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of

THE WEST VIRGINIA ACADEMY OF SCIENCE

Volume 10

The Thirteenth Annual Session

BETHANY COLLEGE

BETHANY WEST VIRGINIA

May 1-2, 1936

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Geology and Mining	Paul Price, Morgantown
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Officers for 1936-37

President	Frank Cutright, Athens
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Geology and Mining	J. H. C. Martens, Morgantown
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Social Science, Group I	E. L. Lively, Fairmont
Social Science, Group II	Roy Woods, Huntington

MEMBERS OF THE WEST VIRGINIA ACADEMY OF SCIENCE

Albert, C. E., acting president, Davis and Elkins College, Elkins.
*Allen, J. S. V., instructor in physics, Bethany College, Bethany.
*Allman, Floy, teacher of science, High School, Normantown.
Ambler, C. H., prof. of history, W. V. U., Morgantown.
Amidon, Ruth Braden, Morgantown.
Ammons, Nelle P., instructor in botany, W. V. U., Morgantown.
Anson, Charles P., prof. of social science, Potomac State School, Keyser.
Arnett, Jerome C., Aurora.
Atha, Lester, teacher, High School, Monongah.
Bailey, Sebie, science teacher, High School, Fairmont.
*Bailey, Wayne, teacher of biology, High School, Rock.
Bartlett, J. V., prof. of chemistry, Marshall College, Huntington.
Bell, Raymond, teacher, High School, Smithers.
*Bennett, Bessie Burns, assoc. prof. of English, Concord State College, Athens.
Bergy, Gordon A., prof. of pharmacy, W. V. U., Morgantown.
Bibbee, P. C., prof. of zoology, Concord State College, Athens.
Bird, Ralph, chemist, Athens.
Blackwell, A. C., prof. of chemistry, Morris Harvey College, Charleston.
Bloss, James R., physician, 418 11th Street, Huntington.
Boggess, Grace, teacher, High School, Farmington.
Boggess, Randolph, teacher, High School, Oakvale.
Bonar, Ross, principal, High School, Buckhannon.
Bond, H. D., prof. of biology, Salem College, Salem.
Bowers, E. V., Prof. of psychology, Marshall College, Huntington.
Brooks, Alonzo B., park naturalist, Oglebay Park, Wheeling.
Brooks, Maurice, instructor in biology, W. V. U., Morgantown.
Brouzas, C. G., librarian, and prof. of classics, W. V. U., Morgantown.
Brown, A. Coleman, address unknown.
Brown, Russel G., dept. of botany, New River State College, Montgomery.
Brown, W. S., Boyce Thompson Institute for Plant Research, Yonkers, N. Y.
Brownell, Phyllis, science teacher, High School, Ripley.
*Burke, J. J., paleontologist, Carnegie Museum, Pittsburgh, Pa.
Burke, Stephen P., 2920 24th St. N. W., Washington, D. C.
Burkhalter, Capt. L. I., C. C. C. chaplain, Elkins.
Cameron, Hazel C., Agricultural Experiment Station, W. V. U., Morgantown.
Campbell, Carl G., prof. of chemistry, Marshall College, Huntington.
Cardear, R. H., prof. of business, Wesleyan College, Buckhannon.
Chapman, Daisy V., biology teacher, High School, Williamson.
Clark, Friend E., prof. of chemistry, W. V. U., Morgantown.
Collett, A. R., prof. of chemistry, W. V. U., Morgantown.
Collins, Bernice E., dean of girls, High School, Charleston.
Colwell, Rachel H., prof. of home economics, W. V. U., Morgantown.
Colwell, Robert C., prof. of physics, W. V. U., Morgantown.
Conley, Phil, editor, West Virginia Review, Charleston.

* Member elected at the Bethany meeting, May 1936.

Core, Earl L., asst. prof. of botany, W. V. U., Morgantown.
Craig, F. Waldo, State Department of Agriculture, Charleston.
*Cramblet, W. H., president, Bethany College, Bethany.
Cushman, M. S, head of dept. of history, Concord State College, Athens.
Cutright, Frank, prof. of biology, Concord State College, Athens.
Cutright, Samuel C., student, Concord State College, Athens.
Dadisman, A. J., prof. of economics, W. V. U., Morgantown.
Darlington, H. C, asst. prof. of biology, Marshall College, Huntington.
Davies, E. C. H., prof. of chemistry, W. V. U., Morgantown.
Davis, Hannibal A., assoc. prof. of mathematics, W. V. U., Morgantown.
Dawson, H. Donald, prof. of chemistry, Bethany College, Bethany.
Dawson, Hubert, chemist, Boomer.
Dodds, Gideon S., prof. of histology, W. V. U., Morgantown.
*Downing, R. H., instructor in mathematics, W. V. U.. Morgantown
Dustman, R. B., prof. of agricultural chemistry, W. V. U., Morgantown.
Eiesland, John A., prof of mathematics, W. V. U., Morgantown.
*Erskine, Wm. H., instructor in mathematics, Bethany College, Bethany.
Farnsworth, Bonnie, teacher of science, High School, Linn.
Frankhauser, Pearl, assoc. prof. of education, Concord State College, Athens.
Fenton, C. C., prof. of pathology, W. V. U., Morgantown.
Ferry, James F., dept. of botany, W. V. U., Morgantown.
Finch, D. B., instructor in manual training, New River State College, Montgomery.
Fisher, Virginia, teacher, North View Jr. High School, Clarksburg.
Forbes, Raymond, teacher of chemistry, High School, Oak Hill.
*Ford, O. R., assoc. prof. of physics, W. V. U., Morgantown.
Forman, A. H., prof. of electrical engineering, W. V. U., Morgantown.
*Fox, Robert K., asst. prof. of chemistry, Bethany College, Bethany.
Franzheim, Charles M., Wheeling.
Fridley, Harry M., assoc. prof. of geology, W. V. U., Morgantown.
Fromme, Fred D., dean, College of Agriculture, W. V. U., Morgantown.
Frye, Wilbert M., teacher, High School, Capon Springs.
Galbraith, F. D.. prof. of chemistry, Potomac State School, Keyser.
Galpin, Sidney L., land planning consultant, Morgantown.
Garber, Ralph J., State College, Pa.
Gardner, S. O., Blacksville.
Gatherum, R. S, head dept. of Math., Concord State College, Athens.
Gay, F. R., prof. of English, Bethany College, Bethany.
Gilbert, Frank H., prof. of botany, Marshall College, Huntington.
Giltner, Virginia, teacher of science, High School, Dunbar.
Gist, Russell H., Agricultural Extension Service, W. V. U., Morgantown.
Gorrell, Elizabeth, teacher of mathematics, High School, Dunbar.
Gould, Chas., Jr., botanist, Marshall College, Huntington.
Green, N. Bayard, teacher of biology, High School, Elkins.
*Greenlee, Leslie E., teacher of biology, High School, Nitro.
Grey, Mrs. H. P., teacher of biology, High School, Beckley.
Gribble, Lloyd R., asst. prof. of zoology, W. V. U., Morgantown.
*Grimes, R. A., teacher of science, High School, Clay.
Grimm, R. J., assoc. prof. of chemistry, New River State College, Montgomery.

Gwinn, Clyde W., prof. of education, Mansfield State Teachers College, Mansfield, Pa.
Hall, Arthur A., prof. of electrical engineering, W. V. U., Morgantown.
Hall, Frank, prof. of education, Fairmont State College, Fairmont.
Handlan, John W., curator of museum, Oglebay Park, Wheeling.
Hansford, R. C., dept. of chemistry, George Washington University, Washington, D. C.
Harris, T. L., prof. of sociology, W. V. U., Morgantown.
Harshbarger, Jennie, teacher of biology, High School, Fairmont.
Haught, D. L., dean, Concord State College, Athens.
Haught, O. L., graduate student, W. V. U. Morgantown.
Hazlett, Mary R., teacher of science, 333 Wellwood St., Pittsburgh, Pa.
Herndon, L. K., 420 Beauregard St., Charleston.
Hill, Caton N., principal, High School, Sutton.
Hill, George H., engineer, S. R. C., Holley Ave., Charleston.
Hill, Hubert, prof. of chemistry, W. V. U., Morgantown.
Hill, L. B., prof. of education, W. V. U., Morgantown.
Hill, Laurence E., student, W. V. U., Morgantown.
Hodge, W. W., prof. of chemical engineering, W. V. U., Morgantown.
Hogue, Mahalia, teacher of chemistry, High School, Wadestown.
*Holtzman, Howard E., technician, Hopemont Sanitarium, Hopemont.
*Holy, John S., teacher of science, High School, Alum Bridge.
*Hopkins, Charles, teacher of social science, High School, Montgomery.
Hornor, Carl L., mining engineer, Clarksburg.
Hoskins, Homer A., chemist, State Geological Survey, Morgantown.
Hron, R. P., prof. of physics, Marshall College, Huntington.
Hunt, Geo. R., prof. of zoology, Fairmont State College, Fairmont.
Hurst, Hugh, teacher of science, University High School, Morgantown.
Hutchinson, Kenneth D., instructor in economics, W. V. U., Morgantown.
Ice, Homer C., geologist, Morgantown.
Jacobson, Carl A., prof. of chemistry, W. V. U., Morgantown.
James, G. Claire, dept. of science, Glenville State College, Glenville.
*Jenni, Clyde B., asst. prof. of chem. engineering, W. V. U., Morgantown.
Johnson, Clyde, teacher, High School, Bluefield.
Johnson, G. S., chemist, Malden.
Jones, Clement R., dean emeritus, College of Engineering, W. V. U., Morgantown.
Jones, Harris A., Government meteorologist, Elkins.
Judson, J .E., prof. of biology, Wesleyan College, Buckhannon.
Kelly, Mathew J., Kelly Foundry and Machine Co., Elkins.
King, Genevieve, graduate student, W. V. U., Morgantown.
*Kirkpatrick, Forrest H., dean, Bethany College, Bethany.
Kiser, R. P., teacher of chemistry, High School, Dunbar.
*Klinger, Earl, chemist, S. R. C., Morgantown.
*Koehler, W. A., prof. of chemical engineering, W. V. U., Morgantown.
Laing, James T., prof. of sociology, Kent State University, Kent, Ohio.
Lambert, John M., 848 Clark St., Shinnston.
Lang, Thomas S., city engineer, Clarksburg.
Largent, Robert J., dean, Marshall College, Huntington.

Lauterbach, C. E., prof. of education, Wesleyan College, Buckhannon.
Law, Lewis B., graduate asst. in geology, W. V. U., Morgantown.
Lawall, Charles E., prof. of mining engineering, W. V. U., Morgantown.
Lazzell, Charles, assoc. prof. of chemistry, W. V. U., Morgantown.
*Leitch, Andrew, prof. of psychology, Bethany College, Bethany.
Lilly, V. G., dept. of plant pathology, W. V. U., Morgantown.
Lively, E. L., prof. of sociology, Fairmont State College, Fairmont.
Loy, Melvin P., prof. of biology, Marshall College, Huntington.
Ludwig, Ross, teacher of science, High School, Dunbar.
McCray, Charles M., teacher of science, High School, Princeton.
McCue, John B., chemist, State Geological Survey, Morgantown.
McGuire, A. E., prof. of education, Concord State College, Athens.
McNeill, E. Meade, prof. of biology, Concord State College, Athens.
Maclin, E. S., president, New River State College, Montgomery.
Marsh, J. F., president, Concord State College, Athens.
Martens, J. H. C., assoc. prof. of geology, W. V. U., Morgantown.
Martin, Elizabeth, teacher, High School, Charleston.
Matheny, John W., asst. prof. of history, New River State College, Montgomery.
Mauzy, Frank, dean, Potomac State School, Keyser.
Maxwell, C. W., attorney, Elkins.
Meakin, H. V., landscape architect, State Park, Watoga.
*Merrill, Vernon L., student, Wesleyan College, Buckhannon.
Miller, Myrtle, teacher of science, Jr. High School, Fairmont.
Molby, F. A., prof. of physics, W. V. U., Morgantown.
Montgomery, J. G., Jr., 308 Seneca St., Oil City, Pa.
Morris, Samuel, prof. of chemistry, W. V. U., Morgantown.
*Musgrave, Sally Lou, teacher of chemistry and biology, High School, Pt. Pleasant.
Netting, M. Graham, herpetologist, Carnegie Museum, Pittsburgh, Pa.
Newins, Harold S., assoc. prof. of forestry, Michigan State College, East Lansing, Mich.
O'Brien, Lawrence R., teacher, High School, Montgomery.
Ohlson, H. C., teacher of science, High School, Huntington.
Oliver, Joe, teacher of mathematics, High School, Smithers.
Orton, C. R., prof. of plant pathology, W. V. U., Morgantown.
Packard, Russell L., prof. of geography, Concord State College, Athens.
Palmer, John C., Jr., attorney, Rock Ledge, Wheeling.
Parks, Otia C., teacher of chemistry, High School, Spencer.
Patterson, J. H., principal, High School, Thomas.
Patterson, Robert C., prof. of biology, Potomac State School, Keyser.
Percival, W. C., assoc. prof. of forestry, W. V. U.. Morgantown.
Potter, Charles, chemist, Coal Authority, Box 1188, Fairmont.
Price, Paul H., assoc. prof. of geology, W. V. U., Morgantown.
Purdum, R. B., prof. of chemistry, Davis and Elkins College, Elkins.
Pyle, F. J., prof. of education, Montgomery.
Raub, Leo G., prof. of physics, New River State College, Montgomery.
Reese, Albert M., prof. of zoology, W. V. U., Morgantown.
Reger, David B., consulting geologist, Box 816, Morgantown.
Regier, C. C., prof. of history, West Liberty State College, West Liberty.

Reynolds, Clarence N., Jr., prof. of mathematics, W. V. U., Morgantown.
*Rice, Ralph L., teacher of social science, High School, Berkeley Springs.
Richards, Margaret, teacher of biology, High School, Morgantown.
Roberts, C. M.,prof. of biology, Fairmont State College, Fairmont.
Rogers, H. F., prof. of chemistry, Fairmont State College, Fairmont.
Rohr, H. D., principal, High School, Weston.
Ryan, Thomas, student, New River State College, Montgomery.
Saleski, R. E., Woodridge, Albemarle county, Virginia.
Saposnekow, Jacob, asst. prof. of sociology, W. V. U.,. Morgantown.
Schoolcraft, A. A., prof. of education, Wesleyan College, Buckhannon.
Seyler, Zelma K., teacher of biology, High School, Wellsburg.
Shahan, J. Buhl, Elkins.
Shearer, M. L., Address unknown.
Shilliday, C. Lee, prof. of biology, Morris-Harvey College, Charleston.
Shouse, James B., dean of teachers college, Marshall College, Huntington.
Shreve, Francis, prof. of education, Fairmont State College, Fairmont.
Shreve, John C., president, West Liberty College, West Liberty.
*Shreve, O. D., teacher of chemistry and physics, High School, Elkins.
Shughron, Nelie, teacher, High School, War.
Shutts, H. A, prof. of mathematics, Fairmont State College, Fairmont.
Skuce, Thomas W., Conservation Commission, Charleston.
*Smith, Reynolds B., extension forester, W. V. U., Morgantown.
Smith, Wallace, prof. of mathematics, New River State College, Montgomery.
Spangler, R. C., dept. of botany, W. V. U., Morgantown.
Speicher, B. I., Morgantown.
Stathers, Allan, teacher of mathematics, High School, Sistersville.
Stayman, Joseph W., president, Potomac State School, Keyser.
Stevenson, C. A., prof. of education, Davis and Elkins College, Elkins.
Stewart, Joseph K., instructor in mathematics, W. V. U., Morgantown.
Stout, Wilbur, state geologist, Columbus, Ohio.
Strader, L. D., teacher of biology, High School, Bolivar.
Straley, H. W., III, Stralehurst, Princeton.
Straley, Joseph, teacher of biology, High School, Davy.
Strausbaugh, Perry D., prof. of botany, W. V. U., Morgantown.
Strickland, Cecil, teacher, high School, Clendenin.
Strosnider, Ruth, teacher of chemistry, High School, Blacksville.
Sutton, J. B., Morgantown.
Sumpstine, Wilbur J., prof. of biology, Bethany College, Bethany.
Talbot, S. Benton, prof. of biology, Davis and Elkins College, Elkins.
Taylor, Leland H., assoc. prof. of zoology, W. V. U., Morgantown.
Tissue, Rhema Smith, Montgomery.
Todd, Leslie J., prof of chemistry, Marshall College, Huntington.
Toothman, H. F., dean, West Liberty State College, West Liberty.
Trent, W. W., State Superintendent of Schools, Charleston.
Tucker, R. C., State Geological Survey, Box 265, Morgantown.
Turner, Bird M., prof. of mathematics, W. V. U., Morgantown.
Ulbrich, Albert, medical student, 1065 E. Broad St., Westfield, N. J.
Utterback, W. I., prof. of biology, Marshall College, Huntington.
Van Tromp, H. O., physician, French Creek.

Vehse, Charles H., asst. prof. of mathematics, W. V. U., Morgantown.
Vest, G. Ellis, teacher, High School, Bluefield.
Vest, M. L., prof. of mathematics, Davis and Elkins College, Elkins.
Wagner, John R., prof. of chemistry, Glenville State College, Glenville.
Ward, John Baylis, coal prospector, Beverly.
Weakley, Chas. E., Jr., chemist, Agricultural Experiment Station, W. V. U., Morgantown.
Weimer, B. R., prof. of biology, Bethany College, Bethany.
*Wells, Dana, instructor in geology, W. V. U., Morgantown.
Wells, Hawley, instructor in biology, Concord State College, Athens.
White, Frank S., prof. of psychology, Fairmont State College, Fairmont.
White, Raymond C. graduate student, W. V. U., Morgantown.
White, Ryland, Fairmont State College, Fairmont.
Wiles, I. A., Morgantown.
Wilmoth, Stark A., principal, Junior High School, Elkins.
*Wilson, Kester, teacher of chemistry, High School, Fairmont.
Wimer, Ralph P., teacher of science, High School, Parsons.
Winter, John E., prof. of psychology, W. V. U., Morgantown.
Wolfe, Russell, physician, Elkins.
Wooddell, W. S., teacher of science, High School, Mullens.
Woods, Roy C., prof. of education, Marshall College, Huntington.
Yost, A. W., teacher, High School, Farmington.
Zucchero, Peter J., teacher of biology, High School, Morgantown.

MINUTES OF THE THIRTEENTH ANNUAL MEETING

THE THIRTEENTH annual meeting of the West Virginia Academy of Science was called to order by the president, G. S. Dodds, at 10 a. m. on May 1, 1936, at Bethany College, Bethany, West Virginia.

The president made a brief report on the progress of the Academy during the past year. The secretary also made a brief report mentioning the Proceedings, the increase in membership during the past year, and the number placed on the inactive list during the past year. An attempt was made to assign some reason for the majority of these cases. The treasurer reported on the financial condition of the Academy and advised that his books were ready for the inspection of the Auditing Committee.

The following report of the Executive Committee was read:

THE EXECUTIVE COMMITTEE REPORT

The Executive Committee of the West Virginia Academy of Science wishes to report that: (1) invitations have been received from Marshall College and from Kanawha College for the Academy to hold its 1937 meeting on their respective campuses; (2) an invitation has been received from the president of West Virginia University, from the University Scientific Society, and from the Sigma Xi Club for the Academy to hold its 1938 meeting at Morgantown; (3) the committee wishes to state its appreciation of the work of Wallace Smith in connection with the Junior Academy organization; (4) the committee has ruled that members making application and paying their fees between meetings shall be considered as paid-up members for one year following the date of their election: i. e., for one year from the date of the next annual meeting following their application; (5) that the committee has agreed to contribute $100 as its share toward the publication of the Proceedings of the 1935 meeting; (6) the committee has increased the Junior Academy Committee to include a member in charge of publicity. The Executive Committee also wishes to make the following recommendations: (1) that the next annual meeting be held at Marshall College April 30 and May 1, and that the Junior Academy meet at the same time and place; (2) that the Academy approve the awarding of the last A. A. A. S. research grant to the state Biological Survey; (3) that a committee of three be set up to award this grant for the coming year; (4) that the Academy allow payment of $30 to the Junior Academy to defray a deficit in the cost of printing the "News Letter".

The report was accepted.

No report was heard from the Legislative Committee.

Mr. Wallace Smith, Senior Counsellor and Chairman, 1935-36, for the Junior Academy Committee, reported as follows:

THE JUNIOR ACADEMY COMMITTEE REPORT

The West Virginia Junior Academy of Science has added nine science clubs to its membership during the year 1935-36. The sponsors of these clubs either were members of the Senior Academy or became members during the year. The high-school students represented in these clubs range from eight to 40 per club.

The Junior Academy published five issues of the Junior News Letter of 300 copies each. These Letters carried 17 articles written by high-school students. It sponsored the second annual program at Charleston, April 24 and 25. About 175 people registered at the convention representing 37 schools, dinner was served to 110, about 350 young people attended the dance, and 60 made the field trip on Saturday the 25th. Twenty-two high-school boys and girls participated in the main program, and in addition a great many served on various committees. All of these young people performed their parts beautifully, with grace and skill.

Two awards of $2.50 each were made: one to the secretary, Miss Mary Oliver, for the best contribution to the Junior News Letter; the other to James Meadows, the new vice president, for the best contribution to the Annual Program.

The new officers are: Miss Mary Oliver, president (Smithers); James Meadows, vice president (South Charleston); Joseph Province, secretary (Fairmont); and Prof. H. F. Rogers, Fairmont, becomes senior counselor.

During the past year the office of the senior counselor sent out approximately 2500 pieces of mail to individuals, science clubs, and high schools. About 800 of these were of the first class. This involved considerable time and labor in letter writing. Those aiding in this work have not received any pay for their time, nor do they expect any.

Up to April 29 the treasurer received $54 in fees. The expenditures were $101.21, leaving a deficit of $47.21.

The report was accepted.

Chairman E. C. H. Davies made a brief report for the Membership Committee which was accepted.

The secretary read the names of 26 proposed new members who had been approved by the Executive Committee. These were elected and are indicated by names starred in the complete membership list on page 6.

The report of the representative to the St. Louis meeting of the American Association for the Advancement of Science was given by the Academy's delegate, C. R. Orton:

THE ACADEMY CONFERENCE REPORT

The Academy Conference of the A. A. A. S. was held in the Jefferson Hotel, St. Louis, December 30, 1935, at 4 p. m. The meeting was called to order by the president of the conference, Professor W. G. O'Kane of the New Hampshire Academy.

The program was opened by a report from Dr. H. E. Enders, Purdue University, on "A Brief History of the Accomplishments of the Academy Conference," a copy of which is appended herewith.

Mr. Watson Davis spoke upon "Ways in which the Science News Letters may Help Junior Academy Members."

Dr. Otis W. Caldwell reported that his Committee on Coordination of Science Clubs and upon Source Material for Junior Academies had not formulated their ideas and had nothing definite to report. The committee was continued.

Dr. Caldwell as General Secretary also reported on State Academy Research Grants.

Twenty-nine academies have benefitted from these grants which vary from $25 to $150. Up to the time of the meeting 24 of these had reported upon the use of the grants of which 20 report approval of the new plan of making grants. The Council has approved grants for another year on the same basis.

There followed a general discussion of matters of interests to the Academies.

Dr. Henry B. Ward stated briefly the financial situation in the A. A. A. S., which is rather serious for the reason that the reserves built up prior to 1930 have been gradually depleted during the past five years. The Association was planning, however, to continue the policy of grants as long as funds were available.

In answer to the question, "What restrictions are placed upon the grants to Academies?" Dr. Ward stated there was none except that the money could not be spent for the publication of research. The matter rests with the Academies.

The Permanent Secretary, Mr. H. B. Ward, made the following requests:

1. Secretaries of all Academies are requested to notify the General Secretary, Dr. Otis W. Caldwell, of all members of their respective Academies who are members of the A. A. A. S. in good standing.
2. All Secretaries of Academies are requested to forward a brief statement of their general activities for the past two years.
3. What policy is in force with respect to the publication of Proceedings and method of financing same?
4. How is membership in the Academies limited?

Considerable discussion centered about the subject of Junior Academies or Clubs and Branch Science Clubs. The Junior Science Club movement has assumed considerable importance in Illinois and in some other states. These are chiefly organized around high-school leaders who have a special interest and ability in organizing young people.

The Branch Clubs have also increased in number, and it was clearly indicated that the A. A. A. S. is very sympathetic in any effort which the State Academies have taken to increase the number and activity of either Junior Academies or Branch Science Clubs. It was further considered desirable that such organizations be affiliated with the State Academies.

The meeting was followed by a complimentary dinner in the Hotel which was attended by President Karl T. Compton; Henry B. Ward, Permanent Secretary; Otis W. Caldwell, General Secretary; Burton W. Livingston, former Permanent Secretary; Dr. A. F. Woods and Dr. J. McKeen Cattel, Councilors of the A. A. A. S. Short talks were made by Dr. Compton, Dr. Cattel, and Dr. Livingston. Prof. W. H. Alexander, President-Elect of the Academy Conference, presided.

The report was accepted.

No report was forth-coming from the Activities Committee.

Chairman Strausbaugh, reporting for the Brooks Garden Committee, stated that little had been accomplished during the past year because of complications arising through changes in the set-up of the various agencies engaged in the work. He stated that the Committee felt especially the loss of H. V. Meakin, landscape architect on the project, who has been transferred during the year by the Government. He indicated, however, that some progress had been made and that the Academy could expect the completion of the project in due time. The report was accepted.

President Dodds then appointed the following committees:

COMMITTEES FOR 1936-1937

Nominations Committee: Earl Core (chairman), Frank S. White, H. C. Martens.

Resolutions Committee: T. L. Harris (chairman), Hazel C. Cameron, N. B. Green.

Auditing Committee: H. A. Davis (chairman), F. R. Gay, C. C. Regier.

Following a short intermission Prof. B. R. Weimer stated to the Academy that it was, unfortunately, necessary that President Cramblet be absent from the city and that he had been delegated to deliver the following welcome in President Cramblet's behalf:

"We are glad to welcome the members of the West Virginia Academy of Science to Bethany for their annual spring meeting. It is a source of genuine regret to me that demands on my time make it impossible for me to be present with you on this occasion.

"I am sure that the arrangements made by our local committee will be adequate for your needs, and I assure you through Dean Weimer that we want to welcome any of you to Bethany at any time.

"On this occasion all the facilities of the college are open for your inspection and use. I sincerely trust that this meeting will be helpful in connection with the development of a deeper interest in science among the several institutions of our state. If there is any way in which we can serve you while you are here, feel free to call upon any member of our staff, and I am sure you will be well taken care of."

W. H. CRAMBLET,
President, Bethany College

Vice-president Cutright then introduced President Dodds, who replied on behalf of the Academy. He then delivered the presidential address, "The Life History of a Bone." This most excellent address was illustrated by a number of lantern slides.

The meeting was closed by an address and demonstration by W. J. Sumpstine on "The Motion Picture As a Teaching Aid."

At noon the Academy lunched by sections at Phillips Hall. On Friday afternoon the various sections held their meetings. The papers presented are listed in the program and printed elsewhere in these Proceedings.

At 6:15 a dinner was held in Phillips Hall.

The principal address of the meeting was delivered Friday evening by Dr. Harvey Brace Lemon of the University of Chicago. His subject was "Some Aspects of the Mystery of Light."

Following this address an informal reception and smoker was held at Pendleton Heights, the home of President Cramblet.

The second general meeting was held Saturday morning, May 2.

Chairman A. M. Reese presented the following report of the State Biological Survey Committee:

THE BIOLOGICAL SURVEY REPORT

During the past year the chairman has tried to bring the Survey to the attention of interested persons whenever opportunity offered. A letter telling of the purpose of the Survey and asking for cooperation was sent to every county school superintendent in the state with the request that the letter be handed to biology teachers; it was stated that as many more copies of the material would be sent as might be asked for, and three or four superintendents asked for additional material, which was supplied.

An article against vermin campaigns was published in *Science,* and a letter of protest against the wholesale destruction of our state animals was submitted to every weekly newspaper of the state through the editorial office of West Virginia University.

The main project of the year was the employment, through a grant of $100 from the State Academy of Science, of Mr. Neil D. Richmond as collector, in cooperation with the West Virginia Biological Expedition of 1935. He specialized in Amphibia and Reptilia, of which he collected and named 42 species and 879 individuals. He also collected 12 mammals and over 700 molluscs. His report is attached. He spent a large amount of time, after his return from the field, in identifying or having identified the animals collected and in arranging them for storage.

A full-time collector for an indefinite period is perhaps the greatest need of the Survey.

Mr. George R. Hunt of Fairmont College has sent to the University a collection of over 500 gastropod molluscs, identified by Smithsonian Institution.

The following plant contributions are reported by Dr. Core:

Mercer county, Meade McNeill	13
Shrubs, Monongalia county, C. R. Jones	6
Hampshire county, Wilbert Frye	143
Polypores, Charles Gould, Jr.	45
Ohio county, Elizabeth A. Bartholomew	128
Ferns of Gilmer county, E. R. Grose	22
Monongalia county, Leo Watkins	231
Lichens of Gilmer county, E. R. Grose	13
Composites, Ward M. Sharp	136
Lichens of Ohio county, Elizabeth Bartholomew	9
Lichens, collected by John L. Sheldon and cited in Millspaugh's check-list	20
Photographs of type specimens of plants just described from West Virginia, received from the New York Botanical Garden	12
Total	778

Dr. Core and your chairman have collected, with N. Y. A. student aid, a bibliography of the articles that could be located dealing with the flora and fauna of West Virginia. Duplicate cards of this bibliography have been typed and arranged alphabetically by author and also by subject. This bibliography is to be printed as a University bulletin and should soon be available for free distribution.

All persons publishing papers of any sort about the life of the state are urged to send one or more reprints for our files in Morgantown.

A few specimen record cards have been received from Professor Hamblin and others, but the total number received has been very disappointing. Secretary Patterson reports that only about 30 membership cards have been received. Your chairman would like suggestions as to methods of securing greater interest and cooperation in the work of the Survey.

The report was accepted.

Chairman Reese also presented the following report by Neil D. Richmond, who accompanied the 1935 field expedition of the University as collector on behalf of the Academy:

THE WEST VIRGINIA BIOLOGICAL EXPEDITION

"This is a brief summary of the results of the writer's work for the West Virginia Biological Survey during the summer of 1935. The work consisted of two phases: six weeks collecting with the West Virginia University Biological Expedition, and about a month spent in Morgantown getting the collection classified, catalogued, and properly stored. In connection with the field work the writer wishes to express his appreciation of the assistance and advice given him by Dr. P. D.

Strausbaugh, director; Dr. Leland H. Taylor, professor in charge of zoology; and Ross Ludwig, business manager of the W. V. U. Biological Expedition. The students of both the botany and zoology classes were very cooperative in donating extra or unusual specimens.

"The writer started out to collect reptiles and amphibians primarily, and to preserve with proper data other zoological specimens that were brought into camp by the students. In the field it was found that since much of the class-work was done around bodies of water, it would require but little extra time to make a collection of aquatic molluscs. The results of the trip show for each of the six counties visited a fairly representative collection of the reptiles, amphibians, and aquatic molluscs.

"At the end of the Biological Expedition the writer identified and catalogued the collection of reptiles and amphibians. The molluscs were sent to several institutions for identification. Although these are now at Morgantown, properly identified, they have not been catalogued, because of lack of space to store them, it being considered better to leave them in their present compact packing.

"The groups represent the number of specimens and species collected during the summer as follows:

Molusca:

Sphaeriidae: 3 species 11 sets

Identified by Dr. Stanley Brooks, Carnegie Museum, Pittsburgh, Pa.

Naides: 29 species 157 specimens

Identified by Dr. Henry Van der Schalie, University Museum, Ann Arbor, Michigan.

Fresh-Water Snails: 50 sets About 500 specimens

Identified by Dr. J. P. E. Morrisson, National Museum, Washington, D. C. As this is the largest part of the mollusc collection, in both species and number of specimens, the identification has not been completed.

Amphibia and Reptilia:

Caudata	15 species	748 specimens
Anura	8 "	55 "
Testudinata	4 "	16 "
Sauria	2 "	12 "
Serpentes	13 "	48 "

Mammalia:

11 species 12 specimens

"The last three groups were identified by the writer, Neil D. Richmond."

Mr. Reese recommended that Mr. Richmond's findings be printed as a check-list and distributed by the Academy.

The report was accepted by the Academy and the secretary was instructed to proceed with the publishing of the check-list by whatever method seemed most suitable.

