

The V_3^3 has now the equation

$$x_4 (2x_5 - \sum_1^4 x_i) (x_1 + x_2) - \sum_1^4 x_i (x_4 - x_3) x_2 = 0,$$

which by means of the transformation

$$2x_5 - \sum_1^4 x_i = 2x'_5, \quad x_1 + x_2 = x'_1, \quad x_3 + x_4 = x'_3, \quad x_3 - x'_4$$

is carried into the form

$$(28) \quad x_1 x_5 (x_3 - x_4) + (x_1 + x_3) x_2 x_4 = 0.$$

Four double-points, namely $(0,0,0,0,1)$; $(0,1,0,0,0)$; $(0,1,0,0,1)$; $(1,0,0,0,0)$; $(1,0,0,0,0)$, lie in the plane $x_3 = x_4 = 0$, and of these the first three are on the double-line $x_1 = x_3 = x_4 = 0$. The remaining three double-points outside the double-line are, $(0,0,1,0,0)$, $(0,0,0,1,0)$, $(-1,0,1,1,0)$. This surface has been considered by SEGRE.* Its dual is a surface of the fourth class and has the equation

$$(29) \quad [u_5 (u_1 - u_3) - u_2 (u_3 + u_4)]^2 = 4u_1 u_2 u_4 u_5.$$

It should be noted that whenever the fifth associated plane (25) intersects the remaining four in four points of which any three are colinear, the plane will coincide with one of the four. The four points of intersection (double-points) are:

1. $(0,0, (\alpha_{51} + \alpha_{25}) (\alpha_{12} + \alpha_{24} + \alpha_{41}), (\alpha_{51} + \alpha_{25}) (\alpha_{13} + \alpha_{32} + \alpha_{21}), \alpha_{12} D)$,
- (30) 2. $((\alpha_{53} + \alpha_{45}) (\alpha_{23} + \alpha_{34} + \alpha_{42}), (\alpha_{53} + \alpha_{45}) (\alpha_{31} + \alpha_{14} + \alpha_{43}), 0, 0, \alpha_{34} D)$
3. $(\alpha_{25} (\alpha_{63} + \alpha_{15}), \alpha_{51} (\alpha_{53} + \alpha_{45}), \alpha_{54} (\alpha_{51} + \alpha_{25}), \alpha_{35} (\alpha_{51} + \alpha_{25}), 0)$.
4. $(\alpha_{53} + \alpha_{45}, \alpha_{15} + \alpha_{54}, \alpha_{15} + \alpha_{55}, \alpha_{51} + \alpha_{25}, D)$, and it is easily seen

that the matrix of any three of these points is of rank 2 whenever any one of the four conditions $\alpha_{45} + \alpha_{53} = 0$, $\alpha_{15} + \alpha_{52} = 0$, $D = 0$, $\alpha_{12} (\alpha_{35} + \alpha_{54}) + \alpha_{34} (\alpha_{25} + \alpha_{51}) = 0$ is satisfied. In the first case 2, 3 and 4 are colinear, in the second, 1, 3 and 4, in the third, 1, 2 and 4 and finally in the last case 1, 2 and 3 are colinear.

6. The transformation (27) is ineffective in the following two cases: 1°. $\alpha_{13} = \alpha_{23}$. 2°. $\alpha_{35} = \alpha_{45}$. In the first place we have $\alpha_{35} = 0$, since $\alpha_{15} = \alpha_{25}$. Writing the plane $A = B = 0$ in the form $\alpha_{12} x_1 + \alpha_{23} x_2 + \alpha_{43} x_4 + \alpha_{53} x_5 = 0$, $\alpha_{15} x_1 + \alpha_{25} x_2 + \alpha_{35} x_3 + \alpha_{45} x_4 = 0$, we see that A and B coincide. V_3^3 is reducible.

In the second case we may find a projective transformation which

*C. SEGRE, Mem. Acc. Torino (2) 39 (1888).

will carry $A=B=0$ into the plane $x_1+x_2-x_3-x_4=0, x_1-x_2+x_4-x_5=0$.

The equation of V_3^3 is now

$$2x_5(x_1+x_2)(x_3+x_4) - \sum_1^4 x_1(x_1x_3+2x_4x_1-x_2x_3) = 0,$$

which may be further simplified by setting

$$2x_5 - \sum_1^4 x = x'_5, \quad x_1+x_2 = x'_1, \quad x_3+x_4 = x'_3, \quad 2x_2 = x'_2, \quad x_4 = x'_4;$$

we have then finally,

$$(31) \quad V_3^3 = x_1x_3x_5 - (x_1+x_3)(x_1x_4-x_2x_3) = 0.$$

This V_3^3 has a double-plane every point of which is bispatial. The locus of unispatial points is a conic section whose equations are $x_1=x_3=0, (x_5-x_4+x_2)^2+4x_2x_4=0$.

Of the 10 double-points only six remain: $(0,0,0,0,1), (0,0,0,1,0), (0,0,0,1,2), (0,1,0,0,0), (0,-1,0,0,2), (0,1,0,1,0)$ the last three lying outside of the double-plane. These points are all bispatial. There are five planes on the surface, namely the four fundamental planes $x_1=x_2$

$$=0; \quad x_3=x_4=0; \quad x_5=0; \quad x_1+x_3=0; \quad x_1-x_3=0; \quad x_2-x_4 + \frac{x_3}{2} = 0; \quad \text{and}$$

the double-plane $x_1=x_3=0$. This V_3 has also been considered by C. SEGRE. It is the only cubic in S , whose Hessian vanishes identically.

Encyclopädie der Mathematischen Wissenschaften, III, C, 7. Also Mem. Acc. Torino (2) 29 (1888).

NON-INVOLUTORIAL CREMONA TRANSFORMATIONS
BELONGING TO A NON-SPECIAL LINEAR
LINE COMPLEX

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Introduction. We here consider the most general non-involutorial Cremona space transformation which has the property that each point of space and its image lie on a ray of a non-special linear complex, a single pair on a generic ray. We say that such a transformation T belongs to the linear complex Γ .

D. Montesano has given a brief synthetic discussion of such transformations T .¹

It is the purpose of the present paper to continue the synthetic discussion and to obtain the equations of the transformation in the most general case.

1. **The correspondence M .**² Consider two superimposed ordinary spaces Σ and Σ' , such that $\Sigma \propto \Sigma'$ under T . To each point P of Σ (or P' of Σ') corresponds the unique Γ -ray PP' . These two representations of the lines of Γ upon the points of Σ and of Σ' shall be designated by M and M' respectively. It is clear that $T \equiv M^{-1} M'$, and $T^{-1} \equiv M'^{-1} M$.

A generic point O corresponds in M^{-1} to a Γ -line o through O , hence O is a simple point on the image curve in M of the Γ -pencil (O, ω) . A line of (O, ω) meets this image curve in O and in one other point, hence the image in M (or M') of (O, ω) is a conic Δ_2 (or Δ'_2) in ω through O . Hence, under T , $\Delta_2 \propto \Delta'_2$.

Two Γ -pencils with a common line correspond in M (or M') to two conics which meet in the image point of the common line. Hence, a Γ -regulus R corresponds in M (or M') to a quartic curve Δ_4 (or Δ'_4) of genus 0 which has the lines of R for unisecants. Hence, under T , $\Delta_4 \propto \Delta'_4$.

The surface F (or F'), locus of the image points in M (or M') of the lines of a linear Γ -congruence Q_1 , is cut by a plane through a directrix p of Q_1 in p and the Δ_2 (or Δ'_2) associated with the Γ -pencil in the plane. Hence, a linear Γ -congruence Q_1 corresponds in M (or M') to a cubic surface $F_3: pq$ (or $F'_3: pq$), where p and q are the directrices of Q_1 . It follows that, under T , $F_3 \propto F'_3$.

2. **The Fundamental Curve C_5 .** The pencil of surfaces $|F_3|$ (or

¹Su la curva gobba di 5° ordine e di genere 1, Napoli Accademia delle Scienze Fisiche e Matematiche Rendiconti, ser. 2 vol. 2 (1888) pp. 181-188.

²l. c.

$|F'_3|$) associated with a pencil of linear Γ -congruences $|Q_1|$ has for base, in addition to the Δ_4 (or Δ'_4) associated with the regulus base of the pencil of congruences, a further curve C_5 (or C'_5), base of the $\alpha^4|F_3|$ (or $\alpha^4|F'_3|$) associated with the lines of space. Since the postulation of C_5 on F_3 must be 15, it follows that the fundamental curve C_5 (or C'_5) is of genus 1 and meets each Δ_4 (or Δ'_4) in 10 points, and each Δ_2 (or Δ'_2) in 5 points.

3. **The Surface R_5 of Trisecants to C_5 .** From a point of C_5 can be drawn a cone K_4 of bisecants to C_5 . Since C_5 is of genus 1, K_4 has two double edges. Hence two trisecants of C_5 issue from a point on it, and C_5 is a double curve on its surface of trisecants. Since each trisecant meets three others, the surface of trisecants of C_5 is $R_5:C_5^2$. Similarly, the surface of trisecants of C'_5 is $R'_5:C'^2_5$.

The Δ_2 in the plane ω determined by two intersecting trisecants of C_5 breaks up into the two trisecants, since it is determined by the 5 points $[\omega, C_5]$. The vertex O of the Γ -pencil in ω must be at their point of intersection, hence the surface R_5 belongs to Γ . Since R_5 can not belong to a linear congruence, it belongs to the unique linear complex Γ . Similarly, R'_5 belongs to Γ .

If a Γ -pencil (O, ω) contains one trisecant t of C_5 , the Δ_2 is composite, being composed of the line t and a residual line b through the two points $[\omega, C_5]$ not on t . A generic linear Γ -congruence Q_1 contains 5 trisecants to C_5 , hence 10 pencils of Q_1 correspond in M to composite conics, and $Q_1 \varsubsetneq F_3:5t_1|0b_1$, where the t_1 are trisecants and the b_1 bisecants of C_5 . Since the two trisecants through a point of C_5 determine the Γ -pencil of the point, no bisecant of C_5 can belong to Γ . This result also follows from Halphen's theorem, since the Q_1 and the $Q_{5,10}$ of bisecants of C_5 intersect in the R_5 counted three times.

In particular, if the Γ -pencil (O, ω) has vertex O on C_5 , its image in M is the composite $\Delta_2 \equiv t_1, t_2$, hence each Γ -line a which is a unisecant of C_5 corresponds in M to the point of incidence.

4. **Some Further Properties of M .** A Γ -congruence Q_n of order n contains n lines of each Γ -pencil with vertex on C_5 , hence the image surface F^N of Q_n contains C_5 to multiply n . Since Q_n contains n lines of a generic Γ -pencil, the Δ_2 , image of the pencil, meets F^N in n variable points. Since $[\Delta_2, C_5] = 5A_1$, $[\Delta_2, F^N] = 2N = 5A^{n_1} + n$, and $N = 3n$. Hence, in M , $Q_n \varsubsetneq F_{3n}:C^n_5$. If the $Q_n:R^h_5$, its image is $R^h_5 + F_{3n-5h}:C^{n-2h}_5$. Conversely, $F_k:C^h_5 \varsubsetneq$ a Γ -congruence $Q_{2k-5h}:R^{k-2h}_5$.

A ruled Γ -surface $R_n \varsubsetneq$ a curve C_{2n} on R_n , where $[C_5, C_{2n}] = 5n$. The complete intersection of R_n with C_5 is on the C_{2n} . In particular if R_n contains π trisecants t_1 of C_5 , its image in M is a $C_{2n-\pi} +$ the π trisecants. Conversely, the image in M^{-1} of a curve C_n which meets C_5 in h points is a ruled surface $R_{3n-h}:C_n$.

5. **The Transformation T.** The image in T of a generic plane ω is $F'_N: C'^2_5$, and $\Delta_2 \omega \Delta'_2$. $[\omega, \Delta_2] =$ for any Δ_2 not in ω , hence $[F'_N, \Delta'_2] = 2N = 2 + 10$, and the T is of order 6. Since there must be a further fundamental curve C'_{10} of order 10, the homoloidal webs of T and T^{-1} are respectively $\alpha^3 |F'_5|: C'^2_5 C'_{10}$, and $\alpha^3 |F_6|: C_5 C_{10}$.

A plane ω cuts its image F'_6 in the Δ'_2 of the plane and in a residual pointwise invariant curve k_4 , hence the pointwise invariant surface of T is $K_4: C_5 C'_5$. This also follows from the fact that the congruence of Γ —lines joining pairs of consecutive points PP' is of order 3 and contains R_5 and R'_5 . The curve k_4 meets Δ_2 in the three points $[\Delta_2, \Delta'_2]$ other than the vertex O of the Γ -pencil is ω , and in the 5 points $[C_5, \Delta_2]$. Similarly, k_4 meets Δ'_2 in the three points $[\Delta_2, \Delta'_2]$ other than O, and in the 5 points $[C'_5, \Delta'_2]$.

Since the image in M^{-1} of C_5 is a Γ -congruence Q_5 , it corresponds in T to $J'_{15}: C'^5_5$.

The image in T of each point P of a trisecant t of C_5 is the same point P' . Hence, in $T^{-1}, P' \omega t$, and is fundamental. Since, aside from C'_5 the only fundamental curve for T^{-1} is C'_{10} , the locus of P' must be C'_{10} , and in $T^{-1}, C'_{10} \omega R_5: C'^2_5$. Similarly $C_{10} \omega R'_5: C'^2_5$ in T.

Since the image in T of a trisecant t of C_5 is P' , the locus C'_{10} of P' is triple on the image J'_{15} of C_5 . The jacobian of T is then composed of $R'_5: C'^2_5$, image of C_{10} , and $J'_{15}: C'^5_5 C'^3_{10}$, image of C_5 ; and the jacobian of T^{-1} is composed of $R_5: C'^2_5$ and $J_{15}: C^5_5 C^3_{10}$.

The R'_5 and J'_{15} meet, besides in C'_5 , in 25 triseants of C'_5 hence $[C'_5, C'_{10}] = 25$, and $[C_5, C_{10}] = 25$.

The genus of C_{10} (or C'_{10}) is 1, the same as that of R'_5 (or R_5).

The equivalence of C_5 and C_{10} (or C'_5 and C'_{10}) on surfaces F_6 (or F'_6) of the homoloidal web is 215, hence three surfaces of the web have in common one point not on the fundamental curves; and that point is the image in T^{-1} (or T) of the point of intersection of the three planes whose images are the three F_6 (or F'_6). It follows that there are no fundamental points in T^{-1} (or T) except those which form the curves C_5 and C'_{10} (or C'_5 and C'_{10}).

6. **The Equations of T.** There are $\alpha^4 |F_3|$ (and $\alpha^3 |F'_3|$), one associated with each linear Γ -congruence. But a single pencil $|F^3|$, together with the associated pencil $|F'_3|$, is sufficient to determine T.

The directrices of the pencil $|Q_1|$ of linear Γ -congruences which give rise to the pencils $|F_3|$ and $|F'_3|$ form a regulus R' lying on the quadric H with the Γ -regulus R, base of the pencil $|Q_1|$. Through a point P of space passes one surface F_3 of the pencil $|F_3|$. Through P passes a unique transversal of the directrices of the congruence Q_1 associated with F_3 . This transversal meets the surface F'_3 corresponding to F_3 in a residual point P' , image of P in T.

If we denote by $x_1 x_3 - x_2 x_4 = 0$, $x_1/x_2 = x_4/x_3 = k$, and $x_1/x_4 = x_2/x_3 = m$, the quadric H , the lines of R , and the lines of R' respectively, the pencil $|F_3|$ may be written

(1) $F_1 - \varrho^2 F_2 = 0$, where $F_1 = ux_1^2 + vx_1 x_2 + wx_2^2$, $F_2 = ux_4^2 + vx_3 x_4 + wx_3^2$, $u = \sum_1^4 a_i x_i$, $v = \sum_1^4 b_i x_i$, and $w = \sum_1^4 c_i x_i$. The pencil (1) becomes

(2) $u(x_1^2 - \varrho^2 x_4^2) + v(x_1 x_2 - \varrho^2 x_3 x_4) + w(x_2^2 - \varrho^2 x_3^2) = 0$. This surface (2) contains the two lines of R' , g_1 ; $x_1 = \varrho x_4$, $x_2 = \varrho x_3$, and g_2 ; $x_1 = -\varrho x_4$, $x_2 = -\varrho x_3$. The pencil $|F'_3|$ associated with $|F_3|$ in T may be written

(3) $u'(x_1^2 - \varrho^2 x_4^2) + v'(x_1 x_2 - \varrho^2 x_3 x_4) + w'(x_2^2 - \varrho^2 x_3^2) = 0$, where $u' = \sum_1^4 a'_i x_i$, $v' = \sum_1^4 b'_i x_i$, $w' = \sum_1^4 c'_i x_i$.

Through a generic point $P(y)$ of space passes a single surface F of (2) for which

(4) $\varrho^2 = F_1(y)/F_2(y)$. The transversal t of g_1 and g_2 through $P(y)$

$$\text{is } t; \begin{cases} (y_2 - \varrho y_3)(x_1 - \varrho x_4) - (y_1 - \varrho y_4)(x_2 - \varrho x_3) = 0, \\ (y_2 + \varrho y_3)(x_1 + \varrho x_4) - (y_1 + \varrho y_4)(x_2 + \varrho x_3) = 0. \end{cases}$$

This line t meets g_1 and g_2 in G_1 and G_2 respectively where

$$(5) \begin{cases} G_1; x_1 = \varrho(y_1 + \varrho y_4), x_2 = \varrho(y_2 + \varrho y_3), x_3 = y_2 + \varrho y_3, x_4 = y_1 + \varrho y_4, \\ G_2; x_1 = -\varrho(y_1 - \varrho y_4), x_2 = -\varrho(y_2 - \varrho y_3), x_3 = y_2 - \varrho y_3, x_4 = y_1 - \varrho y_4. \end{cases}$$

Any point on t has coordinates

(6) $x_1 = y_1 + \varrho^2 n y_4$, $x_2 = y_2 + \varrho^2 n y_3$, $x_3 = y_3 + n y_2$, $x_4 = y_4 + n y_1$. It should be noted that $n = 0$, $1/\varrho$, $-1/\varrho$ gives the points P , G_1 , and G_2 respectively. We wish to find the value of n which gives the point P' , residual intersection of t with F' .

When (6) is substituted in (3) we obtain, after dividing out the factor $(1 - \varrho^2 n^2)$,

$$(7) [a'_1(y_1 + \varrho^2 n y_4) + a'_2(y_2 + \varrho^2 n y_3) + a'_3(y_3 + n y_2) + a'_4(y_4 + n y_1)] [y_1^2 - \varrho^2 y_4^2] + [b'_1(y_1 + \varrho^2 n y_4) + b'_2(y_2 + \varrho^2 n y_3) + b'_3(y_3 + n y_2) + b'_4(y_4 + n y_1)] [y_1 y_2 - \varrho^2 y_3 y_4] + [c'_1(y_1 + \varrho^2 n y_4) + c'_2(y_2 + \varrho^2 n y_3) + c'_3(y_3 + n y_2) + c'_4(y_4 + n y_1)] [y_2^2 - \varrho^2 y_3^2] = 0.$$

In the following we shall write F_1 , F_2 , u , v , w , u' , v' , and w' in place of $F_1(y)$, \dots , $w'(y)$.

When ϱ^2 is replaced by its value from (4) we note that

$$(8) F_2 y_1^2 - F_1 y_4^2 = UH, F_2 y_1 y_2 - F_1 y_3 y_4 = -VH, F_2 y_2^2 - F_1 y_3^2 = -WH, \text{ where}$$

(9) $U = y_1 y_4 v + Hw$, $V = y_1 y_4 u - y_2 y_3 w$, $W = Hu + y_2 y_3 v$, $H = y_1 y_3 - y_2 y_4$, $\mathbf{H} = y_1 y_3 + y_2 y_4$. The expression (7) then becomes

$$(F_2 u' + An)U - (F_2 v' + Bn)V - (F_2 w' + Cn)W = 0, \text{ where}$$

$$A = a'_1 F_1 y_4 + a'_2 F_1 y_3 + a'_3 F_2 y_2 + a'_4 F_2 y_1,$$

$$B = b'_1 F_1 y_4 + b'_2 F_1 y_3 + b'_3 F_2 y_2 + b'_4 F_2 y_1,$$

$C = c'_1 F_1 y_4 + c'_2 F_1 y_3 + c'_3 F_2 y_2 + c'_4 F_2 y_1$. This is of the form $F_2 K_4 + nL = 0$, where $K_4 = Uu' - Vv' - Ww'$, $L = AU - BV - CW$. From

(6) we obtain

$$(10) \quad x_1 = Ly_1 - F_1 K_4 y_4, \quad x_2 = Ly_2 - F_1 K_4 y_3, \quad x_3 = Ly_3 - F_2 K_4 y_2, \\ x_4 = Ly_4 - F_2 K_4 y_1.$$

It appears at once that $K_4 = 0$ is the invariant surface of the transformation.

When K_4 and L are replaced by their values (10) becomes, after the removal of a factor H ,

$$(11) \quad x_1 = (a'_2 F_1 - a'_3 V + a'_4 U) U - (b'_2 F_1 - b'_3 V + b'_4 U) V - (c'_2 F_1 - c'_3 V + c'_4 U) W, \\ x_2 = -(a'_1 F_1 + a'_3 W + a'_4 V) U + (b'_1 F_1 + b'_3 W + b'_4 V) V + (c'_1 F_1 + c'_3 W + c'_4 V) W, \\ x_3 = (a'_1 V + a'_2 W + a'_4 F_2) U - (b'_1 V + b'_2 W + b'_4 F_2) V - (c'_1 V + c'_2 W + c'_4 F_2) W, \\ x_4 = -(a'_1 U - a'_2 V + a'_3 F_2) U + (b'_1 U - b'_2 V + b'_3 F_2) V + (c'_1 U - c'_2 V + c'_3 F_2) W.$$

These are the equations of T^{-1} . Those of T can be written by analogy.

7 Discussion of results. The Plücker coördinates of a generic Γ -line PP' are found from (5) to be proportional to $p_{12} = Q^2(y_1 y_3 - y_2 y_4)$, $p_{13} = (y_1 y_2 - Q^2 y_3 y_4)$, $p_{14} = (y_1^2 - Q^2 y_4^2)$, $p_{23} = (y_2^2 - Q^2 y_3^2)$, $p_{42} = -(y_1 y_2 - Q^2 y_3 y_4)$, $p_{34} = (y_1 y_3 - y_2 y_4)$. These simplify by means of (4) and (8) to $p_{12} = F_1$, $p_{13} = -V$, $p_{14} = U$, $p_{23} = -W$, $p_{42} = V$, $p_{34} = F_2$. It follows from the fundamental relation that $F_1 F_2 = V^2 + UW$.

A generic linear Γ -congruence Q_1 is the intersection of $\Gamma \equiv p_{13} + p_{42} = 0$ with

$$(12) \quad \alpha_{12} p_{12} + \alpha_{13} p_{13} + \alpha_{14} p_{14} + \alpha_{23} p_{23} + \alpha_{42} p_{42} + \alpha_{34} p_{34} = 0. \text{ The image in } M \text{ of } Q_1 \text{ is}$$

$$(13) \quad \alpha_{12} F_1 - \alpha_{13} V + \alpha_{14} U - \alpha_{23} W + \alpha_{42} V + \alpha_{34} F_2 = 0. \text{ If the } \alpha_{1k} \text{ are considered as parameters, these equations represent the } \infty^4 |Q_1| \text{ of } \Gamma \text{ and the associated } \infty^4 |F_3|.$$

The Plücker coördinates of the directrices p and q of Q_1 are respectively $p_{12} = \alpha_{34}$, $p_{13} = \alpha_{42}$, $p_{14} = \alpha_{23}$, $p_{23} = \alpha_{14}$, $p_{42} = \alpha_{13}$, $p_{34} = \alpha_{12}$ and $p_{12} = \alpha_{34}$, $p_{13} = -\alpha_{13}$, $p_{14} = \alpha_{23}$, $p_{23} = \alpha_{14}$, $p_{42} = -\alpha_{12}$, $p_{34} = \alpha_{12}$.

These lines may be written

$$p; \quad y_1 = \alpha_{23} + \lambda \alpha_{12}, \quad y_2 = -\alpha_{13} + \lambda \alpha_{14}, \quad y_3 = \alpha_{12}, \quad y_4 = -\lambda \alpha_{12},$$

$$q; y_1 = \alpha_{23} + \lambda \alpha_{13}, y_2 = \alpha_{42} - \lambda \alpha_{14}, y_3 = \alpha_{12}, y_4 = \lambda \alpha_{12}.$$

By means of (9) two surfaces of (13) may be written

$$F \equiv Ru + Sv + Tw = 0, F \equiv Ru + Sv + Tw = 0, \text{ where}$$

$$R = \alpha_{12} y_1^2 + \alpha y_1 y_4 - \alpha_{23} H + \alpha_{34} y_4^2,$$

$$S = \alpha_{12} y_1 y_2 + \alpha_{14} y_1 y_4 - \alpha_{23} y_2 y_3 + \alpha_{34} y_3 y_4,$$

$$T = \alpha_{12} y_2^2 - \alpha y_2 y_3 + \alpha_{14} H + \alpha_{34} y_3^2,$$

$$R = \check{\alpha}_{12} y_1^2 + \check{\alpha} y_1 y_4 - \check{\alpha}_{23} H + \check{\alpha}_{34} y_4^2,$$

$$S = \check{\alpha}_{12} y_1 y_2 + \check{\alpha}_{14} y_1 y_4 - \check{\alpha}_{23} y_2 y_3 + \check{\alpha}_{34} y_3 y_4,$$

$$T = \check{\alpha}_{12} y_2^2 - \check{\alpha} y_2 y_3 + \check{\alpha}_{14} H + \check{\alpha}_{34} y_3^2,$$

$$\alpha = \alpha_{42} - \alpha_{13}, \check{\alpha} = \check{\alpha}_{42} - \check{\alpha}_{13}.$$

If between $F=0$ and $F=0$ we eliminate in turn $u, v,$ and w the resulting expressions are $\varphi_2 U=0, \varphi_2 V=0,$ and $\varphi_2 W=0$ respectively, where $\varphi_2 = |\alpha_2 \check{\alpha}_{14}| y_1^2 + |\alpha_{12} \check{\alpha}_{23}| y_2^2 + |\check{\alpha}_{34} \alpha_{23}| y_3^2 + |\alpha_{34} \check{\alpha}_{14}| y_4^2 + |\alpha \check{\alpha}_{12}| y_1 y_2 + |\alpha \check{\alpha}_{14}| y_1 y_4 + |\alpha_{23} \check{\alpha}| y_2 y_3 + |\alpha \check{\alpha}_{34}| y_3 y_4 + |\alpha_{14} \check{\alpha}_{23}| H + |\alpha_{12} \check{\alpha}_{34}| H, |\alpha_{ik} \check{\alpha}_{st}| = \alpha_{ik} \check{\alpha}_{st} - \check{\alpha}_{ik} \alpha_{st}.$

This quadratic $\varphi_2=0$ contains p, q, p, q and their regulus R of transversals, the latter being the Γ -regulus common to the congruences Q_1 and Q_1 , images in M^{-1} of F and F .

$[\varphi_2, F] = p, q, \Delta_4,$ and $[\varphi_2, F] = p, q, \Delta_4$ the Δ_4 of type $[1, 3]$ hence of genus 0, being the image in M of R . $[F, F] = \Delta_4 C_5$. The C_5 of genus 1 evidently lies on $U, V, W, F_1,$ and $F_2,$ hence is the base of the system (13).

From (11) we note that the images in T^{-1} of $V'(x)=0, F'_6(x) \equiv (a_2 F'_1 - a_3 V' + a_4 U')U' - (b_2 F'_1 - b_3 V' + b_4 U')V' - (c_2 F'_1 - c_3 V' + c_4 U')W' = 0,$ and $K_4(x)=0$ are respectively $VJ_{15}=0, y_1 J_{15}^2 R_5=0,$ and $K_4 J_{15} R_5=0$. The factors $V=0, y_1=0, K_4=0, J_{15}=0,$ and $R_5=0$ are the images respectively of the proper points on $V'(x)=0,$ the proper points on $F'_6(x)=0,$ the proper points on $K_4(x)=0,$ the curve C'_5 and the curve C'_{10} . In this manner the equations of J_{15} and R_5 may be obtained. It is apparent that $J_{15}: C_5^5 C_{10}^3, R_5: C_5^2,$ and $K_4: C_5 C'_5 C_{10} C'_{10}.$

THE CREMONA TRANSFORMATIONS BELONGING TO
A SPECIAL QUADRATIC COMPLEX OF LINES
MEETING A CONIC

By

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(Abstract)

Introduction. Cremona transformations belonging to quadratic complexes have not been studied to any great extent. Montesano studied the transformations belonging to the general quadratic complex and found that there are no transformations unless the complex contains a linear congruence or a bundle of lines. The tetrahedral complex has been discussed by Montesano and Pieri has discussed the complex of secants of a conic.

In the discussion of Pieri, synthetic methods were used entirely. However synthetic reasoning becomes extremely difficult if there are any contacts. He has discussed the general case where no contact occurs. In this paper the problem has been attacked from the analytic standpoint and special cases which arise due to contacts are discussed.