The following report of the Committee for the Preservation of Birds and Mammal Life was presented by B. R. Weimer:

THE PRESERVATION OF BIRDS AND MAMMAL LIFE

Since the 1935 meeting of the West Virginia Academy of Science, members of its Committee for the Preservation of Bird and Mammal Life have been instrumental in securing a modification of the State Conservation Commission's ''Vermin List'' as indicated below:

Approved Vermin
August 28, 1935

Wildcat
Hunting house cat
Gray fox
Weasel
Great Horned Owl
Hawks
Snapping turtle
Mud turtle
Waterdog
Watersnake
Rattlesnake
Copperhead snake
Crow
Red squirrel
Kingfisher
Fish Hawk
German Carp
Garfish
Starling
Common rat

Approved Vermin
February 3, 1936

Wildcat
Hunting house cat
Gray fox
Weasel
Great Horned Owl
Sharp-Shinned Hawk
Coopers Hawk
Goshawk
Snapping turtle
Mud turtle
Waterdog
Snakes
Crow
Red squirrel
Common rat

The items of the 1935 list which the Committee sought to have modified were: (1) changing ''Hawks'' to the three species mentioned in the 1936 list; (2) elimination of the Kingfisher and Fish Hawk. The other changes, some of which in the Committee's judgment are not good, were not suggested.

Recommendations: (1) That if vermin contests are to be continued, the 1936 list be changed as follows: in the place of ''snakes'' substitute the three species named in the 1935 list; (2) that if other species are to be added to later lists, they include Pennsylvania meadow mice, English Sparrows, and Starlings.

The Committee disapproves of the bounty system and of the granting of cash or other prizes by organizations or individuals for the taking of ''vermin''. It is the belief that in this way more harm is done than good.

Only eight of the 48 states leave all species of hawks and owls unprotected. West Virginia is one of these. The Committee favors the protection of beneficial hawks and owls in West Virginia.

The Committee recommends the enactment of an adequate dog law for West Virginia.

As a general policy, the Committee subscribes to the following:

Whenever a species of bird or other wild animal becomes so disproportionately numerous that, by its feeding habits or otherwise, it clearly disturbs the balance of nature or becomes seriously detrimental to the interests of mankind, we believe that control should be exercised, but only after careful scientific examination has demonstated the need thereof; and that such control should be carried out only by properly qualified authorities.

A. B. BROOKS, *chairman*

After a lengthy discussion the report was accepted and the Committee was empowered to translate its recommendations into practical action.

The following report of the Auditing Committee was then read and accepted:

REPORT OF THE AUDITING COMMITTEE

"We have examined the records of the treasurer of the West Virginia Academy of Science for the year 1935-36 and find them to be correct."

H. A. DAVIS, *chairman*

Chairman T. L. Harris then made the following report of the Resolutions Committee:

REPORT OF THE RESOLUTIONS COMMITTEE

Whereas the West Virginia Academy of Science has just held its thirteenth annual meeting at Bethany College; and whereas the members of the Academy have been treated with the utmost courtesy and consideration by the president, members of the faculty and students of Bethany College, and also by the citizens of the town; be it therefore resolved that this Academy express its appreciation of their kindness and extend to them the sincere thanks of this Academy.

Be it further resolved that the Academy express its thanks and appreciation to Wallace Smith, senior counsellor of the Junior Academy, for his promotion of the work of the Junior Academy during the past year.

Be it further resolved that the Academy express its thanks and appreciation to Dr. P. D. Strausbaugh for his work as chairman of the F. E. Brooks Garden Committee.

Be it further resolved that the Academy pay its respects to the memory of Miss Bernice Akers, a loyal member who died during the past year.

The report was accepted.

The Executive Committee recommended the appropriation of $40 for the use of the Junior Academy Committee to be expended in printing the "News Letter". The Academy approved this recommendation.

The secretary read the names of six additional proposed new members who were thereupon elected by the Academy.

The section chairmen reported as follows:

Biology: 45 present. B. R. Weimer, chairman. Chairman for 1937. R. C. Patterson.

Chemistry: 38 present. R. B. Dustman, chairman. Chairman for 1937, J. F. Bartlett.

Geology and Mining: 19 present. Paul Price, chairman. Chairman for 1937, J. H. C. Martens.

Mathematics and Physics: 20 present. Joseph K. Stewart, chairman. Chairman for 1937, R. P. Hron.

Social Science, Group I: 31 present. C. C. Regier, chairman. Chairman for 1937, E. L. Lively.

Social Science, Group II: 26 present. Frank S. White, chairman. Chairman for 1937, Roy Woods.

President Dodds then appointed the following committees to serve for the coming year:

Legislative Committee: A. J. Dadisman (chairman), J. E. Judson, J. Buhl Shahan.

Junior Academy Committee: H. F. Rogers, Senior Counsellor, Beatrice Collins. Wallace Smith, M. L. Vest.

Membership Committee: R. C. Patterson (chairman), T. H. Gilbert, L. D. Strader.

Activities Committee: R. B. Purdum (chairman), Nelle Ammons, Paul Price.

F. E. Brooks Garden Committee: P. D. Strausbaugh (chairman), E. Meade McNeill, R. B. Dustman.

Committee on A. A. A. S. Grant: W. W. Hodge (chairman), E. Meade McNeill, T. L. Harris.

State Biological Survey: A. M. Reese (chairman), Frank Gilbert, J. E. Judson, S. B. Talbott, H. D. Bond, B. R. Weimer, C. M. Roberts, E. R. Grose, E. Meade McNeill, L. M. Peairs, R. C. Patterson, G. H. Bretnall, C. L. Shilliday, A. P. Hamblan, H. W. Shawhan, A. B. Brooks, J. E. Drummond.

Preservation of Wild Life: A. B. Brooks (chairman), P. C. Bibbee, A. J. Dadisman, N. B. Green, S. B. Talbot.

President Dodds stated that due to lack of time, and also to the rather short notice given, he deemed it unwise to consider the main proposals for changes in the Constitution and By-Laws at that time However, the proposed changes in By-Laws V and VII as submitted previously to the members were adopted.

Chairman Core made the following report of the Nominations Committee:

For president....................Frank Cutright
For vice-president....................T. L. Harris
For secretary....................M. L. Vest
For treasurer....................C. G. Brouzas
For member of Publications Committee....................A. M. Reese

Earl Core, *chairman*
Frank S. White
J. H. C. Martens

This slate was accepted by unanimous election.

The new president, Frank Cutright, was then introduced and commented briefly and humorously upon his election.

Professor Weimer made explanations concerning the trips which had been planned. The meeting then adjourned.

THE GENERAL PROGRAM OF THE BETHANY MEETING

FRIDAY, MAY 1, COMMENCEMENT HALL

Greetings by President Cramblet, Bethany College.

Reply, followed by the Presidential Address: "The Life History of a Bone", by G. S. Dodds.

W. J. Sumpstine: "The Motion Picture as a Teaching Aid—Demonstration of 16 mm. Sound Film."

THE MEETINGS BY SECTIONS

Biology

(Botany, Zoology, Physiology, Medicine, Agriculture)

Hazel C. Cameron, Morgantown: Water Metabolism as Affected by Vitamin-A Deficiency (Preliminary Series). (Lantern)

M. Graham Netting, Pittsburgh: Wehrle's Salamander, *Plethodon wehrlei* Fowler and Dunn, in West Virginia.

E. L. Core, Morgantown: The Botanical Exploration of West Virginia.

A. M. Reese, Morgantown: A Cyclops Lamb. (Lantern)

E. Meade McNeill, Athens: A Study of the Algal Flora of Shawnee Lake.

Jerome C. Arnett, Weston: A Practical Method of Preparing Autogenous Bacteriophages for Staphylococcic Infections.

M. Graham Netting, Pittsburgh: The Carnegie Museum Collections of West Virginia Amphibians and Reptiles. (Lantern)

C. R. Orton, Morgantown: The Uredinales of West Virginia.

B. R. Weimer, Russell DeGarmo, and Beatrice Williams, Bethany: Notes on the Frequency of Appearance of Certain Species of Insects in the Northern Panhandle of West Virginia.

S. Benton Talbot, Elkins: Studies on Schistosome Dermatitis.

F. Waldo Craig, Charleston: The Program of the State Department of Agriculture for the Prevention of the Spread of Crop Pests.

N. Bayard Green, Elkins: The Amphibians of Tucker county.

B. R. Weimer and Josephine Sheets, Bethany: Comparative Study of the Content of Biological Material Studied in High School and College.

B. R. Weimer, Bethany: Notes on a Three-toed Lamb. (Lantern)

Chemistry

(Chemistry, Chemical Engineering, Pharmacy)

C. A. Jacobson, Morgantown: An Improved Method for Determining Solubility. (Lantern)

V. G. Lilly, Morgantown: Growth Promoting Substances for Fungi.

E. C. H. Davies and J. B. Sutton, Morgantown: Rate and Heat of Sorption of Methane by Coal. (Lantern)

Samuel Morris, A. R. Collett, and J. B. Conn, Morgantown: The use of Triethanolamine in Qualitative Inorganic Analysis. (With demonstrations)

Clyde B. Jenni, Morgantown: New Building Materials. (Lantern)

H. D. Dawson and R. C. Brandon, Bethany: The Preparation of 3—Bromohexane. (Lantern)

C. L. Lazzell, A. R. Collett, H. Ashburn and R. C. Conn, Morgantown: Some By-products Formed in the Preparation of Certain p-Aminobenzoates.

H. D. Dawson and B. I. Fietz, Bethany: (a) Some Efficiency Tests on the Water-Softening Ability of "Calgon", (b) The Electrical Conductivity of Some "Calgon" Containing Solutions. (Lantern)

Chas. E. Weakley, Jr., and H. C. Cameron, Morgantown: Bone Composition as Related to Diet in Rats.

R. B. Dustman, Morgantown: Retarding Rancidity in Stored Black-Walnut Kernels.

Geology and Mining

(Geology, Archaeology, Geophysics, Coal and Oil Engineering, State Road Commission, Building Material)

Dana Wells, Morgantown: Note on a Mammoth Tooth from River Gravels of the Monongahela.

J. J. Burke, Pittsburgh: New Discoveries of Fossil Vertebrates in the Local Permo-Carboniferous.

R. C. Tucker, Morgantown: Oriskany Gas Possibilities in the Northern Panhandle.

W. R. Downs, Morgantown: Natural Oxidation of Pyrite.

Earl Klinger, Morgantown: Studies on the Use of Bitumens in Soil Stabilization and Flexible Pavement Types.

O. L. Haught, Colombia, S. A.: Erosion in Humid-Tropic Climate.

L. E. Nugent, Morgantown: History of Oil and Gas Development in West Virginia with Emphasis on the State's Contributions.

Mathematics and Physics

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

H. A. Davis and Amos Black, Morgantown: Birational Transformations Determined by Pencils of Quadrics and a Rational Curve.

Joseph K. Stewart, Morgantown: Some Special Homoloidal Systems in n-Space.

R. P. Hron, Huntington: Gyroscopic Action and Some of its Applications. (Lantern)

M. L. Vest, Elkins: Notes on the Characteristic and Asymptotic Lines of a Surface and its Spherical Image.

Wallace Smith, Montgomery: Preparation of High School Mathematics Teachers.

R. H. Downing, Morgantown: Flat Spread-Sphere Geometry in Non-Euclidean n-Space.

O. Rex Ford, Morgantown: Measurements of Resistance Increments In a Typical Kirchoff's Law Circuit.

Joseph K. Stewart, Morgantown: The Projective Form of the Strophoidal Correspondence.

Social Sciences—Group I

(Philosophy, Philology, Economics, History, Sociology)

F. R. Gay, Bethany: DeQuincey on the Eleusinian Mysteries and the Greek Oracles.

C. G. Brouzas, Morgantown: Current Opinions Regarding the Blonde Type among the Ancient Greeks and Romans.

Jaimes T. Laing, Kent, Ohio: Negro Migration to the Mining Fields of West Virginia.

T. L. Harris, Morgantown: Public Welfare in West Virginia.

A. J. Dadisman, Morgantown: The Toll of Eroded Lands.

C. C. Regier, Montgomery: A Peace Platform for 1936.

Social Sciences—Group II

(Education, Psychology)

A. A. Schoolcraft, Buckhannon: The Morals of Teachers.

Frank Hall, Fairmont: Student Criticism of College Teachers.

Roy C. Wood, Huntington: A Critical Study of a Supervisory Program for West Virginia.

F. H. Kirkpatrick and Luke Cochran, Bethany: Intelligence of Teachers.

Andrew Leitch, Bethany: Academic Survival and Mortality of College Students as Related to Their Scores on Freshman Psychological Examinations.

F. H. Kirkpatrick, Bethany: The Validity of the Thurstone Personality Schedule.

Frank S. White, Fairmont: Intelligence and Academic Achievement. (By title)

THE DINNER PROGRAM, FRIDAY, MAY 1

Address by Dr. Harvey Brace Lemon, University of Chicago: "The Mystery of Light."

Papers Read at the Bethany Meeting

The Mystery of Light †

HARVEY B. LEMON

Professor of Physics, University of Chicago

IN THE PHYSICAL WORLD it sometimes happens that the most obvious conceals the most obscure, that the most every-day ordinary occurrences involve the most fundamental mysteries.

No more perfect illustration can be found of this situation than that offered by the phenomena of light. To a physicist the word light of course includes radiant heat, radio waves, ultra violet rays, X-rays, and gamma rays that originate in processes of atomic transmutation, both natural and artificial—indeed any aspect of energy in radiant form.

Probably there is nothing that we accept more as a matter of course than daylight. Even at night our artificial sources of light provided automatically, or at the flip of a switch, are taken for granted. Yet here is a phenomenon whose essential nature we have not ever been able to fathom. We are children of the light, as doubtless are all other living things. Perhaps the only slender thread that divides the organic from the inorganic is the shift by radiation of an electron from one position to another in a complicated molecule. Many savage peoples from the dawn of history to the present time dimly recognize their parenthood and worship of light, terrestrially in fire or celestially in the sun. One wonders what may have been the chain of circumstances that first directed man's conscious attention to it. From Johannes V. Jensen's book, *Den Lange Rejse**, we have in fancy, marvellously told, the way in which this may have happened.

The first of a long line of heroes in Jensen's three volumes recounting man's long journey is christened Fyr, F-Y-R. To the Greeks, he was Prometheus. Every culture has legends of him. Richly he deserves his heroic place in mankind's history.

The earliest semi-authentic records we possess today of the observations of antiquity in optical matters are associated with the making of fire. From the days of Nineveh there has come down to us a lens of rock crystal whose use we can imagine might have been that of a burning glass. Indeed, we find reference to the burning glass in an ancient Greek comedy, "The Clouds," by Aristophanes. Mirrors whose surfaces might at one time have been like those of limpid pools, but which were kept more readily at hand for women's use, are referred to in the books of Exodus and Job. They are found in many ancient burials. Euclid in his work on "Catoptrics" deals with the geometrical phenomenon of reflection and the burning focus of concave mirrors.

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†The address of the visiting speaker.
*Alfred Knopf, N. Y., 1923.

Far, far along their journey to the light had come by now the descendants of the early legendary forest dwellers. But fire was still a sacred thing, to be worshipped, to be tended, never to be allowed to expire — an unconscious survival from earlier days when ice had invaded all the north and loss of fire at any time became a major catastrophe.

For ages now men had pondered upon fire, had drawn the obvious inference with respect to the charioteer lord of the day, had observed for uncounted generations the slow changes of his daily course across the sky, and had inferred the connection between this and the seasons. Great kings and vast nations were prostrated with terror when this luminous disk was slowly blotted out, and wise and crafty men with records in their prossession had made the most of such occasions. For with the development of language and the writing of it down, the memory of those who could do this had become as that of gods. The ancient Egyptians had noticed that both sun and moon appeared larger when near the horizon than when observed at higher altitudes, and they had tried to guess how far away these luminaries were. Not only had light itself compelled attention, but it had directed thought towards the instrument of vision.

The Pythagorean school (Pythagoras, 582-500 B. C.) had a theory of vision that was corpuscular in nature. They believed that the sense of sight was stimulated by particles which shot off luminous objects, entered the eye. Since such a theory held no explanation for the invisibility of objects in total darkness, Empedocles (c. 465 B. C.) and Plato (427-347 B. C.) considered vision as being due to a mixture of some divine corpuscular fire from the eye with emanations from the object itself, these two being mixed in subtle fashion with a third emanation coming from the sun. If the latter were present, vision resulted from the return of these emanations to the eye; but if it were not, as in total darkness, no vision obtained.

In the writings of Aristotle (384-322 B. C.), on the other hand, we find the beginnings of an opposing point of view; his "pellucid" was not a material substance, but had the quality of a medium. When it was activated, vision was possible, but potential "pellucid," unactivated, was darkness.

In these two conflicting schools of early philosophy, with respect to the nature of vision, we see the beginnings of the two conflicting theories as to the nature of radiation, between which a savage battle has been waged almost to the present time. Victory has seemed secure alternately first for one side of the controversy and then for the other; but the hidden nature of radiant phenomena has turned out to be more subtle than even men of science of most recent times have suspected. It has only been for a period of a scant twenty-five centuries that two or three men from among scores of millions of each generation have given any thought to the solution of this riddle. It is not surprising, therefore, that we have not yet achieved any fundamental understanding of it. We have only reached the conviction that, interwoven with this riddle, there is the solution of several, perhaps all, of those other fundamental puzzles regarding material existence, concerning matter, atoms, stars, and electricity.

Of everything else material, it would seem, light is a part — the gossamer underlying fabric within which the entire pattern of the physical world is woven. Very briefly let us follow, first, the history of men's thought about it.

The most obvious properties of light are those of rectilinear propagation, of reflection, and of refraction. These seem to have been known from earliest times. Ptolemy (c. 140 A. D.) made tables of the angles of incidence and the corresponding angles of refraction but found no law relating the values. Kepler (1571-1630), likewise, primarily interested in improving telescopes, studied refraction, but failed to discover this law found later by Snell (Snell or Snellius, 1591-1626), the Dutch astronomer and mathematician. Snell's discovery was published by Descartes (1596-1650) in its modern form: that the ratio of the sine of the angle of incidence to the sine of the angle of refraction was a constant quantity which we now call the refractive index of the medium. Fermat (1601-1665), later, by a profound bit of analysis which has been revived in modern times in connection with some of our latest theories, deduced Snell's law from a more fundamental general principle—that of least time. This principle, as its name indicates, is predicated on the assumption that a beam of light always travels, of an infinitude of possible paths, that one along which it can pass most quickly.

Since the idea of light propagated by the motion of particles dominated the interpretations of all of these experimenters, we see that the corpuscular theory got off with a flying start. It was the inspiration of the work of Alhazen (c. 1038), who dissected the eye and discovered the functions of its parts. In his interpretations of optical phenomena by means of cones of streaming corpuscles, we see in a crude form the modern text book diagrams interpreting the gross geometrical behavior of lenses and mirrors.

Roger Bacon (1214-1294) so clearly understood the properties of lenses that he correctly attributed the apparent size of a visible object solely to the angle which its rays subtend on entering the eye. Since this angle is less the more remote the object, its apparent size is thereby reduced. This angle can, however, be altered by lenses and mirrors; hence the possibility of telescopes and microscopes was here predicted. Bacon is accredited by some with having actually made a microscope and a telescope, but Cajori ascribes this to a mistranslation of the original.

Although it is undoubtedly true that Della Porta (1543-1615) made spectacles, a camera, and a combination of lenses apparently suggestive of the telescope, the telescope itself came first from the hands of Lippershey in Holland, from whom Galileo (1564-1642) probably got the idea for his invention of it. The microscope was invented by Joannides at about the same time. Gregory (1638-1675) made the first reflecting telescope, purposely using mirrors to avoid color effects due to chromatic aberration. With respect to color, the identity of colors seen in a piece of glass and in light reflected therefrom with those of the rainbow was recognized very early by Seneca (54 B. C.-39 A. D.), who also observed the magnifying power of a globe of water and remarked that nothing was so deceptive as sight. Grimaldi (1618-1633), Descartes, and Hooke (1635-1703) observed the phenomenon of dispersion, which is the bending of the different colors differently as they pass between glass or water and the air.

The great Newton (1642-1727) began his work in optics studying the phenomena of color. The first to recognize the composite character of white light, he insisted that colors were not derived from the prism, as others had supposed, but are "original and connate." The whole subject of spectroscopy begins with this statement: "To the same degree of refrangibility ever belongs the same colour." Wrongly generalizing, however, from but one experiment, that dispersive and refractive powers went together, he rightly reasoned from this supposed fact that achromatic lenses giving images devoid of color would be impossible to make. It was because of this conviction that he constructed his first reflecting telescope, realizing that in reflectors this defect is absent.

In Newton we find the first great champion of the corpuscular theory — the theory which at that time so dominated men's minds that it hardly needed the support of his opinion. Tribute to his genius it is indeed, that he was far from being unconscious of an alternative explanation in terms of waves. He used Galileo's principle of inertia, which he ascribed to light corpuscules as to all other matter. This explained in a simple and direct manner the straight-line propagation of light and the casting of sharp shadows by a small source. In view of the obvious way in which all other kinds of waves turned around corners, a wave explanation must have seemed at this time almost in the nature of a "tour de force." Furthermore, the introduction of the principle of inertia into mechanics had at once wrought order out of chaos in that field — and what could be more reasonable than to use the same fundamental idea for light?

By the simple assumption that transparent material such as glass or water attracted corpuscles of light, it was furthermore possible to give a sound theoretical explanation of the experimental effects of refraction expressed in Snell's law, which implies that the velocity of light is *greater* in the denser medium. Indeed this theory opened the way for a crucial experiment with respect to the corpuscular theory, an experiment which, however, was destined not to be performed for more than a century.

To follow the history of this, if time permitted, we should recount from its beginning the story of man's effort to discover the speed of light.

Suffice it to say: Galileo suspected that light did *not* travel instantaneously; but his proposal as to how this might be tested, by observers flashing dark lanterns back and forth between the hill tops that flank the valley of the Arno, was hopelessly inadequate to entrap so swift a passage. Descartes found that even the moon was too near to reveal, by discrepancies between the calculated and observed times of eclipses, the less than two-second interval involved. Across the 186 million mile orbit of the earth, Römer, observing the sattelites of Jupiter, got the answer — 16 minutes. Fizeau used a short terrestrial distance, a toothed-wheel shutter, and achieved Galileo's dream. Arago proposed a rotating mirror for greater accuracy. Foucault and Newcomb used it first, but only Michelson achieved real precision.

It took no great precision, however, to get an answer to the crucial question raised by Newton's corpuscular theory. Foucault in 1850 used the method of a rotating mirror to measure the velocity of light in water, and found it to be not greater than its speed in air, as demanded by the corpuscular theory, but less. The result of this crucial experiment at that time, had nothing else developed in the meanwhile, would have been sufficient to sound the knell of these corpuscular ideas.

Returning to Newton for a moment, let us review with a little more detail some of his own difficulties with respect to a corpuscular theory. We should note first that on the corpuscular theory he experienced great difficulty in explaining the phenomena of simultaneous reflection and refraction, which takes place whenever a beam of light falls on a polished piece of glass. Hooke had discovered several years earlier the beautiful colored rings which one sees when light is reflected from between the plane surface of a mirror and a slightly convex surface of a plate of glass resting on top of the mirror. Newton experimented further with this matter and, noting the black center of the rings, derived therefrom a very complicated hypothesis in which he describes "fits" of easy reflection and transmission. He measured the distance of the air layers in which these "fits" take place and found them to be of the order of hundred thousandths of an inch. In this he was actually measuring the sizes of light waves, but did not know it. Indeed, in describing the "fits" his words seemed to imply that he was thinking of properties of a medium, distinctly an undulatory conception. So clear in his understanding of the true significance of color, he correctly ascribed the colors of his rings to differences in thickness of the air strata, that is, to differences in wave length, in our modern understanding.

As we have said before, Newton seems to have frequently felt the necessity of some other hypothesis as to the nature of light than the corpuscular one, but was driven back to the latter by the simplicity of its interpretations with respect to reflection, refraction, and most of all the *straight-line propagation* of light, and the simple geometry of shadows. Furthermore, the fact that in crystalline material a beam of light splits into two parts having different properties and, therefore, on any wave theory demands the existence of two different media, seemed to him an unalterable objection. Again, he found it difficult to conceive of an entire universe filled with a fluid medium in which waves could be propagated. His successors a century later had the same difficulty with the idea of the universe being filled with a transparent and elastic solid medium. Stokes, in a masterly summary of this situation, says:

> "Surely the subject is of more than purely historical interest. It teaches lessons for our future guidance in the pursuit of truth. It shows us we are not to expect to evolve the system

of nature out of the depths of our inner consciousness, but to follow the painstaking inductive method of studying the phenomena presented to us, and to be content to learn new laws and properties of natural objects. It shows that we are not to be disheartened by some preliminary difficulties from giving a patient hearing to a hypothesis of fair promise, assuming of course that those difficulties are not of the nature of contradictions between the results of observations or experiment, and conclusions certainly deducible from the hypothesis on trial. It shows that we are not to attack too great importance to great names, but to investigate in an unbiased manner the facts which lie open to our examination."

Leaving the corpuscular theory for a moment, let us look now at the development of its rival hypothesis. Although an undulatory thesis was first advanced by Aristotle, it found no supporters except Democritus (460-370 B. C.) in antiquity. It was not until 20 centuries later that Hooke suggested that light might be a manifestation of a vibratory motion in a medium. The first great champion of this idea was Huygens (1629-1695), who, in 1678, before the French Academy, in the presence of Römer, Cassini, and other notable astronomers, mathematicians and physicists, gave his famous geometrical construction in terms of which the rectilinear propagation and the casting of sharp shadows by a beam of light might be interpreted in terms of waves. It took twentieth-century experimental technique to verify the physical reality of this construction with respect to sound waves and actually make it visible. Huygen's construction still remains to this day a most effective device to use in following the intricate and complex paths pursued by wave fronts as they suffer reflection and refraction in the simpler types of optical systems. Indeed, all methods of modern lens-designing depend upon it. The full import and power of his idea Huygens himself did not entirely grasp. He studied intently the phenomena of polarization of light, and confessed his complete inability to describe it in terms of his construction. However, in later years his method proved to be adequate even to give the complex, dimpled wave-front surfaces that are assumed by light in traversing crystalline media.

The undulatory theory had another vigorous champion early in the 19th century, our own sagacious Benjamin Franklin (1706-1790). Euler (1707-1783) a little earlier had likewise supported it and offered a most constructive suggestion, that the color of light was due to the frequency of the vibrations. Although we now know some aspects of Euler's theory to be incorrect, he nevertheless clearly recognized Newton's error with respect to the relation between dispersion and refraction, and he calculated from the construction a form of achromatic lens. Dolland (1730-1820) using Euler's theory, made the first achromatic telescope, which created a tremendous sensation since it worked clearly in contradiction to Newtonian law.

The great weight of Newton's opinion nevertheless dominated the field until the beginning of the 19th century when Thomas Young (1733-

1829), formerly an archeologist and doctor, but later devoting himself entirely to the physical side of optics, in a Bakerian lecture before the Royal Society brought forth the hypothesis of a luminiferous ether, the undulations of which, when a body becomes luminous, constitute the light that enters the eye. He incorporated Euler's thesis that luminous colors depend on the frequency, or wave length. Ignorant of the earlier work of Hooke on the colors of thin plates, he rightly attributed them to interference between the different "secondary wavelets" by means of which Huygen's Construction had been so successful.

Young correctly traced the analogy between optical interference and the phenomena of beats in sound. He repeated qualitatively the earlier experiments of Grimaldi which showed that under certain circumstances a bright spot of light could be obtained at the center of a dark shadow. The fringes of light and shade seen at the edges of shadows cast by objects illuminated by minute angular sources of light, which Grimaldi also had observed, he interpreted correctly as what now is called diffraction. That light waves like sound waves turned around corners he clearly maintained. The difference was only one of the scale of the effect. The black center of Newton's rings he correctly explained by the loss of half a wave length on reflection. He analyzed the conditions necessary experimentally to reproduce Newton's rings with a white center and gave a brilliant experimental confirmation of the fact.

Right though he was in nearly every matter, Young was not to be allowed a peaceful life, nor to obtain early recognition. He was subjected to violent attacks by Lord Brougham in the *Edinburgh Review*. His articles were declared to contain "nothing which deserves the name either of experiment or discovery;" as being "destitute of every species of merit." "We wish to raise our feeble voice," says Brougham, "against innovations that can have no other effect than to check the progress of science."

Young's able reply, published as a pamphlet, failed to turn public opinion because as he said, "one copy only was sold." Says Tyndall,

> "For twenty years this man of genius was quenched — hidden from the appreciative intellect of his country-men — deemed in fact a dreamer, through the vigorous sarcasm of a writer who had then possession of the public ear. . . . To the celebrated Frenchmen Fresnel and Arago, he was first indebted for the restitution of his rights."*

The work of this Frenchman, Fresnel (1788-1827), fifteen years later began to attract attention. He reproduced the interference phenomena of Young using mirrors instead of slits, thereby meeting the objection of the corpuscular theory's adherents that Young's phenomena were due to the passage of the corpuscles close to material edges which in some manner combed out particles of different size and produced the colors thereby. Indeed Fresnel's technique of mirrors was attacked violently by the corpuscular enthusiasts since the beam of light was re-

*Tyndall, *Six Lectures on Light*, 2nd ed., New York, 1877, p. 51.

flected at nearly grazing incidence from the surface of the mirrors, and a similar combing action was alleged to be possible.

Fresnel met this suggestion in a most brilliant fashion by again reproducing Young's interference fringes by passing light at nearly perpendicular incidence through two different prisms of very slight angle. Nevertheless, still grasping at straws, champions of the corpuscular theory cited the now well-known dispersion phenomena as the cause of the color, although the angle between the sides of the prisms was so nearly zero that they were utterly useless for dispersion in the ordinary sense. Indeed, it was not until the work of Michelson many years later that these small straws, still tenaciously held by occasional adherents of corpuscular ideas, were entirely wiped away by his brilliant invention of the interferometer.

Following Fresnel a host of investigators entered the list on behalf of the undulatory theory at the beginning of the last century, notably Arago, Brewster, Biot, and Poisson. Of all these, clearly the most inspired was Fresnel. He has been called by some the greatest genius of the 19th century, indeed the greatest in physics, prior to the 20th century and subsequent to Newton.

There is no time to follow in detail the history of the attempt to place these now well established waves of light within a medium. First proposed was an elastic solid theory of the ether, developed by Neumann, MacCullagh, Green, and Stokes. After the manner of all other ether theories, it gave little in the way of crucial results to be tested. It had properties, unlike those of any known material substance, of almost infinite density and incompressibility. Irrespective of any theory, however, the crucial experiment of Foucault had by now been performed, and no form of corpuscular theory could be revived. As more and more experimental facts began to be unearthed, the elastic solid theory of the ether, like many physical theories of more modern times, had to be tinkered and repaired and doctored up, until it ultimately seemed doomed to collapse of sheer weight of its a posteriori character.

Then appeared Clerk Maxwell (1831-1879). Thirty-six years old at the time of the death of Michael Faraday, he recognized that Faraday's fundamental work in electricity and magnetism was nothing short of genius. Still more today do we honor this brilliant Irishman who within fifteen years laid the foundations of all modern developments of electrical industry, and likewise performed the first experiments which were destined to reveal the atomic character of the electric charge. That electrical charges and magnetic poles could affect each other at a distance seemed inexplicable to Maxwell except in terms of some medium. Faraday was not a mathematician, and his conclusions were reached by insight rather than by formal proof. Maxwell translated Faraday's genius into mathematical form and added thereto the brilliance of his own. He saw that the medium requisite for electromagnetic phenomena could account for light as well. He predicted such bizarre notions as displacement currents in non-conductors, subsequently to be found experimentally by Hertz (1857-1894). This gave us, through the hands of Marconi (1874—)* and subsequent great industrial groups of investigators, the modern radio.

Maxwell recognized that the combination of electric and magnetic properties of the medium demanded by electromagnetic experiments gave two entirely different sets of electrical units, depending on whether one started with the phenomena of electrostatics or the phenomena of electric currents and the associated magnetic effects. Furthermore, it appeared that the ratio of certain of the electric units in these two systems was dimensionally that of a velocity and numerically of a magnitude identical with the velocity of light. In terms of the electromagnetic theory of light which he then formulated, wireless waves, radiant heat, and other invisible regions, like the ultraviolet, were now included in one complete category of radiation, and a great many though not all of the difficulties of the old elastic solid theory disappeared.

Comprehensive as was the electromagnetic theory, it gave no explanation of the existence of the discrete charges of electricity discovered by Faraday in solutions, which later when isolated by twentieth century workers were to necessitate a complete revision and reconstruction of all physical theory. The great Kelvin (1824-1907), at first openly hostile to the electromagnetic theory — note his Baltimore lecture of 1884 — was subsequently somewhat won over, but never fully satisfied. The medium, the seat of the energy involved, still remained obscure; later it was to be removed from any direct observational test by Michelson and Morley (1838-1906) and from any scientific importance at all by Einstein in the theory of relativity. Nevertheless, Maxwell's brilliant prediction with respect to long electromagnetic waves subsequently was fully confirmed and put to work all over the world.

Furthermore, another brilliant prediction by Maxwell of the existence of a radiation pressure, to the effect that a beam of light falling on any surface free to move will actually communicate momentum to it — *a quasi-corpuscular property of wave theory* — was later discovered to be a fact by the Russian, Lebedev (1866-1911), and our own American physicists, Nichols (1854-1926) and Hull (1870—).

Each one of the successive theories, whether bold and daring in conceit, or more conservative in nature, growing out of one of its predecessors, seems to have more than justified itself. Indeed, what more should be expected of a theory than that it be suggestive of new types of experiments along new lines of attack. These theories all did this and more — in each, one finds cases of predictions made which were later verified as facts. Furthermore, the unification into one category of the phenomena of magnetism, electricity, light, heat, X-rays, and short and long-wave wireless was a tremendous simplification of point of view, and hence a tremendous advance.

With the work of Maxwell, the corpuscular hypothesis was almost entirely lost to sight. Kelvin, as we have seen above, was to the end of his life not sure that all was entirely well. In a discourse before the Royal Institution entitled, "Clouds Over the Dynamical Theory of

*[Marconi died July 20, 1937—Ed.]

Light and Heat," he referred to two highly significant things. The first of these was the apparent non-existence of any relative motion between the earth and the luminiferous ether motion which the brilliant experimental technique of Michelson and Morley was unable to reveal, and the lack of evidence for which later resulted in the theory of relativity. The second involved certain difficulties respecting the well established law of equipartition of energy in connection with the process of radiation of light from incandescent solids.

In Kelvin's day, however, these clouds had not extended to the region of material objects. Their shadow was confined to the realm of optics. Indeed, the clouds did little more than heighten the brilliance and enhance the color of the dawn of the twentieth century. It was not until later, as the harvest of the tremendous accomplishments of the last few years of the nineteenth began to be gathered together, that the full significance of these clouds came into view. Then it turned out in the subsequent first twenty years of the twentieth century that those very same clouds overwhelmed the sky. There resulted a storm which gathered such violence that it seemed as if all the triumphs of the glorious days of the undulatory theory were to be completely swept out of the consciousness of a younger generation. A new corpuscular theory, the quantum theory, submerged the scientific world and shattered its complacency as nothing else had ever done. However, during the last few years the storm has finally begun to abate, and the clouds to be resolved. In the west the skies are clearing and here and there a gleam of sunlight appears. As this new light begins to break we glimpse the outlines of a fresh landscape in which a new theory of tremendous power and great beauty has begun to take form — the theory of wave-mechanics Most remarkable of all to relate is the fact that this new theory applies not only to radiation, but quite as well to every form of matter itself. It has its roots deeply buried in the past, drawing its most vivid appeal from a relation very similar to that between geometrical and physical optics. A very great many of the time honored conclusions of former classical theories are but limiting special cases of the new theory's deeper penetration. Furthermore, it is at one and the same time both *corpuscular and undulatory*. New as it is, it has already demonstrated its acuteness; it has made some astonishing predictions.

Among the most notable of these was one by a young Englishman Dirac, in 1928, that when light with sufficiently high energy (high frequency or low wave-length) impinged upon an atomic nucleus we should expect not one but a pair of electrons to be given off. A curious pair this was too — twins, not identical, but of zero total charge, a positive one as well as a negative one.

Now the long-lived negative electron we have known for many years. But a positive counterpart had never been dreamed of before. Positive electricity had always resided in the atomic nucleus. Associated with it was 99.9 per cent or more of the atom's mass. In the case of hydrogen this positive alter ego of the electron — the hydrogen nucleus — had a special name, the PROTON. Accompanying it in this simplest of all atoms was a single negative electron. In the case of heavier atoms negative electrons surrounded their more complex nuclei like a cloud, or better, like gnats around an over-ripe plum. That there should be hidden within this plum another gnat, black instead of white but otherwise the same, was something to listen to of course; but not a few were skeptical, and no one but Dirac was much excited about it. The ablest theorists not infrequently get off the deep end. At several national meetings vigorous discussions took place, many of the ablest physicists of the country jeering at the substantiality of the "hole" in Dirac's atomic doughnut. A few of the younger men were serious as to its reality. The younger men were right — their elders and superiors were to have a shock. But it did not come until shortly after August 2nd, 1932, when young Carl Anderson at Caltech discovered, on one of his plates exposed to the escapades of cosmic rays, the writing of this positive electron. It was a shock to him also. Millikan, his chief, is fond of relating how Anderson and a companion, Neddermyer, sat up all night long trying to find some error, some other interpretation, unwilling to believe the authenticity of this signature of an interloper — even a predicted interloper — on the sub-atomic stage. But its presence was not to be denied. It soon was found that these mysterious celestial rays were not the only summons to which it would respond. Gamma rays from well known thorium "C", terrestrial in origin, were able to call it forth from a variety of nuclei other than lead. Presumably the new theory of light was right; these "positrons" had been with us all the time. It took an exceptionally vigorous knock to wake them to life; their lives were frightfully short, only a ten thousand millionth of a second — and they were gone — but whither? In their disappearance they exactly bear out their nature, predicted so perfectly. They are a hole into which a negative electron vanishes.

Millikan, Lauritson, and several others have found suggestive evidence that each positive electron that appears has already made a suicide pact with an electron of the negative variety that is so common. As twins they come into view, as twins they disappear; but their energy is deathless, and it is readily measurable. As they perish, radiation is born of them — twin beams of it at that, two half-million volt X-rays — which speed away in opposite directions from the scene of the tragedy. Thus we have achieved the vision of events humanly under control in our laboratories, events that only our sense of logic and intuition formerly led us to guess must be commonly occurring deep in the interiors of stars. These events are the transformation of energy from material into radiant form and back again.

Before summing up our 1936 list of the more fundamental entities in physics, we may mention in passing the Neutron, although its history is not germane to our present story. Bothe and Becker working on artificial transmutation in 1931 discovered what they thought was an unusually penetrating gamma ray, where such a one did not belong. Irene Curie and her husband Joliot in 1932 found it again in another connection, and thought it only a misplaced bit of radiation. Chadwick in England not long after gave it an unequivocal interpretation; it was a *chargeless* PARTICLE of about the mass of hydrogen, but something far more compact than hydrogen, of course, since like hard gamma rays it traveled with ease through myriads upon myriads of even heavier atoms. Thus our present list of building blocks includes (1), free negative electrons, old friends of many years, for some unknown reason especially abundant perhaps in our little corner of the universe; (2), the newcomer, the free positive electron, or positron for short — These two are the least massive on the list; then comes (3), our old acquaintance the proton, nucleus of hydrogen, and a recently discovered isotope or two, rare varieties of this common element. These nuclei are named (3a) deuterons and (3b) triterons perhaps. The latter is so rare that its existence is uncertain still. Their weights are two and three times the proton's weight respectively. Four times as heavy as the proton is our next building block, the alpha particle (4) — another old acquaintance — not a simple thing, this nucleus of helium. Views of its composition have differed, but the consensus of opinion today is that it is a close and staple union of two protons and two neutrons. The neutron is next (5), with a mass not far from that of the proton; but the difference is exceedingly important.

In addition to these, all well authenticated by experiments independently in France, Germany, Italy, England and America, the builders of the soaring new structu.e of wave mechanics have suggested that there is probably one other and perhaps two. A neutral electron (6), or neutrino, of zero charge and negligible mass is desired by Pauli and Fermi to interpret certain facts relating to the ejection of beta rays from nuclei, and to reconcile certain difficulties about the spin energy of interactions of other particles. A negative proton (7), called a "negatron," might be added to make the list more symmetrical. It doubtless might be useful, too.

You may be wondering if by now we have not lost our way and wandered far afield from the story of light. No, we have not. At the present time, and most likely from now on, the subjects of radiation and of matter are inextricably connected, as we have already indicated. In the preceding list of particles more or less fundamental in our present knowledge we have omitted without doubt the most important. Certainly it is one to which we owe much of our knowledge of all the others; it is (8), the PHOTON, the atom of light, or better, the atom of radiant energy. Radiation in a *corpuscular role* today occupies the front center of the stage. Unlike these other discrete particles, these atoms of radiant energy are not all alike in magnitude. There is as wide a range of them as there is of the wave-lengths or frequencies that express the wave aspects of their nature. Some are colossal, as such things go, and contain as much as an erg of energy. Some possess less than a million, million, millionth of this amount. In the range of radio waves wherein these tiniest of photons dwell, small wonder is it that we cannot find them as individuals. The broad wave-like character of gross motion that envelopes them completely conceals the discrete infinitesimals that compose it.

Even in the range of visible light, the wave characteristics of radiation still predominate, although by now the photons are large enough to betray their presence in a few well chosen combinations of circumstances, such as the photo-electric effect of the alkali metals. Indeed, in this connection was their existence first suspected. By the time we get to radiations a few thousand times shorter, in the X-ray region, the wave characteristics in turn begin to be harder to discover. The smooth flowing waves are all mussed up as it were by the swelling size of the entities whose *statistical distribution after all is all that the wave form signifies.*

And yet even in the X-ray scale we can produce diffraction and discover wave-length if we use a crystal lattice instead of a man made grating. Perhaps this may be made clearer by very crude analogy. Imagine that with little Alice in this wonderland we could shrink ourselves down to just a modest midget scale that would enable us to crawl between the interstices of water molecules just below the surface of a lake across which waves were traveling. We would of course see no waves at all — only a jumble of irregular motions of all kinds in all directions. If, however, we took great pains to measure carefully many thousands of millions of these motions and averaged them all together, we would find this average tending more and more to motion round and round a circle whose plane was vertical and oriented in a definite direction.

The radius of this circle we would find diminished very rapidly and according to a perfectly definite law, as we descended farther and farther below the surface. Armed with our data all taken below the surface and our powers of analysis, we could then deduce every aspect of the invisible waves which a macroscopic eye could see proceeding upon the surface of the water.

Photons of gamma rays produced by radioactive transmutation or by transmutations artificially produced, are still larger in size than those of X-rays. In the case of the ultra gamma rays that are emitted when those celestial bullets that constitute at least 98 percent of the cosmic radiation impinge on terrestrial materials, the photons finally become of almost macroscopic size. Measured by the velocity that a few billion volts can give an electron's charge, the energy of the corresponding radiation amounts to an erg of work. At such high energies, the actual difference between a high velocity charged particle of either sign and an equally energetic super-high frequency photon is exceedingly difficult to determine from their observable effects when absorbed by other matter. Since by this very act of absorption either entity may be transformed into the other with but slight loss of energy, the problem of which came first, this hen or this egg, constitutes a real question. Thus the long disagreement between the experts as to the nature of primary cosmic rays is better understood. Behavior in a magnetic field provides the crucial experiment that shows these cosmic-ray primaries to be charged particles.

We are then by now convinced that this dual aspect, wave and corpuscular, of energy in its radiant form is precisely characteristic also of energy in that other form that we call matter, not only with respect to its finest sub-divisions but also with respect to complex entities of greater mass. This is true of every one of the other nine particles aforementioned. In the case of two of them the fact has not only been described in the equations of the wave-mechanics, but the details of the description have been confirmed by experimental measurement. Here electric charge is involved as well as mass. Its smallest package on both counts is our familiar negative electron identifiable in the exterior of all atoms. The corpuscular nature of the electron is only half the story. It is the half that is obvious to our macroscopic eyes. But treat the electron as if it were a gamma ray and shoot it through a crystal onto an ordinary photographic plate and the diffraction pattern of its wave character appears. Its wave length can be measured and strange to relate, the color of this flying particle depends upon its speed, $= \frac{h}{m\,c}$, more exactly upon its momentum since its mass is not exactly invariant. The greater its momentum, the smaller is its wave length. What we observe as the energy of the particle is to a slight extent analogous to the energy of a short train of waves such as are made by a stone tossed into a quiet pool. A moving electron is a moving wave group. The velocity of the group of waves is quite different from that of the waves themselves, as any close observer will readily testify. The analogy goes no further however. The energy of the stone's disturbance is scattered about among vigitillions of smaller entities and thus dissipated. The electron waves are self-contained and their energy conserved through flights across prodigious distances.

Protons likewise, 2,000 times larger, and at any given speed thus possessing 2,000 times as much momentum as an electron, have their own wave lengths and, although 2,000 times as small, these also have been measured. They exhibit conformity to precisely the same law.

Crowther† puts the matter very well in another way: "The electric charge that protons and electrons have to drag about makes them slower in their movements and at the same time more massive than the photon. .... As far as we can tell that is the sole difference between them. When we rob an electron or a proton* of its electricity, it automatically becomes a photon" — *radiation.*

Thus the partition that has always separated energy from matter in our minds has dissolved away in the matrix of our thoughts. Fortunately, since it was only our more immature thoughts that first placed a partition there, we do not mind the loss. We know that we can measure progress, not in any absolute terms, but only as we discern greater simplification coming out of what at first appears to be greater confusion. The air has been somewhat cleared at long last by the storm of a conflict that has been raging for nearly a decade. Wiser and

†Mason: *The Great Design.* Macmillan, 1934.

*To fit some more recent ideas we might alter this statement to read "When an electron and a positron are robbed of their electricity they become photons". The mass element, the neutron, may always be conserved. A proton is a neutron plus a positron. [cf. A series of papers by Walke on the synthesis of atoms in the Philosophical Magazine, Vols. 18, 19, and 20, (1935-6)] humbler no doubt should physicists be, much less cocksure than formerly; and let us hope in the same ratio more capable of progress.

Could our great patron saint, Prometheus, grown all wise, return to us today, what would he say to those men, his sons, who still seek to understand the fire? We suspect that he would say nothing to discourage us from further striving, but I wonder if he would regard our wisdom as being very far beyond that of the forest dwellers of his youth.

The Life History of a Bone*

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In this address the speaker gave an account of the origin, development, growth, and maturity of a typical bone of the body, such as one of those of the arm or leg. The presentation included both original observations (most of which have been previously published) and facts gleaned from the work of other students of bone; matter with which the speaker has become familiar during several years of research upon certain phases of the structure and growth of bones. In this address the important facts upon the subject were presented in such a way as to be intelligible to a general scientific audience.

The address was illustrated with 32 lantern slides, nearly all of which were prepared expressly for the occasion from original drawings and photo-micrographs. Inasmuch as most of the material included has been published elsewhere, and because the subject could not be clearly presented without an excessive number of illustrations, only a brief outline is published here. The topics treated follow:

An adult bone: its gross and microscopic structure with notes on its chemical composition; the problem of the growth of bone tissue and of bones; the origin, development, and growth of a cartilage bone, with brief note on membrane bones; a general account of ossification, including the manner in which bones grow in thickness and in length; the growth, removal, and replacement of cartilage; a statement of manner in which bone tissue is formed and removed; the structure and functions of marrow; the epiphyseal cartilages and the manner in which their capacity for growth is utilized by the growing bones; the attainment of full size by bones; the bones of middle life and old age; various mischances of bones, such as abnormalities of growth, nutritional disturbances, diseases, and injuries.

*Abstract of the address of the president of the Academy.

TEACHING WITH THE AID OF THE MOTION PICTURE (DEMONSTRATION OF THE 16 MILLIMETER SOUND FILM)

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MUCH HAS BEEN WRITTEN concerning the use of motion pictures in classroom procedure. The writer really doubts if he can add anything original to teaching methods utilizing films, but if he can stimulate an interest, or arouse a desire in the mind of any one teacher in our state, the effort spent on this paper will not have been wasted.

APPARATUS

It is the belief of the writer that it pays to buy good equipment for motion picture presentations. Comparatively cheap projectors are now found on the market. These may seem satisfactory in sales demonstrations but are bound to give trouble and worry in a short time after purchase. It will pay to buy the best.

For general classroom use the 16mm. film has its own advantages over the 35mm. or so-called standard size. One 400-ft reel of 16mm. film is equivalent to 1000 feet of the 35mm. and weighs less than a pound. The first advantage, then, is a saving in transportation costs.

The light weight and small size of both the projector and reels of film make them well adapted to travel, if one should care to use them in such a manner.

The simplicity of the 16mm. projector means that it can be operated successfully by anyone after a few moments of instruction.

The image projected from a 16mm. projector in a classroom compares favorably in all respects with the image from a 35 mm. projector under like conditions.

It is the writer's belief that the 16mm. film is the one best adapted to classroom work.

CARE OF APPARATUS AND FILMS

One will find that success of projection will depend largely upon proper care of both the projector and films. Most of the better quality projectors are practically fool proof, but the mechanism does require an occasional oiling as recommended by the manufacturer. The lens should be kept clean, a clean piece of chamois skin being used for this purpose. The film gate and aperture should also be kept free from lint and a gummy deposit that collects from the flm. An occasional dusting of all parts of the machine will not be amiss. Keep the machine in a tight case when not in use.

The care of the film is best summarized in "A Prayer"(?) taken from Eastman's Kodascope library catalogue:

THE FILM PRAYER

"I am film, not steel; O user, have mercy. I front dangers whenever I travel the whirring wheels of mechanism. Over the sprocket wheels, held tight by the idlers, I am forced by the motor's might. If a careless hand misthreads me, I have no alternative but to go to my death. If the pull on the take-up reel is too violent, I am torn to shreds. If dirt collects in the aperture, my film of beauty is streaked and marred, and I must face my beholders — a thing ashamed and bespoiled. Please, if I break, never fasten me with pins which lacerate the fingers of my inspectors. Don't rewind me — my owner wants that privilege, so that he may examine me, heal my wounds, and send me rejuvenated upon a fresh mission.

"I travel many miles in tin cans. I am tossed on heavy trucks, sideways and upside down. Please see that my first few coils do not slip loose in my shipping case, and become bruised and wounded beyond the power to heal. Put me in my own can. Scrape off all old labels on my shipping case so I will not go astray.

"I am a delicate ribbon of fiilm — misuse me and I disappoint thousands; cherish me, and I delight and instruct the world."

A large part of the brilliancy of the image depends on the type of screen used. A silver screen is not necessary. A white surface of a non-glazed type will give excellent results if used with a good source of light. No projection light source of less than 500 watts should be used, as the dullness of the image, especially with dense films, causes eye strain and reduces the effectiveness of the picture as a teaching medium.

SOURCES OF FILMS

It is the writer's intention to present a small list of distributors from whom film may be secured. In many cases commercial films can be utilized. Most of these films are comparatively free from objectionable advertising matter or propaganda, but in all cases the teacher should examine the film and not show it to a class if it contains too much advertising. Many of the commercial films advertise through the medium of a short trailer, announcing that this film was loaned through the courtesy of the Such and Such Company. Such gentle advertising is really not objectionable to the average teacher.

The writer during this past school year has been procuring films of quality from the various government agencies at Washington, D. C. The United States Department of Agriculture has an especially good selection.

To those who wish to build own film libraries this department of the Government offers 16mm. prints for sale at very reasonable prices.

AMERICAN FILM INSTITUTE

The American Council on Education at the present time is making an exhaustive study on the subject of motion pictures in education. The writer has been in communication with Dr. Edgar Dale, who has charge of this particular project. An interim report from this American Film Institute sets forth its objectives as follows:

1. To collect and distribute significant information concerning motion pictures in education, at home and abroad.

2. To stimulate the production and use of motion pictures for educational purpose.
3. To promote the cooperation of agencies interested in the production and use of motion pictures in education.
4. To initiate and promote research pertaining to motion pictures and allied visual and auditory aid in education.
5. To develop a national appreciation of the potential contribution of the motion picture to the cultural life of America.

It is suggested that teachers in West Virginia who use the motion picture keep in touch with the above-mentioned division of the American Council of Education, at 744 Jackson Place, Washington, D. C.

At the suggestion of Dean Weimer of our faculty the writer started a card index of educational films available for classroom use. While the list is not complete, the files now contain approximately 1500 titles classified according to content, so that any teacher may quickly turn to those films listed in his special field and select the subjects wanted. The card for each film states its title, length, width, short synopsis of content, rental price, if silent or in sound, and the address of the company distributing that film. It is hoped that more of our teachers will take advantage of this service during our next school year.

THE SOUND FILM

While the so-called "talking picture" is not exactly new, its successful adaptation to classroom use is a very recent development. The production of a small piece of portable apparatus at a reasonable investment of money has been the aim of several companies in this field, and some of the equipment on the market today gives as high a quality of sound and a greater simplicity of operation than is found in the 35mm. sound apparatus of the larger theater.

No discussion as to the relative merits of the sound film over the silent film is necessary. It is very evident to all that this type of film takes advantage of another avenue or channel in the learning process and hence is more valuable as a teaching medium than is the silent picture.

While the silent film will hold attention in the classroom, this quality will be almost doubled when the film has the ability to speak. Two avenues of reception are now open to the brain instead of one and the patterns of learning are stamped much deeper than with the silent type of film.

Above all, the sound film is dramatic. Action is its essential quality. It compels attention, holds interest, and stirs the imagination such as is found in no other vehicle of learning.

WHEN TO USE THE MOTION PICTURE

The criticism is sometimes given that the motion picture is a lazy way to teach. The proper use of the film in the classroom involves a better teaching technique than is generally realized. The film should never take the place of the lecture or conference, but should be made part of a general work project on one specific phase of the subject under consideration. Examinations and quizzes should contain questions relative to films exhibited.

Should the films be shown before or after the class discussion? This question has never been answered in a satisfactory manner. Many educators prefer to show the film first, believing that the student visualizes during the discussion period the materials seen on the screen. Others think that the study project should be closed by the showing of the motion pictures dealing with that particular subject. In working practice, one will find that it is not always possible to get films when needed because of booking schedules of the distributors, and so it is necessary in some cases to show films before class discussions, in others after the discussion. At no time should the film be exhibited at a time too far removed from class period.

SOME SOURCES OF EDUCATION FILMS

For the benefit of those who wish some information as to sources of films the writer is going to list a few of the many places from which films may be secured. Many of the references given are listed in "Sources of Educational Films and Equipment", Circular Number 150, edited by Cline M. Koon of the U. S. Department of the Interior, Washington, D. C. Those remaining were collected from other sources.

1. Akin & Bagshaw, 1425 Williams St., Denver, Col.
2. Amkino Corporation, 723 Seventh Ave., New York.
3. Army Pictorial Service, U. S. Department of War, Washington, D. C.
4. Auten, Harold, 1540 Broadway, New York.
5. Bass Camera Co., 179 Madison Ave., Chicago, Ill.
6. Bell & Howell Co., 1801 Larchmont Ave., Chicago, Ill.
7. Bray Library of Motion Pictures, Bray Pictures Corp., 729 7th Ave., N. Y.
8. Brown, H. S. Inc., 6 North Michigan Ave., Chicago, Ill.
9. Bureau of Mines Experiment Station, 4800 Forbes St., Pittsburgh, Penn.
10. Bureau of Reclamation, U. S. Department of Interior, Washington, D. C.
11. Catholic Film Guild, P. O. Box 4704, Philadelphia, Penn.
12. Central Distributing Department, The General Council, Presbyterian Church of the U. S. A., 156 Fifth Ave., New York.
13. Chicago Film Laboratory, Inc., 1322 Belmont Ave., Chicago, Ill.
14. Chief, Bureau of Navigation, U. S. Dept. of the Navy, Washington, D. C.
15. Cine Classic Library, 1041 Jefferson Ave., Brooklyn, N. Y.
16. Carl Henry Davis Library, 425 East Wisconsin St., Milwaukee, Wis.
17. Davis and Geck, 217 Duffield St., Brooklyn, N. Y.
18. Department of Embryology, Carnegie Institution of Washington, Wolfe and Madison Sts., Baltimore, Md. (Embryological films — sale only)
19. DeVry, Herman A., Inc., 1111 Center St., Chicago, Ill.
20. Director of Information, Tennessee Valley Authority, Knoxville, Tenn.
21. Division of Publicity, Women's Bureau, U. S. Department of Labor, Washington, D. C.
22. Division of Venereal Diseases, Bureau of Public Health, U. S. Department of the Treasury, Washington, D. C.
23. Dudley, William H., Visual Education Service Inc., 736 South Wabash Ave., Chicago, Ill.

24. Eastman Teaching Films, Inc., 343 State St., Rochester, N. Y.
25. Edited Pictures System, 330 West 42nd St., New York.
26. Edwin Carewe Pictures Corporation, 1040 North Las Palmas Ave., Hollywood, Cal.
27. Erpi Picture Consultants, Inc., 250 West 57th St., New Work.
28. F. C. Pictures Corporation, 265 Franklin St., Buffalo, N. Y.
29. Felber, Mr. Mark, Goodyear Tire & Rubber Co., Inc., Akron, O.
30. Films of Commerce Co., Inc., 35 West 45th St., New York.
31. Fitzpatrick Pictures, Inc., 729 Seventh Ave., New York.
32. Ford Motor Co., Detroit, Mich.
33. Fox Film Corp., 444 West 56th St, New York.
34. Garrison Film Distributors, Inc., 729 Seventh Ave., New York.
35. General Electric Co., 1405 Locust St., Philadelphia, Penn.
36. Gutlohn, Walter O., 35 West 45th St., New York.
37. Harcol Motion Picture Industries, Inc., 610 Baronne St., New Orleans, La.
38. Hill, Howard, 1043 Sixth Ave., Oakland, Cal.
39. Holmes, Burton, Films, Inc., 7150 North Ashland Ave., Chicago, Ill.
40. Home Film Library, 500 Fifth Ave., New York.
41. Ideal Pictures Corporation, 30 East 8th St., Chicago, Ill.
42. International Educational Pictures, Inc., 40 Mt. Vernon St., Boston, Mass.
43. Kodascope, Libraries, Inc., 33 West 42nd St., New York. (Many branches)
44. Lutheran Film Division, Inc., 132 West 46th St., New York.
45. March of Time, 135 East 42nd St., New York.
46. Mead Johnson & Co., Evansville, Ind.
47. Methodist Episcopal Church Board of Home Missions, 1701 Arch St., Philadelphia, Penn.
48. Metropolitan Motion Picture Company, 108 West 34th St., New York.
49. Michigan Film Library, 2539 Woodward Ave., Detroit, Mich.
50. Motion Picture Bureau, Canadian Dept. of Trade and Commerce, Ottawa, Ontario, Canada.
51. Motion Picture Section, Federal Housing Administration, 1001 Vermont Ave., Washington, D. C.
52. National Motion Picture Co., Mooresville, Ind.
53. National Park Service, U. S. Department of the Interior, Washington, D. C.
54. Northern Baptist Convention, Board of Missionary Cooperation, 152 Madison Ave., New York.
55. Nunn-Bush Shoe Co., Milwaukee, Wis.
56. Office of Motion Picture, U. S. Department of Agriculture, Washington, D. C.
57. The Religious Motion Picture Foundation, Inc., 140 Nassau St., New York.
58. RKO Radio Pictures, Radio City, New York.
59. School Films Service, Inc., 55 West 42nd St., New York.
60. Society for Visual Education, 327 So. La Salle St., Chicago, Ill.
61. Stewart's School Films, 21 Liberty St., Trenton, N. J.
62. U. F. A. Films Inc., 1540 Broadway, New York.
63. University of Chicago, Chicago, Ill.
64. Warner Brothers, 321 West 44th St., New York.
65. World Service, 740 Rush St., Chicago, Ill.
66. Y. M. C. A. Motion Pitcure Bureau, National Council of W. M. C. A., 327 Madison Ave., New York.

CONCLUSIONS

1. It pays to buy good motion-picture equipment.
2. For best teaching results keep equipment in good mechanical condition.
3. Take proper care of and return films promptly to the distributors.
4. For classroom work the 16mm. film is superior to the 35mm. film.
5. Films overladen with advertising matter should not be used for classroom purposes.
6. If possible the school should build its own film library.
7. The sound film is gradually replacing the silent type for classroom purposes. It is superior as a teaching medium to the silent films.
8. A careful, well-planned teaching technique is necessary when using the motion picture in class-room procedure.

The Biology Section

Water Metabolism As Affected By Vitamin-A Deficiency†

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THE AMOUNT OF WATER consumed by rats increases at first when vitamin A is withdrawn from their diet, then declines below that on normal diet. The volume of urine voided shows a similar change in a series of 30 rats (16 males, 14 females). The percent of water in the tissues in the vitamin A deficient rats shows a significant increase only in the trunk, the change in liver and skin being doubtful and in brain, negative. This study is part of an attempt to explain how vitamin A produces its effect.

The Botanical Exploration of West Virginia*

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CHARLES FREDERICK MILLSPAUGH, in his "Living Flora of West Virginia" published in 1913 as a part of Vol. V (A) of the West Virginia Geological Survey, included a list of 164 names of collectors who have contributed to our knowledge of the botany of the state. More than twenty years have now elapsed since the publication of that historical sketch, and it seems worthwhile, in view of the greatly increased botanical activity of the past few years, to bring Dr. Millspaugh's valuable account up to date. Since some additions have been made to our knowledge of the early period, I have thought it advisable to include this period, despite the fact that it involves a certain amount of duplication. For the period up to 1913 I have drawn freely on the work of Dr. Millspaugh.

The following chronologic tabulation, based on the arrangement adopted by Millspaugh, brings the record of the botanical exploration of West Virginia down to 1936.

1. Andre Michaux, the renowned French botanist, made many journeys, under conditions of great hardship and danger, along the borders of West Virginia. He collected at Harper's Ferry, Charles Town, and Summit Point, in Jefferson county, and at Wheeling, Buffalo Point, and the mouth of the Little Kanawha river, on his journey to Kentucky and Illinois in 1793. His collections are in the herbarium of the Museum of Paris. (See his "Flora Boreali-Americana sistens Caracteres Plantarum quas in America septentrionali collegit et detexit," 2 vols., 1803; also extracts from his Journal.)

2. Matthias Kin, a German nurseryman residing in Philadelphia, made many extensive trips in search of living plants and seeds for horticultural purposes. During these excursions he also preserved plants for herbarium specimens. About the year 1800 he collected ex-

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†Abstract.

* Contribution No. 1 from the Herbarium of West Virginia University.

tensively from Cumberland, Md., through "Deigher Walli in der Wilderniss" By "Deigher Walli" is doubtless meant Tygart's Valley, since Carex Fraseri, one of the plants he collected there, is found in that region and does not occur farther north in Pennsylvania. His collection of dried plants is in the herbarium of the Berlin Botanical Garden.

3. Frederick Pursh, a noted German botanist, located at Philadelphia in 1799 and made many important botanical trips into the Alleghenies. His most interesting collections were made in the vicinity of Harper's Ferry, Jefferson county; near White Sulphur Springs, Greenbrier county; and Sweet Springs, Monroe county in 1805. (See his "Flora Americana septentrionalis," 2 vols., 1814.)

4. Constantine Samuel Rafinesque, an eccentric naturalist born in Turkey of Franco-German parents, immigrated to Philadelphia in 1802. In 1818, on his way to Kentucky, he collected plants at Wheeling, Williamstown, and Point Pleasant; and on the return trip collected through Ohio, Brooke and Hancock counties from Wheeling to Kenilworth. In 1819 he collected along the Potomac River from Harpers Ferry to Cumberland, Md., through Jefferson, Berkeley, Morgan and Hampshire counties. In 1825 he collected in Ohio county from Valley Grove to Wheeling; and later followed the South Branch of the Potomac from its mouth through Hampshire, Hardy, and Pendleton counties to the South Fork Mountains. In 1832 he again collected in Jefferson county near Harper's Ferry. His collections were numerically very large and very valuable, but his private herbarium has never been found. A few of his duplicates are in the herbarium of the Philadelphia Academy of Sciences.

5. Dr. William E. A. Aikin of Baltimore, Md., collected near Harper's Ferry, Jefferson county, about 1832. His collection is not known to have been preserved.

6. Asa Gray and William Starling Sullivant collected through the Allegheny Mountains from Maryland to Georgia in 1843. They crossed the Cheat Mountains from Tygart's Valley via Cheat Bridge to Durbin; also collecting along the Greenbrier River and at Big Spring, in Mercer county. They collected *Aconitum reclinatum* on Cheat Mountain, which mountain, in the 7th edition of Gray's Manual, is still accredited to Virginia (see p. 407), although it has been West Virginia territory for nearly 75 years. Their plants are in the Gray Herbarium of Harvard University.

7. Isaac Farwell Holton collected from Charleston to Hawk's Nest in October, 1849. His private collection is in the Herbarium of the New York Botanical Garden.

8. William Henry Brewer, while professor of botany at Yale, made, in 1860, a collection of plants in Ohio county near Wheeling and in Brooke county near Bethany. His plants are in the herbarium of Yale University.

9. In 1867 and in 1871, Dr. A. S. Todd, as chairman of a committee of the Medical Society of West Virginia, published a list of the

"Medicinal Plants of West Virginia," enumerating 9 trees, 7 shrubs, and 60 herbs.

10. William Marriott Canby, a well-known botanist of Wilmington, Del., made a small collection near Grafton in Taylor county in 1868. His plants were deposited in the herbarium of the New York College of Pharmacy.

11. In 1870, J. H. DissDebarr, State Commissioner of Immigration, in his "Handbook of West Virginia" compiled a list of the timber trees of the state in which he enumerated 52 species and added 12 species of shrubs.