Determination of T. Consider a conic φ_2 , lying in plane π , and a line g meeting φ_2 at 0. A pencil of quadratic surfaces $\infty^3 |F_4| = \infty (F_1 - \rho F_2)$ passing simply thru g and doubly thru φ_2 together with the associated pencil $\infty^3 |F'_4|$ is sufficient to determine T. Any line t which meets g and φ_2 will meet $|F_4|$ in a point on g which we will call D; a point on φ_2 which we will call B, counted twice; and one other point. If we determine the parameter so that $|F_4|$ passes through the point $P_{(y)}$, and then put this parameter in the associated $|F'_4|$, the $|F'_4|$ then passes through D once, B twice, and one other point $P'_{(x)}$.

$$\therefore P_{(y)} \underset{\mathcal{Q}}{T} P'_{(x)}$$

We stated first that Montesano had proved that transformations do not exist unless the complex contains a linear congruence or a bundle. Consider any line l whose Plücker coordinates are p_{ik} . Then

$$p_{12} p_{34} + p_{13} p_{42} + p_{14} p_{23} = 0.$$

If this line meets φ_2 then the p_{ik} must satisfy the equation of the complex, or

$$\Gamma = (p_{12} - p_{14}) (p_{23} + p_{34}) + p_{42}^2 = 0.$$

Take a general linear complex of lines

$$\infty^5 |\Gamma_1| \equiv \beta_1 p_{12} + \beta_2 p_{13} + \beta_3 p_{14} + \beta_4 p_{23} + \beta_5 p_{42} + \beta_6 p_{34} = 0.$$

Now Γ and Γ_1 intersect in a quadratic congruence, or

$$[\Gamma \Gamma_1] = Q_{2,2}.$$

We choose a line $l\alpha_{1k}$, and if we make lp_{1k} and $l\alpha_{1k}$ intersect, we must have

$$\alpha_{34}p_{12} + \alpha_{42}p_{13} + \alpha_{23}p_{14} + \alpha_{14}p_{23} + \alpha_{13}p_{42} + \alpha_{12}p_{34} = 0.$$

Making $l\alpha_{1k}$ belong to Γ_1 , we have,

$$\infty^4 |\Gamma_1| \equiv \alpha_{34} p_{12} + \alpha_{42} p_{13} + \alpha_{23} p_{14} + \alpha_{14} p_{23} + \alpha_{13} p_{42} + \alpha_{12} p_{34} = 0, \text{ and}$$

$$\alpha_{12} \alpha_{34} + \alpha_{13} \alpha_{42} + \alpha_{14} \alpha_{23} = 0.$$

We have ∞^4 special complexes, consisting of all lines meeting a line $l\alpha_{1k}$. If we make this directrix meet φ_2 then

$$(\alpha_{12} - \alpha_{14}) (\alpha_{23} + \alpha_{34}) + \alpha_{42}^2 = 0.$$

Then the surfaces associated with the complexes are

$$\infty^3 |F_7| = \infty^3 |F_4 F_3|$$

for the congruence of lines meeting g and φ_2 consists of two parts

- (i) lines meeting g and φ_2 outside of O .
- (ii) the bundle of lines on O .

The lines meeting g and φ_2 outside of O correspond to the F_4 and the bundle of lines through O correspond to the F_3 .

This gives us a second way of setting up our transformations. Instead of using the $\infty^3 |F_4|$ we may use the $\infty^3 |F_3|$. These surfaces have a double point at O . Then any line of the bundle on O meets $|F_3|$ in two points at O and in one other point. If we choose the parameter such that $|F_3|$ passes through $P^{(y)}$ and put this in the associated $|F_3'|$, then the line meets $|F_3'|$ twice at O and in one other point $P'^{(x)}$.

$$\therefore \begin{array}{ccc} P^{(y)} & T & P'^{(x)} \\ & \mathcal{Q} & \end{array}$$

Special Transformations. The general transformation is of order 12. In it our $|F_4|$ was set up so that no contact existed between the base surfaces. However, if we have F_1 and F_2 tangent along one branch in φ_2 then we find that π^2 factors off our transformation and we get a T_{10} instead of a T_{12} . The T_{10} is set up in the same way as before.

Again if we make F_1 and F_2 tangent along both branches in φ_2 the factor which comes off is $\pi^3 p$, where p is one of the common tangent planes to F_1 and F_2 . In this case the transformation reduces to a T_8 .

The question arises that, if now we have made both branches of F_1 and F_2 tangent in pairs in φ_2 , can we make the two tangent planes coincide, and hence have a cuspidal edge? The answer is no; for if we make both tangents coincide we have placed so many conditions upon F_1 and F_2 that we fail to have the $\infty^3 |F_4|$ necessary for a transformation.

RELIGIOUS CONCEPTS OF COLLEGE STUDENTS

By

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What do religious concepts such as God, Christ, church, Christian, or immortality mean to typical college students of our day?

In recent years, current opinion holds that our young people lack inclination and ability to do serious thinking; that the sundayschool as it is conducted is losing its efficiency and must be either supplemented or supplanted; and that the church is losing its hold on the rising generation. If this picture be based on fact may we not detect a weakness in the religious concepts shared by young people who have come up through the elementary and high school grades?

Ideally, religious concepts through home influence, the sundayschool instruction, the church environment, and other socio-religious experiences enlarge and become more meaningful with the maturation of the individual. This being the case, there is no reason for apologies for an attempt to secure objective data concerning the fundamental religious concepts of college students. It has been pointed out that a person must know about 114 such terms¹ as those referred to here, to fully comprehend church literature but almost half of these are so seldom used that they are not regarded as fundamental. Because poor concepts mean poor understanding and vague thinking that may end in vicious attitudes, we have assumed that certain terms of high frequency and expressing indispensable ideas to Christian thinking are fundamental concepts.

The writer is here reporting a study made by himself assisted by students in his classes in Education, of the religious concepts of students in Bethany College which is probably as nearly typical of liberal arts colleges of today as one may find. This study, though on the college level, is quite similiar to that of Bose who tested pupils below the college to determine, "the religious thinking of some 2500 children between ages 8 and 18 in the church schools of Southern California to attempt to discover the meaning that children associate with some concepts current in religious thinking and to measure the development in meaningfulness of these concepts with maturing youth."

The conclusions reached were that "if one's thinking is no better than his concepts, the religious thinking of the children studied is inadequate, vague and confused. The children are unfamiliar with the religious experiences epitomized by the various religious concepts current in religious thinking."

¹Roy G. Bose, Religious Concepts of children, Religious Education, Nov. 1929.

The Objective of the Present Study

The three-fold objective of the present study is:

1. To measure the degree of uniformity of meaning held by college students.
2. To measure the maturation of these concepts within the college.
3. To compare the concepts of college students with similiar data for students of pre-college age and with standard definitions of such religious terms.

The Data

A chapel period in Bethany College was devoted to explaining to the pupils present the importance of scientific attitude in studies of this sort and to giving a questionnaire containing 60 religious concepts. This is the same list used by Bose and represents the judgment of 22 directors of religious education as to the fundamental concepts found in religious literature comprising the International Graded Series or Quarterlies; ten current religious books; and the periodicals of the major denominations. While Bethany is known as a denominational college, many churches are represented as shown in Table I.

TABLE I, SHOWING THE CHURCH PREFERENCE OF STUDENTS IN BETHANY COLLEGE

No. Reporting	Denominational Preference
207	Disciples of Christ (Christian)
39	Methodist Episcopal
38	Presbyterian
14	Baptist
12	Catholic (Roman)
11	Episcopal
8	Lutheran
5	United Presbyterian
3	Christian Science
2	Congregational
2	Evangelical (German)
1	Methodist Protestant
1	Emerson New Thought
1	Jewish
<hr/> 344	<hr/> All included

A membership of 207 of one denomination as against 137 of all other denominations combined, at first appears to indicate a selected group but when it is known that the data given do not conform to denominational lines, the large number of one faith does not seem significant. The data of this study, no doubt, are typical of colleges of the Liberal Arts, in church schools, but there may be a variance because of the difficulty in getting youth to take a study of this sort seriously. Then

too, all the students here stated a church preference and this may mean that the non-church youth is not represented in this type of school.

Contrary to anticipations of the test, the data were furnished in good faith. The consistency of answers and other means of checking each paper indicate an average accuracy and reliability for studies based on questionnaires given to a group assembled. The few cases of evident insincerity or unwillingness to cooperate in a group study were detected and thrown out of the computations. All told, this is less than 1% of the total.

The list of sixty terms and the meanings they hold for a decided majority (55-100%) of each class and the faculty members who chose to take the test together with a standard definition such as that given in the *DICTIONARY OF RELIGION AND ETHICS* or else in Webster are given here. The students were directed to underscore one of five words following each term thereby indicating which came nearest to expressing what the term means.

WHAT THE FUNDAMENTAL RELIGIOUS CONCEPTS MEAN TO COLLEGE STUDENTS: STANDARD DEFINITIONS FOR COMPARISONS

1. **Sundayschool** in 80% to 90% of the cases of college students, is thought of as a place of religious instruction.
(a) (A school for religious instruction).
2. **Bible** is usually God's Word or the Christian's guidebook.
(A sacred book of the Christians).
3. **Old Testament** means the first part of the Bible or the part before Jesus.
(History of Jewish people).
4. **Savior** connotes saved from sin or Jesus died for us.
(Webster: One who saves, preserves, or delivers from evil, destruction or danger. Jesus Christ).
5. **God** most often means Heavenly Father or Supreme Being.
(A Supreme Being).
6. **Christian** is unanimously defined as a follower of Jesus.
(Disciple: racial and religious brotherhood).
7. **Sin** usually means disobeying God. It is sometimes thought of as against Christ's will.
(American conception is pollution, vice, crime).
8. **Salvation** means saved from sin.
(Redemption from sin).
9. **Christ** is our Savior or Jesus.
(Webster: the Anointed; the Savior; Jesus).
10. **Forgiveness** means to the college group sins pardoned or wrongs forgotten.
(a) Note: Statements in parenthesis are definitions from Dictionary of Religion and Ethics unless otherwise stated.

- (Establishment or restoration of union with God—to find grace with God).
11. **Holy Spirit** is understood as Spirit of God or a member of Trinity.
(A Being above the rank of angels and thought of as identical with Supreme Creator).
 12. **Conversion** is to become a Christian.
(The turning of man to God).
 13. **Prayer** means talking to God.
(Uplifting of the heart to God. Includes supplication, intercession, confession of sins, etc.).
 14. **Repentance** means that one is sorry for sins.
(Is the act of the soul breaking away from its past on a preliminary step to ethical reform).
 15. **New Testament** more often means the part of the Book about Jesus or the second part of the Bible.
(Second book of the Bible composed of 27 books).
 16. **Missions** mean either to extend the Gospel or convert heathen.
(Stations established to teach and train natives of a particular vicinity the teachings of a certain sect).
 17. **Fatherhood of God** suggests fatherhood of all with a suggestion that it means father of Christians.
(God is the Father of all. He created the world. This relation is shown by His dealing with Christ and man).
 18. **Mercy** is defined as forgiving wrongs or as helping others.
(A condition asked by an inferior person to a superior with the recognition of power ascribed to the powerful. A quality expressed by man in his relation with God and man).
 19. **Duty** is thought of as what ought to be done.
(Comes to us with a claim; it is a thing laid on us whether we like it or not).
 20. **Preacher** connotes one who proclaims the gospel. A leader of a church.
(One who proclaims; prophecy; one who leads public worship; teacher).
 21. **Sacrifice** means to give up something; burnt offering is most frequently suggested to those taking Old Testament.
(To ancient peoples, worship meant not only words but also offerings, as things dear to the worshiper which he denied himself in favor of his God).
 22. **Lord's Supper** to students means Christ's body and blood but the faculty responded in terms of Jesus' crucifixion.
(Breaking of bread; a sacred rite; Apostolic sacrificial eucharist).

23. **Brotherhood of Man** means all men as sons of God or all men brothers.
(A collective name for the whole body of mankind. All related).
24. **Worship** calls out the response "praise God" or "believe God."
(Praise and adoration).
25. **Son of God** usually means Jesus or Christian.
(Christ was Son of Living God in a deeper sense than words).
26. **Service** suggests willing helpfulness. Freshmen about as frequently responded in terms of waiting on some one.
(Looking after needs of others, physical, social, spiritual).
27. **Resurrection** means unananimously that Jesus rose from the dead.
(Jesus rose from His burial place).
28. **Sacred** means holy.
(Bible, sacred book, Word of God).
29. **Faith** is belief in God.
(Trust in power and goodness of God).
30. **Christmas** suggests Jesus' birthday.
(Feast of the nativity of Christ, Dec. 25).
31. **Sunday** means day of worship. The faculty is inclined to react more strongly to the fact of the first day of the week.
(Day for Christians to join in worship).
32. **Lord** is God to most students. Almost as many think of Christ as Lord.
(Either God or Christ).
33. **Soul** means inner spirit or the part that never dies.
(The whole "self;" personality; basis of conscious individual existence).
34. **Cross** is the symbol of Christianity of where Jesus was nailed.
(A wooden post supporting a crossbeam).
35. **Lord's Prayer** is the prayer that Jesus taught.
(Christ gave a form prayer that is to serve as a pattern).
36. **Redemption** means redeemed from sin.
(Of first born sons, sacrificed to God).
37. **Spiritual** usually means spirit of God (as against devil), or, not flesh.
(Of or pertaining to the soul or its affections as influenced by Divine).
38. **Easter** suggests Jesus rose from the dead.
(An annual church festival commemorating Christ's resurrection).
39. **Righteousness** means loyalty to right or to do God's will.
(The living essence of social ethics embracing honesty in business and impartial justice in the courts. The straight thing).
40. **Love** almost equally suggests friendship and worship.
(Earnest effort to promote the welfare of a person).