12. J. S. Merriam collected near Harper's Ferry in 1871, depositing his specimens in the National Herbarium.

13. Timothy Field Allen of New York collected in July, 1872, on Kate's Mountain and at other places near White Sulphur Springs. His plants are in the herbarium of the New York Botanical Garden. One of his most interesting numbers was the plant now known as *Eriogonum Alleni*.

14. In 1876, W. M. Fontaine, in compiling his portion of the Centennial Volume on the "Resources of West Virginia," listed 69 trees and 16 shrubs.

15. Joseph Francis James spent about two weeks in 1877 studying the flora of the region of the Guyandotte and Great Kanawha Rivers from Huntington to Kanawha Falls, Hawk's Nest, and Loup Creek. His collections are in the Gray Herbarium of Harvard University and in the Farlow Herbarium of Cryptogamic Botany.

16. E. Richardson collected in Ohio county in the vicinity of Wheeling in 1877 and 1879, and near Bethany in 1878. His plants are in the National Herbarium.

17. 18. H. N. Mertz and Gustav Guttenberg, of Wheeling and Pittsburgh, collected extensively from 1877 to 1888 through all the northern counties from Wheeling to Harper's Ferry. Their collections are in the herbarium of the Carnegie Museum, Pittsburgh. They published, in 1878, "A checklist of the plants of West Virginia," in which they enumerated 590 species.

19. H. N. Mertz and Miss Hattie Jones made a comprehensive study of the plants of Cranberry Summit, Preston county, in 1878, depositing their specimens in the herbarium of the Carnegie Museum, Pittsburgh.

20. Charles Reid Barnes, of the University of Chicago, spent a few days in June, 1879, collecting along the Kanawha River from Charleston to Gauley Bridge. His collections are in the herbarium of Wabash College. (See his "Notes from West Virginia," Bot. Gaz. 4: 181, 182. 1879.)

21. John Merle Coulter, while professor of botany at Wabash College, conducted a field trip to southern West Virginia in 1879. He collected a few plants along the Kanawha River from Charleston to Gauley Bridge, depositing them in the herbarium of the College.

22. Captain John Donnell Smith spent his summers from 1879 to 1882 at Oakland, Md., making occasional short trips to various points in West Virginia located along the Baltimore and Ohio Railroad, particularly near Grafton and Mannington. His plants are in the National Herbarium.

23. Cyrus Guernsey Pringle, a noted botanical collector of Charlotte, Vt., made a small collection at White Sulphur Springs and at points near Ronceverte in 1880. His specimens are in the herbarium of the University of Vermont.

24. 25. Thomas Conrad Porter and John Howard Redfield collected from White Sulphur Springs to Hawk's Nest in 1880. Prof. Porter's plants were deposited in the herbarium of LaFayette College, Easton, Pa. Those of Dr. Redfield are in the herbarium of the Philadelphia Academy of Sciences.

26. Augustine Dawson Selby, superintendent of schools at Huntington, collected plants in his neighborhood from 1885 to 1887, extending his observations up the Kanawha River as far as Kanawha Falls.

27. Samuel Boardman Brown, while principal of the Normal School at Glenville, collected a large number of plants in Berkeley and Gilmer counties from 1885 to 1890.

28. Charles David White, while engaged in paleobotanical studies in various portions of the State from 1886 to 1894, collected a few recent plants, principally ferns, which are deposited in the National Herbarium.

29. Adolph Koenig, a physician of Pittsburgh, collected about 20 numbers during the summer of 1887 at Wapacomo ("The Rocks"), near Romney, Hampshire county. His collection is in the herbarium of West Virginia University, constituting the oldest part of the herbarium.

30. Miss Verona Mapel, while preceptress of the high school at Glenville and later teacher of botany in the Normal School at that place, collected extensively in her neighborhood from 1888 to 1901. Her collection is in her private herbarium, now in the possession of her son, Mapel Brannon of Weston.

31 Dr. Rosecrans Workman, a physician of Bayard, Mineral county, collected in his neighborhood from 1888 to 1891.

32. Winfield E. Hill notes (in "Garden and Forest" 3: 182-183, 1890) a few plants from Fairview, Hancock county, observed in 1889.

33. Dr. Hamilton McSparrin Gamble, a physician of Moorefield, Hardy county, did considerable collecting in the valley of the South Branch of the Potomac River in Hardy, Grant, Mineral, and Hampshire counties from 1889 until his death in 1917. He donated his collection of 157 species in 1891 to the herbarium of the West Virginia Agricultural Experiment Station and it has been, since 1933, in the herbarium of West Virginia University.

34. Merton Benway Waite, pathologist in the Bureau of Plant Industry, U. S. Department of Agriculture, spent about a week in 1889 in Fayette and Greenbrier counties collecting parasitic fungi, securing about 300 numbers at Kanawha Falls and about 200 at White Sulphur

Springs. In 1911 he collected a few additional numbers of like material in Berkeley county, near Gerrardstown, and in Morgan county, at Sleepy Creek, Paw Paw, and Hancock. His specimens are deposited in the herbarium of the U. S. Bureau of Plant Industry.

35 Walter Bruce Nutter, an attorney of Buckhannon, collected extensively in Upshur, Lewis, Gilmer, and Randolph counties from 1890 to 1897. His collection, numbering about 700 specimens, is in his private herbarium.

36. John Kunkel Small, of the New York Botanical Garden, collected in 1890 along the Potomac river in Mineral county about 50 interesting plants which are now in the herbarium of the New York Botanical Garden.

37. Mrs. N. L. Britton (Elizabeth Gertrude Britton) collected a number of mosses in August, 1890, in the neighborhood of White Sulphur Springs. They are deposited in the Elizabeth Gertrude Britton Moss Herbarium at the New York Botanical Garden.

38. Charles Frederick Millspaugh, "the Father of West Virginia Botany," came to Morgantown in 1889 as botanist of the Agricultural Experiment Station, and began in 1890 a systematic survey of the plant life of the State. In this work he visited several localities in nearly every county. On one trip he drove through Wood, Wirt, Calhoun, Gilmer., Lewis, Upshur, Randolph, Webster, Nicholas, Fayette, Kanawha, Putnam, and Jackson counties, collecting leisurely throughout. During his field work, covering two seasons, he collected 1580 numbers; these were preserved in the herbarium of the West Virginia Agricultural Experiment Station, and have been since 1933 in the herbarium of West Virginia University. (See his "Preliminary Catalogue of the Flora of West Virginia," published as Bulletin 24 of the Experiment Station in 1892; Millspaugh and Nuttall's "Flora of West Virginia," published as a Bulletin of the Field Museum in 1896; Millspaugh's "The Living Flora of West Virginia," published as Part 1 of Vol. 5 (A) of the West Virginia Geological Survey in 1913; and Core's "Contributions of Charles Frederick Millspaugh to the Botany of West Virginia," Proc. W. Va. Acad. Sci. 8: 82-93. 1935).

39. Nathaniel Lord Britton, director of the New York Botanical Garden, collected in August, 1890, in the vicinity of White Sulphur Springs, securing about 40 interesting numbers; again in the same region in 1898, he obtained about the same number of specimens. His collections are deposited in the herbarium of the New York Botanical Garden.

40. Lawrence William Nuttall, then a mine owner at Nuttallburg, Fayette county spent most of his spare time from business duties from 1890 to 1898 in a comprehensive study of the flora of his neighborhood. His collection of several thousand numbers was presented to the herbarium of West Virginia University in 1927, although a considerable duplicate series, including his types in Lichens, are in the Field Museum of Natural History. His types in Fungi are in the Ellis Herbarium, now at the New York Botanical Garden (See Millspaugh and Nuttall, "Flora

of West Virginia,'' mentioned above; also, ''Former student gives work to University,'' by Douglas Miller, in the West Virginia Agriculturist for February, 1929. The title is misleading; Mr. Nuttall was never a regularly enrolled student at the University.)

41. Captain K. D. Walker of Fairmont collected a few plants at Little Falls, Monongalia county. His specimens were contributed to the West Virginia Agricultural Experiment Station in 1891, but have been lost.

42. 43. Addison Brown and J. K. Small spent a few days in July, 1892, in a botanical exploration of White Sulphur Springs, including Kate's Mountain. The resulting material, including the type of *Trifolium virginicum,* the famous Kate's Mountain clover, is in the herbarium of the New York Botanical Garden. (See Small & Vail's ''Report on the Botanical Exploration of Southwestern Virginia,'' Mem. Torr. Bot. Club 4:92-202. 1894.)

44. Andrew Delmar Hopkins, forest entomologist of the U. S. Department of Agriculture, collected numerous unusual plants during his many trips in various parts of the State from 1892 to 1902, depositing his collections in the herbarium of the Agricultural Experiment station while he was vice-director of the Station.

45. Amos Arthur Heller of the University of Nevada collected several specimens in the neighborhood of White Sulphur Springs in 1893. A set of his plants is preserved in the herbarium of the Field Museum of Natural History.

46. Lee Cleveland Corbett, while at the Agricultural Experiment Station, collected a number of plants from 1894 to 1896, depositing them in the herbarium of the Station. (See his ''Cranberries in West Virginia,'' W. Va. Agr. Exp. Sta., Bull. 86. 1903.)

47. William McCalley Pollock, while a student at West Virginia University, collected largely from 1893 to 1897 in Lewis, Upshur, Preston, Pocahontas, Taylor, and Wood counties, and in 1898 and 1899 in Monongalia county. His prime series amounting to about 1700 specimens was accidentally destroyed.

48. William Earle Rumsey, State Entomologist, collected a considerable number of plants in various parts of the state from 1894 to 1899. His plants are in the herbarium of West Virginia University.

49. T. F. Allen and Nathaniel Lord Britton collected in May, 1897, in the neighborhood of White Sulphur Springs. They secured about 50 species of especial interest, now preserved in the herbarium of the New York Botanical Garden.

50. Rev. A. Boutlou of Fairmont did considerable botanizing from 1897 to 1907 in Marion, Taylor, Monongalia, and Preston counties.

51. Edward Lee Greene, of the National Herbarium, spent a day or so of each year from 1897 to 1912 in the vicinity of Harper's Ferry. His collecting in this region has been of a highly discriminating character. He selected only such plants as appeared to differ from the usual form. His plants are in the National Herbarium.

52. Edward Strieby Steele spent several days in August and September, 1898, collecting in the neighborhood of Aurora, Preston county, securing about 325 numbers which are preserved in the National Herbarium. In 1903 and again in 1905 he collected near Sweet Springs, Monroe county, and in 1906 at White Sulphur Springs. In 1910 he gathered a few specimens in Grant county and in 1911 in Hardy county. These later collections are also deposited in the National Herbarium. (See his "New or Noteworthy Plants from the Eastern United States." Contrib. U. S. Natl. Herb. 12: 359-374. 1911.)

53. 54. Charles Louis Pollard and William Ralph Maxon collected in August, 1899, in Fayette county near Quinnimont, and in Summers county near Lowell. Of the 125 numbers they secured, about 30 were new to the state. Their plants are in the National Herbarium. (See "Some new and additional records of the flora of West Virginia," Proc. Biol. Soc. Wash. 14: 161-163. 1901; also "Notes on American ferns," Am. Fern Jour. 9:1-5. 1919.)

55. Edward Lyman Morris, curator of the Brooklyn Institute Museum, while engaged in field work for the U. S. Fish Commission in 1900, made a collection of plants in the region lying south of the New, Greenbrier, and Kanawha rivers in Summers, Monroe, Mercer, McDowell, Raleigh, and Wyoming counties. His collection of 397 numbers is deposited in the National Herbarium. (See his "Some plants of West Virginia," Bull. Biol. Soc. Wash. 13: 171-182. 1900.)

56. Henry Curtis Beardslee spent the summer of 1900 collecting chiefly fleshy fungi near Brookside, Preston county. His collections numbered about 600 specimens. (See his "Notes on the Boleti of West Virginia," Torreya 1: 37-39. 1901.)

57. Curtis Gates Lloyd of the Lloyd Herbarium, Cincinnati, collected for two weeks at Eglon, Preston county, in 1901. His specimens, principally fungi, are preserved in the Lloyd Herbarium at Cincinnati.

58. William Ashbrook Kellerman, professor of botany at Ohio State University, collected, principally fungi, at Durbin and Marlinton in August, 1902.

59. Albert Spear Hitchcock, agrostologist of the U. S. Department of Agriculture, made small, discriminating collections, mostly of grasses, near Morgantown in 1902 and in 1929, and at Harper's Ferry in 1905. His specimens are in the National Herbarium.

60. Fred Ernest Brooks, of the U. S. Bureau of Entomology, traveled extensively throughout the state engaged in field work for the Bureau, from 1902 to 1933. During that time he collected such plants as appeared of particular interest. His plant collection is preserved in the herbarium of West Virginia University. A remarkable collection of living plants may be seen along trails on his estate at French Creek. (See, among many others, his articles, "Things Small and Great," W. Va. Review 2: 234. 1925; and "A sower went forth to sow," W. Va. Review 7:235. 1930; "The Wild Gardens," W. Va. Review 1: 9. 1924; "Our doomed chestnuts," W. Va. Review 1; 24. 1924; "A day afield in

southern West Virginia," W. Va. Review 3: 137-139. 1926; "West Virginia wild flowers," W. Va. Review 7: 326, 327. 1930; "Our beautiful wild azaleas," W. Va. Review 7:173. 1930; "When Autumn comes to South Branch Valley," W. Va. Review 9: 112, 113. 1931; "The flower bed under the maple," W. Va. Review 9:259. 1932.)

61. Kenneth Kent Mackenzie, an attorney of New York, collected from August 27 to September 9, 1903, in the vicinity of White Sulphur Springs. He secured 187 numbers of interesting plants, among which is his new genus, *Pseudotaenidia*, and a new species of *Oenothera* (*O. argillicola*). His specimens are in the herbarium of the New York Botanical Garden. (See his "A new genus of North American Umbelliferae," Torreya 3: 158, 159. 1903; and "Notes on Evening Primroses," Torreya 4: 56, 57. 1904.)

62. Charles L. Boynton of the Biltmore Herbarium collected in June, 1903, at Huntington, Kenova, Milton, St Albans, Salters, Charleston, Eastbank, Gauley Bridge, Thurmond. Hinton, and White Sulphur Springs revisiting the latter place in October. In May and September, 1904, he again collected in the neighborhood of White Sulphur Springs and Tuckahoe. His total collection amounted to 295 numbers, now preserved in the National Herbarium.

63. Albert LeRoy Andrews, while connected with West Virginia University in 1903 and 1904, collected in many localities in Monongalia and Preston counties, specializing in Bryophytes. His plants are in the University herbarium, at Williams College, and in his own private herbarium. (See his "Additions to the Bryophytic Flora of West Virginia," Bryologist 8: 63-65. 1905.)

64. John Lewis Sheldon, professor of botany at West Virginia University from 1903 to 1919, made discriminative and specialized collections in the state, covering principally the counties of Monongalia, Preston, Greenbrier, Monroe, Pocahontas, Berkeley, Jefferson, Randolph, and all those counties along the Ohio River. His field work added a large number of species to the previously known flora. His prime set of approximately 5,000 numbers is in his private herbarium in Morgantown, with many duplicates in the University Herbarium. He contributed to the 1913 edition of Millspaugh's Flora full lists of all fungi in his collection that had passed under the critical examination of specialists in the various groups. He also sent to Dr. Millspaugh for examination unusual species of his flowering plants, and in other ways assisted materially in the compilation. (See, among many others, his "A study of the leaf-tip blight of Dracaena fragrans," Jour. Mycol. 13: 138-140. 1907; "Concerning the identity of the fungi causing an anthracnose of the sweet-pea and the bitter-rot of the apple," Science. n.s. 22: 51, 52. 1905; "Concerning the relationship of Phyllosticta solitaria to the fruit blotch of apples," Science n.s. 26: 183-185. 1907: "The taxonomy of a leaf-spot fungus of the apple and other fruit trees," Torreya, 7: 142-143. 1907; "The Andropogon-Viola Uromyces," Torreya 10: 90. 1910; "Notes on the blue-berried huckleberry," Rhodora 4: 14. 1902; "A rare Uromyces," Torreya 6: 249, 250. 1906; "Species of

Hepaticae known to occur in West Virginia," Bryologist 10: 80-84. 1907; "Another leaf-spot fungus of the apple, Illosporium malifoliorum sp. nov.," Torreya 8: 139-141. 1908; "Notes on Uromyces," Torreya 9: 54-56. 1909; "Menyanthes trifoliata in West Virginia," Rhodora 12: 11, 12, 1910; "Additional West Virginia Hepaticae," Bryologist 13: 64, 65. 1910; "Additions to the recorded mosses of West Virginia," Bryologist 15: 95-97. 1912.)

65. Dr. Jesse Moore Greenman, curator of the herbarium, Missouri Botanical Garden, spent September, 1904, collecting at Parsons and Hendricks in Tucker county; Spruce Knob in Pendleton county; Dry Fork, Horton, Elkins, Reed, Whitman, Glady, Harman, and Huttonsville, in Randolph county. The prime set of his collection, consisting of 1,500 specimens, is in the Gray Herbarium.

66. Albert Hanford Moore of Cambridge, Mass., collected with Dr. J. M. Greenman in 1904, over the route mentioned above, taking essentially the same specimens which were preserved in his private herbarium.

67. Frank Fitch Grout, while connected with the West Virginia Geological Survey, collected a number of plants in various parts of the state from 1904 to 1906, especially parasitic fungi. His collections are in the University herbarium.

68. Huron Herbert Smith, while assistant in dendrology at the Field Museum of Natural History, collected, in 1908, 246 numbers in Randolph, Webster, Nicholas, Lewis, Upshur and Wood counties. His specimens are in the herbarium of the Museum.

69. Otto Emery Jennings, curator of botany, Carnegie Museum, Pittsburgh, has collected in West Virginia on numerous occasions from 1909 to 1935. His specimens are in the herbarium of Carnegie Museum.

70. William Webster Eggleston collected from 1909 to 1911 with a view to securing all possible material in the Pomeae and gathering also a considerable number of other plants that appeared to be of particular interest. He collected in 1909 at White Sulphur Springs, Gauley Bridge, Thurmond, and Hinton. In 1911 he collected again at White Sulphur Springs. His material is in the herbarium of the New York Botanical Garden.

71. Alonzo Beecher Brooks, while occupied in amassing data on the Forests of West Virginia, collected a considerable number of particularly interesting plants, from 1909 to 1911. His collections are in the University herbarium. In connection with his work as director of Oglebay Nature Training School he has, since 1928, made careful observations of the flora of many regions, especially in the mountain counties. (See especially his "Forestry and Wood Industries," W. Va. Geol. Surv. Vol. 5; "West Virginia Trees," W. Va. Agr. Exp. Sta. Bull. 175. 1920; "The Oglebay Park Nature Training School," Jour. So. App. Bot. Club 1:45-48, 1936, and numerous descriptions of forests published in the country reports of the West Virginia Geological Survey.)

72. 73. M. J. Robinette of Fort Gay, and Drexel Plymale of Kenova, have studied extensively the flora of Wayne county.

74. Norton Plymale of Kenova has collected extensively in Wayne county, depositing his specimens in the herbarium of Ohio State University.

75. Per Axel Rydberg, of the New York Botanical Garden, while on a collecting trip through the Southern Applachians in 1925, visited Spruce Knob and Snowy Mountain, in Pendleton county. His material, consisting of especially interesting forms, is in the herbarium of the New York Botanical Garden. (See his "Botanizing in the Higher Allegheny Mountains, I. West Virginia," Jour. N. Y. Bot. Gard. 27: 1-6. 1926; "Two new species from the mountains of West Virginia," Torreya, 26: 29-33. 1926.)

76. E. Meade McNeill, professor of botany at Concord State Teachers College, has made extensive studies of the flora of south-eastern West Virginia since 1930. (See his "Algae of Shawnee Lake, Mercer Co.," Proc. W. Va. Acad. Sci., this volume, p. 64.)

77. C. A. Weatherby, of the Gray Herbarium, collected 37 numbers in Greenbrier, Fayette, Pocahontas, and Randolph counties from May 24 to 26, 1933. His specimens are in the Gray Herbarium.

78. F. W. Pennell, Curator of Botany at the Philadelphia Academy of Sciences, made several collecting trips in West Virginia while working on a monograph of the Scrophulariaceae of eastern North America. His collections are in the herbarium of the Academy, with numerous duplicates in the herbarium of West Virginia University.

79. C. N. Hill of Fairmont made a careful botanical survey of Marion county in 1934. (See his "Botanical Survey of Marion county, West Virginia," Proc. W. Va. Acad. Sci. 8: 99-110, 1935.)

80. Mrs. Eva Fling Roush while a student and instructor at the University and afterwards made many discriminative collections, especially in the mountain counties. Her specimens are in the University herbarium. Her master's thesis, "One hundred algae of West Virginia," represented the first, and until 1936, the only paper on West Virginia algae.

81. Charles Chapman of Keyser has made careful studies of the flora of Mineral county. His specimens are in his private herbarium and in the University herbarium.

82. Mrs. Jane S. Netting while accompanying her husband, Dr. Graham Netting, herpetologist at the Carnegie Museum, Pittsburgh, Pa., on collecting trips in West Virginia, has discovered numerous new records for plants. (See her "A second record for *Listera smallii* Wiegand in West Virginia," Torreya 32: 72. 1932.)

83. Harry Cordray, while a student at the University from 1930 to 1935, made plant collections near his home at Core. In 1935-36, while in the Barberry Eradication Service, he also made collections in Monroe and Summers counties.

84. Oscar Haught made an intensive study of the flora of eastern Wetzel county in 1931. His collection of more than 300 sheets is filed in the University herbarium. (See "Ecological Notes on the Vegetation

of eastern Wetzel County, W. Va.," Proc. W. Va. Acad. Sci. 6: 43-46. 1933.)

85. Clinton C. Taylor made a survey of the flora of Mineral county in the late summer of 1933, depositing his collection of 150 specimens in the University herbarium.

86. Anton Berg, pathologist on the Agricultural Experiment Station staff since 1913, has made important additions to our knowledge of the pathogenic fungi of West Virginia. (See especially his "Causative organism of a papular type of apple measles," Science n.s. 74:485-486, 1931; "A fruit spot associated with the papular type of apple measles," Phytopath. 23:4, 1933.)

87. Leon H. Leonian, member of the plant pathology department of the University since 1922, has been especially interested in the physiology and taxonomy of Fusarium, Valsa, and Phytophthora. (See "The Physiology of Perithecial and Pycnidial formation in Valsa leucostoma," Phytopath. 13: 257-272, 1923; "Physiological studies on the Genus Phytophthora," Am. Jour. Bot. 12:444-498, 1925; "The morphology and pathogenicity of some Phytophthora mutations," Phytopath. 16: 723-730. 1926; "Studies on the Variability and Dissociations in the Genus Fusarium," Phytopath. 19: 753-868, 1929; "Identification of Phytophthora species," W. Va. Agr. Exp. Sta. Bull. 262.)

88. W. J. Sumpstine of Bethany College has studied carefully the flora of his neighborhood. His collections are in his private herbarium. (See his "Origin and development of the tissues in the rhizomes of Onoclea sensibilis," Proc. W. Va. Acad. Sci. 5:37-42, 1931.)

89. Ward McClintic Sharp made a careful study of the Compositae of the state while a student in the University from 1928 to 1931. His collection of 136 sheets representing typical forms is deposited in the Herbarium. (See his "Pore fungi of Monongalia County," Proc. W. Va. Acad. Sci. 6: 29-31, 1933.)

90. Earl E. Berkley, while a student in the University and afterwards, made an intensive study of the grasses of the state from 1928 to 1934, preliminary to the publication of a bulletin on the subject. His collection, numbering more than 1,000 sheets, is in his private herbarium at Alton, Ill.

91. Maxine Thacker of Buckhannon, in connection with her duties as biology teacher has noted several interesting plants of the region.

92. Marvin G. Williams of Bluefield College is making interesting studies of the plants of the Bluefield region.

93. W. A. Archer, assistant pathologist, Bureau of Plant Industry, during 1928 and 1929, made in cooperation with the United States Department of Agriculture and the Department of Plant Pathology of West Virginia Agricultural Experiment Station, a survey of the diseases of plants occurring in the state. The results of the survey were published in "The Plant Disease Reporter," Suppl. 72: 324-365, issued December 30, 1929.

94. Clara F. Sheldon in 1908, while a student in the University, made a study of the mildews of the state. (See her 68-page thesis, "The Erypsiphaceae of West Virginia," unpublished.)

95. Bailey Sleeth, while a student in the department of plant pathology at the university, made a study of watermelon wilt. (See his "Fusarium niveum, the cause of watermelon wilt," W. Va. Agr. Exp. Sta. Bull. 257.)

96. Everett Clifton Sherwood, Extension pathologist since 1920, has made extensive studies of the plant diseases of the state. (See "The Nature of Plant Diseases," W. Va. Agr. Exp. Sta. Circ. No. 41. 1926.)

97. Thomas Wesley Skuce, Extension forester from 1925 to 1935, has made extensive studies of the ligneous flora of the state. (See his "Forest types as recognized and used in West Virginia," Proc. W. Va. Acad. Sci. 4:31-36, 1930.)

98. H. B. Graybill of Lewisburg has investigated thoroughly the flora of his vicinity.

99. Rev. William Benefield of Sinks Grove has made studies of the plants of his region.

100. Isabelle Lycan made a study of the flora of Wayne county in 1931. Her collection of 200 sheets is in the University herbarium.

101. Fred W. Gray, a Presbyterian minister, now of Philippi but formerly located at Cass, has been making careful studies of the flora of the mountain region since about 1920. Numerous new records of seed plants have been established through his investigations, but pteridophytes, bryophytes, and lichens have been his chief interest. His prime collection is in his private herbarium at Philippi, but more than 600 numbers, principally lichens, have been deposited in the University herbarium. (See his "Ferns of Eastern West Virginia," Am. Fern Jour. 14: 1-13. 1924; "An explanation of the occurrence of certain new Cladonias," Bryologist 34: 71-72, 1931; "Pygmies, here and there, now and then," Bryologist 35: 18-23, 1932.)

102. Edgar T. Wherry, of the University of Pennsylvania, has made remarkably comprehensive and discriminating studies of the flora of the mountain region, expecially of the shale barrens and of certain plant families. His collections are in the National Herbarium and the herbarium of the Philadelphia Academy of Sciences, with numerous duplicates in the herbarium of West Virginia University and elsewhere. (See his "Ferns of eastern West Virginia," Am. Fern Jour. 13: 104-109, 1924; "A new acid soil onion from West Virginia," Jour. Wash. Acad. Sci. 15: 370-372. 1925; "The Appalachian Aspleniums," Am. Fern Jour. 15: 47-54, 1926; "West Virginia locality of the southeastern relative of Woodsia scopulina," Am. Fern Jour. 14: 92-95, 1926; "A new circumneutral soil prickly pear from the Middle Atlantic States," Jour. Wash. Acad. Sci. 16: 11-14, 1926; "Further occurrences of the Allegheny cliff fern," Am. Fern Jour. 19: 101-102, 1929; "A long lost phlox," Jour. Wash. Acad. Sci. 20: 25-28, 1930; "Plants of the Appalachian shale barrens," Jour. Wash. Acad. Sci. 20: 43-52, 1930; "*Heuchera hispida* Pursh rediscovered," Rhodora 35: 118-119, 1933;

"Temperature relations of the bunchberry, Cornus canadensis," Ecology 15: 440-443, 1934; "The box huckleberry as an illustration of the need for field work, Bull. Torr. Bot. Club cl: 81-84, 1934; "Polemoniaceae of the Middle Appalachian region," Jour. So. App. Bot. Club 1: 13-15, 32- 35, 1936.)

103. W. J. Judy, a teacher in Clarksburg High School, in 1934 made a study of the vegetation of the environs of that city, depositing his 162 numbers in the University herbarium.

104. Peter J. Zucchero, a member of the biology department of the University, collected 202 numbers near Morgantown, in Monongalia county, chiefly in the region near Cheat Lake, in 1931. (See his "A second record for Asarum grandiflorum in West Virginia," Jour. So. App. Bot. Club, 1: 7, 1936.)

105. C. M. Roberts, a member of the faculty of Fairmont State Teachers College, has collected extensively over the state, taking chiefly bryophytes. His collections are in his private herbarium and the herbarium of West Virginia University. (See his "Leucobryum albidum for West Virginia," Bryologist 34: 22, 1931.)

106. Leo Watkins, a teacher in the Monongalia county schools, collected 231 numbers near Cassville in the fall of 1935, presenting them to the University herbarium.

107. Ray Harris, instructor of biology in Grantsville High School, studied the flora of Calhoun county in 1932-35, reporting his findings in a master's thesis filed in the University Library. His collection of over 1,000 numbers is in the University herbarium.

108. Weldon Boone, a teacher in Hinton High School, collected 250 numbers in Summers county in 1933, presenting them to the University herbarium.

109. Nahum James Giddings, pathologist at the University from 1909 to 1929 and head of the department of plant pathology from 1919 to 1929, made substantial contributions to our knowledge of apple rust. He has added many numbers to the fungi collections in the herbarium. (See his, "Potato and tomato diseases," W. Va. Agr. Exp. Sta. Bull. 165: 4-24, 1917; also, Giddings and Berg, "Apple rust," W. Va. Agr. Exp. Sta. Tech. Bull. 154:5-73, 1915.)

110. Clayton Roberts Orton, head of the department of plant pathology at the University since 1929, has made outstanding additions to our knowledge of the rust flora of the state. His collections are in the University Herbarium. Important contributions to the knowledge of the fungi that cause plant diseases are to be found in the annual reports to the Bureau of Plant Industry made by Dr. Orton and his predecessors and published in "The Plant Disease Reporter." (See annual indices to that Journal; also Dr. Orton's, "The Uredinales of West Virginia," Proc. W. Va. Acad. Sci., in press.)

111. Robert Martin, a graduate student in the botany department of the University, made a study of the plants of Harrison county in 1934, depositing his collection of 124 specimens in the University herbarium.

112. Charles Gould, Jr., a student in the botany department of Marshall College, made a survey of the polypores of the southwestern counties in 1934-35. His prime set is in his private herbarium with duplicates in the Marshall College herbarium and the University herbarium. (See his "Some Polyporaceae of Southern West Virginia," Jour. So. App. Bot. Club, 1: 3-6, 1936.)

113. Frank Cutright, of Concord State Teachers' College, has made collections of interesting plants of his vicinity, depositing them in the herbaria of Concord College and of the University.

114. Nelle Ammons, a member of the University botany department, has since 1929 been engaged in a very intensive study of the bryophytes of the state. The results of her investigations will be published in a forthcoming thesis. Her collections are in her private herbarium and in the herbarium of West Virginia University. (See "Bryophytes of McKinney's Cave," Bry. 36: 16-19, 1933; "Preliminary List of W. Va. Mosses," Bry. 37: 65-74, 1934; "Preliminary List of W. Va. Liverworts," in press; also Strausbaugh, Core, Ammons, "Common seed plants of the mid-Appalachian region," Morgantown, 1931, a book of 305 pages.)

115. Frank Albert Gilbert, head of the department of botany at Marshall College since 1927, has made a careful study of the flora of the southwestern counties, being especially interested in slime molds. His collections are in the herbarium of Marshall College and in the University herbarium. (See his "A preliminary report of the slime molds of West Virginia," Proc. W. Va. Acad. Sci. 3: 71-73, 1929; "Additions to the slime-mold flora of West Virginia," Proc. W. Va. Acad. Sci. 8: 38-39, 1935; "Notes on some plants from southern West Virginia," Jour. So. App. Bot. Club 1: 22-23, 1936.)

116. 117. Asa Howard Anderson and Freeman Paul Smith made a botanical survey of Monongalia county in the summer of 1933, depositing their collection of about 350 numbers in the University herbarium.

118. G. Ledyard Stebbins, Jr. then of Colgate University, visited Hanging Rock, Hampshire county, in the spring of 1933, studying the shale-barren species of Antennaria. His investigations resulted in the discovery of a new species in that genus. (See "A new species of Antennaria from the Appalachian region," Rhodora 37: 229-237, 1935.)

119. Joseph Ashcroft, while a student in the plant pathology department of the University, made important studies of the fungi of the state, expecially of the black walnut canker. (See his "European canker of black walnut and other trees," W. Va. Agr. Exp. Sta. Bull. 261. 1934.)

120. Leonard Marion Peairs, professor of entomology at the University since 1914, has made numerous plant collections while engaged in the study of insects of the State, depositing his collections in the University herbarium.

121. Hannibal Albert Davis, member of the mathematics depart-

ment of the University since 1921, has made numerous discriminating collecting trips for plants.

122. Robert Clifton Spangler, professor of botany at the University since 1914, acting in cooperation with P. D. Strausbaugh and Miss Edith Stevens, laid the foundations of the present Spermatophyte herbarium. The summer of 1924 was passed in collecting, mounting, and filing several hundred specimens which formed the nucleus of the present herbarium. Dr. Spangler is now engaged in a study of the algal flora of the state. (See "The female gametophyte of Trillium sessile," Bot. Gaz. 69: 217-221, 1925.)