41. **Disciple** is a follower of Jesus. The faculty is inclined to think "learner."
(One who through earnest effort tries to promote the unity of the power of God).
42. **Baptism** suggests to this body of students, as a rule, immersions, but many responded, "to wash away sins."
(By the institution of God, the material elements of water together with the prescribed form of words is used to confer spiritual gifts).
43. **Gospel** means salvation through Christ. It also suggests the life of Christ.
(In the combination of these ideas—God the Father, Providence, the position of men as God's children, the infinite value of the human soul—the whole Gospel is expressed).
44. **Commandments** refer to rules of Moses or God's list of commandments but rarely of Christ's will.
(The ten commandments).
45. **Eternity** suggests endless time or everlasting life.
(Unending time; that which is entirely timeless; or that which includes time but also somehow transcends it).
46. **Word of God** means the Bible or possibly truth.
(An utterance or saying of God).
47. **Confession** refers to telling of sins or it is to admit belief in God and Christ.
(A public avowal and formal statement of the doctrinal contents of religious belief, framed by an individual or by a group of individuals).
48. **Temptation** suggests desire to do wrong, urgings of Satan or swerve from the right.
(That which tempts; an inducement; an allurements—especially to sense evil).
49. **Immortality** means that souls live forever.
(Exemption from death or annihilation).
50. **Will of God** about equally suggests doing the will of God and His commandments.
(Not given).
51. **Religion** means belief in God or else to be a Christian.
(A belief in an invisible superhuman power. Any system of faith, doctrine and worship).
52. **Children of God** is interpreted "human beings" or believers in God.
(Not given).
53. **Scriptures** means books of the Bible or else the whole Bible.
(The sacred writings of any people; text or passage from the Bible).
54. **Divine** is like God or sacred.
(Of the nature of God).

55. **Pacifist** suggests peacemaker.
(One who advocates peace; to bring into peaceful state, quiet).
56. **Conscience** is a feeling of right or wrong.
(The faculty by which distinctions are made between right and wrong).
57. **Creed** is a statement of faith.
(A formal statement of fundamentals of a religious belief).
58. **Church** is a place of worship or God's house.
(Any building dedicated to Christian worship. A body of Christians with a distinct history).
59. **Sacrilege** means mockery of religion.
(The act of violating or profaning anything sacred).
60. **Worldliness** suggests love of "things" to upperclassmen; "Ungodliness" to faculty and to others, "knowing the world."
(Not given in dictionary of religion. Webster: Devotion to this world's pleasures).

The foregoing definitions given by the majority of the individual pupils show in comparison with the definitions taken from the Dictionary of Religion and Ethics or else from Webster's Dictionary, that college students as a rule have clear religious concepts. This does not picture the whole problem, however, because it represents central tendency only and does not portray the concepts of the minority of each class. This fact necessitates a more detailed distribution showing the meanings in percentages for the different classes. Table II gives this information for the college group and for the pupils younger than the college group as well.

TABLE II, SHOWING TYPICAL DISTRIBUTION OF MEANINGS OF RELIGIOUS TERMS

Concept	Public School Age (Bose)			Bethany College				
	8-12	13-15	16-18	Fresh.	Soph.	Jr.	Sr.	Fac.
GOD								
Supreme Being	1	10	21	39	45	33	49	25
Heavenly Father	67	66-76	57-78	44-83	39-84	51-84	45-94	50-75
Holy Spirit	13-80	12	8	6	0	6	5	0
Highest Ideal	2	10	11	9	8	8	1	15
Good Man	2	1	0	0	0	2	0	0
No Answer	15	1	3	2	8	0	0	10
CHRIST								
Good Man				0	0	1	0	0
God				1	2	6	0	0
Jesus				26	30	17	26	50
Only Son of God		No Data		23	26	26	22	0
Our Savior				50	42	50	50	40
No Answer				0	0	0	2	10

SIN

Disobey God		35	19	45	41	33
Bad Thoughts		0	8	4	3	0
Against Christ's will		33	33	29	42	28
Mistake		7	8	8	7	28
Break Covenant	No Data	25	32	14	7	11
No Answer		0	0	0	0	0

CONVERSION

Become Christian	40	53	67	78	70	80	81	75
Saved	29	29	20	12	10	10	9	15
Join Church	6	5	10	2	8	6	1	0
Be Baptized	0	1	1	5	8	2	9	0
Talk to Someone	17	7	2	3	4	2	0	0
No Answer	8	5	0	0	0	0	0	10

	8-12	13-15	16-18	Fresh.	Soph.	Jr.	Sr.	Fac.
SALVATION								
Saved from sin	22	55	77	86	87	80	76	70
Become Christian	17	13	12	9	9	14	11	10
Salvation Army	9	2	1	0	0	0	0	0
Help Poor	24	13	4	5	0	2	0	0
Need Food	4	1	1	0	0	4	4	5
No Answer	24	16	5	0	4	0	9	15

BIBLE

Christian's Guide								
Book	13	17	16	24	38	32	36	45
God's Word	54	64	59	58	38	44	34	30
Sacred History	8	11	15	4	24	16	24	20
Book About Jesus	22	8	7	6	0	0	2	0
Story of Jewish								
Race	1	0	3	8	0	8	4	5
No Answer	2	0	0	0	0	0	0	0

SUNDAY SCHOOL

Place of religious								
instruction	16	50	71	79	81	44	90	100
Study Bible	9	0	3	6	15	10	7	0
Learn about God								
and Jesus	46	34	16	12	4	32	3	0
Place of Worship	24	16	10	3	0	1	0	0
Church	3	0	0	0	0	13	0	0
No Answer	2	0	0	0	0	0	0	0

IMMORTALITY								
Soul Live Forever	22	33	43	46	56	38	65	65
Eternal	15	20	20	20	31	38	22	25
Not Human	22	23	10	10	8	11	9	10
Unreality	2	6	5	2	2	3	2	0
Wrong Doing	11	9	11	22	3	11	2	0
No Answer	28	9	11	0	0	0	0	0
CONSCIENCE								
Feeling of Right								
or Wrong	35	48	62	71	70	62	82	85
Voice of God	13	17	16	8	2	6	4	10
Your Soul	6	10	10	12	16	10	6	0
Your Thoughts	13	13	7	8	12	16	0	5
Your Heart	7	4	1	1	0	6	0	0
No Answer	26	8	4	0	0	0	8	0
CHURCH								
Place of Worship	14	26	39	35	54	60	33	35
Group of Believers	2	2	2	6	4	4	24	0
God's House	49	62	51	34	30	32	36	30
Holy Place	11	6	2	5	4	4	2	30
Sunday School	2	1	0	0	0	0	0	0
No Answer	22	3	6	20	8	0	5	5
WILL OF GOD								
Commandment of								
God	30	38	38	24	38	31	33	40
Do Right	23	29	31	52	32	33	41	45
Bible	10	10	6	9	8	9	17	5
Love Everybody	17	18	18	15	20	25	9	10
Inherit Property	1	0	0	0	2	2	0	2
No Answer	19	5	7	0	0	0	0	0
WORSHIP								
Praise God	39	43	46	38	44	40	58	55
Pray and Sing in								
church	15	10	3	5	0	4	4	10
Idolize	3	5	6	4	14	5	10	0
Love Someone	6	4	5	11	4	18	28	10
Believe God	32	34	36	28	38	33	0	20
No Answer	5	4	4	14	0	0	0	5

Note: Figures in the first three columns are the percentages given by Bose, with fractions omitted.

The data of Table II read as follows: God means a Supreme Being to only 1% of the children 8-12 years old but this group usually thinks of God as Heavenly Father (67%). The concepts of Supreme Being is

evidently too difficult for children of the elementary grades but it becomes more meaningful to adolescents and nearly half the seniors in college express God in terms of Supreme Being. Combined with the concept Heavenly Father, the percentages are 76, 78, 83, 84, 84, 94 and 75 for the respective groups beginning with the Junior High School age and including the senior high, the four classes of the college, and the faculty respectively. Christ to college pupils suggests Savior, Jesus, Only Son of God or probably all of these three expressions in quick succession. Worship has many meanings but most often suggests to the various groups about alike, the idea of praising God.

By reading horizontally across the page in this way, it is seen that some of these terms defined by college students just as children define them and that as a rule the concepts of college students are about the same as the meanings expressed by students of the senior high school age.

Summary and Conclusions

In interpreting this study, several things must be borne in mind. The method of gathering the data was made identical with the study based on the responses of pre-college students so as to permit a comparison to measure maturation. This method as explained fully by Bose, emphasized the fact that the pupil was not asked to say what the term should mean but to indicate which term MOST NEARLY expressed the right meaning. Five possible answers were suggested and the student merely underlined the term that to him was the best answer if not the exact answer. These suggestive responses were all taken from actual definitions given by other students 8-18 years old on the basis of frequency.

As far as these data are to be relied on, we are justified in saying that freshmen, sophomores, juniors and seniors indicate a high degree of uniformity of meaning and but little maturation of concepts above that expressed by students of the senior high school age. There are about the same percentages of agreement and of scatterment in each college group. As a rule, the meanings preferred for the various concepts included in the questionnaire are much the same as that expressed by the dictionary definitions by which they were judged.

In contrast with this statement that "if one's thinking is no better than his concepts, the religious thinking of the children studied is inadequate, vague and confused," we may conclude that when judged by the religious concepts, the college students studied are capable, of adequate, clear thinking in the important field of the Christian religion. This conclusion, of course, only applies to a majority of the college students and does not take into account students of the non-churched group. Moreover, the dispersion of meanings indicate the desirability of focusing attention on concepts as part of the Biblical training of college students.

A STUDY OF HANDEDNESS

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Introduction

Lefthandedness has been accorded considerable attention by psychologists. The basic issue seems to be the native or acquired character of the trait. The practical problem involved, is the transfer of lefthanded children, particularly in penmanship. If lefthandedness and its attendant manifestations are native, the problem of transfer is considerably more complicated than if these functions are acquired. At least that is the implication of the argument. If we add to these problems the suggestion that stuttering and some oral reading difficulties are related to lefthandedness, and that possibly twinning and lefthandedness have a common origin, the question assumes challenging proportions.

THE HABIT SCALE FOR MEASURING HANDEDNESS

The investigation was first approached from the standpoint of measurement. Many attempts to measure handedness have been made. These include tests of strength, tests of eye sight, anatomical dimensions, and skill in specific performances such as star tracing, etc. Many of these tests yield high correlations with the actual facts of handedness. But they are unsatisfactory for diagnostic purposes because a coefficient of correlation is unreliable in individual cases.

After considerable experimenting and measuring the writer developed a "Habit Scale" which appears to be the first instrument to yield a practical index of handedness. The scale passed through several revisions and several hundred applications, finally assuming the form shown on the next page. It is best understood by reading the directions for its administration.

HABIT SCALE FOR HANDEDNESS

Name No.
 Index

INSTRUCTIONS for administering the Habit Scale are given in the Examiner's Manual. No attempt should be made to apply the scale until these instructions have been carefully studied.

SHOW ME HOW YOU

	R	L		R	L
	—	—		—	—
A. 1. Point (with finger)	()	()	D. 31. Cut bread	()	()
2. Hold rattle (spoon)	()	()	32. Beat eggs (with spoon)	()	()
3. Pick up (blocks, pins)	()	()	33. Sift flour	()	()
4. Throw (a ball)	()	()	34. Pour coffee (tea)	()	()
5. Shake hands	()	()	35. Wash dishes	()	()
6. Open a door	()	()	36. Peel (potatoes)	()	()
7. Brush your teeth	()	()	37. Iron (clothes)	()	()
8. Play marbles	()	()	38. Sweep (with broom)	()	()
9. Roll a hoop	()	()	39. Sew	()	()
10. Draw (a picture)	()	()	E. 40. Thread a needle	()	()
B. 11. Write (with pen)	()	()	41. Throw javelin (spear)	()	()
12. Eat (soup)	()	()	42. Bat a ball	()	()
13. Wind a clock (watch)	()	()	43. Play tennis	()	()
14. Deal cards	()	()	44. Play golf	()	()
15. Swat a fly	()	()	45. Shoot billiards (pool)	()	()
16. Strike a match	()	()	46. Pitch horse shoes	()	()
17. Hold a tea cup	()	()	47. Shoot gun (pistol)	()	()
18. Cut with shears	()	()	48. Cast with rod	()	()
19. File finger nails	()	()	49. Play ukelele (guitar)	()	()
20. Stir (coffee, tea)	()	()	50. Play trombone (cornet)	()	()
C. 21. Shave	()	()	F. 51.	()	()
22. Shovel (coal, sand)	()	()	52.	()	()
23. Hoe (garden)	()	()	53.	()	()
24. Rake (leaves)	()	()	54.	()	()
25. Fork (hay)	()	()	55.	()	()
26. Saw	()	()	56.	()	()
27. Hammer	()	()	57.	()	()
28. Chop (with ax)	()	()	58.	()	()
29. Mow (with sickle)	()	()	59.	()	()
30. Whittle	()	()	60.	()	()

USE THIS SPACE FOR REMARKS AND ADDITIONAL DATA:

"To use the scale determine whether the activities listed are performed with the right or left hand by saying, 'Show me how you write,' or 'Show me how you throw a ball,' etc. If an activity is **habitually** righthanded, assign it a score of 10 in the column headed 'R'; if it is **habitually** lefthanded, a score of 10 in the column headed 'L'. If an activity is performed **habitually** without preference for either hand, assign a score of 5 in each column. If an activity is performed with both hands, but more frequently with one than with the other, estimate the approximate score value for each hand, i. e., (6) (7); (8) (2); etc. If the activity has never come within the experience of the testee do not score it at all. Under 'F' write in and score other activities which come to your attention.

"In activities involving only one hand, handedness is easily determined. In writing, sewing, throwing, whittling, hammering, etc., the activity is righthanded if the tool is held in the right hand. In the case of bimanual activities the matter is not always so clear. For the sake of uniformity handedness will be tentatively defined as follows as regards the activities listed in the scale. Shoveling, hoeing, raking, forking, sweeping, chopping, batting and playing golf are righthanded when the right hand is below the left on the handle of the tool (in chopping, for example, when the right hand is toward the head of the ax). Shooting billiards is righthanded when the right arm propells the cue, the fingers of the left hand serving as the bridge. In the case of stringed instruments, the performance is righthanded when the bow or pick is held in the right hand. In the case of wind instruments, the performance is righthanded when the slide or the valves are manipulated with the right hand.

"Note that the point involved in the scale is one of **habit**. It is not a question whether the testee **can** write with either hand but whether he actually **does**. When put to the test any activity can be performed with either hand, but, of course, not with equal efficiency. Many cases of true ambidexterity are on record and intermediate cases between complete dominance and ambidexterity are numerous. In fact the rare case is one of complete dominance. To illustrate, many lefthanded folks have learned to write with the right hand; some habitually shake hands with the right hand; some use shears with the right hand; etc. Some righthanded folks deal cards with the left hand; and some even write with the left hand.

"An inventory of activities as suggested by the Habit Scale yields a fairly reliable sample of an individual's manual habits. The Handedness Index is an expression of the percentage of righthandedness. It is found by dividing the score of the right hand by the total score yielded by the scale. The following classifications of indexes is suggested: 0-19, dominant lefthandedness; 20-39, left-

handedness but not dominant; 40-59, ambidexterity; 60-79, righthandedness but not dominant; 80-100, dominant righthandedness."

The habit scale, supplemented with a questionnaire and a writing test, was administered to several hundred men, women and children. The questionnaire sought to determine the handedness of parents, grandparents, brothers and sisters; the approximate date of transfer in writing, or attempted transfer; the methods of transfer employed; and the facts concerning speech defects. The age range of the group was from approximately one year to eighty years. Five hundred twenty-four cases were studied.

THE INDEX OF HANDEDNESS

Table I shows the distribution of the Index of Handedness under three classifications. Group I includes all cases of successful transfer; Group II includes attempted transfers which failed; Group III includes all cases where no attempt at transfer was made.

Table I throws considerable light on the nature of handedness. It suggests that there are degrees of handedness ranging from extreme lefthandedness through ambidexterity to extreme righthandedness. This fact, while rather obvious, has never been clearly recognized. Yet it may have an important bearing on the question of transfer. It may be noted that the truly lefthanded person is one who has lost the right arm; the truly righthanded person, one who has lost the left arm. In between these extremes lie all degrees of dominance.

The table further suggests a U-shaped curve for the Index of handedness with the smallest number of frequencies at 50.

Turning to the percentage column of Table I, a consistent increase in the ratio of successful transfers to unsuccessful transfers may be noted as the index increases. If we omit the one transfer from right to left, not a single successful transfer was accomplished in the index range of 0-4. The ratio seems to increase consistently beyond the point of ambidexterity. This fact may have considerable diagnostic value. One question needs to be considered, however. Has the index influenced the transfer, or has the attempt to transfer influenced the index? It may very well be that the attempt to transfer in penmanship has carried with it some transfer in other activities. The point needs further consideration.

TABLE I. Distribution of the Index of Handedness grouped according to (I) successful transfer in penmanship, (II) unsuccessful transfer, and (III) no attempt at transfer.

	Handedness Index				Percentage		
	I	II	III	Tot	I	II	III
0-4	1 ¹	36	24	61	0	59	41
5-9	13	25	50	88	15	28	57
10-14	23	24	24	70	33	33	34
15-19	17	23	12	52	33	44	23
20-24	15	19	10	44	34	43	23
25-29	16	10	9	35	46	29	25
30-34	15	9	11	35	43	28	24
35-39	16	6	6	28	57	22	21
40-44	13	5	4	22	59	23	18
45-49	15	4	5	24	63	17	20
50-54	10	2	2	14	71	10	9
55-59	8	1		9	89	11	
60-64	5			5	100		
65-69	9	2	1	12	83	16	1
70-74	2	1		3	67	33	
75-79	4		2	6	67		33
80-84	4		3	7	57		43
85-89	2	3		5	40	60	
90-94	1			1	100		
95-100	2	1		3	67	33	
Totals	191	170	163	524			

¹This transfer is from right to left due to the loss of the right arm.

THE PENMANSHIP OF THE LEFTHANDED

Table II-A shows the scores of approximately 475 lefthanded persons in Quality and Rate in penmanship as measured by the Kansas City Handwriting Scale. The first striking fact that the table reveals is that the transfers write better on the average than the group who never attempted transfer. But the still more striking fact is that Group II, the group that attempted transfer and failed, also writes better on the average than the group that never tried to change hands. The intensive effort made to transfer, even though transfer was not accomplished, seems to be reflected in the lefthand writing of these individuals. This looks like a pretty clear case of cross education.

These data seem to answer the oft reiterated popular objection that transfer ruins the child's handwriting. The attempt to transfer, even though it fails, seems to make for better writing.

METHODS OF TRANSFER

The questionnaire shows methods of transfer as employed by parents and teachers to be almost wholly of the trial and error type. They group themselves under six main heads, as follows: (1) Unconscious transfer; (2) Training; (3) Punishment; (4) Rewards; (5) Accident; (6) Voluntary transfer.

Of the first type, unconscious transfer, there seem to be a few authentic cases. The subject seems to have been unaware of anything unusual in his situation. Although lefthanded he has always written with the right hand and that is all there is to it.

TABLE II-A. The mean scores of lefthanded writers in Quality and Rate as measured by the Kansas City Handwriting Scale.

Index	QUALITY			RATE		
	I	II	III	I	II	III
0-19	8.6	8.6	8.3	70	76	62
20-39	9.1	8.6	8.3	80	80	76
40-59	8.5	8.8	8.6	83	70	61
60-79	9.1	9.3	8.8	85	93	73
80-100	8.1	8.4	9.7	70	95	83
Mean ¹	8.8	8.6	8.3	79	77	66

¹Based on the summation of scores.

TABLE II-B. The number of cases involved in each corresponding score in TABLE II-A.

Index	QUALITY			RATE		
	I	II	III	I	II	III
0-19	47	99	101	38	89	85
20-39	59	40	29	56	38	24
40-59	44	11	10	41	11	8
60-79	16	3	3	13	3	2
80-100	7	3	3	5	2	3
Totals	173	156	146	153	143	122

TABLE III. The frequency with which various methods were used in effecting transfer in penmanship in 356 cases of lefthandedness.

METHOD	I	II	Total	%
1. Unconscious transfer	8	1	9	2
2. Training	109	110	219	62
3. Punishment	49	48	97	27
4. Rewards	3	3	6	2
5. Accident	4	2	6	2
6. Voluntary transfer	2	1	3	1
No report	14	2	16	4
Totals	189	167	356	100

Under training were included the requirement of righthand writing by the teacher, persistent changing of pencil and other tools (spoon, etc.) to the right hand, persuasion, explanation and encouragement. This method is often used, frequently combined with punishment. Of course, to secure any sort of transfer, there must be training, so that in case of successful transfer, training must be taken for granted.

An interesting phase of the investigation is the revelation of the extent to which punishment is resorted to as a means of securing transfer. The list of tortures employed sounds like the Inquisition:

1. Tying gourd over left hand, wrapping cloth over left hand, compelling the wearing of a mitten.
2. Tying left hand behind the back; tying fingers together.
3. Cuffing, slapping, spanking, whipping, boxing the ears cracking the knuckles with a ruler.
4. Ridiculing, scolding, threatening.
5. Leaving the table, sending to bed, confining in closet.
6. Keeping after school, giving low grades for work written with the left hand, refusing to accept work done with the left hand, doubling the amount of practice with the right hand.

These are not isolated instances but represent quite a general practice. It was astonishing to discover how frequently cracking the knuckles with a ruler was resorted to as a corrective. Table III shows that in 27% of the 356 cases studied, punishment was used as a corrective.

Rewards are frequently used to secure transfer. This includes the payment of money, the award of prizes, and praise.

Accidents account for a negligible percentage of all transfers. The breaking of an arm or the burning of a hand now and then accounts for handedness but not often. The incidence of accident is so infrequent that it has been dropped from the questionnaire.

There are some cases of voluntary transfer. These are usually among the older subjects, of highschool or college age. The desirability of right hand writing has become apparent, so the subject has set about transferring himself.

In connection with transfer it has been interesting to note how frequently the child has deceived his teacher. Again and again the reports show that when the teacher's back was turned the pupil immediately reverted to the use of the left hand. In one case the child became so adept in the use of both hands that when she was kept after school and required to copy a word a hundred times as a punishment, she used both hands at the same time and cut her punishment in half.

SPEECH DISORDERS

Among the 524 cases of lefthandedness studied, 33 cases of speech disorder occurred. This yields a six per cent frequency of speech disorder, a very high incidence when compared with the percentage of speech disorder in the whole population, estimated at one percent. However, an analysis of Table IV shows that of these 33 cases, 11 no longer stuttered at the time of the investigation; three cases were reported as a slight stoppage of speech; two were reported as lisping; three were clearly cases of organic stuttering; in two cases the stuttering was due to St. Vitus dance. There were 17 cases of active stuttering, both organic and functional, a percentage slightly over three. This still leaves the incidence of speech disorder three times as high as in a random sample of the population.

It was hoped that the data would show some clear connection between transfer and the beginning of stuttering. Unfortunately the results are inconclusive. In a very few cases the two are coincidental. In several cases stuttering clearly preceded the attempt to transfer. In others the data are incomplete. It is worthy of note that there are four cases of speech disorder where no attempt was made at transfer.

TABLE IV. The frequency of occurrence of speech disorders in a lefthanded population grouped according to type.

Group	Organic	Stuttering disappeared	Stutter now	Slight stoppage of speech	Lisping	St. Vitus dance	Totals
I	3	7	5	2	0	0	17
II		2	7		1	2	12
III		2		1	1		4
Totals	3	11	12	3	2	2	33
Mean index	27	38	26	45	51	19	33
Mean age	16	17	27	14	15	24	24

TABLE V. The frequency of occurrence of speech disorders in a lefthanded population arranged according to the type¹ of training used in effecting transfer.

Type	1	2	3	4	5	6	Group III	No data
Frequency	2	12	14				4	1
Percentage	6	36	42				12	3

¹For types see TABLE IV.

It is very likely that the problem of stuttering in relation to transfer will resolve itself into the two elements of personality and method. Functional stuttering is a well established fact in certain personality types. If by chance the rigorous discipline of transfer is imposed upon one of these personalities, conflict and stuttering may very easily result. This seems particularly likely when we reflect that 27 per cent of the cases of transfer or attempted transfer involved punishment as a corrective; and that 42 per cent of all cases of speech defect involved punishment as a corrective (Table V).

The following case reveals the type of individual who must be handled intelligently in the matter of transfer. The account is that of a highschool teacher, female, 26 years of age, written in response to questions in the questionnaire.

"I felt I was different. The teacher sent me to the board a great deal. I thought they tried to show me off. When in highschool a teacher stood over my desk I used to try and think he thought I was cheating for I did sit different from others. Due to the fact that a teacher called me 'peculiar' I felt that students watching me thought so too. Every one watches me write just the same in my own classes as in college. I used to think maybe they thought I was cheating on acct. of the position.

"My parents tried to suggest it (transfer) to me. The teachers threatened not to promote me. They used to keep me in recess time and force me to use the right hand. They told me that I was a 'peculiar' child. I can't write rapidly enough (with the right hand). It makes me very nervous, in fact, hysterical, to use my right hand very long. At one time in 6th grade I wrote almost as well with my right hand, but I began to stutter dreadfully. Talk about a miserable child! When I began to use the natural hand I gradually got away from it. Now I stutter only under excitement. I'm only glad I'm left handed.

"I'm getting out of my inferiority complex. Recently I won a prize for distinguished handwriting if there is such a thing. This is my plea: Why don't schools have seats for lefthanders? It causes a great discomfort to take an exam five hour long, for instance, trying to write on a righthander's seat. I believe that every left-handed person is selfconscious to an extent, and are psychological problems."

What is plainly needed is a scientific method of diagnosing handedness and a scientifically determined procedure in attempting transfer. It seems probable that in most cases transfer can be undertaken to the advantage of the child if thoroughly motivated and intelligently directed. But in the case of certain personality types with low Handedness Indexes caution should be exercised.

SUMMARY

These studies suggest the following tentative conclusions:

1. The Habit Scale yields a practical measure of the degree of manual dominance.
2. The "Curve of Handedness" is U-shaped.
3. The higher the Index of Handedness in any particular case, the higher the chance of transfer in penmanship from left to right hand.
4. The penmanship of lefthanded transfers is better on the average than the penmanship of lefthanders who have never attempted transfer.
5. The penmanship of lefthanders who have attempted transfer and failed is better on the average than the penmanship of lefthanders who have never attempted transfer.
6. The methods of transfer heretofore employed are unscientific and often detrimental to the individual, involving punishment in 27% of all cases and in 42% of the speech disorder cases.
7. The incidence of speech disorder among the lefthanded seems to be considerably higher than in a random sample of the population.
8. The use of wrong methods imposed upon certain types of personality probably accounts for stuttering in conjunction with transfer in penmanship.

SOME PROBLEMS OF SCIENTIFIC METHOD IN
SOCIOLOGY

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In this discussion I am making one important assumption to begin with, an assumption that may be open to criticism, but which, nevertheless, is being accepted by a larger number of thinking people every year. This is the assumption that sociology is or can become a real science and take its rightful place among its sister or brother sciences. If evidence is called for to support this assumption, we may cite the fact (as one evidence) that for several years there has been a regularly recognized section of the American Association for the Advancement of Science, which section includes sociology. This is "Section K," the "Economic and Social Sciences."

A corollary of the above named "assumption," also increasingly (but not universally) accepted in modern discussions of the sciences in their relations to one another, is the classification of all sciences into three groups. The older classification (probably still adhered to by some of the scientists present at this meeting) is the classification which puts all sciences or would be sciences into 2 groups—the natural sciences and the social sciences. No doubt all of you are familiar with this older classification, whose accuracy I propose here and now, politely and positively, to challenge.

If by science we mean a systematic knowledge of the structures and processes of some part of nature, then why should we use the word "natural" at all in this connection? If a body of knowledge is not a natural science, it is no science at all. Therefore, why not, in the interest of clearer thinking and greater accuracy, speak of the three large groups of science thus?

1. The physical sciences, including physics, chemistry, astronomy, geology, physical geography, etc.
2. The biological sciences, including botany, zoology, physiology and a large part of psychology.
3. The social sciences, including economics, sociology, political science; also ethics, history, law, and psychology, in so far as they deal with social groups and use the scientific method.

Speaking figuratively, the social sciences are the children, we may truly say, the infants, in the great family of the sciences. The biological sciences may be spoken of as the adolescents and husky young men and women of the family; while the physical sciences are the adults and even patriarchs of wisdom and maturity; for was not astronomy born into the world through the ingenuity and intelligence of the old Egyptian

observers peering through the little windows of the pyramids and making more or less accurate observations and predictions of the movements of the heavenly bodies?

Also, it is a well-known but very fundamental fact, to all careful thinkers and observers, that the sciences, especially certain ones of them, are closely related and interdependent. For instance, who knows where chemistry leaves off and physics begins, or vice versa? The border-line between zoology and botany is a faint line, to say the least; and it is certainly true that sociology is closely related to and dependent upon, economics and history on the one hand and biology and psychology on the other hand.

In spite of this close and at times inseparable relation of the different members of the family of sciences, it has been decidedly helpful and even necessary for each of them to lead quite an independent existence. This situation again, is analogous to that of the human family. As each child grows towards adult life in capacity and experience, it is better for him, for the family, and for society as a whole, that he stand on his own feet so far as possible, at the same time retaining a lively appreciation of the inter-relationships he bears and should continue (in a different sense) to bear to all the other members of his family, no matter how old he is or how far some of his wanderings may lead him from his old home. It is nothing less than a fine art for the individual person to preserve the appropriate balance between his own individual interests on the one hand and the interests of his family and society on the other hand. It is also a fine art for the individual scientist, enthusiastically busy in his own field, to keep a balanced viewpoint and to realize that after all, his own field of knowledge, properly vital and absorbing to him, is only one phase of the **whole** field of knowledge; and that the chief reason for dividing up scientific studies into many parts is **not** because the facts of nature are found thus disassociated, but because it has been found by experimental processes that more rapid headway is made in the attempt to wrest nature's secrets from her when each scientist devotes himself **chiefly** to that aspect of nature which his hereditary aptitudes or his social environment or pure accident, has brought into the focus of his attention.