123. Perry Daniel Strausbaugh, professor of botany at the University since 1923, has, since 1926, conducted an annual summer botanical expedition through West Virginia, resulting in the discovery of hundreds of species of seed plants hitherto unknown in the state. The plant collections of these botanical expeditions, numbering more than 5,000 specimens and representing explorations in every county of the state, are filed in the University herbarium. (See his "The West Virginia University Botanical Expedition," Jour. So. App. Bot. Club. 1: 35-36, 1936; "An abnormal inflorescence of Symplocarpus foetidus," Bot. Gaz. 84: 328-329, 1927; "Cranberry Glades," Amer. For. 362-364, 382-383, 1934; "Some rare and little known inhabitants of West Virginia," W. Va. Review 13: 144-147, 1936; also Strausbaugh, Core, and Ammons, "Common Seed Plants of the Mid-Appalachian Region," Morgantown, 1931; and Strausbaugh and Core, "Some additions to the Millspaugh check-list of West Virginia Spermatophytes," Proc. W. Va. Acad. Sci. 4: 38-48, 1930.)

124. Russell West, in connection with the organization and development of the Oglebay Plant Club, has played since 1931 an important part in the exploration of the flora of the northern panhandle. His collections are principally in the herbarium of Oglebay Park, Wheeling. (See "The Oglebay Plant Club," Jour. So. App. Bot. Club. 1: 8-9, 1936.)

125. Edgar B. Simmons, a teacher in the High School at Moorefield, has, since 1935, made studies of the flora of the South Branch Valley. His specimens are in the University herbarium.

126. William W. Webb, formerly of Wheeling but now of California, made careful and discriminating collections of Bryophytes, presenting his specimens to the University herbarium in 1931.

127. Maurice Brooks, a son of Fred E. Brooks, while a teacher of biology at Buckhannon from 1926 to 1934, and a member of the University faculty since 1934, made numerous collecting trips over the state, gathering unusual or specially interesting forms, particularly ferns and orchids. His specimens are in the University herbarium. (See his "Asplenium gravesii in West Virginia," Am. Fern. Jour. 16: 97-98, 1926; "Listera cordata found in West Virginia," Jour. So. App. Bot. Club, 1: 15-17, 1936; "West Virginia's orchid wealth," W. Va. Review 11: 166-168, 1934: "Spring comes to the New River Gorge," W. Va. Review 11: 198-199, 1934.)

128. Joseph E. Harned of Oakland, Md., has made numerous extensive and critical studies of the flora of the West Virginia counties near Oakland, resulting in the discovery of numerous species new to the state. See his book, "Wild Flowers of the Alleghenies," a work of some 670 pages, with 400 figures and 8 colored plates, published by the author at Oakland in 1931.

129. Gail Holliday, a teacher in the Wheeling High School, has for several years been engaged in a study of the bryophytes of northern West Virginia. Her thesis, "Mosses of the Panhandle Counties," is now in preparation.

130. E. R. Grose, professor of botany in Glenville State Teachers' College, has made a careful study of the flora of Gilmer county, depositing his most interesting collections in the University herbarium.

131. Leslie Greenlee, following a botanical survey of Kanawha county in the summer of 1934, deposited her collection of 250 numbers in the University herbarium.

132. Ben R. Roller, an Episcopal minister of White Sulphur Springs, has made some interesting discoveries in the Alleghenies near that place. (See "Showy Lady's Slipper in West Virginia," Jour. So. App. Bot. Club, 1: 9-10, 1936.)

133. Elizabeth Martin, a teacher in Charleston High School, made in 1934 a critical study of the violets of West Virginia, chiefly from material in the University herbarium.

134. Elizabeth Ann Bartholomew, of Wheeling, collected extensively in Ohio and Wirt counties, 1931-6, presenting her collections numbering more than 1,000 specimens to the University herbarium.

135. Wilbert Frye, a teacher in the Hampshire county schools, made a very detailed botanical survey of that county, presenting his collections of more than 2,000 numbers to the University herbarium. (See his "Flora of Hampshire County, West Virginia," Proc. W. Va. Acad. Sci. 8: 59-82, 1935.)

136. Cecil A. Garrison of Holiday's Cove is making a study of the flora of his vicinity.

137. Teresa Gibbons of New Martinsville is studying the flora of that region.

138. Susan Hammer, a teacher in Martinsburg High School, is investigating the plants of the eastern panhandle.

139. John W. Handlan, member of the staff of Oglebay Park, has made interesting observations on the plants of the region of Wheeling.

140. Jennie Harshbarger of Fairmont has studied the plants of Marion county in connection with her duties as teacher of biology.

141. Clement Ross Jones, dean of the College of Engineering, West Virginia University, has made an extensive collection of the ligneous flora of the state, depositing his material in the University herbarium in 1934.

142. Genevieve King of Huntington is studying the plants of the southwestern counties.

143. Edith Lemley, of Core, made collections of the plants of that vicinity while a student at the University from 1932 to 1936.

144. Laura Brooks Moore of Parkersburg has made interesting studies of the plants of that region.

145. Lewis Plymale of Huntington has studied the flora of his vicinity, depositing his specimens in the herbaria of Marshall College and of West Virginia University.

146. Stanley Harris of Romney High School made a collection of the Pteridophytes of the state while a student in the University in 1933, depositing his specimens in the University herbarium.

147. Mildred Hadden of Charleston High School made a collection of the woody plants of the state while a student in the university in 1933. Her specimens are in her private herbarium.

148. Mary Louise Grumbein of Morgantown made several interesting plant collections while a student in the University from 1931 to 1935.

149. Russell G. Brown, now of the University of Maryland, made careful studies of the flora of Kanawha and Fayette counties while professor of biology at New River State School in 1935 and 1936, depositing his specimens in the herbarium of that school.

150. James L. Creasy of Summersville has carefully studied the plants of Nicholas county. His specimens are in his private collection.

151. Andrew Jackson Dadisman, of the department of economics of West Virginia University since 1914, has made studies of the flora of the state, especially of the trees and shrubs.

152. S. S. Dickey of Waynesburg, Pa., has made interesting observations on the flora of the mountain glades, depositing his specimens in the University herbarium in 1934.

153. James F. Ferry, State Land Planning Specialist for West Virginia since 1935, has collected a number of interesting plants while travelling over the State.

154. William Conrad Hall of Hurst has made numerous collections in the region of his home and, while a student in the University from 1922 to 1926, in other parts of the state. His collections, principally of fungi and composites, are in the University herbarium.

155. James C. Cox of Marshall county has collected and contributed to the herbarium of West Virginia University several species of that county.

156. Lee Dean formerly of Elk Garden, W. Va., now at the University of Iowa, made careful studies and discriminating collections of the West Virginia species of dodder. (See his "Host plants of Cuscuta Gronovii," Rhodora 36: 372-375, 1934; "Host responses to haustorial invasion of Cuscuta species," Science n.s. 80: 588, 1934.)

157. Irvan Speicher, in the summer of 1931, while a student with

the West Virginia University Biological Expedition, collected several hundred numbers of flowering plants which are preserved in the university herbarium.

158. Daisy Chapman, now of South Charleston, has made collections of interesting plants throughout the State, especially in Webster, Morgan, Monongalia, Mineral, Mingo and Kanawha counties.

159. P. C. Bibbee, of the department of biology of Concord State Teachers' College, made plant collections near his former home at Hanna and elsewhere, especially in the mountain counties.

160. H. D. Rohr of Weston is an enthusiastic student of the plants of Lewis county.

161. Cecil Strickland of Clendenin has made studies of the flora of his region, depositing his material in the University herbarium.

INDEX TO COLLECTORS

(The numbers following the names refer to those of the preceding paragraphs.)

A STUDY OF THE ALGAL FLORA OF SHAWNEE LAKE

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NORTHWEST OF PRINCETON, West Virginia, lies Shawnee Lake, an artificial lake consisting of approximately five acres, fed by a small stream, two springs, and the surface run-off following rains. It is divided into two parts; one section is used for swimming, the other for boating. This latter portion has recently been leased by the state of West Virginia for a bass hatchery.

Shawnee Lake is in the Harrisburg peneplain section of Mercer county and has an elevation of 2070 feet. It varies in depth from a few inches near the shore line to approximately seven to nine feet. Beginning August 24, 1935, and continuing intermittently during the autumn, winter, and spring, the writer has examined collections from many locations in the open lake and along the shore.

This lake abouds in plankton, epiphytic, and filamentous forms.

Species of *Sagittaria, Carex, Juncus, Eleocharis, Typha, Potamogeton, Elodea, Polygonum,* and other hydric forms of seed plants show numerous epiphytic forms.

Most of the collections examined showed mixed cultures. Unicultures of *Lyngba, Oedogonium, Chaetophora, Spirogyra, Diatoms, Scenedesmus, Tetraspora, Draparnaldia,* and *Vaucheria,* however, were collected.

Several interesting things were observed in this study. On September 26, 1935, collections were limited to the swimming pool proper. No epiphytic or filamentous forms were found, only unicultures of diatoms being present.

Since this area is chlorinated at frequent intervals during the summer season, perhaps filamentous types including epiphytic forms cannot withstand the chlorine treatment of the water.

The habitats on which algae were found, such as the carapace of turtles, tongue of a dead duck, guano, submerged piers, muskrat burrows, snail shells, and other bizarre abodes were of interest.

The list of algae observed follows:

MYXOPHYCEAE

CHROOCOCCALES

Family and Generic Name	*Location*	*Frequency*	*Date*
Chroococcaceae—			
Chroococcus—Nageli, 1849	Plankton	Not Common	8/25/35
Gloeocapsa—Kutzing, 1843	Plankton	Not Common	8/25/35
Aphanocapsa—Nageli, 1849	Plankton	Not Common	8/25/35
Microcystis—Kutzing, 1833	Plankton	Not Common	8/25/35
Holopedium—Langerheim, 1883	Plankton	Rare	2/23/36
Coelosphaerium—Nageli, 1849	Plankton	Not Common	8/25/35
Glaucocystis—Itzigsohn, 1854	Plankton	Not Common	8/25/35

CHAMAESIPHONALES

Chamaesiphonaceae—			
Chamaesiphon—A. Braun, 1865	Epiphyte	Common	8/25/35

HORMOGONALES

HOMOCYSTINEAE

Oscillatoriaceae—			
Oscillatoria—Vaucher, 1803	Plankton	Common	8/25/35
Spirulina—Turpin, 1827	Plankton	Rare	2/20/36
Lyngba—Agardh, 1824	Free Floating	Common	9/13/35
Microcoleus—Desmazieres, 1823	Mud Flat	Not Common	12/11/35
Schizothrix—Kutzing, 1843	Free Floating	Not Common	10/7/35

HETEROCYSTINEAE

Family and Generic Name	*Location*	*Frequency*	*Date*
Nostaceae—			
Anabaena—Bory, 1822	Plankton	Not Common	12/11/35
Nostoc—Vaucher, 1803	On Snail	Rare	2/17/36
Nodularia—Mertens, 1822	In Ditch	Rare	9/13/25
Rivulariaceae—			
Calothrix—Agardh, 1824	On Pier	Not Common	10/7/35
Rivularia—Roth, 1797	Submerged	Not Common	8/25/35
Gloeotrichia—Agardh, 1842	Free Floating	Common	10/7/35

HETEROKONTAE

RHIZOCHLORIDALES

Stipitococcaceae—			
Stipitococcus—W. and G. S. West, 1898	Epiphyte	Rare	10/7/35
Botrydiaceae—			
Botrydium—Wallroth, 1815	Mud Flat	Common	9/13/35

BACILLARIEAE

CENTRALES

Coscinodiscineae—			
Stephanodiscus—Ehrenberg, 1845	Plankton	Rare	8/25/35

PENNALES

Fragilarineae—			
Fragilaria—Lyngbye, 1819	Plankton	Common	9/13/35
Naviculineae—			
Navicula—Bory, 1822	Plankton	Common	9/13/35
Gomphonemataceae—			
Gomphonema—Agardh, 1824	Plankton	Common	8/25/35
Cymbellaceae—			
Epithemia—de Brebisson, 1834	Plankton	Common	9/13/35
Surirellaceae—			
Surirella—Turpin, 1828	Plankton	Not Common	9/13/35

CHLOROPHYCEAE

VOLVOCALES

Chlamydomonadaceae—			
Chlamydomonas—Ehrenberg, 1833	Plankton	Not Common	8/25/35
Volvocaceae—			
Pandorina—Bory, 1824	Plankton	Not Common	8/25/35
Eudorina—Ehrenberg, 1832	Plankton	Rare	2/26/36
Pleodorina—Shaw, 1894	Plankton	Rare	8/25/35

Family and Generic Name	*Location*	*Frequency*	*Date*
Sphaerellaceae—			
Sphaerella—Sommerfelt, 1824	Plankton	Common	2/17/36
TETRASPORALES			
Palmellaceae—			
Sphaerocystis—Chodat, 1897	Plankton	Not Common	9/13/35
Tetrasporaceae—			
Tetraspora—Link, 1909	Plankton	Not Common	9/13/35
ULOTRICHALES			
Ulotrichaceae—			
Stichococcus—Nageli, 1849	Free Floating	Rare	2/17/36
Geminella—Turpin, 1833	Plankton	Rare	2/17/36
Binuclearia—Wittrock, 1886	Free Floating	Rare	4/17/36
Hormidium—Kutzing, 1843	Free Floating	Rare	9/13/35
Microspora—Thuret, 1850	In Ditch	Common	10/30/35
Cylindrocapsaceae—			
Cylindrocapsa—Reinsch, 1867	In Ditch	Rare	10/30/35
Chaetophoraceae—			
Stigeoclonium—Kutzing, 1843	On Log	Not Common	2/17/36
Pseudochaete—W. and G. S. West, 1903	Epiphyte	Rare	10/17/35
Chaetophora—Schrank, 1798	Submerged Plants	Common	2/17/36
Draparnaldia—Bory 1808	Lake Margin	Not Common	4/8/36
Aphanochaete—A. Braun, 1851	Epiphyte	Not Common	10/7/35
Protococcaceae—			
Protococcus—Agardh, 1824	On Log	Not Common	2/17/36
Coleochaetaceae—			
Chaetosphaeridium—Klebahn, 1892	Submerged	Not Common	10/7/35
Trentepholiaceae—			
Gomontia—Bornet, 1888	Snail Shell	Rare	2/17/36
CLADOPHORINEAE			
Cladophoraceae—			
Cladophora—Kutzing, 1843	Muskrat Burrow	Rare	2/17/36
Basicladia—Hoffmann, 1930	On Turtle	Not Common	9/13/36
OEDOGONIALES			
Oedogoniaceae—			
Oedogonium—Link, 1820	Free Floating	Common	2/17/36
Bulbochaete—Agardh, 1817	Free Floating	Not Common	10/7/35

CHLOROCOCCALES

Family and Generic Name	*Location*	*Frequency*	*Date*
Characiaceae—			
Characium—A. Braun, 1849	Epiphyte	Not Common	2/17/36
Hydrodictyaceae—			
Pediastrum—Meyen, 1829	Plankton	Not Common	12/11/35
Coelastraceae—			
Coelastrum—Negeli, 1849	Plankton	Rare	4/7/36
Westella—de Wildemann, 1897	Plankton	Rare	4/8/36
Oocystaceae—			
Ankistrodesmus—Corda, 1838	Plankton	Not Common	9/13/35
Schroderia—Lemmerman, 1899	Plankton	Not Common	9/13/35
Kirchneriella—Schmidle, 1893	Plankton	Not Common	9/13/35
Quadrigula—Printz, 1915	Plankton	Not Common	2/20/36
Tetraedron—Kutzing, 1845	Plankton	Not Common	9/13/35
Scenedesmaceae—			
Scenedesmus—Meyen, 1829	Plankton	Common	2/25/36
Crucigenia—Morren, 1830	Plankton	Common	8/25/35

SIPHONALES

Vaucheriaceae—			
Vaucheria—De Candolle, 1803	In Ditch	Common	9/13/35

ZYGNEMATALES

Zygnemataceae—			
Mougeotia—Agardh, 1824	Free Floating	Common	8/25/35
DeBarya—Wittrock, 1872	Free Floating	Common	8/25/35
Zygnema—Agardh, 1824	Free Floating	Common	12/11/35
Spirogyra—Link, 1820	Free Floating	Common	2/17/36
Sirogonium—Kutzing, 1843	Submerged	Rare	2/20/36
Mesotaeniaceae—			
Gonatozygon—DeBary, 1856	Snail Shell	Rare	2/17/36
Netrium—Nageli, 1849	Plankton	Common	2/17/36
Desmidaceae—			
Closterium—Nitsch, 1817	Plankton	Common	8/25/35
Penium—de Brebisson, 1844	Plankton	Not Common	8/25/35
Pleurotaenium—Nageli, 1849	Plankton	Not Common	8/25/35
Docidium—de Brebisson, 1844	Plankton	Rare	8/25/35
Euastrum—Ehrenberg, 1832	Plankton	Not Common	8/25/35
Cosmarium—Corda, 1834	Plankton	Common	8/25/35
Xanthidium—Ehrenberg, 1837	Plankton	Not Common	8/25/35
Straurastrum—Meyen, 1829	Plankton	Common	8/25/35
Desmidium—Agardh, 1825	Plankton	Not Common	10/7/35

DINOPHYCEAE

Dinoflagellatae—			
Glenodinium—Stein, 1883	Plankton	Rare	8/25/35

EUGLENOPHYCEAE

Euglenaceae—			
Euglena—Ehrenberg, 1838	Plankton	Not Common	2/17/36
Astasiaceae—			
Menoidium—Perty, 1852	Plankton	Rare	4/7/36

The summary of this study is as follows:

Class	*Orders*	*Families*	*Genera*
Myxophyceae	3	5	19
Heterokontae	1	2	2
Bacillarieae	2	6	6
Chlorophyceae	8	22	53
Dinophyceae	1	1	1
Euglenophyceae	2	2	2
Total	17	38	83

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A PRACTICAL METHOD OF PREPARING AUTOGENOUS BACTERIOPHAGES FOR STAPHYLOCOCCIC INFECTIONS

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THE NATURE OF BACTERIOPHAGE in its action against disease organisms has stimulated a large amount of research. This has been brought about by the increasing importance of bacteriophage in experimental bacteriology, medicine, and surgery.

Within the last two years the writer has had occasion to observe some of the activities common to his phenomenon. This has necessitated a study of different methods of preparation employed by others, testing each in turn for its efficiency. Such investigations have afforded the opportunity of observing and studying the steps in the development of bacteriophagy into what Dr. Albee considers as one of the most life-saving and influential principles in the welfare of mankind *(1)*.

The following definition of bacteriophage may be found in the Modern Drug Encyclopedia: "Bacteriophage preparations are obtained from live bacterial cultures by the lytic action of undefined principles, specific for each bacterial organism. . . . Such lysis of living bacteria by phages occurs in vitro as well as in vivo. The phages contain antigens, stimulate phagocytosis, are non-toxic, non-damaging, harmless to the tissue cells, but are inhibited by antiseptics *(2)*."

The bacteriologist who has not yet determined the exact nature of this lytic agent needs to do some intensive investigation. Where best clinical results have been observed, it has been necessary to employ fresh autogenous phages prepared for each individual case; this makes the problem of preparation one for every hospital and clinical laboratory.

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METHODS

Smear pus thinly on Loeffler's Blood Serum *(3)* media which has been warmed to body temperature. After eight hours incubation at 35° or 37° C. *(4)*, examine and record the appearance of at least four typical colonies, noting any concavity or clarity in, and surrounding, the area covered by the colony for hemolysis. Make two separate slides containing thin, diluted smears from each of these colonies. Stain Slide #1 by the Gram's method, decolorizing the crystal violet stain with acetone for not over ten seconds. Stain Slide #2 by the same method, allowing the acetone to remain on the slide for at least the whole of a minute. The temperature of both slide and staining solutions for best results should be as near 32° C. as possible. We use a solution of Safranin for secondary staining; this is fifty percent stronger than that generally employed and is used to bring out more clearly the morphological characteristics of the bacteria staining Gram's Negative.

If upon microscopic examination it is found that most of the organisms are Gram's Negative, five of the following conditions might exist: first, the technique of staining is defective; second, the pH. of the media is too low; third, there may be present an active lytic resistance; fourth, the organisms are not *Staphylococci;* and fifth, the temperature and humidity of the incubator have not been properly adjusted. Generally it will be found that after eight hours incubation, the organisms will be of uniform size, with the exception of about five percent which will appear Gram's Negative. If all four colonies appear very irregular, and there is noticed many abnormally large ones, it may be possible that an active phage is present. Choose a colony containing the most uniform-sized Gram's Positive organisms, and make a phage for Gram's Negative ones only after examining four more colonies in order to pick the most virulent organisms.

Lift a loopful of the chosen colony, disperse it in a tube containing 10 c. c. of normal saline, agitate, and smear on a slant of Haner & Frost's Milk Agar *(5)* prepared specifically for the cultivation of *Staphylococci.* Incubate this tube for eight hours and examine under the microscope to make sure the culture is free from contamination.

Lift a loopful of this culture and disperse into 5 c. c. of "Savita" *(6)* broth; incubate this tube until broth becomes turbid, the time being from two to six hours; then make a count by the "agar plate method" or microscopically to determine the concentration of bacteria per c. c. Store this in the refrigerator at 3° to 5° C., if not ready for proceeding with the preparation.

If seed-phage cannot be successfully used, the active agent is most generally found in the urine of the infected individual. 50 c. c. of fresh urine is titrated to calculate its pH. and then discarded; another 50 c. c. is neutralized by calculated titration, 15 c. c. of this centrifuged at 500 revolutions per minute for 15 minutes; 10 c. c. of the clear, neutral solution is then diluted with an equal volume of normal saline and filtered through an old porous filter kept especially for this purpose. Use the sterile filtrate immediately, or bottle and store in the refrigerator at 3° to 5° C.

For bacteriophage preparation media containing blood serum should never be used *(7)*, except upon initial isolation; then, the bacteria must be transferred to a serum-free medium before used for phage preparation. This is necessary because of the power possessed by the serum to inhibit the progress of phage lysis, probably due to the active immunity produced on the organism rather than its inhibitive effect on the phage *(8)*. In this laboratory we use the Haner & Frost's Milk Agar *(9)*, which is prepared by sterilizing 1.5 percent dehydrated Difco nutrient agar and adding an equal part of sterile separated milk.

For the most efficient therapeutic results "Savita" *(6)* broth is used. This has been confirmed by Bronfenbrenner *(9)*, Zaytzeff-Jern and Meleny *(10)*, and Goldsmith *(11)*. Further, it has been pointed out that although "Asparagin" *(12)* preparations are most ideal for intravenous and intramuscular applications, they are not sufficiently nutritive for the development of either bacteria or bacteriophage *(10)*. It is reported *(1)*, however, that MacNeal of the New York Post-graduate Hospital, using "Asparagin" phage intravenously, has obtained favorable results in treating cases of *bacteremia,* even in those that were showing two positive blood cultures.

Zaytzeff-Jern and Meleny *(10)* have shown further that *Staphylococcic* phages develop more readily in beef infusion broth than in the "Savita" medium; but the severe local reaction resulting from its use, and the absence of such a reaction with "Savita", indicate that the latter is preferable for clinical purposes. It is reported *(13)* (March 1936) that the media generally used in the New York Post-graduate Hospital Laboratories is plain nutrient beef; however, the majority of investigators find "Savita" preparations most desirable. We use 10 grams "Savita" extract to 3.5 grams NaCl per liter. This preparation is double filtered and autoclaved (18 lbs. for 15 min.).

The final pH of media for *Staphylococcic* bacteriophage preparations used by most investigators is relatively the same, ranging from (pH) 7.4 to (pH) 7.8. Several attempts were made *(14)* (February 1935) to detect any change in the pH of media containing phage, but these investigations failed to disclose any perceptible change.

The temperature of incubation used by d'Herelle *(15)* for preparation of phages is 33° C.; this temperature is the same as that used by Zaytzeff-Jern and Meleny *(10)* for *Staphylococcic* phages. Both Scalera *(13)* and Goldsmith *(16)* have a variable temperature scale, ranging from 32° to 37° and 38° C. respectively. Larkum of Lansing and Asherhov of India used as low as 22° C. Gratia at Liege used 37° C.; this is the same as that generally used in our laboratory, except for infections of the skin, in which cases we use 35° C. We have observed that bacteriophages may be prepared most profitably by using the temperature in which the organism lives. To prepare a phage at a low temperature for therapeutic results and apply it to a much warmer medium is, in our opinion, not advisable.

The humidity of the incubator should be as high as possible, ranging around 50 to 60 percent. A sponge may be placed in an evaporating dish filled with a one percent alcohol solution, which was found to decrease danger of phage dispersion in the atmosphere of the incubator.

The apparatus used in our laboratory for filtering phage suspensions consists of the following: A Chamberland (L-5) filter with collar, into which is inserted a small (65 m. m.) funnel containing a double layer of dense filter-paper, is necked with a ring of cotton and inserted into a large (3 x 18 c. m.) test tube. This tube is wrapped in gauze and set vertically into a standard "urine bottle". The vertical apparatus, standing 26 c. m. high, is topped with a 250 c. c. beaker, which keeps the funnel from becoming contaminated while in use. The whole apparatus may be sterilized in the autoclave (18 lbs. for 25 min.) and will yield around 2 c. c. of filtrate per hour. While in use, exposure to natural or artificial light should be avoided. The apparatus may be used conveniently in the incubator, refrigerator or at room temperature. It must be cleaned and autoclaved immediately after use.

The filtrate is removed from the tube by the use of a 10 c. c. hypodermic syringe with attached 4-inch needle, which is injected directly into 10 c. c. bottles and stored in the refrigerator at 3° to 5° C.

For the actual preparation of bacteriophages, we have found the following data recorded by Zatyzeff-Jern and Meleny *(10)* to check with our own observations, namely, that best results are obtained when using 150 to 250 million organisms per c. c. to 0.1 or 0.01 c. c. of phage in 10 c. c. of broth. We use around 125 million organisms in each of four tubes containing 5 c. c. of warmed "Savita" *(17)* and add phage in the following amounts:

Tube No. 1, 0.25 c. c. (or 0.10 c. c. of urine solution);
Tube No. 2, 0.025 c. c. (or 0.25 c. c. of urine solution);
Tube No. 3, 0.005 c. c. (or 0.01 c. c. of urine solution);
Tube No. 4, containing no phage and used for a check.

These tubes are agitated at regular hour intervals during incubation at the desired temperature.

When the first tube has cleared, which will probably be within eight hours, all three of the phage tubes are filtered together. If a larger amount or higher titration is desired, repeat the procedure using proportional amounts of material.

If there is no noticed clearance of the tubes, it is advisable to spray on agar slants to observe whether there is any phage activity present at all. An immediate microscopic examination is sufficient to the experienced observer. If there is found to be no phage activity present, rather than attempt to grow a new strain, secure another strain of seed-phage.

Care must always be taken in handling organisms to keep them free from phage contamination. This is almost impossible in a laboratory where phages are prepared every day, but if inoculations are made in another room and tubes are capped at all times with rubber or sealed with paraffin, there should be no trouble at all.

There are two instances in our experience where it was not possible after two months of constant labor to isolate a bacteriophage for the specific organism. In both cases the organism was a virulent strain of *Staphylococcus epidermidis (18)*, measuring 0.8 to 0.9 microns, hemolytic, and isolated from chronic cases of *acne vulgarus*.

THEORIES

The exact nature of bacteriophage is not known. D'Herelle *(15)*, who has named the phenomenon, holds the opinion that the bacteriophage is a living submicroscopic virus; that it is an autonomous, organized parasite, which can be readily detected on the bacterial wall by the granular appearance of the ectoplasm with the use of an ultramicroscope. In a summary of the characteristics of this lytic principle, Topley and Wilson state that "The bacteriophage appears to be a particulate body. So-called races of bacteriophage have been estimated to have diameters of the order of from 10 to 50 millimicrons" *(19)*. Others estimate them to approach approximately 20 millimicrons in diameter, having a calculated mass of 4/3 (pi) 10-18 gram. Gates *(20)*, investigating the irradiating effects of monochromatic ultraviolet light on *Staphylococcus aureus* bacteriophage at Harvard in 1933, measured the "incident energies required to kill *Staphylococcus aureus (21)* or to inactivate its homologous bacteriophage." He found their measurements "at various wave-lengths of the quartz mercury vapor arc" to run between 238 and 302 millimicrons and that their curves run strictly parallel with each other, the readings for *Staphylococcus aureus* bacteriophage being obtained at a uniformly higher energy level. The similarity of these curves, he states, leads obviously to the conclusion that the bacteriophage particle is a submicroscopic organism. Clifton *(22)* of Stanford in November 1935 observed that during the period of logarithmic bacterial growth of *Escherichia coli*, the rate of phage growth is also logarithmic but proceeds much more rapidly. Under carefully controlled conditions, he has found the ratio between the two to be around 1600 phage units per bacterium.

Some investigations indicate that the active agent is composed of free molecules of some inanimate material and that these supposedly particulate autonomous units are indivisible. They exhibit no gradual diminution of activity upon serial dilution, such as that found in antiseptics, and become totally ineffective at a certain point of dilution, estimated to be around 10-10 per c. c. *(23)*. Further evidence that phage is not a living organism is found in the total absence of carbon dioxide as the result of respiratory metabolism. By using a specially constructed micro-respirometer, Bronfenbrenner was unable to detect CO_2 production in 10-12 active units of bacteriophage during a period of 96 hours *(24)*. These observations are similar to those of Fejgin *(25)*, Gozony and Suranyi *(26)*, Kauffmann *(27)*, and Schwarzmann *(28)*.

The fact that the active agent is not a crystalloid is evidenced by the action of dried, highly purified phages, which cannot be brought to a state of initial dispersion in water *(29)*. Its colloidal nature is evidenced by the manner in which it acts as an antigen, causing the production of specific antibodies *(30)*. These highly dispersed colloidal micellae are supposed to be adsorbed on the cell ectoplasm so thoroughly that infinite washings with water will not remove them; however, they may be washed off easily by using broth, with agitation and centrifugal force *(31) (32)*. Again, this colloidal dispersion, according to Bronfenbrenner *(9)*, may be simply the medium carrying the active principle.

It is generally accepted on the basis of experimental evidence that the actual lysis of bacteria by bacteriophage is a secondary phenomenon; this is due to an increase of cellular metabolism, which results in increased osmotic pressure within the cell wall. This causes swelling and finally disruption of the cell *(33)*. Sometimes the bacteria are killed, or growth is stopped; or a rapid multiplication takes place, which generally yields inactive organisms.

Gates has observed an almost identical reaction by exposing individual bacteria to from 2377 to 3022 angstrom units of monochromatic ultraviolet light *(34)*. The similarity of the reactions merits further investigation.

SUMMARY AND CONCLUSIONS

1. After trying several methods for the preparation of bacteriophage we have found that the above method has the following advantages:

(a) Since brevity of time in the production is most important, this method is very desirable because it reduces the time 50 percent (from 96 to 48 h'rs), even though we do not employ suction in filtering. Large numbers of protein particles are found to be present in filtrates where suction is employed; this reduces the strength of the phage by the hydrolysis of protein into amino acids; also, phage adheres to the inert particles making impossible any dependable method of titration for virulence.

(b) The virulence of the bacteria itself is retained, or perhaps is even greater than that found *in vivo*, due to the use of specific media, temperatures, and a relatively high humidity.

(c) The apparatus is not costly; it is easily washed, assembled, and autoclaved; it is applicable to any type of environmental conditions.

(d) Keeping tubes capped with rubber at all times reduces the danger of phage contamination in stock and check solutions; this we found to be an important measure when preparing several autogenous phages at the same time.

2. The exact nature of the bacteriophage is not yet determined. It may be a solution in which are suspended living organisms; again, it may be a colloidal matter of an inanimate nature.

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2. Mod. Drug. Encl., Paul B. Hoeber, pub., New York: p. 781 (1934).
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5. Levine, M. and Schoenlein, H. W.: A Compilation of Culture Media, Baltimore: The Williams & Wilkins Company (1930). No. 1846 Haner and Frost's Milk Agar,

   Constituents:
   1. 1.0% nutrient agar (Dehydrated Difco) 1000.0 c. c.
   2. Milk, sterile 1000.0 c. c.

   Preparation:
   (1) Prepare 1.0% agar from dehydrated Difco product.
   (2) Add an equal part of sterile milk to sterile (1).

   Reference: Haner & Frost (1921 p. 270).

6. SAVITA BROTH FORMULA (Norman R. Goldsmith, M. D.):
10 gms. Savita to a liter. 5 gms. of NaCl.
1000 c. c. sterile water. Boil and get in solution.
Adjust pH. to 8.2 with .1 N NaOH; boil 15-18 lbs.
25 min. Filter thru double filter paper. Check pH. to 7.4-7.6. Tube and bottle 10-12 lbs. 15 min. Incubate for sterility. Add 1% agar for plates.