Sociology may be defined roughly as the science of social groups or group relationships. It has to do with man, not as an individual, but as he relates himself to his fellows. Inasmuch as the problem of how he relates himself to his fellows depends, in part, upon what kind of man he is, his physical make-up and temperament, the climate he lives in, and many other factors, these are of concern to the sociologist. These facts, however, are not the primary concern of the sociologist. Robinson Crusoe, on his lonely island (before he saw the savages and found his man Friday), had absolutely no sociological phenoma. His memories of dear old England, his problem of how he could get the best of the

wild beasts and protect himself from the lightning, wind and rain, gave him much cause for thought, and furnish subject matter for the psychologist. His food, obtained from nature and wild plants and animals, furnish subject matter for the chemist and physiologist. His observations of the rocks, valleys, plant and animal life, of the island, furnish subject matter for the botanist, zoologist, geologist, and geographer. Indeed, even though Robinson Crusoe is fiction, the story had to measure up to an approximation of what the physical and biological scientists would expect to find in the part of the world where the island was supposed to be located.

So long, however, as Crusoe lived alone on his island, so long as Daniel Boone lived alone with his dog in the woods of Kentucky or Missouri, just so long neither of these famous men furnish any material whatever for the sociologist.

Perhaps enough has now been said to suggest at least what sociology is, and what some of its objectives are. These objectives cannot be attained without the use of the scientific method. If any real progress, beyond the progress made by trial and error and by accident, is to be made in the large, complex, and vital field of human relations, this progress must needs have for its foundation a specific and objective knowledge of human relationship, organization, groups and institutions. We, that is, intelligent people (or those who try to be intelligent), no longer believe that physical disease can be cured by the witch-doctor or the medicine man. The physiologist and the physician have yet a long road to follow before the complete conquest is made of the great curse of mankind, preventable disease. Nevertheless, the physiologist and the physician are on the way to a greatly worthwhile goal, and every step of this way has been made possible or greatly aided by the use of the scientific method.

The science of sociology, admittedly in its infancy, is making an encouraging **beginning** in an objective way of looking at vital facts concerning human relationships. To use a rather crude illustration, if we had made **more** progress in the attainment of this objective scientific attitude in regard to human affairs, present day American society would no more tolerate an organization like the Ku Klux Klan than it would tolerate the general practice of drawing blood from every sick person to make him well.

Another example: If our Protestant church people, both lay and clergy, were governed in their church politics more by social science and less by custom, tradition and narrow-minded jealousy and prejudice, we would not have such absurd situations as frequently exist in the U. S. A.—six Protestant churches in a village where two strong churches would be much better able to care for the religious interests than six weak churches competing with each other and struggling to keep alive. Fortunately, there is some evidence of improvement in these conditions,

but custom and tradition put on the brakes very effectively. All human institutions, even educational institutions, have very similiar problems facing them.

During the last fifteen years more progress has been made in the application of the scientific method to the study of social problems than in the preceeding fifty years. Two chief reasons for this are (1) the fact that the preliminary, foundation work in any science is necessarily more tedious and time consuming than are the later stages, after good working technique has been established and brought into general use. Albion W. Small and George E. Vincent of the University of Chicago, F. H. Giddings of Columbia University, E. A. Ross of the University of Wisconsin, William Graham Sumner of Yale University, Herbert Spencer in England, and August Comte in France, labored valiantly and well on the foundations of sociology; or perhaps it is more accurate to say, they cleared away the forest and the underbrush so the foundations could be laid; for not one of these men would even claim that he made very much use of a scientific method. The development and use of such a method has remained for the present generation of sociologists to work out. In its more complete development and use it remains a task for the future generation of sociologists, yet unborn.

A few of the present leaders in the working out of a scientific technique for sociology are: Park and Burgess, of the University of Chicago, (Park, a journalist before he was a sociologist); Thrasher, of New York University; Miller, of Ohio State University; Zimmerman, of the University of Minnesota; Sanderson, of Cornell University; Morgan, of the University of Missouri; Renter, of the University of Iowa; Kolb, of the University of Wisconsin, Chapin, editor of *Social Science Abstracts*; Hornell Hart, of Bryn Mawr; Galpin, of U. S. D. Agriculture.

In passing, it is interesting to note that the United States Government, since July 1, 1925, has made funds available for research in rural sociology, under the Purnell Law. About twenty-five of the agricultural experiment stations of the United States are now carrying on such research studies. At the present time there is probably more money spent and larger personnel at work in the field of rural sociology research than in any other one field. A considerable number of directors of experiment stations have come to the point of being at least open minded on the policy of giving research in human affairs an even chance with reseach on live stock, soils, and crops.

In spite of the very encouraging development of scientific sociology in recent years, there still remain several very substantial difficulties or obstacles to be overcome before we can truthfully say that sociology is scientific to anything like the same degree that physics or chemistry is scientific.

These difficulties, problems, or obstacles, can be divided into two groups—relatively temporary or transient problems, and more perma-

ment and deep seated problems or obstacles. Taking up the first, or temporary problems for consideration, we have the following:

1. A number of fascinating but foolish fallacies afflicted the early development of sociology. One of these was the so-called organic theory of society. This theory was stated and vigorously expounded by Herbert Spencer, a charming writer, keen thinker, and influential philosopher. Spencer, however, would not rank with a present-day first-year graduate student in scientific sociology. He made no sociological investigations; he did not even attempt to do so. Most of the real merit of his writings derives from the fact that he was deeply interested in human society and he was an ardent believer in the then new and dangerous ideas of Charles Darwin. Spencer lived to a ripe old age; he wrote many books that were widely read; some of them even were used as college text books. He lectured widely, both in this country and in his native country, England. Scientific sociology has now moved far beyond the elementary ideas about human groups advanced by Spencer, such as the idea that every society, every nation, may be compared to a biological organism which follows a regular life cycle of birth, growth, maturity, decline and death. Spencer used as (supposed) proofs of his theory the historical facts of the ancient societies, especially Greece, Rome, and Egypt. He applied this same course of reasoning to all human institutions except the family which of course he admitted **must** remain, in some form, as a permanent institution. In all probability, if Spencer were living now, he would say that his own beloved England had reached her peak of destiny and was on the permanent downward road to practical extinction as a powerful nation; he would also be inclined to say that certain Protestant churches have passed their peak of power and influence and are now tending downward to certain dissolution and extinction.

Our present-day sociological investigations have become sufficiently scientific to make it reasonably certain that such a fatalistic view of human societies and groups, as held by Spencer, is very inadequate, to say the least. We know enough of the laws of growth and vitality of human institutions to understand that national or group decline can be prevented and growth and permanence **can** be secured, depending upon the willingness of intelligent people to use the knowledge now at their command.

Just here is where scientific sociology recognizes a vital dependence upon religion, ethics, or whatever may be the vitalizing, purpose giving motive in human life. That is, it is the function of sociology to analyze, **understand** and make clear to those who would know, as much as possible of the laws or principles affecting group relations and group processes. What **use** will be made of this knowledge is **not** the primary concern of the scientific sociologist. There are many analogies to this situation in other fields of human thought and activity. Where the scientific chemist or physicist makes new and deadly drugs or explosives, it

is not for them to determine (indeed they **cannot** determine, even if they wished to) whether this new product of their scientific labors will be used for human destruction or for human betterment in the arts, sciences, and industries. The chemist, physicist, or sociologist, as a good **citizen**, if he is such, will be interested in seeing his knowledge so laboriously gained, put to constructive and beneficent use, but if he gives his **chief** attention to this latter function, he becomes a preacher, a reformer, or a propagandist, any one of whom is or may be a useful person, but none of whom are primarily scientists. In these days of increasing specialization, it is exceedingly rare to find a man who is **equally** interested in pure science and in the application of that science.

To go back to Herbert Spencer, it is an interesting commentary on the philosophical and rather vague nature of his sociological teachings that the men and women who studied college sociology in the latter part of the 19th century when Spencer was much in vogue, received little or no knowledge of concrete social processes and problems. Indeed, until very recently it has been a matter of indifference to the directors of our training schools for social workers, as to whether their entering students had ever studied sociology in college or not. This situation was exactly analogous to what would have **been** (of course was **not**) the case if deans of medical schools had said to their entering students: "It makes no difference to us, so far as your medical training is concerned, whether you have had any biology or chemistry in college."

Happily, these conditions, in the sociological field, are rapidly changing. No man or woman is now admitted to the training course in a standard school of social work who has not had substantial undergraduate training in both sociology and economics.

2. Another of the temporary obstacles in the bringing into use of the scientific method in sociology, an obstacle which has not yet entirely disappeared, is the fact that for at least a generation in the early development of sociology, an unduly large proportion of the college teachers were preachers (active or retired), or philosophers, or men trained chiefly in other fields. Preachers were attracted into this field because, presumably, of their humanitarian interests, philosophers because of the broad, comprehensive field of thought held out before them by the subject. The least harm to sociology came from men trained in economics, or history, or literature. It was both inevitable and desirable that there should be many of these, for sociology as a college subject came in rapidly in the first decade of the 20th century, and of course, there were no college teachers who had academic training in sociology; therefore, some excellent sociological teaching was done by men who considered economics or history or literature their real specialty but were prevailed upon by the college authorities to offer a course or two in sociology.

It is easy to understand then, that very many of these early sociology teachers were lacking in either the ability or in the inclination, or

in both, to do any original work in sociological investigations. Quite a number of them did excellent teaching, however, and were able to inspire some of their students with the genuinely scientific spirit, so that they (the second generation of sociologists), are the ones who are now, for the most part, slowly building up some really scientific sociology.

3. A third **temporary** difficulty has been found in the confusion in the public mind and to some extent even in academic circles, as to the **meaning** or **purpose** of sociology; and this has been largely the fault of the sociologists themselves. Any intelligent layman knows that physics deals with measurements, with forces, with physical materials, with electricity, etc. He knows that zoology deals with animals below man, and that botany deals with plant life; but this new thing called sociology—what is it? The man on the street has often taken "sociologist" and "socialist" to be synonyms. A few have even added the term "bolshevist" as a third synonym. Perhaps a rather widespread conception even yet of a sociologist is that he is closely akin to, if not the real thing, described by the terms "reformer," "propagandist," or "crank." No doubt the sociology group has its fair share of these peculiar and non-conformist types; but it has no monopoly on them.

A widely prevalent and erroneous conception of sociology has been the idea that it was a subject concerned with the abnormal or ugly side of society. It was only natural, perhaps, that in its early stages, sociology was concerned largely with a study of the **abnormal** sides of social life—crime, poverty, insanity, feeble-mindedness, etc. It is no discredit to the science of sociology, (to all the social sciences), that much of the motivation of effort for research comes from the desire to get at and remove fundamental conditions which produce abnormality and human suffering. Alfred Marshall, one of the three greatest economists England has produced, said that his chief reason for studying economic phenomena was his desire to help abolish poverty and his strong conviction that the greater part of poverty could be abolished when more scientific knowledge of economic phenomena was available and put to use. In recent years sociologists have definitely recognized that their field of study, teaching, and research, includes processes, groups and problems of **both** normal and abnormal social phenomena; this natural and inevitable broadening of the sociological field has gone far to correct the earlier and partly incorrect conception of sociology as a science concerned **only** with social pathology or **abnormal** social phenomena.

The early handicap sociology suffered because of a more or less general confusion as to its meaning, purpose and methods, is rapidly disappearing. No longer is a bright young man, interested in a scientific study of social phenomena, discouraged from entering the field of sociological research because of the vagueness of its meaning or the alleged disreputable or uncertain character of his prospective associates. In September, 1928, the last date for which definite data were obtainable,

there were 119 master's theses in sociology in progress in American colleges and universities, and 138 doctor's theses. A very large proportion of these studies had to do with the scientific measurement and analysis of very definite, limited and specific phases of social reality; some were of a broader nature. (See pp. 348-49, *American Journal of Sociology*, September, 1928).

4. A fourth temporary difficulty, also now steadily, if not rapidly, disappearing, is the check placed upon the independent development of sociology by its too long continued and necessarily close relationship to and dependence upon, its elder brothers, economics, history, philosophy, or theology. Nearly all of the early university and college work in sociology was done in departments of economics or history, some of it in departments of philosophy or ethics or theology. These earlier arrangements have, to a large extent, been displaced by a policy of putting sociology upon its own feet and letting it stand or fall on its merits. No longer do we have situations, once frequent, where such courses were listed as "Christian Sociology," "Social Economics," etc. Only to a slight extent now, do we have sociology dragged in at the back door, as it were, under the guise of its more established and presumably more respectable relatives— history, theology, philosophy or economics. The close relationship of sociology to all these interesting branches of human knowledge will always be gladly recognized by the sociologists, but this does not justify the **absorption** of sociology by these other subjects.

Now taking up the more permanent factors which create special problems of scientific method for sociology, we have:

1. The nature of the subject matter of sociology is such that the attainment and maintaining of an objective, scientific attitude towards the basic subject matter of the science is and will remain, particularly difficult. No intelligent person has more affection or more hatred for one chemical element than another, or more love for the alternating current in physics than for the direct current, or more love for the frog than for the earthworm in zoology; immediately, however, on our entrance into the field of sociology, we are confronted with a vast array of conditions and problems concerning which it is exceedingly difficult to consider facts and phenomena with scientific objectivity. Just to mention a few of these:

(1) The problem of crime and its treatment. Among otherwise intelligent people we find all degrees of attitudes, from one favoring extremely drastic treatment of the criminal to the sentimental attitude of coddling the criminal or at least treating him as if he, himself, were in no way responsible for his crime.

(2) Labor and industrial problems. In a sociology class discussion on the merits of union labor vs. non-union labor in West Virginia, two upperclassmen in West Virginia University came to diametrically opposite conclusions, not because of difference in sincerity or ability or

open-mindedness, but because one man had been born and reared in a family circle headed by an active and able union labor organizer, and the other man had been born and reared in the home of a capitalist well known to be either indifferent or hostile to organized labor. Thus, the feelings and sympathies of these two men, when drawn to the surface in the consideration of this vital issue, controlled their thinking and their judgment. Their university training in economics, psychology and sociology, of which they had both had a considerable amount, seemed to have little effect.

(3) Still another significant phase of human relations in which custom, tradition and emotion tend to direct our attitudes and actions, is in the field of sex and family relations. Every scientific sociologist knows that the abuse and criticism that have been heaped upon Judge Ben Lindsey because of his views on companionate marriage are not based to any large degree upon an impartial examination of the data presented by Lindsey, or upon the present day situation and conditions as to relations between men and women; but these abuses and condemnations of Lindsey's ideas are based upon the feeling that he has advocated ideas and practices contrary, not necessarily to the welfare of the race, but contrary to our cherished traditions and emotions in regard to these fundamental relationships.