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11. Goldsmith, Norman R.: Personal correspondence, Apr. 11, 1935.

12. Asparagin formula used by Morton, G. and Wasseen, M.: N. Y. Post-graduate Med. School & Hosp.: J. of Lab. & Cl. Med. vol. 20, no. 11, (August 1935), pp. 1188-1192:

Asparagin	3	g'ms
Magnesium Sulphate	2	g'ms
NaCl	4½	g'ms
Bipotassium hydrogen phos.	2	g'ms
HOH	1	liter

(Prepared in same manner as "Savita").

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14. Personal investigations in February 1935 at West Virginia Wesleyan College, Department Biology.

15. D'Herelle, F.: The Bacteriophage & Its Clinical Appplication, trans. by G. H. Smith 1930.

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17. Same "Savita" formula as Note No. 6, with exception to instead of using 5 g'ms NaCl, we use 3.5 g'ms.

18. *Staphylococcus epidermidis* Bergey et al (Staphylococcus epidermidis albus Welch, Am. J. of Med. Sci., Phila., 1891, 439).

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PREVENTING THE SPREAD OF CROP PESTS

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THE SAVING OF A SPECIES OF PLANTS from almost complete extermination should be of interest to biologists. The limiting of the distribution of a species of fungi or of insects should arouse the curiosity of those interested in forms of life. The assisting of a species of plants to perform its proper functions should likewise be worth relating at a gathering of this sort. It is for these reasons, primarily, that I am presenting this paper.

Of course the practical side of the prevention of the spread of insects and diseases is of first importance, and I am sure is of interest to every one here; even though the biological phases of a problem are being stressed at these meetings.

An incident occurring in the early days of my work with the Department has had a profound influence on my reactions to the problems of the work. A market gardener located near one of the larger cities in the southern coal field stated, in response to an inquiry as to whether he was controlling the bean bettle: "No, I don't grow beans any more; the beetles ate them up, and I quit trying to raise them." Failing to get the proper response to open a general discussion of garden pests, I then asked: "Do you have any trouble with the cucumber bettles?" To this the gardner answered, "Don't grow any; the beetles ate them up so I quit planting cucumbers." Being persistent I then inquired: "Do you have any trouble with cabbage worms?" "I gave up trying cabbage as the worms devoured all I ever planted," was the response. This was my first experience with this method — the elimination of the host — for the control of a garden pest.

Our state and nation could adopt such a policy for the control of plant diseases and insect enemies that threaten the destruction or the usefulness of a species of plants. The havoc of chestnut blight is an example of the results of such a policy. I do not mean to infer that the chestnut blight could have been checked, for I am aware that the leading forest pathologists feel that our knowledge was too limited in the early days of its ravages to have coped successfully with it; yet it illustrates the results of a policy of "do nothing". Our state is threatened with as complete extermination of our elm and white pine as has happened to our chestnut, unless we continue our present policy of fighting to save these trees. Other forest trees are threatened with serious depredation from gypsy moth, brown tail moth, beech scale, cankers, etc., unless the program of the United States Department of Agriculture is supported and we continue our present inspection activities.

It is apparent that we can be successful with a portion of these suppression and prevention of spread measures. The Mediteranean fruit fly was eliminated from Florida. The pink bollworm has been eradicated from limited areas in the southern states, and gypsy moth has been cleaned up in areas of Ohio and New Jersey. The present quarantine measures against the gypsy moth and the brown-tail moth appear to be preventing spread beyond the barrier zone east of the Hudson River.

Also, it is just as apparent that we will be unable to stop completely the spread of other insects. No one hopes to stop the Japanese beetle, beech scale, alfalfa weevil, etc. Present measures are employed to slow up their rate of spread, and in this we are being successful.

Other pests on which war is now being waged may or may not be stopped. This is the case with the Dutch elm disease, which threatens the destruction of this important shade tree. In this category also falls the Phoney peach disease which could be so destructive to the southern peach industry. Pink bollworm, white snail, date scale, etc. are also in this group.

You may be thinking these problems are mostly without the state and are therefore national problems. This is true, but many of them are also our problems. Those that are without the state we hope will continue to stay without. Our support is needed to obtain federal appropriations for the continuation of the fight.

Another method of preventing the elimination, practically speaking, of a species of plants, or of preventing the successful functioning of a plant involves the destruction of the alternate host plant of the disease. In this group falls the white pine blister rust, apple cedar rust, and black stem rust of wheat. The control of these diseases within a designated area must be done by co-operative efforts. Blister rust of white pine is now present in the state, and a comprehensive program is underway for the elimination of Ribes in the areas where pines are abundant and are immediately threatened with infection. There is a chance that we can keep ahead of this disease, if a small initial state appropriation is made by the next legislature.

Stem rust of wheat has not caused much alarm in this state, yet the loss has been sufficient to justify a program for the elimination of barberry in restricted areas. The present program is eradicating many of these bushes, but if the work cannot continue in future years its value will be lost.

Another type of work can best be classified as the elimination of the pathogen, even though the intent of the measures is to protect the host. I refer to the program for the eradication from the infested area in West Virginia of the organism causing potato wart.

So far I have attempted to create a picture of the general nature of the work of preventing the spread of plant pests. We may get at it in another way — historically. The first legislation was designed to prevent the spread of San Jose scale on infested nursery stock. State after state followed each other in enacting these measures. The next step was to require the spraying of orchards infested with scale. From this the idea grow of similarly treating many other pests. Today there is a set-up in every state in the union.

The famous ten million dollar experiment, conducted in 1927 for the control of the European corn borer, illustrates the operation of this latter phase of these regulations. Little was accomplished in this incident except the opportunity for research afforded; yet Canada, by continuing the clean-up over more than one year, has restored the growing of corn to the Ontario peninsula from which it had been driven by the borer. In this state our activities in controlling apple cedar rust, by eliminating cedars from the vicinity of orchards, is an example of this type of work.

At first the emphasis was placed on securing clean nursery stock. Today the emphasis is placed on community control of a dangerous pest. In the west many states fight the grasshoppers in this manner. Other states are fighting European pine shoot moth, Japanese beetle, corn borer, pink bollworm, Phoney peach disease, Dutch elm disease, etc. Immense good could be accomplished if similar measures were inaugurated for the Mexican bean beetle, cattle grubs, corn earworms, etc. In the future less will be accomplished by nursery inspections and more will be done by community co-operation in the control of plant diseases and insect enemies of plants.

In this week West Virginia is merely a unit. Co-operation with the federal government and with other states must take place. We must support the demands of federal agents for appropriations to carry on their work. We must insist on trained personnel handling the work in our own state and in other states. We must arouse the public to the need for this work and solicit their backing for appropriations and approval of the program.

At the present time the nurseries of the state are being inspected and kept reasonably free from crop pests. This past winter and fall two lots of apple trees were destroyed on account of apple measles or similar diseases; populars were burned in several nurseries on account of cankers; several infestations of scale on lilac and mountain ash was either sprayed or destroyed; two nurseries were required to remove the over-wintering cocoons of the bagworm; and two nurseries were required to spray for pine bark aphids. Holly leaf miner in another nursery is under observation, and several unknown maladies are being carefully watched for development.

Nursery stock brought in from neighboring states are required to show certificates of inspection.

Quarantines in operation are against potato wart, Japanese beetle, and white pine blister rust. We are attempting to prevent the spread of wart and to locate infested soil more definitely by planting susceptible varieties. Scouting operations are being conducted for discovering infestations of the Japanese beetle. Recently quarantines have been placed on Chester, Parkersburg, Clarksburg, and Fairmont; and Keyser has been quarantined for two years on account of this insect. White pine blister rust is being kept out of the Federal Forest Nursery at Parsons and the State Forest Nursery at LeSage by preventing the planting of Ribes within 1,500 feet of the nursery.

Work in the state (WPA, state and federal) this year will employ a dozen or more of full-time and several score of part-time employes. I feel we can justly be proud of this comprehensive program, but the program of the future holds concern. What will happen when the WPA withdraws? Can we expect more support from our own citizens to carry on a small portion of the work now under way? The future program can be no greater than is demanded and supported by the people. Our work cannot be more efficient than the advice received from experts in the many fields of biology.

THE AMPHIBIANS OF TUCKER COUNTY

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THE AMPHIBIANS OF WEST VIRGINIA, especially the salamanders, are interesting because many gaps occur in their life histories, habits, and relationships that need to be filled.

This paper presents a list* of the amphibia that have been collected in Tucker county, West Virginia, during 1935 and the spring of 1936.

Of the 33 species of amphibians that have been identified in this state, 21 of these have been found in Tucker county. The writer believes that with more diligent investigation several of the remaining species will be found. *Eurycea longicauda, Eurycea lucifuga, Plethodon wehrlei,* and *Aneides aeneus* may be found there.

1. *Cryptobranchus alleganiensis* (Daudin)

The "hellbender" is found in Cheat River. No records are available to its presence in Shaver's Fork or Blackfork. Specimens may be found in pools or swimming close to the shore. They are more active at night than in the daytime.

2. *Triturus viridescens viridescens* Rafinesque

This is the most widely distributed and abundant salamander in the county. It has been collected in Haddix Creek, Shaver's Fork, Cheat River and Blackwater.

*The writer is indebted to M. Graham Netting of the Carnegie Museum for helpful criticism in the preparation of this manuscript.

3. *Ambystoma maculatum* (Shaw)

This salamander has been found at St. George, Parsons, and Moore. The characteristic whitish egg masses have been observed in many ponds and sluggish streams throughout the county as early as March 15. One specimen was dug out of a rotten log near the Randolph county line on March 9, 1936.

4. *Hemidactylium scutatum* (Schlegel)

The writer has not collected this salamander in the county, but one specimen (Carnegie Museum 8794) was taken in Canaan Valley on June 27, 1933, by M. Graham Netting. Two specimens were collected on Laurel Mountain near Tucker county on March 28, 1936, by the writer.

5. *Plethodon cinereus* (Green)

The Red-backed Salamander is usually found under logs. It has been collected at Moore and St. George. Both the red striped and lead-backed phase have been collected, and in one instance both phases were found under the same log. The red-striped phase is more abundant.

6. *Plethodon glutinosus* (Green)

This salamander is called the slimy salamander because of the slime that exudes from its skin when captured. Specimens have been taken near Parsons, Davis, and St. George. It has been found under logs, rocks, and the rotten bark of fallen trees.

7. *Gyrinophilus porphyriticus porphyriticus* (Green)

The Purple Salamander has been found in springs and small streams. Both larvae and adults were collected from a spring oozing from a hillside near Porterwood on March 16, 1936. On April 23 of the same year several larvae in various stages of development were taken from Roaring Run on the road to Thomas.

8. *Pseudotriton ruber ruber* (Sonnini)

This species may be found in small streams or close to the water. One specimen was collected on April 23, 1936, under a rotten long along the Parsons-St. George Road.

9. *Eurycea bislineata bislineata* (Green)

One of the most abundant salamanders in the county, it has been taken from Haddix Creek and numerous streams in Canaan Valley. It is found under the water in small streams, or near the water under rocks, or where it is damp.

10. *Desmognathus fuscus fuscus* (Rafinesque)

Next to the common newt this is the most abundant salamander in the streams of Tucker county. It has been taken from several streams, pools, and from under wet rocks.

11. *Desmognathus fuscus ochrophaeus* Cope

Two specimens of this salamander were taken from a wet bank along the Elkins-Parsons road. They were found in the mud. One was a typically marked specimen while the other was somewhat abnormally marked.

12. *Desmognathus phoca* (Matthes)

Three adults and three young of this salamander were taken from Roaring Run on April 23, 1936. Several others were seen but escaped. They were collected in the short space of three yards where a cold mountain stream falls rather abruptly over many small stones.

13. *Bufo americanus americanus* Holbrook

This toad may be collected anywhere throughout the county. On April 15, 1936, many specimens were collected along the road on a collecting trip to St. George. Upon arriving at St. George many more were taken. Several were found in Cheat River. Their call was also heard.

14. *Bufo woodhousii fowleri* Hinckley

This toad does not seem as abundant as the American toad in some sections of Tucker county. One specimen was taken in Canaan Valley in 1935. On April 15, 1936, a toad was seen along the bank of Cheat River that from all appearances was a Fowler's Toad.

15 *Pseudacris brachyphona* (Cope)

This small frog was first heard in Tucker county on April 5, 1936. On the evening of April 9 several specimens were taken from a ditch along the Elkins-Parsons Road. The males were calling. Their call resembled the drawing of a sharp instrument across a coarse comb. The frogs made no effort to conceal themselves but floated with legs outstretched in the water or rested on the bank. The eggs in clusters, averaging 25-30 to a cluster, were attached to leaves and grass lying in the water. More specimens were taken from the ditch on April 10. The writer visited the same locality in the afternoon of the next day. The males were calling as lustily as ever. On April 15 specimens were taken at St. George from a ditch along the road. The eggs were also collected and preserved.

16. *Hyla crucifer* Wied

These are plentiful throughout the county and are among the first to be heard in the spring. They may be found in marshy ground where they usually conceal themselves in the stubble or leaves while calling.

17. *Hyla versicolor versicolor* (Le Conte)

This amphibian has been collected in Canaan Valley and at Parsons. It is not as plentiful as the spring peeper. It breeds later in the spring.

18. *Rana catesbeiana* Shaw

This large frog is found along Cheat River and Blackwater and many smaller streams throughout the county.

19. *Rana clamitans* Latreille

This species is more abundant than the bull frog and may be found along smaller streams and ponds. Specimens have been collected at St. George and Davis.

20. *Rana palustris* Le Conte

One specimen of the pickerel frog has been collected. It was taken at St. George on April 15, 1936. Others have been seen but escaped.

21. *Rana sylvatica* Le Conte

This frog is one of the first to emerge in the spring. On March 11, 1936, one Wood Frog was found near the Randolph county line. Several others were splashing around in a marsh but they escaped. The one captured was a female. On March 18 a mass of eggs was taken from the marsh where the wood frogs had been seen on March 11 which proved to be the eggs of the wood frog.

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THE UREDINALES OF WEST VIRGINIA

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THE *first* PUBLISHED LIST of the rust fungi of West Virginia is found in a "Preliminary Catalogue of The Flora of West Virginia" by C. F. Millspaugh, published as Bulletin 24, West Virginia Agricultural Experiment Station, 1892. According to a note in the introduction, this list is based on specimens sent to Dr. W. A. Kellerman for identification. It contains 17 listed species of Uredinales of the following distribution: Uromyces, 4; Puccinia, 4 (*P. flosculosorum* as listed is really the same as *P. suaveolens* in which event there are only 3 species of Puccinia); Gymnosporangium, 1; Phragmidium, 1; Coleosporium, 2; Aecidium, 1; Roestelia, 1 (this is the common apple rust which was not recognized as belonging to *Gymnosporangium macropus* already listed); Peridermium, 2 (*P. balsameum* on *Abies balsamea* is the aecial stage of *Uredinopsis mirabilis* and *P. peckii* on Tsuga is the aecial stage of *Pucciniastrum* *myrtilli*); Caeoma, 1. The two duplicates listed reduce the actual number of species represented to 15.

The *second* published list is in the "Flora of West Virginia" by C. F. Millspaugh and L. W. Nuttall, issued as Field Columbian Museum Pub. 9, 1896. This list contains 45 names with the following distribution: Uromyces, 9 (one species listed as *U. terebinthi* on *Rhus radicans* has long been recognized as *Pileolaria toxicodendri*); Melampsora, 1; Puccinia, 19 (one species *P. tenuis*, is based on aecial collections only and undoubtedly belongs to *P. eleocharidis*, a heteroecious rust with uredia and telia on Eleocharis, rather than to the autoecious species on Eupatorium to which it was assigned); Gymnosporangium, 3; Phragmidium, 2 (one species *P. potentillae* has long been accepted in the genus Kühneola); Coleosporium, 3 (one species listed as *C. sonchi* is to be assigned in part to *C. vernoniae* and in part, *C. solidaginis;* a second species listed as *C. senecionis* is the aecial stage of *C. solidaginis*); Aecidium, 2; Peridermium, 2 (same disposition as in first list); Uredo, 2 (one of these *U. agrimoniae* is to be referred to Pucciniastrum and the other *U. caeoma-nitens* to the well-known *Caeoma (Kunkelia) nitens*. Total 43 species.

The *third* list is by far the most extensive because it includes the collections of Dr. J. L. Sheldon. It is entitled, "The Living Flora of West Virginia" by C. F. Millspaugh, published as West Virginia Geological Survey 5 (A), 1913. The nomenclature is in part that set up by Arthur in the North American Flora, Nigredo being recognized as well as certain minor genera. Disregarding this nomenclature for the sake of comparison, we find this 1913 list contains 110 names distributed as follows: Uromyces, 22 (there were 3 duplications appearing under other names in the list); Melampsora, 1; Puccinia, 49 (there appear to be four duplications in that *P. caricis* and *P. albiperidia* are each synonyms of *P. grossulariae*, *P. tenius* as represented in the herbarium is the aecial stage of *P. eleocharidis* and *P. albiperidia* is synonymous with *P. grossulariae*. On the other hand, one species not listed, *P. asperifolii*, is represented in collections on *Secale cereale* listed under *P. rubigo-vera*): Phragmidium, 5 (again *P. potentillae* is listed and should be deleted for it appears again in its proper place under *Kuehneola obtusa*); Kuehneola, 2 (one species is referable to Frommea); Coleosporium, 7 (two of the species listed are undoubtedly synonyms, *C. senecionis* and *C. sonchi*); Aecidium, 4 (two of of these are synonyms, *Ae. impatientis* belonging to *P. impatientis* and *Ae. solidaginis* belong to *P. caricis-asteris: Ae. ludwigiae* is the aecial stage of *P. ludwigiae* and *Ae. ilicinum* is now referable to *Chrysomyxa ilicina*); Peridermium, 2 (*P. balsameum* is the aecial stage of *Uredinopsis mirabilis* and *P. peckii* the aecial stage of *Pucciniastrum myrtilli*): Uredo, 3 (all three of these appear in their proper place elsewhere in the list, *U. agrimoniae* as *Puccinistrum agrimoniae* and *U. bigelowii* as *Melampsora farinosa*, and *U. medusae* as *Melampsora medusae*): Gymnoconia, 1; Ravenelia, 1; Pileolaria, 1; Tranzschelia, 1: Polythelis, 1 (now listed as *Tranzschelia fusca*); Pucciniastrum, 4: Gymnosporangium, 7, of which the collections cited under *G. clavariaeforme* represent three species, *G. globosum*, *G.*

germinale (Thatcher, 1714) and *G. juniperi-verginianae* (Nuttall, 1637) and the collections cited as *G. juniperinum* are *G. juniperi-virginianae*. With the synonyms and duplicates omited, there are 95 species of rusts in this list which we recognize at the present time.

The following table represents the distribution into genera of the three published lists, as well as the present list, and includes the additions since 1913.

1892	1896	1913		1936	
1	2		Aceidium	0	
			Chrysomyxa	2	1 species not previously reported.
2	3	5	Coleosporium	8	3 species not previously reported.
			Cronartium	2	2 species not previously reported.
		1	Frommea	1	Previously reported as Phragmidium.
		1	Gymnoconia	1	
1	3	5	Gymnosporangium	6	1 species not previously reported.
			Hyalopsora	1	1 species not previously reported.
	1	2	Kuehneola	1	
1	1	1	Kunkelia (Caeoma)	1	
	1	2	Melamposra	5	3 species not previously reported.
1	1	4	Phragmidium	5	1 species not previously reported.
	1	1	Pileolaria	1	
3	19	46	Puccinia	60	14 species not previously reported.
1	2	4	Pucciniastrum	4	
		1	Ravenelia	1	
		2	Tranzschelia	2	
1	1	1	Uredinopsis	1	
4	8	19	Uromyces	20	1 species not previously reported.
15	43	95		122	27

The following species are new additions to the check-list of West Virginia. The counties where they were collected appear after each host.

Chrysomyxa weirii Jacks.
III. on Picea rubens Sarg. — Pocahontas and Randolph

Coleosporium delicatulum (A. & K.) Hedg. & Long
II, III on Euthamia graminifolia (L.) Nutt. — Preston

Coleosporium elephantopodis (Schw.) Thuem.
II, III. on Elephantopus carolinianus L. — Boone

Coleosporium inconspicuum (Long) Hedg. & Long
II, III. on Coriopsis tripteris L. — Kanawha

Coronartium quercus (Broad.) Schroet.
O, I. on Pinus rigida Mill. — Randolph
O, I. on Pinus virginiana Mill. — Hardy
II, III on Quercus prinus L. — Monongalia
II, III on Quercus velutina Lam. — Grant, Hardy

Cronartium ribicola Fischer
O, I. on Pinus strobus L. — Pendleton
II, III on Ribes cynosbati L — Pocahontas
II, III on Ribes rotundifolium Michx. — Pendleton, Pocahontas, Randolph, Tucker

Gymnosporangium exterum Arth. & Kern	
O, I on Porteranthus trifoliatus (L) Britton	Pendleton
Hyalopsora polypodii (Pers.) Magn.	
II, III on Cystopteris fragilis f. Bernh.	Grant
Melampsora abietis-canadensis (Farl.) Ludwig	
O, I on Tsuga canadensis (L.) Carr.	Randolph
II, III on Populus grandidentata Michx.	Monongalia
Melampsora euphorbiae-gerardianae W. Mull.	
O, I, II, III on Euphorbia commutata Engelm.	Jefferson
Melampsora farlowii (Arth.) Davis	
O, III on Tsuga canadensis (L.) Carr.	Nicholas, Preston, Tucker
Phragmidium rosae-Pimpinellifoliae Diet.	
On Rosa sp.	Berkeley, Monroe, Upshur
Puccinia angustata Peck.	
II, III on Scirpus cyperinus (L.) Kunth.	Preston, Lewis
Puccinia anomala Rostr.	
II, III on Hordeum vulgare L.	Randolph
Puccinia barbanae Corda.	
O, II, III on Arctium minus Schlecht.	Monongalia
Puccinia caricis-strictae Diet.	
II, III on Carex stricta var. angustata (Boott) Bailey	Calhoun, Randolph
Puccinia extensicola Plowr.	
O, I on Dirca palustris L.	Boone, Pendleton
II, III on Carex asa-grayi Bailey	Upshur
Puccinia McClatchieanum Diet. & Holw.	
II, III on Scirpus sp.	Monongalia
Puccinia microsora Kern.	
II, III on Carex frankii Kunth.	Monongalia
Puccinia minutissima Arth.	
II, III on Carex laxiflora Lam.	Monongalia
Puccinia pammelii (Trel.) Arth.	
II, III on Panicum virgatum L.	Monongalia
Puccinia phrymae (Hals.) Arth.	
II, III on Carex flexuosa Muhl.	Preston
Puccinia tumidipes Peck	
O, II, III on Lycium halimifolium Mill.	Berkeley
Puccinia uniporula Orton	
II, III on Carex flexuosa Muhl.	Preston
II, III on Carex virescens Muhl.	Preston
Puccinia urticata (Link.) Kern	
II, III on Carex gynandra Schwein.	Preston
Puccinia verbesinae Schw.	
O, I, II, III on Verbesina occidentalis (L.) Walt.	Boone, Fayette, Lincoln, Wayne
Uromyces rudbeckiae Arth. & Holw.	
III on Rudbeckia laciniata L.	Hardy

Of the 27 species new to the state list, 19 are heteroecious, 5 are autoecious macrocyclic, and 3 are microcyclic. Of special interest is *Chrysomyxa weirii* previously reported only from Oregon, Idaho, Montana, and British Columbia, but subsequently reported from Tennessee. It is a microcyclic rust producing only telia on the leaves of Picea.

The rarest rust in West Virginia is that which occurs on *Ilex opaca*, which was described as *Aecidium ilicinum* by Ellis and Everhart in

1897. It was collected near Nuttallsburg in Fayette county by Mr. L. W. Nuttall in 1896, and was not collected again until 1932 when the writer found it still recurring at the type locality. Only uredia and telia are found on the holly. A study of its nearest relatives indicates that this rust is heteroecious and probably had its haplontic stage on Picea, but there has been no living spruce within many miles for a considerable number of years. Possibly the rust survives in the uredial stage on this evergreen holly.

Of the known rusts occurring in West Virginia, there are 23 species which may be claimed to be of economic importance. These are:

Coleosporium solidaginis on cultivated aster.
Cronartium ribicola on white pine, currants, and gooseberries
Gymnoconia interstitialis on raspberry
Gymnosporangium germinale on quince and apple fruits
Gymnosporangium juniperi-virginianae on apple leaves
Kunkelia nitens on blackberry and dewberry
Puccinia anomala, the leaf rust of barley
Puccinia asperifolii, the leaf rust of rye
Puccinia asparagi on asparagus
Puccinia clematidis, the leaf rust of wheat
Puccinia cororata, the crown rust of oats
Puccinia epiphylla, the leaf rust of blue grasses (Poa)
Puccinia graminis, the stem rust of wheat
Puccinia grossulariae on gooseberry
Puccinia helianthi on sunflower
Puccinia malvacearum on hollyhock
Puccinia menthae on mints
Puccinia sorghi on corn
Puccimastrum hydrangeae on hydrangia
Uromyces appendiculatus on bean
Uromyces caryophyllinus on carnation
Uromyces medicaginis on alfalfa
Uromyces trifolii on clover

THE CARNEGIE MUSEUM COLLECTION OF WEST VIRGINIA AMPHIBIANS AND REPTILES

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IN VIEW OF THE EXCELLENT WORK which the West Virginia Biological Survey is now doing to increase our knowledge of the West Virginia biota, I feel that the members of the Academy may be interested in a short account of the work on the herpetology of the state which is being carried on at the Carnegie Museum. My own interest in this state dates back a considerable number of years to collecting trips along Buffalo Creek at Bethany in the company of one of the distinguished local residents, Dr. George M. Sutton. For the past six years I have made numerous collecting trips to various parts of the state, and I have been particularly fortunate in having been associated with the Oglebay Nature Training School as a staff member at many of the camps of this organization. The Nature Training students have always been of great assistance to me in collecting on the various occasions when I have been in the field with them. A large number of persons in West Virginia, who cannot be mentioned individually, have generously contributed specimens from various parts of the state. As a result, the Carnegie Museum now houses by far the largest collection of West Virginia amphibians and reptiles in existence. Our collection is more extensive, both as to number of species represented and number of specimens as well, than all of the other museum collections combined. It is our purpose to secure specimens of each species which occurs in the state from every county in which it can be found. A scientific collection of preserved specimens should be thought of as a reference library, in which each specimen serves as reference material by means of which questions about the life history, food habits, structure, or distribution of the animal may be answered. As our collection increases in size, the studies which we base upon it will become increasingly accurate and complete. It is my earnest hope, therefore, that this collection will continue to grow and to expand until it is complete enough to justify the publication of a comprehensive herpetology of West Virginia. I hope also that members of the Academy will feel perfectly free to call upon me for any assistance which I may be able to give in connection with their studies of local herpetology. I shall be pleased to identify specimens for anyone in the state who cares to send material to the Carnegie Museum. In this connection I would like to encourage collectors to send duplicate specimens whenever possible so that one may be added to the museum collection and an identified duplicate returned to the sender. Directions for collecting and preserving specimens, and convenient shipping containers, will be sent to any persons who are interested in collecting these animals.

A number of manuscripts dealing with details of the herpetology of West Virginia are now in press. A complete cross-referenced bibliography of the herpetology of West Virginia has been completed during the past month. This will be published in the near future as an aid to local herpetologists.

A brief comparison of the herpetofauna of Pennsylvania and West Virginia may be of interest:

	No. of kinds in U. S.	*No. found in Pa.*	*No. found in W. Va.*
Salamanders	92	19	21
Frogs and Toads	85	14	12
Turtles	59	13	7
Crocodiles & Alligators	2	0	0
Lizards	120	4	4
Snakes	200	23	20
TOTAL	558	73	64

This comparison indicates that West Virginia has a greater representation of salamanders than Pennsylvania. This is to be expected since West Virginia is much more intimately associated with the southern Appalachian complex, which was probably the evolutionary center of the Plethodontidae, the dominant family of salamanders in eastern North America. On the other hand, turtles which are generally found in warm sluggish streams and lakes are poorly represented in West Virginia because of the dearth of such habitats. In a number of instances, Pennsylvania supports two races of snakes by reason of the separation between the eastern and western sections occasioned by the Allegheny front. West Virginia, on the other hand, generally has only one race of these same forms represented.

(This paper was terminated with a series of lantern slides displaying the majority of West Virginia amphibians and reptiles.)

WEHRLE'S SALAMANDER, *Plethodon wehrlei* FOWLER AND DUNN, IN WEST VIRGINIA

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ALTHOUGH THE PRESENCE of Wehrle's Salamander in West Virginia has been attested to by numerous authors, no recent attempt has been made to present a complete account of the locality records and ecological preferences of the species in this state. I have had available for this study the largest series of *P. wehrlei* yet assembled, but in spite of this fact my material is inadequate for a thorough study of certain puzzling features. I ask your indulgence, therefore, in offering these notes which are admittedly incomplete but which may stimulate local biologists to collect and to study additional specimens of this interesting salamander.

In 1917 Fowler and Dunn (2: pp. 23-24) described a new species of salamander of the genus *Plethodon*, which they named *wehrlei* in honor of Mr. R. W. Wehrle, of Indiana, Pa., who had collected six of the eight Pennsylvania specimens upon which their description was based. *Plethodon wehrlei* is a slim, black salamander which is frequently confused with the Slimy Salamander, *Plethodon glutinosus*. It differs from the latter superficially in color, markings, and body form. Alcoholic specimens of *wehrlei* are brownish or grayish black while similarly preserved specimens of *glutinosus* are bluish black. These color differences are unreliable if specimens have been improperly preserved or kept too long in strong formalin. Specimens of *wehrlei* have uniform white or blotched white throats, whereas *glutinosus* may have light colored but not white throats. Furthermore, the white blotches of *wehrlei* frequently extend backward onto the breast and anterior belly — regions normally uniform gray or blue gray in *glutinosus*. The most reliable character for the beginner to use, however, is the restriction of white spots to the sides of the body in *wehrlei*. The Slimy Salamander has white spots scattered over the entire upper surface of the body. Young specimens of Wehrle's Salamander frequently exhibit tiny, paired red spots on the dorsum which do not occur in the contrasted species. Finally, *wehrlei* has a slender body with an average costal groove count of 17, *glutinosus* a stout, heavy body with 14 to 15 costal grooves. Living specimens of the two forms vary so markedly in actions and appearance that they are readily separated, but preserved specimens are at times puzzling. The nearest relative of *Plethodon wehrlei* is *Plethodon ouachitae* which occurs only in the Ouachita Mountains in Oklahoma and Arkansas. The latter differs from its eastern congener in having brown or reddish brown spots on its back which may fuse into a stripe.

The first published record of *P. wehrlei* in West Virginia is that of Stejneger and Barbour (8: p. 12) who merely mention the state in the general range of the species. Next, Dunn (1: pp. 133-136) discusses the species at length and lists four specimens from Parkersburg, in the collection of the American Museum of Natural History, and six specimens from Bristol, in the Museum of Comparative Zoology collection. Netting (3: p. 105) states that the species occurs in West Virginia in cave entrances. deep rock crevices, and near "ice caves." Netting (4: p. 6) repeats these habitats and mentions that the species occurs in five counties in the state. Stejneger and Barbour (9: p. 12) again include West Virginia in the range of the species. Reese (6: p. 50) lists *wehrlei* as an inhabitant of Arbuckle's Cave, Greenbrier county, and in a second paper (7: p. 572) lists the species as a cave inhabitant without mentioning any definite localities. Finally, Netting (5: MS) contrasts the habitat of the species in Pennsylvania with its habitat in West Virginia, and mentions for the first time the occurrence of the species in montane red spruce forests in the latter state.

There are 28* specimens of *P. wehrlei* from West Virginia in the Carnegie Museum collection. These are listed below. An additional specimen (not listed) which was originally identified as *wehrlei*, but which is now doubtfully referred to this species, is also discussed below.

*On April 15, 1936.

Lewis County
CM 7516 Jane Lew 1934 J. D. Neil.

Marion County
CM 6081 exact locality unknown Oct. 1932 Neil D. Richmond.

Mercer County
CM 7483 exact locality unknown July 3-10, 1933 Neil D. Richmond.

Pocahontas County
CM 5394-95 Droop Mt., near Bear Den June 26, 1931 Netting & Chalmers.
CM 7476-77 near Marlinton (probably Cranberry Glades) July 2, 1933 Neil D. Richmond

Randolph County
CM 10, 155-64 Barton Knob June 25, 1935 Edward C. Raney, alt. 4,400 ft.
CM 10, 280-87 Barton Knob June 29, 1935 Netting & Llewellyn, alt. 4,400 ft.
CM 9848 White Top Mt. June 23-28, 1935 Leonard Llewellyn
CM 10, 306-07 White Top Mt. June 30, 1935 M. Graham Netting, alt. 3,800 ft.

Specimens of *P. wehrlei* from West Virginia differ from Pennsylvania topotypes in the following respects: they have throats which are generally heavily blotched with white instead of being uniformly light in color; the blotched condition of the throat frequently extends backwards onto the breast and anterior belly while Pennsylvania specimens exhibit uniform light brown chests and bellies; the lateral white markings are much more prominent in West Virginia specimens.

The specimen referred to above as a doubtful example of *P. wehrlei*, CM 6196, was collected in Arbuckle's Cave, Greenbrier county, on October 1, 1932, by A. M. Reese. On this same date, Dr. Reese secured two additional specimens. When I originally examined these specimens, I had only a small series of *wehrlei* for comparison, and I considered Dr. Reese's specimens to be atypical examples. During recent years great progress has been made in the study of the genus *Plethodon* and while much of the newer work is as yet uncompleted, it appears that my earlier identification is now open to doubt. The specimen at hand agrees in markings with *wehrlei*, but it agrees far more closely with *glutinosus* in body form. There is a bare possibility that these specimens, the only ones which have so far been taken in a true cave habitat, may have been affected by that habitat; but I am inclined to believe that they represent an undescribed *Plethodon* of the *glutinosus* group. Several studies of this group are now in progress and, until the present confusion has been eliminated, I feel that it is highly inadvisable to describe another species on the basis of a single or even a small series of specimens. I think it is worth while, however, to mention this matter in the hope that persons who are located near caves in West Virginia will make a strenuous attempt to secure additional specimens of *Plethodon* from the caves in their vicinities.

The specimens collected on Barton Knob by Mr. Raney, and the students of the Oglebay Nature Training school who accompanied him, were the first specimens taken in what I now believe to be the preferred habitat of this species. Only a few feet below the crest of Barton Knob there is a considerable belt of red spruce. The forest floor is here littered with hundreds of decayed logs, and the area is both moist and cool. Here *wehrlei* has been taken in greater numbers than at any other locality known to me. Several days after Mr. Raney collected at the locality, I visited the same spot in company with other students of the Nature Training School. I was assisted, however, chiefly by Mr. Leonard Llewellyn. We collected for about one hour in the morning, securing 8 specimens of *Plethodon wehrlei*, 29 *Plethodon cinereus*, 1 *Plethodon* sp?, 5 *Desmognathus fuscus ochrophaeus*, 1 immature *Bufo americanus americanus*, and 1 *Rana sylvatica*. The specimens of *wehrlei* were found chiefly in decaying logs and under the bark of such logs. There are many endemic species of *Plethodon* in the southern Appalachians which have very restricted ranges, but within these confines they are extraordinarily abundant. Field experience with these southern endemics has led me to expect such forms to me more common in their preferred habitats than the associated species of the genus which have more extensive ranges. In the case of the Barton Knob locality, however, *Plethodon cinereus* is far more common than *wehrlei*. In spite of this fact I feel convinced that the areas in West Virginia which still support spruce forests are those in which the species will be found to be most abundant. It must be mentioned in this connection that no one has yet collected on Barton Knob at night; practically all species of the genus can be secured with much greater facility and in far larger numbers after dark.

CM 9848 was secured on White Top Mountain where spruce also occurs, but unfortunately this specimen was not recognized as *wehrlei* by the collector and no exact notes were made of the location at which it was found. On the night of June 30, 1935, I managed to secure two specimens at an altitude of about 3,800 ft on White Top. One of these was found on a rock wall about three feet above the ground in a narrow crevice. The other specimen was found on top of moist leaves at the bottom of the same crevice. The spot where these two specimens were taken is not spruce covered, but scattered trees are present and heavier stands are not far distant. The only additional specimens upon which I have exact habitat notes are the two collected on Droop Mountain, near Bear Den. These were taken in the afternoon in a very deep crevice, the rock walls of which were separated by not more than three feet. The leaves at the bottom of this crevice were extremely moist and cool. Very little light penetrated to the bottom of the crevice so that the condition was similar to twilight. One specimen was taken walking on the damp leaves and one was found beneath them.

SUMMARY

Plethodon wehrlei has been collected at nine localities in West Virginia, and a tenth locality is represented by aberrant specimens. All of the localities for the species within the state, and the extra-limital localities known to me, fall within the limits of the Kanawha section of the Appalachian Plateaus Province. Within this physiographic area the

species appears to inhabit a preferred habitat of montane spruce forest, or situations which provide similar conditions of moisture and coolness, such as narrow rock crevices. It may also occur in smaller numbers as a relict form in less favorable habitats.

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The Chemistry Section

A New Method for Determining Solubilities

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A preliminary announcement of this work was made in the Chemical Section of the Bethany meeting of the Academy.

The author started this undertaking about two years ago, and secured five pieces of special glass solubility apparatus made by Mr. William Levitt, who was then connected with the Corning Glass Works of Corning, New York.

The above-mentioned glass apparatus, after being filled with the required solute and solvent, were clamped in a metal shaking device that was lowered into the water of a large thermostat, and the temperature maintained at 25° Centigrade.

When the solutions in the five solubility flasks had become saturated, the shaking was stopped and the apparatus tilted, while still under water, so that the major part of the solutions in each flask was ransferred to the corresponding empty but weighed flask. This transfer was made through a suitably placed filter paper in order to retain suspended particles of the solute.

After the saturated solutions had been transferred to the weighed flasks the shaking device was again placed upright and each pair of flasks lifted out of the thermostat bath, wiped dry, and disconnected. The weighed flasks were stoppered with perfect fitting stoppers and weighed.

The difference between the latter weights and those of the empty flasks and stoppers gave the weights of the solutions. To determine the weight of solute in each weighed solution entailed more or less difficulty. Some substances were found to be volatile at the temperature of the steam bath, and others decomposed slightly, so that the exact weight of the solute could not be obtained by evaporating the solvent in this manner.

Among the seventeen solubility determinations that have so far been completed, five different methods of finding the weights of the solutes in given weights of solutions were employed:

1. By evaporation of the solvent on the steam bath and weighing the residue, the solubility of the following substances was determined:

   (a) Sodium chloride, (b) potassium chloride, (c) Para Amino acetanilide, (d) Para Phenylenediamine fluosilicate, (e) Di aniline fluosilicate, (f) Arbutin, (g) Eosin.

2. By precipitating and weighing an insoluble and non volatile derivative of the solute, and from these weights calculate the solubility, (a) ammonium oxalate, (b) diphenylamine.

3. By titrating the organic acid or fluosilicic acid addition complex with standard alkali using suitable indicators, (a) furoic acid. (b) aspirin, (c) di-para toluidine fluosilicate, (d) diphenylamine fluosilicate, (e) diphenylhydrazine fluosilicate.
4. By removal of the solute from the solution by extracting with ether and evaporating the latter at room temperature. (a) Ethyl acetanilide, (b) naphthalene.
5. By reduction of the nitro group to amino by means of titanous chloride in excess, and the excess titrated with methylene blue, (a) 2, 4, dinitrophenol.

The above mentioned solubilities were all determined in 100 cc water solution at 25°C. and may be summarized as follows:

1. (a) 33.35g, (b) 35.96g, (c) 1.234, 1.230, 1.250, (d) 1.065g, 1.060g, (e) 14.705, 14.713, 14.667, (f) 12.32, 12.97, (g) 12.68. 12.22, 12.37, 12.51.
2. (a) 7 06, 7.04, 7.06. (b) 0.01702, 0.01700, 0.01705.
3. (a) 4.95, 4. 93, 4.95, (b) 0.905, 0.903, (c) 4.172, 4.179, 4.170 (d) 0.819, 0.828. 0 818, (e) 1.334, 1.337, 1.320.
4. (a) 3.46, 3.53, 3.33. (b) 0.038, 0.033
5. (a) 0.0519, 0.0517.

An improved shaking device is being constructed for the continuation of this work The author was assisted in the preliminary work by student assistants, but the above record was obtained by Mr. Holden McClung, who has signified a willingness to continue the work for eventual publication in some chemical journal.

The method is unique, rapid, and more accurate than the ordinary methods now in use.

GROWTH SUBSTANCES FOR FUNGI*

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SACHS *(20)* more than 40 years ago considered the flowering of plants to be due to the accumulation of a "flower-substance" in the plant. Sachs supported this thesis by the following observations. A cutting taken from a *Begonia* plant in bloom produced flowers much sooner than a cutting taken from a non-blooming plant. The early flowering of the first cutting was due to the relatively high initial concentration of "flower-substance". The idea that plant responses are controlled by chemical regulators has made rapid advance in the past decade.

What are these chemical regulators? Here, as elsewhere in science, the question of nomenclature arises. Shall they be called phytohormones? The name hormone implies that these regulators are the product of ductless glands, which are lacking in plants. Various names are used

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in the literature, such as bios, pantothenic acid, auxins, and auximones. All of these are "factors" that cause increased growth in particular instances. Perhaps the best solution is to use the non-committal term "growth substance".

What do "growth substances" imply? These are recently discovered factors affecting the nutrition and growth of plants. The older knowledge of plant nutrition embraced a knowledge of the gross requirements of plants such as water, carbon dioxide, nitrogen, phosphorus, potassium, and the other elements that are found in plant ashes. Should the more recent discovery that minimal quantities of other elements are necessary for plant nutrition lead us to call these elements "growth substances"? A few criteria are suggested: (a) a growth substance is an organic compound of definite structure (which may be known or not); (b) a growth substance causes a definite plant response; e.g., epinasty, cell elongation, or rooting; (c) the observed response should be many times greater than that due to the intrinsic energy content of the amount of growth substance used. This is perhaps the only justification for grouping this series of compounds under the rubric of growth substances. A crude analogy is that of a detonator and a charge of powder. In any complicated system such as a plant, any factor that is *necessary* (even if required in minute amounts) is just as important as that which is required in large amounts.

Are growth substances specific? In some instances apparently so, and in others relatively so. It is probable that there is no pan-growth-substance. For example, inositol greatly increases the growth of Miller's strain of yeast but is without effect on Williams' yeast. Leonian and Lilly *(13)* have found that in general Oomycetes respond to pea extract, while this material is largely without effect on Zygomycetes. In this case the response is not as specific as the effect of inositol on yeast. Neither is the pea extract composed of a single chemical compound.

The literature upon growth substances for yeast is voluminous. Such substances are collectively called Bios *(2)*. The literature up to 1924 is well summarized by F. W. Tanner *(24)*. Lash W. Miller's *(16)* historical paper is of great interest. Edna V. Eastcott *(3)* working in Miller's laboratory at Toronto isolated the first chemically pure growth substance (Bios) so far as I know. This Bios was found to be inactive inositol. When this material was tried on different strains of yeast in other laboratories the results were frequently disappointing. To Williams *(25, 26)* must go the credit for resolving this question. Williams and his co-workers found that various strains of yeast require different growth substances (Bioses). Also see Miller *(17)*.

Williams has found that asparagine and aspartic acid have high growth-promoting power for certain yeasts. Very recently Williams *(27)* has found that synthetic beta alanine in concentrations of 1 part in 12 million is a growth factor for yeast, especially when used in conjunction with aspartic acid.

From the use of aspartic acid or asparagine in his medium Williams *(27, 29)* was led to discover "pantothenic acid", a substance that has marked growth-promoting properties for yeast. The name suggests its wide distribution. Williams has extracted crude preparations of this acid from the following substances: (a) rice polish (Spermatophyte); (b) *Aspergillus niger* (Fungi); (c) *Spirogyra* and *Oscillatoria* (Algae); (d) *Bacillus subtilis* (Schizophyte); (e) Planarian worms (Platyhelminthes); (f) earthworms (Annulata); (g) oysters (Mollusca); (h) sea urchin eggs (Echinodermata); (i) crab's eggs (Arthropoda); (j) beef liver (Chordata); (k) milk (Chordata).

The highly-purified extract (electro-dialysis) does not contain any olefin double bonds, aldehyde or ketone group, aromatic nucleus, sugar group, sulfhydril group, amino, or other basic nitrogenous group. The molecule contains one hydroxyl group and probably forms a lactone. Molecular weight, 150. Pantothenic acid is readily esterified by methanol in the presence of 0.1*N* sulfuric acid. Autoclaving in basic medium (pH 9) at 119° C. for four hours inactivates the acid.

R. R. Williams *(30)* has recently announced the structure of vitamin B_1. Chemically, vitamin B_1 contains two heterocyclic rings, a pyrimidine and thiazole ring. Both are substituted, the pyrimidine ring is 4-ethyl-6-aminopyrimidine, the thiazole is 3-chloro-4-methyl-5-ethanol. These rings are linked through the five position of the pyrimidine and the three position of the thiazole. It will be remembered that Funk postulated an amino compound when he coined the term vitamin(e).

Williams *(27)* has found vitamin B_1 to be a growth substance for certain strains of yeast.

W. H. Schopfer *(21)* has found that vitamin B_1 is necessary for the growth of *Absidia ramosa, Parasitella simplex, Mucor ramannianus, Dicranophora fulva, Chaetocladium brefeldii, Choanephora cucurbitarum, Choanephora persicaria, Pilaira anomala.* Various Phycomycetes respond to 0.01-0.02 gamma in 25 ml. of medium. On the other hand, Schopfer *(22)* found the growth of many species of *Rhizopus* to be inhibited by vitamin B_1.

N. Nielsen *(18)* has shown that *Rhizopus suinus* when cultivated under certain conditions excretes a substance(s) which causes the curvature of *Avena* coleoptile (auxin) and promotes the growth of *Aspergillus niger.* To this substance(s) Nielsen gives the name Rhizopin. In later work Nielsen and Hartelius *(19)* found that two growth substances were present in medium in which *Rhizopus suinus grow.* (a) Growth Substance A is soluble in ether and is easily destroyed by oxidation (hydrogen peroxide). Substance A affects the growth of *Avena* coleoptiles. (b) Growth Substance B is insoluble in ether, soluble in alcohol, and is not destroyed by oxidation (hydrogen peroxide). Substance B affects the growth of *Aspergillus niger.*

Leonian *(14)* found that corn roots contain a growth substance for *Phytophthora cactorum.* Green garden peas also contain a growth-promoting substance for this fungus. Leonian *(15)* found that pea extract greatly increases the growth of *Chlorella viscosa, Coccomyxa simplex, Oocystis naegelli,* and *Scenedesmus flavescens.* Also these four algae excrete growth and sexuality-promoting factors for *Phytophthora cactorum* when grown upon a synthetic medium.

Von Euler and Philipson *(4)* report that *Avena* coleoptiles contain a growth factor for *Rhizopus tritici, Rhizopus nigricans, Aspergillus wentii,* and a species of *Penicillium* as well as for *Saccharomyces cerevisiae.* Almoschlechner *(1)* classifies the growth substance found in *Boletus edulis* with the growth substance B of Nielsen.

That fungi may excrete growth substances for higher plants was shown by the work of Shimada *(23)* and Ito and Shimada *(9)*. This growth substance is soluble in alcohol, adsorbed on animal charcoal, thermostable, and is diffusible through a semipermeable membrane. The test plants used were: rice, wheat, barley, corn, azuki bean, and soybean. The controls were cultured in Knop's medium, the test plants in Knop's medium with the addition of an alcoholic extract from "Bakanae" fungus. It is noteworthy that the growth promoting substances in this case resulted in normal plants,[1] in distinction to results obtained by Hitchcock and Zimmerman*(5)* by the use of beta indolyl acetic acid. Hetero-auxin was first isolated by Kögl *(10, 11)* from urine and later from yeast. Investigation showed this substance to be an auxin (i e , it induced curvature of *Avena* coleoptile).

Fungi along with bacteria are the scavengers of the plant world. As fungi have no chlorophyll they are dependent upon pre-formed organic food Nor is it astonishing that fungi require a variety of organic compounds for growth. Glucose is the common source of energy furnished in culture media. Glucose and inorganic salts suffice for many types of fungi, especially saprophytes. The basis of the present work was the observation of Leonian that highly-purified sugars were not as effective in promoting growth of *Phytophthora cactorum* as cruder sugars. When pure glucose is used in a synthetic medium no growth results.

Since garden peas caused good growth of *Phytophthora cactorum* this material was chosen for further work. The first work was done on canned peas. To test the stability of the growth factor a sample of pea infusion was heated on a steam bath in an open beaker. The growth-promoting activity gradually decreased until after 184 hours of heating *Phytophthora cactorum* showed only a slight growth response to this material.

The effect of protein precipitants was tried on pea infusion. Half saturated and saturated ammonium sulfate, and saturated sodium chloride did not remove the growth factor. Trichloroacetic acid caused a diminution of the growth response. It was found later that any acid had the same effect. Ethanol (95%) did not precipitate the growth factor On treating the alcoholic solution with Norit, a diminution of growth response was observed.

A can of peas was passed through a colander and extracted with hot water. The extract was made alkaline with sodium hydroxide and extracted with ether. Most of the active principal remained in aqueous layer. The same was true when ammonia was used as the alkali. When

[1] This early normal growth in field tests is followed by severe injury. Apparently the more mature plants respond differently, or an excess of "growth substance" is toxic.

the hot water extract was acidified with acetic acid and extracted with ether, the ether extract showed only slight growth-promoting properties as in the two experiments above. The aqueous layer was inactive.

Dried canned peas (100° C.) were extracted with ether. Only a small amount, if any, of the growth substance was removed by this procedure. Following the ether extractions the pea residue was extracted with alcohol, which removed much growth substance.

Further experiments with Norit showed that all of the growth substance could be removed from an aqueous infusion of canned peas by boiling repeatedly with this charcoal. When the Norit was extracted with water acidified with hydrochloric acid, a slight amount of growth factor was removed. This experiment makes it probable that acid *per se* does not inactivate the growth substance but produces deleterious substances from the accompanying material. Extraction of the Norit with dilute ammonium hydroxide was no more successful than with dilute hydrochloric acid.

In one experiment 30 grams of dried canned peas was extracted 168 hours with ether in a Soxhlet. A total of 489 mg. of material was extracted. The growth factor remained in the peas as was shown by continuing the extraction with 95% ethanol for 96 hours. The various alcoholic extracts gave good growth response with *Phytophthora cactorum.*

Dried split peas were selected as a source material for further work because of convenience and lower cost. To show the effect of various solvents on dried peas, the following experiments are reported:

Table 1

No.	Solvent	Growth of Phytophthora cactorum
165	Benzene	Good
169	Carbon tetrachloride	Very good
168	Acetone	Good
172	Iso-propyl ether	None
120	Ethanol	Good
84	Ether	None
254	Ligroin	None
163	Methyl cellosolve	None

To determine if the growth substance for *Phytophthora cactorum* was widespread, various seeds were ground and extracted with alcohol for 24 hours in a Soxhlet, and the extract tested.

Table 2

No.	Substance	Growth of Phytophthora cactorum
C-1	Whole corn plant (a)	Poor
L-2	Navy beans	Slight
L-3	Lima beans	Poor
L-4	Kidney beans	Good
L-5	Lentils	Good
C-2	White corn (grain)	Fair
R-1	Rye (grain)	Good
L-22	Alfalfa (seed)	Poor
L-23	Cow peas	Good
L-24	Sweet Clover	Poor
L-25	Red Clover	Poor
L-26	Soy beans	Very good
W-1	Wheat (grain)	Very good
O-1	Oatmeal	Fair
L-3	Lima beans	Poor

(a) Many thanks are due Dr. R. B. Dustman for this sample.

Since Kögl *(12)* found that sprouting of barley increased the auxin content, some experiments were made with sprouted peas. The sprouted peas were divided into 3 parts: seed, roots, and shoots. This material was then dried and extracted 24 hours with 95% ethanol in a Soxhlet. The extract from the sprouted pea seeds was quite active. Fuller's earth removed considerable of the growth substance from aqueous solution.

Unfortunately no way has been found to liberate the growth substance from the fuller's earth.

Table 3

No.	Plant part	Treatment	Growth
237	Seed	Extracted 24 hours with alcohol	Very good
252	Seed	Alcohol extract from 237 treated with fuller's earth	Slight
242	Shoots	Extracted 24 hours with alcohol	Fair
247	Shoots	Alcohol extract from 242 treated with fuller's earth	Poor
241	Roots	Extracted 24 hours with alcohol	Fair
248	Roots	Alcoholic extract from 241 treated with fuller's earth	Slight
245	Shoots	Residue from 242 extracted with hot H_2O	Good
246	Roots	Residue from 241 extracted with hot H_2O	Good

The method used in testing the activity of the various preparations was by dilution. The material to be tested is added to a medium having the following composition:

Medium A

Potassium dihydrogen phosphate	0.50 grams
Magnesium sulfate heptahydrate	0.25 "
Potassium nitrate	1.00 "
Glucose (Bacto)	5.00 "
Water to make	1000 ml.

The following table shows some of the results obtained by this method.

Table 4

P.p.m.	Growth of Phytophthora cactorum		
	411 (a)	567 (b)	544 (c)
5,000	Excellent	Very good	Fair
3,000	Excellent	Very good	Trace
2,000	Excellent	Very good	Trace
1,000	Very good	Good	None
400	Good	Good	Trace
200	Fair	Fair	Trace
100	Fair	Fair	Trace
20	Trace	Fair	Trace
10	None	Poor	Trace
2	None	Trace	Trace

(a) Crude alcoholic extract from dried peas.
(b) Pea infusion from canned peas.
(c) Ground peas autoclaved at 15 pounds for 1 hour. Infusion tested.

In view of the large number of recent papers from the Boyce Thompson Institute on the "growth" promoting substances of the indole series *(6, 7, 8, 13, 32)*, three of these compounds were obtained from Dr. R. H. Manske of the National Research Council, Ottawa, Canada: Indole-3-n-acetic acid, indole-3-n-propionic acid and indole-3-n-butyric acid. These three compounds have been tested on *Phytophthora cactorum* in concentrations ranging from 400 p.p.m. to 1 part in 2 million. None induced growth. In concentrations above 10 p.p.m. the mycelium was killed. In addition, beta indolyl acetic acid (Hetero-auxin of Kögl) has been tested on some 75 fungi. In no case was this compound found to be a growth-promoting substance for the fungi tested. It proved to be especially toxic to some Oomycetes (Saprolegniales). In high concentrations it was always toxic. When it was not toxic the fungi grew as well in the check as in the test solution.

SUMMARY

(a) Garden peas have been shown to contain a growth substance for many fungi. (b) The initial steps for a purification of this growth substance have been devised. (3) The growth substance found in peas is thermostable, soluble in alcohol, acetone, carbon tetrachloride, and benzene, and insoluble in ether, ligroin, and methyl cellosolve. (d) No statement can be made at this time as to the chemical nature of the compounds necessary for the growth of *Phytophthora cactorum*. (e) Beta indolyl acetic acid has been tested on 75 fungi and found not to promote growth but to act as a toxic substance.

* * * * *

All the biological tests reported in this paper were made by Dr Leon H. Leonian, to whom the thanks of the author are due.

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RATE AND HEAT OF SORPTION OF METHANE BY COAL

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RATE OF SORPTION

TRUE ADSORPTION is nearly instantaneous and any lag can be accounted for by the comparative inaccessibility of a portion of the surface of a porous adsorbing agent. This time may be quite appreciable if the surfaces exist inside adsorbing material in macroscopic or microscopic capillary pores, and if the material itself is not very permeable to the gas or vapor being absorbed. This is largely the condition presented by coal, and consequently time is necessary for adsorption to take place.

Using pure methane gas at 17.77°C. on West Virginia Pocahontas No. 4 coal, ground in a "coffee mill," we found that in 3 minutes sorption was about one-third of its final value, in 30 minutes it was one-half completed, in 3 hours about 85 percent of its saturation value, and that sorption was practically finished in 24 hours.*

The amount of adsorption is nearly independent of the size of the particles, provided the coal has been crushed to reasonable fineness; but the time necessary for adsorption to take place depends very largely on the particle size. Thus, 90-mesh coal adsorbs practically the same amount of methane as 200-mesh coal but requires much more time.

Preliminary measurements seem to indicate that at low pressures, where the surface is only partly covered, addition of more methane results in the further filling up of the surface without solid solution. This would result if the energy change for the surface adsorption is more than that for the solution of methane in the coal. At higher pressures, however, after the surface of the coal has been covered with a monomolecular layer, both adsorption and solid solution may take place. The term sorption is used to include both the surface adsorption and the solution of the gas in the solid.

At 17.77°C, in about 35 minutes after the desorbed coal was brought into contact with the gas, a rapid change in the rate of sorption of methane by our coal seemed to occur. At this time 1.55 c.c. of methane

*A description of the apparatus devised for this purpose, analysis of the coal and methane, and six graphs which summarize the results will be found in J. Am. Chem. Soc. 57, 1785 (1935). Slides for these and other phases of this work were shown at Bethany.

(N.T.P., that is the volume corrected to 0°C and 760 mm. pressure) had been adsorbed by 1 gram of coal. Assuming that a monomolecular layer of methane then covered the coal surface this would be $\frac{1.55}{22412} \times 6.06 \times 10^{23} = 4.19 \times 10^{19}$ molecules of methane. An adsorbed methane molecule has a diameter of about 7.72×10^{-8} cm. Hence the minimum total surface necessary for the adsorption of a monomolecular layer of methane per gram of the ground coal was $(7.72 \times 10^{-8})^2 \times (4.19 \times 10^{19}) = 3.235 \times 10^4$ sq. cm. This is a little more than seven times the surface area as roughly calculated from the data obtained by fractional sieving and rate of settling, where the assumption was made that the coal particles were smooth and spherical, and where there were no capillary openings or pockets upon the surface of which adsorption would occur. Moreover, the surface area of 3.235×10^4 sq. cm. per gram of ground coal was calculated by assuming that the molecules of methane in the adsorbed layer are closely packed together without any intervening spaces, which is of course not true. This calculated value is then a minimum value, the true value being somewhat larger depending upon the arrangement of the adsorbed molecules.

HEAT OF SORPTION

The heat of adsorption of a gas on a solid is the number of calories evolved when one molecular weight of the gas is adsorbed by the solid. Use is made of the Clausius Clapeyron equation,

$$\log \frac{P_2}{P_1} = \frac{\triangle Q}{4.58} \frac{T_2 - T_1}{T_1 T_2}$$

where P_2 is the experimentally determined pressure at the temperature T_2, P_1 is the pressure at T_1, and $\triangle Q$ is the number of calories of heat actually evolved.

With pure methane on our ground Pocahontas No. 4 coal these heats ranged from 6900 calories for adsorption on a surface containing little methane (27.5 mm. pressure) to the approximately constant value of 5200 calories for further additions to a surface already covered with methane molecules. This latter, nearly constant value, seems to be attained after about 1.55 c.c. (N.T.P.) have been adsorbed by one gram of the coal, and offers further evidence that this amount of the gas is first adsorbed as a monomolecular layer.

EFFECT OF CHANGE OF TEMPERATURE ON ADSORPTION AT LOW PRESSURES

It is important to know how much adsorbed gas would be released by a rise in temperature within a mine and to see if the effect of this would be significant. The lower explosive limit for methane in air containing 21% oxygen is 5% methane. The upper limit is unimportant, since eddy currents and diffusion would produce an explosive mixture along the edge of any body of methane-air mixture, whether it was 16%

or 100% methane. The partial pressure exerted by the methane in an air mixture containing 5% methane would be 38 mm. Using our data it is found that at 17.77°C (average mine temperature), one gram of the coal adsorbed 0.375 c.c. (N.T.P.) of methane, whereas at 24.60°C only 0.263 c.c. was adsorbed. This is a decrease of about 30%.

Most mines, however, keep the methane content below 2% by ventilation, and it would then take an increase of over 100% to cause the formation of an explosive (5%) mixture. Thus the formation of such a mixture would not be formed by an increase in temperature of 6.83°C. As a matter of fact the temperature in a mine seldom changes as much as 5°C. These considerations apply only to the broken down coal and dust and not to the coal still in the seam where methane is probably present under pressure.

EFFECT OF MOISTURE ON ADSORPTION

Preliminary measurements at 10.94°C showed that the adsorption capacity of the coal for methane was decreased by about 10% when the gas contained some water vapor.

THE USE OF TRIETHANOLAMINE IN QUALITATIVE INORGANIC ANALYSIS

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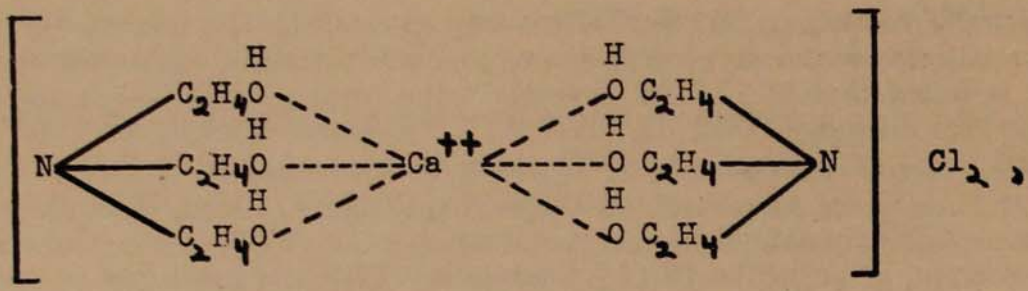
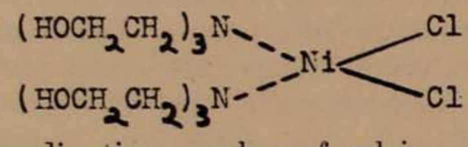
DURING THE SUMMER of 1935 the authors were engaged in the preparation of a laboratory manual for use in the courses offered in general and inorganic chemistry. At that time a survey of the recent literature was undertaken, particularly with reference to newer methods which might be applied to the scheme of inorganic qualitative analysis. Our attention was also directed to some work which had been carried out on the reaction of triethanolamine with metallic salts. We were thus stimulated to research on the subject, and the results elicited are in our opinion highly satisfactory. The following paper is a review of some of these results.

Triethanolamine, $N(CH_2CH_2OH)_3$, is a colorless, viscous, basic liquid which is miscible with water in all proportions and is highly hygroscopic. It may be purchased from Carbide and Carbon Chemicals Co. at about $3.00 per gallon, this quantity being sufficient for 20 liters of the 20 percent solution in water used as the laboratory reagent.

According to Tettamanzi and his co-workers[1] triethanolamine reacts with metallic salts in two ways: by complex formation and by alcoholysis. As examples of the first type we may present

[1]Tettamanzi and Carli — C. A. 28, 1295 (1934)
Garelli and Tettamanzi — *Ibid.* 28, 1295-96 (1934)
Garelli — *Ibid.* 28, 2638 (1934)
Tettamanzi and Carli — *Ibid.* 28, 5360 (1934)
Garelli and Tettamanzi — *Ibid.* 29, 68 (1935)
Garelli and Tettamanzi — *Ibid.* 29, 5766 (1935)



and 

where the coordination number of calcium in the first case is 6 and of nickel in the latter case 2. The evidence for the above structural formulas lies in the fact that calcium forms a complex with glycerol, which possesses three hydroxyl groups, and none with ammonia, while the reverse is true for nickel.

As examples of the second case we may cite the compounds

$(HOCH_2CH_2)_2NCH_2CH_2OCoCl$,
$HOZnOCH_2CH_2N(CH_2CH_2CZn)_2SO_4$,
and $N(CH_2CH_2OPbI)_3$.

The first applications of these compounds in the separation of metals were those of Raymond[2] who employed them in the quantitative separation of antimony from tin and of cobalt from nickel. For the first case, he made use of the fact that both $Sb(OH)_3$ and $Sn(OH)_4$ are soluble in a mixture of triethanolamine and NH_4HCO_3, but on decomposing the NH_4HCO_3 by boiling, the tin precipitates as $Sn(OH)_4$, leaving the antimony in solution, probably as

$$(HOCH_2CH_2)_2NCH_2CH_2OSb{=}O.$$

For the separation of cobalt from nickel, advantage was taken of the fact that the nickel triethanolamine complex is unstable in hot alkaline solution, precipitating $Ni(OH)_2$, while the cobalt alcoholate is unaffected.

Both of these processes have been simplified and adapted to routine qualitative analysis by the authors, and in addition improvements on the test for zinc and in the separation of strontium and calcium have been developed.

EXPERIMENTAL

Unless otherwise specified, the test solutions contain 10 mg. of the ion desired per cc. If there is a possibility that the unknown in use may contain much in excess of this amount, the solution is best diluted. The lower limit of sensitivity for a particular test is given in each case.

[2]Raymond, Compt. Rend *198*, 1609 (1934)
Ibid. *200*, 1850 (1935)

The Separation of Sb^{+++} and Sn^{++++}. A ten cc. portion of a solution of the above ions in the form of chlorides is made faintly alkaline with NH_4OH, and treated with 20 cc. of saturated NH_4HCO_3 solution and 15 cc. of triethanolamine reagent. The solution is kept at the boiling point for 10 minutes, at the end of which time all of the NH_4HCO_3 should have been decomposed. The gelatinous precipitate of $Sn(OH)_4$ is filtered off, washed, dissolved in HCl, and reduced with iron card teeth, after which the usual $HgCl_2$ test for the Sn^{++} ion is applied.