(4) A fourth phase of human relationship problems in which opinion, custom, emotion tend to prevail unduly is the whole group of problems connected with race relations. You have no doubt read in a recent number of the Literary Digest of the New York rector who let it be distinctly known that he did not want negroes to attend his church.

There are many evidences that race consciousness and race bitterness are increasing rather than decreasing at the present time.

The statements sincerely made by a large proportion of a Y. W. C. A. group at West Virginia University in a discussion on the Negro Problems in West Virginia, strongly suggest that to a large number of white West Virginians there is only one side to the negro problem worth considering, and that is the white man's side. As some slight evidence that patient, persistent, sociological education does help us to get rid of these unscientific and unfair attitudes, we may cite the fact that the leader of this Y. W. C. A. group had our University course on Race Problems. According to her own voluntary statement, her views at the beginning of the course were the ordinary, conventional race attitudes; at the end of the course they were substantially different and she was willing to take a chance on being thought queer or unpopular in order to conduct discussion groups among the women students on this subject. There are many other everyday human situations in which prejudice and narrow, one-sided early training set up a psychological complex hard to overcome, so far as productive and objective scientific attitudes and work are concerned. For example, were it not for religious and

racial prejudices, such an organization as the Ku Klux Klan would be impossible. The people in England and other European countries would not tolerate such an organization. To be sure, their conditions are vastly different from ours, in not having a large negro and foreign born population. That fact does not excuse us, however; for it simply means that in this particular matter, it **happens** that they can see the situation objectively, and with unprejudiced minds. We Americans, being closer to the facts, do not see them so objectively.

2. A second rather permanent factor among the difficulties encountered in the development of scientific method in sociology is the fact that the man or woman who would do effective research and any great amount of it, must not only have originality, industry and ability above the average as is true for all scientists; he must also have more than an elementary knowledge of several closely related subjects, especially economics, history, biology, and psychology. A good working knowledge of foreign languages and of mathematics is also indispensable. In addition, and perhaps most important of all, and most rare of all, he must have a sincere and genuine, not pretended, interest in and sympathy with, all kinds of people and all kinds of groups—the wise, the foolish, the good, the bad, the white, black, yellow and brown man, the rich, the poor, the Christian, Mohammedan, Jew and atheist, are all equal in his eyes and mind, so far as being worthy of fair and impartial study is concerned. Among groups and institutions the struggling little country church, the prosperous big city church, the Rotary Club, the Masonic Order, the Ku Klux Klan, are considered without sentiment or partiality. The great study of race relations on our Pacific coast could never have been of either scientific or practical value unless it had been directed by such impartial and objectively minded men as Robert E. Park of the University of Chicago, and E. S. Bogardus of the University of Southern California. Probably our social settlement workers, in the negro and foreign born sections of our large cities, or those sociology teachers and scientific investigators who have had settlement experience, come the nearest to being free of prejudice in regard to race problems, of any group of workers at present. With a relatively open mind to start with, they have lived in the midst of objective facts which have tended to make clear to them the fallacy of much of the so-called race inferiority idea. A sociologist who would even make a promising **beginning** of being scientific cannot limit his contacts and studies to his office, class-room or even the well equipped library. He must have a real share in human affairs. Sociologists have invented a new phase to describe this indispensable attitude and practice of one who would make headway in a scientific understanding of human problems. This phase is the "participant-observer-student" attitude and practice. That is, careful observation, natural participation, and thoughtful reflections, are all necessary

for the most complete understanding of social groups, institutions and processes.

Conclusion: In spite of the many problems involved in the use of the scientific method in sociology, encouraging progress has been made in many different directions. Perhaps the University of Chicago has taken the lead in this new movement, but many other universities, a few colleges, the Federal Government, and the National Social Science Research Council, have all played an important part. Graduate fellowships in sociology are numerous; scientific or partially scientific publications, both books and periodicals, are increasing in quantity and improving in quality.

Four well defined and tested **methods** of scientific work in sociology are in use. They are: The Case Method, The Survey Method, The Historical Method, and the Statistical Method. To adequately describe the technique of any one of these methods would take us beyond the limits of this paper. A new research technique is being worked out. This technique uses, so far as appropriate, all the research principles and processes developed by the physical and biological sciences; but it has already been clearly realized that, to a considerable extent, a new or additional technique must be developed in the field of sociological research, and several able men and women are devoting most of their time to this problem of a comprehensive, flexible, adequate technique of investigation.

That sociology will go forward as a science is no longer open to doubt. Just how far it will go, or whether it will be subject to permanent limitations **not** met with in the physical and biological sciences, only the future will tell.

WHAT TYPE OF TESTS SHOULD BE USED IN RATING
COLLEGE STUDENTS?

By

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Examinations or tests of what the students have learned have had a place in nearly every system of education of which we have record. Many of the examinations were tests of the ability to perform or to endure, but the design of them was to measure the knowledge and skills that had been acquired. They have been used not only in school work, but outside of school, notably for the purpose of determining fitness for admission to civil service.

Examinations are not only an aged institution, but have endured severe criticism. Perhaps, more criticism has been made in the last few years of the form, purpose and method of administering examinations than in any former period. It would seem that the earlier criticisms were not strong enough to produce any great change in the form, administration and function of examinations. Not so, however, with the recent volume of criticism, because out of it has come new types of tests with new methods of administering, scoring, interpreting and using. Notwithstanding the fact that there are some authorities in education who would abolish all school examinations, the great majority of instructors in all types of education make use of them. Odell¹ says: "At present, examinations are probably more prevalent than ever before, being used by practically all teachers in rating pupils, by government officials, by numerous business concerns and various other agencies."

We are safe in saying that it is and will likely continue to be the general educational practice to use tests for the purpose of rating college students, but we have the big problem of selecting the type or types of tests to be used. This is a question of primary consideration for every teacher. It is especially important for the instructor in a college. It is important because: some tests are more difficult to construct than others; some are more difficult than others to score; some are better adapted to certain types of subject matter than others; and finally, there are many different types of mental activity to be measured. It is this last reason that makes it necessary to give attention to the type of test.

If any one of the various types of tests will measure all types of mentality, then the test that is most quickly constructed, most easily administered and scored, and that is best adapted to the nature of the subject matter should be used. On the other hand, if a test does not measure certain types of mental ability, it should not be used, except

¹C. W.—Traditional Examinations and New Type Tests, page 4.

in connection with some other type of test that does measure that mental quality.

As a means of obtaining some evidence that would aid in the selection of a type or types of tests that would be fair to students in assigning them marks, results of two batteries of tests have been assembled. The tests were given to thirty pupils in two different courses taught by the writer during the first semester of 1929-1930 at the Fairmont State Normal School. The students whose scores were studied were members of the senior class of the two-year curricula.

One of the courses was educational measurements for the elementary school, the other, school management. The classes met twice a week during the semester. There were two groups in each subject. There were fifty-five students in each course. The scores of the thirty students were chosen because they were all in both courses.

The tests given to the members of the class in educational measurements were: true-false, completion, multiple choice and judgment. The battery used for the school management class was made up of a true-false test, traditional test, a multiple-choice test and a judgment test. The judgment test consists of a number of true statements. The student's problem is to give one good reason why each statement is true. The traditional test was made up of objectively scored questions. Each test had thirty points, except the multiple-choice test used in the course in educational measurements which contained sixty points. Ten minutes were allowed for each test in the two batteries.

Reliability of the batteries of tests. The reliability of the battery used in the class in educational measurements as shown by the correlation of different forms of the entire battery given to 120 students is .94 with a probable error of $\pm .04$. The reliability of the battery of tests used in the course in school management as indicated by the correlation of two forms, given to 60 students is .97 with a probable error of $\pm .026$. No reliability coefficients have been worked out for the separate units of either battery.

The results of the various tests in the battery used for the class in educational measurements are given in table I. The table is read thus: Pupil A made a score of 11 with a rank of 7 on the true-false test; a score of 7 with a rank of $16\frac{1}{2}$ on the completion test; a score of 19 with a rank of 18 on the multiple-choice test; a score of 11 with a rank of $10\frac{1}{2}$ on the judgment test; his total score on the battery is 48 with a rank of 21.

An examination of Table I shows clearly that nearly all of the students in this group varied their ranking on the different types of tests. In a few cases the variation was comparatively small. This is true of pupils C, G, and K. In many cases the change of rank from one test to another is great. Outstanding cases of this kind are: Student F who ranked $1\frac{1}{2}$ on the completion test, but dropped to rank 17 in the

TABLE I

Student	True-False Test		Completion Test		Multiple-Choice		Judgment		Total	
	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
A	11	8	7	16½	19	18	11	10½	48	21
B	13	6	10	13½	15	21	8	14½	46	22
C	0	21	7	16½	21	17	2	19½	30	26
D	10	9	20	1½	23	15	5	17½	58	13
E	13	6	14	7	18	19½	13	9½	68	7½
F	3	17	20	1½	25	13	7	15	55	17
G	1	19½	10	13½	18	19	6	16	45	23
H	1	19½	11	11	22	16½	5	17½	39	24
I	12	7	0	19	22	16½	3	17½	37	25
J	4	15	19	2	26	11	30	1	79	3
K	7	12½	7	16½	30	9	11	10½	55	17
L	16	4	17	4	34	4½	10	11	77	4
M	4	15	11	11	33	6½	9	13	57	14
N	8	11½	14	7	33	6½	9	13	64	10½
O	1	19½	16	5	29	10½	3	18½	49	20
P	7	12½	10	13½	33	6½	9	13	59	12
Q	8	11½	12	9	34	4½	0	21	59	12
R	24	1	13	8½	35	3½	19	5	91	1
S	6	13	3	18	16	20	3	18½	28	27
T	9	10½	17	4	25	13	21	3	72	5
U	4	15	17	4	25	13	17	7	63	11
V	17	3	10	13½	36	2	20	4	83	2
W	13	6	7	16½	29	10½	1	20	50	19
X	1	19½	14	7	33	6½	18	6	66	9
Y	0	21½	16	5	32	8½	16	8½	64	10½
Z	0	21½	16	16	32	8½	16	8½	64	10½
A'	9	10½	9	14	37	1	13	9½	68	7½
B'	3	17	11	11	32	8	9	13	55	17
C'	18	2	10	13½	24	14½	2	19½	54	18
D'	3	17	13	8½	32	8	8	14½	56	15

true-false, and maintained the latter rank in the combined results of the entire battery; J ranked 1 on the judgment test, but fell to rank 15 on the true-false test; student Q fell from rank 4½ on the multiple-choice test to rank 21 on the judgment test; U dropped from rank 4 on the completion test to rank 15 on the true-false test; student C went down from rank 2 on the true-false test to 19½ on the judgment test.

TABLE II

This table contains the scores of the thirty pupils arranged in rank order for each test of the battery used for the course in educational measurements, and the composite scores for the battery.

True-false	Completion	Multiple-choice	Judgment	Total
24	20	37	30	91
18	20	36	22	83
17	19	35	21	79
16	17	34	20	77
13	17	34	19	72
13	17	33	18	68
13	16	33	17	68
12	16	33	16	66
11	14	33	16	64
10	14	32	13	64
9	14	32	13	64
9	13	32	11	63
8	13	32	11	59
8	12	30	10	58
7	11	29	9	57
7	11	29	9	56
6	11	26	9	55
4	10	25	9	55
4	10	25	8	55
4	10	25	8	54
3	10	24	7	53
3	9	23	6	50
3	7	22	5	49
1	7	22	5	48
1	7	21	3	46
1	7	19	3	45
1	6	18	2	39
0	3	18	2	37
0	0	16	1	30
0	0	15	0	28

If we were assigning scores to the members of this group on the basis of the normal distribution curve, we should have: 1 or 2 A's; 7 or 8 B's; 10 or 11 C's; 7 or 8 D's; and 1 or 2 E's. The assignment on this basis for the various tests would likely be as shown in Table III.

TABLE III

This table is read thus: A score of 11-18 on the true-false test is equal to a grade of B. There would be 8 B's assigned from the true-false scores.

True-False		Completion		Multiple-Choice		Judgment		Composite Scores						
Score	Grade No	Score	Grade No	Score	Grade No	Score	Grade No	Score	Grade No					
24	A	1	19-20	A	3	36-37	A	2	30	A	1	83-91	A	2
11-18	B	8	14-17	B	8	33-35	B	7	16-22	B	8	64-79	B	10
4-10	C	11	10-13	C	10	25-32	C	11	8-13	C	11	54-59	C	9
1-3	D	7	3-9	D	7	18-24	D	8	2-7	D	8	37-50	D	7
0	E	3	0	E	2	15-16	E	2	0-1	E	2	28-30	E	2

The foregoing table shows that the distribution of marks made from the point scores of any one of the four tests composing this battery give a near approach to a normal distribution. This, probably, means that any one of the tests has measured the group approximately correctly. There is one very decided advantage here in the use of the composite scores¹ in determining the marks² over the use of the scores of any one test. That advantage is that there is a distinct difference between the scores that are rated as the equivalent of one letter and those that are rated as meriting another. For example, between the highest score, 50, rated as D and the lowest score, 54, rated C there are four points. Making the intervals for the marks of B begin with 59 instead of 63 gives a distinction between the B's and C's that we would not have if we tried to adhere closely to the normal distribution curve. While the preceding table gives us evidence to the effect that any one of the four tests has measured the group as a whole, it gives us no information as to the degree of fairness with which any one test has measured the various individuals of the group. Table IV will give us some aid in answering this question.

The results of the various tests in the battery used for the class in educational measurements are given in Table I. The table is read thus: Pupil A made a score of 11 with a rank of 7 on the true-false test; a score of 7 with a rank of 16½ on the completion test; a score of 19 with a rank of 18 on the multiple-choice test; a score of 11 with a rank of 10½ on the judgment test; his total score on the battery is 48 with a rank of 21.

¹The composite score for each student was obtained by taking the sum of his scores on the four tests.

²Marks and grades are used inter-changeably in this discussion.

TABLE IV

Student	True-False Test Score Mark	Completion Test Score Mark	Multiple- Choice Test Score Mark	Judgment Test Score Mark	Total Score Mark
A	11 B	7 D	19 D	11 C	48 D
B	13 B	10 C	15 E	8 C	46 D
C	0 E	7 D	21 D	2 D	30 E
D	10 C	20 A	23 D	5 D	58 C
E	13 B	14 B	18 D	13 C	68 B
F	3 D	20 A	25 C	7 D	55 C
G	1 D	10 C	18 D	6 D	45 D
H	1 D	11 C	22 D	5 D	39 D
I	12 B	0 E	22 D	3 D	37 D
J	4 C	19 B	26 C	30 A	79 B
K	7 C	7 D	30 C	11 C	55 C
L	16 B	17 B	34 C	10 C	77 B
M	4 C	11 C	33 B	9 C	57 C
N	8 C	14 B	33 B	9 C	64 B
O	1 D	16 B	29 C	3 D	49 D
P	7 C	10 C	33 B	9 C	59 C
Q	8 C	12 C	34 B	0 E	59 C
R	24 A	13 C	35 A	19 B	91 A
S	6 C	3 D	16 E	3 D	28 E
T	9 C	17 B	25 C	21 B	72 B
U	4 C	17 B	25 C	17 B	63 B
V	17 B	10 C	36 A	20 B	83 A
W	13 B	7 D	29 C	1 E	50 D
X	1 D	14 B	33 B	18 B	66 B
Y	0 E	16 B	32 C	16 B	64 B
Z	0 E	16 B	32 C	16 B	64 B
A'	9 C	9 D	37 A	13 C	68 B
B'	3 D	11 C	32 C	9 C	55 C
C'	18 B	10 C	24 D	2 D	54 C
D'	3 D	13 C	32 C	8 C	56 C

Marks that some students would receive on the different tests of the battery. Student C, as shown in Table IV, has a zero score for the true-false test which would give him a mark of E or failure; his score of seven would give him by the distribution in Table II, column two, a mark of D, or passing, on the completion test; his score of 21 on the multiple-choice test would give him a D according to the ranking in Table III; his score of 2 on the judgment test would also give him a D. However, his composite score of 30 would give him an E. This student would in all probability object to having his mark assigned from the

true-false scores. However, he is so near the border line on the other three tests, and his ranking on the composite scores gives him an E, so that it is probably a fair mark for him.

Student I with a score of 12 would be given a mark of B on the true-false test; an E on the completion test; a D on the multiple-choice test; a D on the judgment test; and a D on the composite test. It is certainly evident that this individual would be favored by assigning his marks on the basis of the true-false test. It is also evident that it would be an injustice to him to assign his marks on the basis of the completion test scores. The marks obtained from his composite score ranking would certainly represent his achievement more accurately than the one obtained from his ranking on either the true-false or completion test.

J would have a mark of C on the true-false test; a B on the completion test; a C on the multiple-choice test; an A on the judgment test; and a B on the composite scores. If he were assigned a mark as a result of his rank on either the true-false or the multiple choice test, it would imply mediocrity of achievement for him. If his grade were to be made out on the judgment test, he would be marked as a very superior student. It is probable that the nearest representation of his true achievement is the mark resulting from his rank on the composite scores.

O would be given an E or D on his true-false score; a B on the completion test; a C on the multiple-choice test; a D on the judgment test; and a D on his composite score. His composite score almost merits a mark of C- which perhaps would be nearer his true rating than that given by any one of the tests.

A should have a C on the true-false test; D on the completion test; an A on the multiple-choice test; a C on the judgment test; and a B on his composite score which is in all probability a fair index of his achievement.

C would get a B on his true-false score; a C on his completion score; a D on the multiple-choice; a D on the judgment test; and a C on his composite score.

There are several other cases of individuals in this group whose case would show that a student may make a high grade on one type of test and a low mark on another type, even when the tests are comparatively equal in difficulty. The numerous variations, resulting from the use of different test scores, exhibited here, furnish rather definite evidence that some students would be rated too high by the use of any one of the types of tests in the battery, and that others would be rated too low by the use of any one type.

Table V shows the number of students who would receive the same mark from the scores of the various units of the battery as they would receive on the composite scores. The table is read thus: twelve students would receive the same mark from the true-false test scores that they would receive from their composite scores.

TABLE V

Number of Students	Name of Test
12	True-false
11	Completion
9	Multiple-choice
6	Judgment

The results shown by this table would indicate that the true-false and completion tests have measured correctly about an equal number of students in this group. However, neither of them give the true rating of the majority of the group. The fact that most of the students have

TABLE VI

Student	True-False Test		Traditional Test		Multiple-Choice Test		Judgment		Total	
	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
A	12	15	16	9	10	14	9	17	47	18½
B	16	10	17	7½	14	8	28	1	67	5
C	16	10	17	7½	8	16½	6	19	47	18½
D	20	4½	4	21	12	11	21	4	57	9
E	9	17½	11	15	6	18	15	13	41	21
F	15	11½	16	9	12	11	16	11½	59	7½
G	9	17½	15	11	12	11	14	14½	50	16½
H	12	15	9	16	10	14	14	14½	45	20
I	12	15	5	20	8	16½	21	4	46	19
J	8	19	20	3½	20	5	18	8½	55	12
K	20	4½	12	13	10	14	7	18	49	17
L	15	11½	20	3½	16	11½	21	4	72	3½
M	8	19	17	7½	10	14	20	5	55	12
N	16	10	22	1½	4	19	10	16½	52	14
O	16	10	17	7½	12	11	15	13	60	6½
P	20	4½	18	5	18	4	18	7	74	2
Q	18	5½	14	12	10	14	17	10	9	23
R	17	6	15	11	22	1	17	10	71	4
S	8	19	18	5	2	20	0	20	29	22
T	13	13½	16	9	14	8	16	11½	59	7½
U	20	4½	21	2	18	4	17	10	76	1
V	16	10	8	18	8	16½	18	7	50	16½
W	16	10	18	5	14	8	12	15½	60	6½
X	13	13½	11	15	6	18	21	4	54	13
Y	14	12	8	18	8	16½	21	4	51	15
Z	18	5½	8	18	12	11	19	6	57	9
A'	22	1½	22	1½	16	5	12	15½	72	3½
B'	22	1½	6	19	14	8	15	15½	57	9
C'	21	2	11	15	6	18	18	8½	56	10
D'	16	10	15	11	14	8	10	16½	55	12

had a great deal of practice in taking the true-false test, and but little practice in taking the other types may partly account for the slight superiority of the true-false test in this respect. The judgment test makes the poorest showing of any unit of this battery.

The results of the different units in the battery of tests given to the class in school management are shown in table VI, which is read the same as table I.

In Table VI, we also observe, as in table I, a difference of the same individuals' rank for different tests. However, the variation as shown in this table is not quite so great as that revealed in the first table. Some pronounced cases of shifting are: J, who changed from rank $3\frac{1}{2}$ on the

TABLE VII

True-False Test	Traditional Test	Multiple-Choice Test	Judgment Test	Composite Test
22	22	22	28	76
21	22	20	21	74
21	21	18	21	72
21	21	18	21	71
20	20	18	21	67
20	18	16	21	60
18	18	15	20	60
18	18	14	19	59
17	17	14	18	59
16	17	14	18	57
16	17	14	18	57
16	17	12	18	57
16	16	12	17	56
16	16	12	17	55
16	16	12	17	55
16	15	12	16	55
15	15	10	16	54
15	15	10	15	52
14	14	10	15	51
13	12	10	15	50
13	11	8	14	50
12	11	8	14	50
12	11	8	12	49
12	9	8	12	49
11	8	6	10	47
9	8	6	10	46
9	8	6	9	45
8	6	4	7	41
8	5	2	6	29
8	4		0	9

traditional test to rank 19 on the true-false; D who dropped from the rank of $4\frac{1}{2}$ on the true-false test to 21 on the traditional; B fell from rank $1\frac{1}{2}$ on the true-false test to 19 on the traditional. On the other hand, there is a slight tendency shown here for those who rank high in one test to rank comparatively high on all tests. Likewise, there is a slight tendency for those who rank low in one test to rank comparatively low in all of them.

Table VII contains the scores of the thirty students arranged in rank order for the various tests of the battery given in the course in school management and the composite scores for the battery.

Table VIII gives us a near approach to a symmetrical distribution of scores for each one of the tests in this battery. This fact is some evidence that any one of the tests measures the achievement of the group and that one does it as well as another. On the same basis that the marks were distributed in Table II, we would assign marks from the various distributions in Table VIII as follows:

True-False	Traditional	Multiple-Choice	Judgment	Composite Score
22=A	22=A	22=A	28=A	74-76=A
17-21=B	18-21=B	15-20=B	19-21=B	59-72=B
13-20=C	14-17 C	10-14 C	15-28 C	51-57=C
9-12=D	8-12 D	6-8 D	7-14 D	41-50 D
8-10=E	4-6 E	2-4 E	0-6 E	9-29 E

The marks that would be assigned on tests given to the class in school management are shown in table IX which is read the same as table I.

TABLE IX

Student	True-False Test Score Mark	Traditional Test Score Mark	Multiple-Choice Test Score Mark	Judgment Test Score Mark	Total Score Mark
A	12 D	16 C	10 C	9 D	47 D
B	16 C	17 C	14 C	28 A	67 B
C	16 C	17 C	8 D	6 E	47 D
D	20 B	4 E	12 C	21 B	57 C
E	9 D	11 D	6 D	15 C	41 D
F	15 C	16 C	12 C	16 C	59 B
G	9 D	15 D	12 C	14 D	50 D
H	12 D	9 D	10 C	14 D	45 D
I	12 D	5 E	8 D	21 B	46 D
J	8 E	20 B	20 B	18 C	55 C
K	20 B	12 D	10 C	7 D	49 D
L	15 C	20 B	16 B	21 B	72 B
M	8 E	17 C	10 C	20 B	55 C

N	16 C	22 A	4 E	10 D	52 C
O	16 C	17 C	12 C	15 C	60 B
P	20 B	18 B	18 B	18 C	74 A
Q	18 B	14 C	10 C	17 C	59 B
R	17 C	15 C	22 A	17 C	71 B
S	8 E	18 B	2 E	0 E	29 E
T	13 D	16 C	14 C	16 C	59 B
U	20 B	21 B	18 B	17 C	76 A
V	16 C	8 D	8½D	18 B	50 D
W	16 C	18 B	14 C	12 D	60 B
X	13 D	11 D	6 D	21 B	54 C
Y	14 C	8 D	8½D	21 B	51 C
Z	18 B	8 D	12 C	19 B	57 C
A'	22 A	22 A	16 B	12 C	72 B
B'	22 A	6 D	14 C	15 C	57 C
C'	21 A	11 D	6 D	18 C	56 C
D'	16 C	15 C	14 C	10 D	55 C

Let us observe some of the marks that certain individual students would receive on the scores of the various units of this battery and on the composite scores.

Student B would be assigned C on his true-false test; C on his traditional test score; C on his multiple-choice test score; A on his judgment test score; and B on his composite score. This latter rating in all probability represents his achievement better than his rating in any one of the tests.

Student D would be rated as: a B student on his true-false score; an E student on the traditional test score; a C student on his multiple-choice test scores; a B student on his score on the judgment test; a C student on his composite score. It would certainly make a difference to D whether he were rated on the tradition or the judgment test.

Student I would be assigned a D on the true-false test; an E on the traditional test; a D on the multiple-choice test; a B on the judgment test; and a D on the composite scores. If the traditional test mark would be too low for this student, the judgment test mark would likely not over-rate his ability, but in all probability it would over-rate his achievement.

J would be assigned: an E on the true-false test; a B on his traditional score; a B on his multiple-choice test score; and a C on his composite score.

R would be marked from the various test scores thus: from his true-false test score B; and from his traditional test score C; from his multiple-choice score A; from his judgment test score C; from his composite score B.

Student B. would be given on the true-false test an A; on the traditional test D; on the multiple-choice test C; on the judgment test

C; on the composite scores a C. This student would get the lowest passing mark that could be given on the multiple-choice test, and the highest mark that could be given on the true-false.

A number of other cases could be cited from tables VIII and IX, showing that a rating given a student from his scores on one test would be one or two letters higher than a rating given from his scores on another test. Some pupils rate higher on a true-false test than on any of the others. The same thing can be said of any of the other tests. All of this suggests the implication that different types of tests measure different intellectual qualities; and that composite tests scores give a fairer rating of most students than that obtained by the use of any one of the types used in this battery. One of the difficulties that would be encountered in assigning grades on the basis of the composite scores would be caused by the wide range between the lowest score, 59, rated B and the highest one, 72, given the same mark. The writer would adjust this by assigning a B for the score of 67, a B- for all scores above 67 in the range for the B's, and B- for all scores below 67 coming within the range of the B's. A distinct advantage of the use of the composite scores in this case would be the very noticeable difference between the point scores of the different letters. For example, the highest point score rated D is 50 and the lowest one rated C is 54.

Table X shows the number of students that would receive the same mark on the various units of the battery used for the class in school management, that they would receive on their composite scores. The table is read the same as Table V.

TABLE X

Number of Students	Name of Test
10	True-False
6	Traditional
9	Multiple-Choice
9	Judgment

The preceding table indicates that the true-false, multiple-choice, and judgment tests each measured about the same number of students approximately justly. The true-false, multiple-choice and judgment tests have each measured about the same proportion of the members of the classes. The traditional test has, it would seem, measured the smallest number.

Summary

This study has been based upon scores of thirty students all of whom were in two courses given by the writer during the first semester 1929-1930 at the Fairmont State Normal School. There were two sections of either course. There were fifty-five students in each course. Only the scores of those students who were in both courses have been

considered. The classes for both courses met the same day, one hour a day, two days a week for eighteen weeks. The tests were given at the last meeting of the class for the semester. The same time was given to each unit of each test in the two batteries.

The ranking and final marks that would be assigned the individual students on the different types of tests vary greatly. Very few students would receive the same or nearly the same mark from his scores on each of the types of tests used. The true-false and multiple-choice tests have apparently measured about the same proportion of people in both batteries. The true-false test in either battery measured the accomplishment of a slightly larger proportion of the members of the group than was measured by the multiple-choice test. The group as a whole was measured satisfactorily by the judgment test of either battery, but in the course in educational measurements only six persons would have received the same mark from his score on this test that he would have received from his composite score. In the course in school management nine individuals would have received the same marks from their scores on the judgment test that they would have received from their composite scores. Both the completion and traditional test measured the group satisfactorily. Since the completion was used in one battery and traditional displaced it in the other battery, no comparison of the scores of these two tests that would be applicable to both batteries can be made. The completion test seems to have measured about the same number of individuals in the course in educational measurements as the true-false. The traditional appears to have measured the smallest number of any of the types used in the course in school management.

Conclusions

This study has been too limited in the number of cases considered as well as in the number of types of tests used to justify any definite conclusions as to what type or types of tests should be used in assigning marks to college students. However, there is evidence that justifies two conclusions: 1. The use of any one type of test in grading college students will result in some students receiving a higher mark than they merit, and others receiving a lower mark than they justly deserve.

2. A composite score made from several types of tests will give each individual in a group a more just rating than the score made on any one type of test.