The filtrate from the $Sn(OH)_4$ is acidified with HCl and saturated with H_2S. Orange precipitate of Sb_2S_3, presence of Sb^{+++}. Since the solubility of $Sn(OH)_4$ is very small, the test is limited only by the smallest amount of $Sn(OH)_4$ which can be seen and effectively handled.

The Separation of Co^{++} and Ni^{++}. A 10-cc. portion of a solution of the above ions in the form of chlorides or nitrates is neutralized with NaOH and then treated with HCl dropwise until faintly acid. An excess of triethanolamine solution is added, followed by 1 cc. of 6*N*-NaOH, and the mixture is boiled gently for 1 minute and allowed to stand 5 minutes. The pale green precipitate is $Ni(OH)_2$; the rose color of the solution is due to $(HOCH_2CH_2)_2NCH_2CH_2OCo^+$. The color of the cobalt alcoholate is visible in dilutions up to 1:20,000. The above procedure obviates the use of such expensive reagents as dimethylglyoxime for nickel and phenylthiohydantoic acid or α -nitroso β -naphthol for cobalt.

The Test for Zn^{++}. The solution is slightly acidified with HCl if necessary, and treated with an excess of triethanolamine. The resulting solution may be heated, resulting in the separation of a bulky white precipitate which probably has the formula

$$(HOZnOCH_2CH_2)_2NCH_2CH_2OZnX,$$

or the solution may be saturated with H_2S, resulting in the precipitation of ZnS. The former is preferable, since cobalt and nickel do not interfere. The test is sensitive to about 0.5 mg.

The Separation of Ca^{++} and Sr^{++}. The problem of testing for strontium in the presence of calcium, and vice versa, has always presented great difficulty, especially to the beginner. Up to the present two chief methods have been employed, one involving the precipitation of $SrCrO_4$ in the presence of alcohol — a procedure of uncertain outcome in the hands of a novice, since $CaCrO_4$ is also easily precipitated — and the other involving the treatment of the test solution with saturated $CaSO_4$ solution, use being made of the fact that the $SO_4^{=}$ concentration in saturated $CaSO_4$ is roughly 10 times that in a saturated $SrSO_4$ solution. However, the amount of $CaSO_4$ in such a solution is not large, and when it is diluted with the test solution, the $SrSO_4$ precipitate is often reduced to a mere turbidity.

Since Tettamanzi and his co-workers (loc. cit.) had recorded the existence of complexes of triethanolmine with calcium and strontium salts, it occurred to the authors that perhaps the presence of triethanolamine in such a solution would reduce the Ca^{++} concentration to a point where $CaSO_4.2H_2O$ would not precipitate even in the presence of a large excess of sulfate. This proved to be the case, precipitation being greatly delayed even in solutions as concentrated as 2.5 molar with respect to Ca^{++}. On the other hand, the solubility of $SrSO_4$ remained practically unaffected.

The following procedure is designed for a solution containing about 100 mg. each of Sr^{++} and Ca^{++}. Correspondingly larger quantities should be used if the amounts of these ions may be much in excess of the above.

The filtrate from the $BaCrO_4$, containing Ca^{++}, Sr^{++}, $K_2Cr_2O_7$, CH_3COONH_4, and CH_3COOH is neutralized with NH_4OH. To this solution 20 cc. of the triethanolamine reagent are added with stirring, and then 5 cc. of 6N-$(NH_4)_2SO_4$. After 10 minutes the precipitation of $SrSO_4$ should be complete. Filter, and apply the flame test to the precipitate. The filtrate, which contains the calcium complex, is treated with $(NH_4)_2C_2O_4$, a precipitate of CaC_2O_4, being at once obtained if Ca^{++} is present.

The test, if performed under the above conditions, is limited to the smallest amount of $SrSO_4$ which can be seen and effectively handled.

SUMMARY

New and improved methods applicable to routine qualitative inorganic analysis including the separation of antimony from tin, of cobalt from nickel, of strontium from calcium, and a test for zinc have been described, using triethanolamine as the principal reagent.

NEW BUILDING MATERIALS

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THE DEVELOPMENT of the chemical industry in our country has been divided into three periods: (1) The development of the heavy chemicals industry, (2) the development of the synthetic organic industry, and (3) the period of creating new materials and new markets. We are now definitely in the third period of development and evidences of its effects are seen at every hand.

The work of development in pure science and promotion in applied science are necessary in the production of new materials. Both the chemist and the chemical engineer are thus essential in dealing with the many pressing problems that are involved. Workers in pure science continually observe and discover new facts while specially trained men are utilizing these facts and producing new and better products for many wide and varied uses.

The economic depression of the past several years has presented severe problems to people of the scientific world; many new and interesting facts have thus been uncovered. An important by-product of this period of stress has been the renewed, vigorous attack on many research problems which has produced abundant results. The recent Children of Depression and Children of Recovery exhibitions in New York well illustrate this observation.

Activity has been intense in many branches of research and a complete narrative would be a prodigious work. Let us therefore limit our study to some of the new building materials and building accessories that have been produced.

While new applications are being made of well known materials, many of these products are new in both composition and applications. Frequently the desire to utilize waste products has been a factor in the production of a new material. Advance in building technique, the desire to secure greater comfort, or economic factors often demand new and better materials. For example, various types of wall-board have been manufactured from waste materials; various types of insulating materials have become necessary with the advent of air-conditioning; and factory pre-fabricated structures are now contemplated for the erection of economical low-cost buildings.

The evolution of shelter for man is an interesting study spanning the range of caves and crude huts of primitive peoples to the massive sky-scrapers and apartment houses of the present civilization. A study of the materials utilized, methods of construction, and results obtained is likewise intensely interesting. For many years the natural resources available served as the materials for construction. This fundamental group, — wood, stone, and clay — are yet of great importance to modern builders.

From time to time other materials are introduced, and definite progress in the art of building and securing comfort is thus attained. Modern sky-scrapers would not be possible if steel were not available as a structural material. Our homes would indeed be depressing without glass windows or means of artifical illumination. A few of the newer materials of construction and their applications will now be considered; for as was metnioned previously, a complete exploration would be quite beyond the scope of a 20-minute paper. The order in which individual products are taken up has no significance either chronologically or economically. The story of the individual materials is presented as briefly as possible, and is not intended as a comprehensive study.

FIBER BUILDING BOARDS

A large group of new products are the fiber building boards. These are essentially synthetic materials made principally from agricultural plant wastes and sawmill wood wastes. Fiber building boards were first made from unbleached ground-wood pulp. Many well-known brands are still made from this source. The utilization of other fibrous raw materials consisting of crop and industrial wastes is of interest particularly from an economic standpoint. Fibers are now obtained from extracted sugar cane, sawmill waste, straws, cornstalks, grasses, tobacco stems, bark, and similar vegetable materials.

Manufacture of fiber boards can be divided into three stages: (1) Pulping the raw material, (2) forming a mat from a water suspension of the pulp on a modified type of paper machine, and (3) pressing and drying the mat to form the finished product.

The procedure of pulping varies considerably with the type of raw material used. Crop wastes are usually digested in dilute caustic or in water under pressure. Wood waste is frequently pulped by exploding with steam or by softening treatments followed by mechanical disintegration. The pulps formed are further refined in beaters, rod mills, or equipment similar to paper mill procedure. Sizes, gums, resins, asphalt emulsions, water-proofing and fire-proofing materials may be incorporated in the pulp in this stage. Actual forming operations are usually carried out on modified cylinder or Fourdrinier machines. Some products are made in thin boards and then laminated by cementing several plies with a suitable adhesive. The practice is tending toward a homogeneous product with the thickness desired built up in the forming operation. Drying is usually carried out by rolls in tunnel dryers, or pressing may be done on heated press platens.

Fiber building boards are classified into wall boards which are designed for interior finsihes, and insulating boards which are used for heat insulation or to absorb sound. Ordinary wall boards are used in cottages, partitions, and temporary constructions where low cost and speed of erection are principal factors. Boards are now developed with special finishes and properties so that they can be applied as an interior finish for building construction of the better classes. Pleasing effects are secured in paneling with the decorated types.

Fiber boards designed for heat and sound insulation are an important class. These properties are due to the many minute air spaces and the small number of fibers parallel to the line of flow which serve as conductors. In home construction fiber boards are used in walls, roofs, attic floors, and basement ceiling for heat insulation. Applications are made as sheathing under brick and stone veneer. The acoustic properties are utilized by applying the boards as inside wall coverings for theaters, auditoriums, hotels, restaurants, schools, and churches.

INSULATING MATERIALS

The use of insulating materials greatly increases the comforts of our homes in all seasons. In summer the houses are kept cooler and in winter they are kept warmer by proper insulation. Large savings in fuel costs are also made by preventing the heat losses of radiation, conduction, and convection through the walls and roofs of the buildings. These materials, usually fireproof, prevent the spread of a fire in a building by limiting the chimney or flue effect in the space between the inner and outer walls. Insulating materials are designed for use in new construction or for application in houses already built.

Fiber boards as insulating materials have already been mentioned.

Other materials used include balsam-wool, rock or mineral wool, slag wool, glass wool, and others.

The balsam-wool is a mat of moisture-proof, fire-proof material sealed in layers of asphalted kraft paper. By suitable nailing strips these mats are fastened between the frame studs of the building. Rock wool or mineral wool is produced by fusing certain rocks or minerals, injecting the molten material through an outlet into a jet of live steam, thus producing a fibrous, fluffy, wool-like material. This wool can be made up in "bats" and applied between studding, or it can be blown in the walls of houses already built. Slag wool is similar to rock wool but is produced from slags of various metallurgical smelting operations. Glass wool is similarly made and has similar insulating properties.

CELLULATED CLAY

This product is an example of research designed to improve an old building material for modern requirements and modern competition. Interest in light-weight masonry has been manifest for some time. Light-weight brick and tile have been produced by burning out sawdust which had been incorporated into the clay mix; this product, however, is heavier than desired. A similar procedure with refractory brick gives a good furnace insulating material. A light-weight building unit has been produced by adding an acid to a clay slurry containing dolomite and Plaster of Paris. The acid and dolomite react to form enough gas to make the fluid mass rise; the Plaster of Paris causes the mass to set. These products are not true to shape and must be cut to size. Another method is to add a permanent foam made from oleates to the clay slip; a setting or hardening agent is also used. A fourth method mixes naphthalene with the clay and then distills it off.

The cellulated clay product has sufficient strength to take up part of the structural load, when used as a backing-up material, and in addition is a good insulator. It also has good acoustic properties for use in auditoriums, etc. It can be sawed and shaped on the job with the ease of cutting wood The units can be cemeted together with a sodium silicate cement, and if desired can be glazed like ordinary clay products.

GYPSUM PRODUCTS

Gypsum has a variety of applications in the building industry. When calcined or dehydrated it is used in wall plasters. Keene's cement is an important member of this group. Wall and plaster boards and structural gypsum products are also fabricated.

Gypsum products are fire-resistant, have low thermal conductivity, are light weight, resist the devastating action of termites, and are resistant to acid fumes. These properties make this an attractive material for building purposes.

Gypsum wall boards are now furnished with wood-grained finishes so realistic that the imitation is scarcely noticeable. This material gives very attractive interior finishes and is used in home remodeling, offices, display rooms, hotels, restaurants, etc. This material can be cut and nailed and is easily applied.

A new gypsum product is known as Gypsteel Plank. This is a factory-molded unit 2 in. thick, 15 in. wide, and 6 or 10 ft. long. It is reinforced on the sides and ends by a tongue-and-grove, galvanized, copper-bearing steel channel. The gypsum core is reinforced with steel mesh. This material is used in many types of building construction such as the construction of fire doors, air ducts, partitions, sheathing, etc.

ASBESTOS- CEMENT

Portland cement and asbestos fibers are fabricated into shapes with an even distribution of materials. The mix is subjected to a considerable hydraulic pressure to give the product density. This material is thus fireproof and waterproof. Suitable coloring materials can be incorporated in the mix, and by suitable molds many pleasing textures and finishes are secured.

This material had its first application as a roofing material. These rigid asbestos roofing shingles, made in many forms, result in very attractive roofs. These shingles are water-proof, fire-proof, can be easily applied, and are practically indestructible.

Siding shingles have been designed with special textures, so that they resemble cedar or cypress wood shingles or building bricks. An advantage of this type of siding material is the low upkeep cost since periodic painting is eliminated. This material is used extensively in remodeling old buildings.

Asbestos-cement wall panels are made for interior walls. They can be scored at intervals so that they resemble ceramic tile, even to the mortar joint. These are applied in kitchens, bathrooms, sun parlors, etc. These panels are furnished in a variety of colors, are lustrous, and are easily cleaned.

CONCRETE

The inherent qualities of concrete have been known for a long time, but applications to building construction have not developed very rapidly. The demand for housing, and the scarcity of the usual building materials during the war, greatly accelerated the use of concrete as a building material.

Concrete is utilized in three general types of construction: (1) Concrete masonry unit construction for exterior walls and partitions; (2) monolithic concrete construction for exterior walls, partitions, floors, and flat roofs ;(3) pre-fabricated or factory made units for assembling into walls, partitions, floors, etc.

Concrete masonry unit construction is the better known and most widely used of the three methods. Buildings of this type are usually finished with an application of Portland cement stucco. A variety of surface textures can be made on the units when cast. By the use of colored aggregates, mixed pigments, or chemical stains, a wide variety of appearance can be given the finished walls.

The hollow monolithic wall has been used extensively for houses. This construction provides a continuous air space which has an appreciable insulating value. Research is being directed toward the development of more efficient methods of construction of this type.

Pre-cast concrete sections are now being utilized, and the factory-made home is a reality. Floor joists, slabs, and beams are now factory fabricated. Pre-cast unit types and methods are being studied, for the fundamental economy of this type of construction is obvious. Refinement in design and certain maufacturing problems are now being considered.

GLASS

The use of glass in windows to allow the sunlight to enter our homes and buildings is so common that little thought is given to glass as a building material. A future development will be the compounding of a window-glass that will allow a greater amount of the beneficial ultra-violet rays to enter. Helpful strides have been taken in this direction, but the goal has not yet been reached.

A new type of translucent masonry or glass building blocks has recently been developed which gives promise of widespread application. These blocks have low heat conductivity, great structural strength, and have desirable light transmiting and diffusing properties. These units are hollow, partially evacuated, translucent blocks of clear glass, which are laid up with Portland cement mortar joints. Prismatic patterns are impressed on the inside faces of the blocks. By variation of these patterns the light transmitting values and diffusing properties can be varied over a wide range, with the absence of glare. Walls of these blocks have a deadening effect against the transmission of sound; are fire resistant, easily cleaned, and present an attractive appearance.

Translucent masonry blocks are especially adapted for industrial buildings, office buildings, store fronts, interior partitions, and in residence construction. With modern air conditioning methods. the heat loss of large windows is a critical factor. Use of these blocks, giving perfectly diffused lighting, reduces the cost of heating in winter and of air conditioning in summer. Attractive store fronts can be designed, and by floodlighting and colored floodlighting at night, good advertising effects are secured. The use of these blocks will permit architects to further revolutionize the design of future dwellings to secure greater comforts and pleasing designs.

SYNTHETIC PLASTICS

The story of the development of the synthetic plastics, and their present wide-spread applications, is far too expansive to be reviewed at this time. Their intrusion into the building industry has been slow, but this material is becoming a factor to be considered in the competition of the various materials in the industry. Resinoid-laminated materials are furnished in many colors and appearances in sheet form. These are used in store counters, soda fountain trim, store fronts, wall surfaces, window sills, etc. These materials are light weight, are easily applied, and have a finish more permanent than wood.

The use of these materials has proven successful in commercial installations and in interior decorations. Press molded plastics and cast material also are produced. These generally can be secured in any color or finish. They have good strength and are quite tough and resilient. In the building industry, hardware such as door knobs, escutcheons, and switch plates are made from this material. Varnishes made from these resins, dissolved in suitable solvents, are now proving very successful in forming hard tough films and protecting wood surfaces.

METALS

Metals are used in heating systems, water supply and sanitation systems, roofing, flashings and conductors, weather stripping, hardware, etc., in modern buildings. The competition of the various metals and alloys is keen for these applications. Metals are also playing important roles in the drama of recent developments. Many store fronts, stairway grilles, wall surfaces, doors, decorative trim, windows, spandrels, etc., are now made of metals. Stainless steels, aluminum, monel metal, nickel silver, and others are some of the metals competing for these applications.

The strong aluminum alloys are now seriously entering the structural field. Certain bridges and bridge members have been fabricated from the high-strength aluminum alloys. Structural members of small buildings have been made of these alloys. Further expansion in this field will no doubt take place.

Erection of all-metal houses has recently taken the fancy of many architects and engineers. A certain group of filling stations in the Middle West have been built entirely of metals. A few all-metal houses have been erected in various sections of the country, chiefly for demonstration purposes. Predictions are freely made that more low-cost factory fabricated units will soon be erected, and that this type of building will soon be common. Structural steel is used for the skeleton of the house, while enamelled sheets are applied as the interior and exterior walls Suitable insulation must of course be provided. The application of welding methods has been a boon in the erection of this type of building. Special methods of fastening the porcelain enamelled sheets has also been devised. Advantages are low-cost construction, permanence of surface, low up-keep and maintenance, and pleasing appearance.

SOME BY-PRODUCTS FORMED IN THE PREPARATION OF CERTAIN p-AMINOBENZOATES

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DURING THE PREPARATION of some β-alkoxyethyl esters of para-aminobenzoic acid, there always appeared a red-colored product which contaminated our desired product, a white compound. These red compounds were separated and identified.

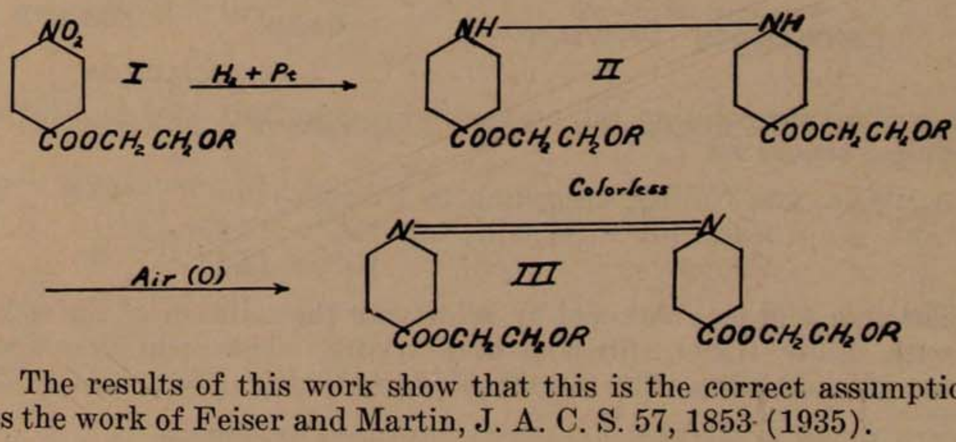
The method used for the preparation of the β-alkoxyethyl esters of para-aminobenzoic acid was as follows: The apparatus used was a Burgess-Parr Catalytic apparatus, Illinois model. It was standardized by the use of maleic acid, a drop in pressure of 71 lbs. per sq. in. at 26°C being equivalent to one mole of hydrogen. One-tenth mole of the β-alkoxy ethyl ester of para nitro-benzoic was dissolved in alcohol and poured into the reaction flask with 0.2 gram Adam's platinum — platinum oxide catalyst. The system was evacuated, then hydrogen added to 45 lbs. pressure. After the theoretical quantity of hydrogen had been added, an additional amount of hydrogen was added so as to insure as complete hydrogenation as possible.

The reaction bottle was removed from the apparatus and the reaction mixture was colorless at this point. After evaporation of the alcohol the reaction mixture turned red. This color began to develop just as soon as air came in contact with the mixture and increased until it was a dark red color.

In separating the para-aminobenzoates, the reaction mixtures were extracted with ether and the product precipitated with HCl. This gave a colorless compound which gradually turned red upon exposure to air. Several recrystallizations failed to eliminate this phenomenon. Since this color seemed to appear after exposure to air, the product was put into alcoholic solution and air passed through it. The compound causing the red color is less soluble in alcohol than the amino compound and was thus removed by several recrystallizations from 50% alcohol. It was found that upon crystallization after the air treatment, the amino compounds remained colorless. This indicated that hydrazo compounds were causing the trouble. The other possibility was that the amino compounds were being oxidized.

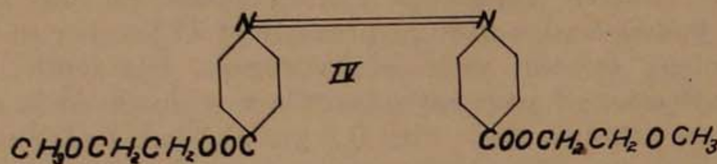
It was shown that the amino compound was not the source of the coloring matter by passing air through a boiling alcoholic solution of β-methoxy ethyl para-aminobenzoate, made alkaline with sodium hydroxide. No discoloration occurred after several hours and the ester was recovered unchanged. The amino compounds were then stable.

The other probability can be shown by the equations:



The results of this work show that this is the correct assumption as does the work of Feiser and Martin, J. A. C. S. 57, 1853 (1935).

Two of these azo compounds were separated and identified; namely, 4,4′ di(β-methoxy carbethoxy azobenzene,



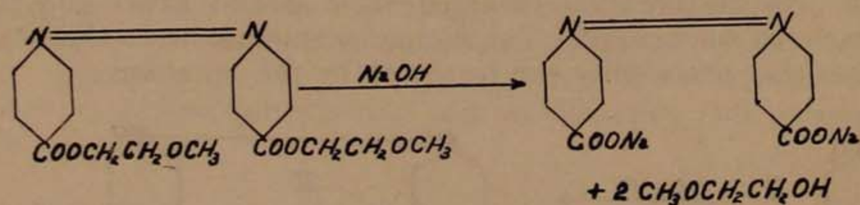
and the corresponding ethoxy compound. The results are as follows: 4,4′ di(β-methoxy) carbethoxy azo benzene (IV).

This compound was isolated from the alcoholic solution obtained from the catalytic reduction of β-methoxy ethyl para-aminobenzoate by passing air through the alcoholic solution, evaporating the alcohol, taking up the residue in ether, and precipitating the aminobenzoate as the hydrochloride. This left the azo compound in ether solution. The ether was removed and the azo compound crystallized several times from 50% alcohol. An orange-red crystalline product having a melting point of 129° resulted.

Analysis, calc. for $C_{20}H_{22}O_6N_2$	N = 7.25	Mol. wt. 386.18
Found	N = 7.25	Mol. wt. 384.8 and 385.6

This compound (*IV*) was also prepared in the following manner: A solution of β-methoxy ethyl para-amino benzoate in glacial acetic acid was boiled for several minutes with CrO_3. The solution was cooled, diluted with water, filtered, and washed repeatedly with water. The crude product was recrystallized from hot alcohol (95%) and was shown by a mixed melting point determination to be the same as the compound obtained from the alcoholic reduction solution analyzed above.

Five-tenths of a gram of the azo ester was saponified by refluxing with 25 c.c. of 10% aquesous sodium hydroxide until complete solution was effected.



Upon cooling the solution the orange-red sodium salt of 4,4′ dicarboxy azobenzene separated.

Analysis. (As Na_2SO_4 according to Pregel)

Calc. for $C_{14}H_8O_4N_2Na_2$,	Na = 14.65
Found	Na = 14.59

The free acid was obtained by acidifying the solution of the sodium salt with dilute H_2SO_4, filtering and drying. This acid decomposed between 335 and 340°. The literature[1] states that it decomposes at 337°.

[1]Carre C. 1905 II 1534; 4,4′ di(-ethoxy) carbethoxy azobenzene.

Five-tenths grams of β -ethoxy ethyl para-amino benzoate was oxidized by boiling with CrO_3 (.5 gr.) in 5 c.c. of glacial acetic acid. The orange-red crystalline product when recrystallized from 95% alcohol or dilute acetic acid melted at 97° (uncorrected). This azo compound was also shown to be identical with that obtained from the reduction reactions of the nitro derivatives.

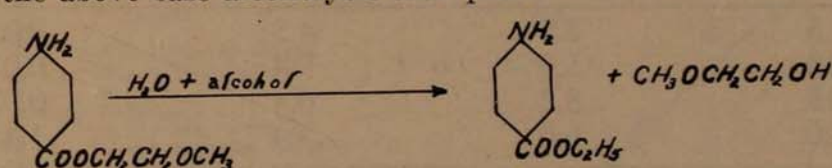
Analysis.	Calculated for $C_{22}H_{26}O_6N_2$,	N = 6.76
	Found	N = 6.54

In studying the effects of various oxidizing agents upon the para amino benzoates, the action of alcoholic mercuric oxide upon β -methoxy ethyl para-aminobenzoate was investigated. After refluxing the compound with an alcoholic suspension of yellow mercuric oxide for several hours, a product was obtained in quantitative yield, which proved to be ethyl para-aminobenzoate. The identity of this compound was established by the following data. Melting point 88-89°, (literature 89°) melting point of the picrate 129.5°-130.5° (literature 130.2°-131.2°).

Analysis:	Calculated for $C_9H_{11}O_2N$	Mol. wt. 165
	Found	168

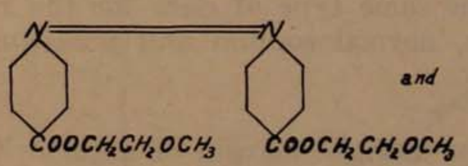
An identical product was obtained when β -ethoxy-ethyl para amino benzoate was treated with the alcoholic suspension of mercuric oxide. Thus these para-aminobenzoates resist not only the oxidizing action of air but also the oxidizing action of such weak oxidizing agents as mercuric oxide.

In the above case alcoholysis took place.

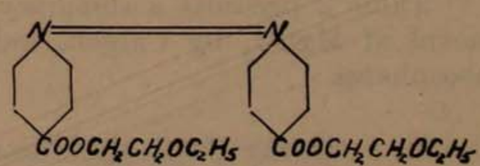


SUMMARY

Two new azo compounds:



and



were separated and identified.

(I) SOME EFFICIENCY TESTS ON THE WATER SOFTENING ABILITY OF CALGON*

(II) THE ELECTRICAL CONDUCTIVITY OF SOME CALGON-CONTAINING SOLUTIONS*

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CALGON *(1)* unadjusted is sodium hexa meta phosphate. Adjusted Calgon contains an additional nine percent of sodium carbonate. The first section of the paper is devoted to a comparison of the effectiveness of Calgon as a water softener with certain other softeners. Standard soap solution was prepared and used in accordance with Standard Methods of Water Analysis *(2)* to determine how much hardness had been removed. $CaCl_2$ and $MgSO_4$ were the hardeners. In the original paper 25 tables or figures present the full data obtained.

A summary of the material collected on the removal of the $CaCl_2$ by unadjusted Calgon, adjusted Calgon, and normal sodium phosphate is given in Table 1.

TABLE 1

(1)	(2)	(3)	(4)
$CaCl_2$ added mols x 10^{-5}	Unad. Calgon $CaCl_2$ removed mols. x 10^{-5}	Adj. Calgon $CaCl_2$ removed mols. x 10^{-5}	Na_3PO_4 $CaCl_2$ removed mols. x 10^{-5}
5	3.5	4.5	0.02
10	5.5	9.4	0.03
15	8.2	6.4	0.03
20	6.6	4.4	1.43

Column one indicates the amount of $CaCl_2$ added to distilled water. The other columns show in comparative units the amounts removed by the respective reagents.

Table 2 presents a summary of the same type of data for the removal of $MgSO_4$ by Calgon, soda ash, normal sodium and potassium phosphates.

In removing $CaCl_2$ these tests show a slight margin of superiority for adjusted Calgon over unadjusted, but both appear much superior to Na_3PO_4. In removing $MgSO_4$, the adjusted Calgon seems to take out twice as much as the unadjusted, 37 times as much as Na_2CO_3, and 12 times as much as either Na_3PO_4 or K_3PO_4.

Adjusted Calgon removes $MgSO_4$, under the conditions of these tests, twice as effectively as it does $CaCl_2$; adjusted removes $MgSO_4$ 3½ times as effectively as it does $CaCl_2$; Na_3PO_4 removed some $MgSO_4$ and

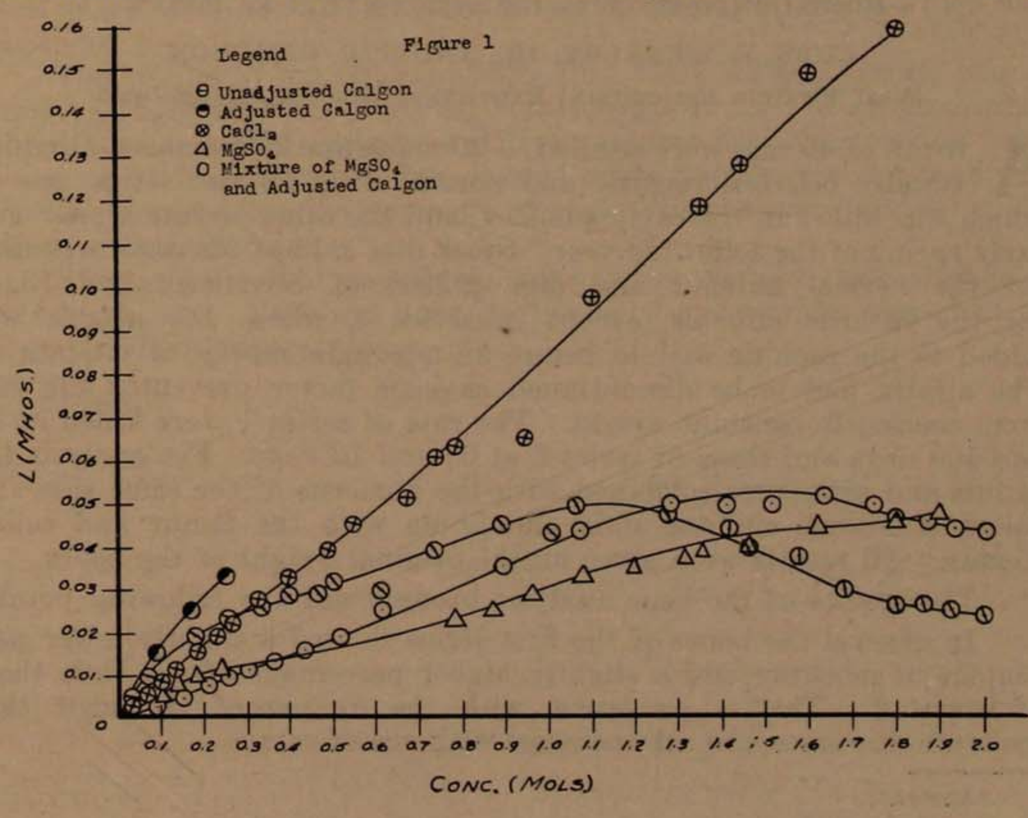
*Abstract.

about one-half as much $CaCl_2$, but in neither case did it approach the efficiency of the hexa meta phosphate.

TABLE 2

(1)	(2)	(3)	(4)	(5)	(6)
$MgSO_4$ added mols. x 10^{-5}	*U. C.* $MgSO_4$ remvd. mols x 10^{-5}	*A. C.* $MgSO_4$ remvd. mols x 10^{-5}	Na_2CO_3 $MgSO_4$ remvd. mols x 10^{-5}	Na_3PO_4 $MgSO_4$ remvd. mols x 10^{-5}	K_3PO_4 $MgSO_4$ remvd. mols x 10^{-5}
5	4.2	4.6	0.9	0.1	0.4
10	8.9	9.5	0.3	1.00	2.4
15	13.2	14.7	0.7	2.2	2.7
20	16.5	19.2	0.7	2.8	2.2
25		24.7			
30		28.8			
35		33.5			
40		20.6			

The manner in which Calgon removes these hardeners is interesting. Up to certain points, termed breaking points, a soluble complex ion is formed with the hardener; and no objectionable precipitation occurs as it does with the other softeners. No test for the calcium ion was obtained until sufficient calcium was added to permit the formation of the



compound of possible formula $Na_5(Ca_{1/2}P_6O_{18})$. The breaking point for $MgSO_4$ did not occur until enough salt had been added to form the compound of possible formula $Na_2(Mg_2P_6O_{18})$.

A study of the electrical conductivity of Calgon-containing solutions is under way. A summary of the data obtained so far is presented by the curves of Figure 1 in which specific conductance in reciprocal ohms is plotted against the molar concentration of specific solutions.

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BONE COMPOSITION AS RELATED TO DIET IN RATS*

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A TOTAL of 40 rats were studied — 20 males and 20 females —, divided equally between rachitic and normal diets, in two series, one of which was killed in the early summer, and the other in late winter and early spring of the following year. Stock diet #13 of Sherman was used for the normal animals and diet #2965 of Steenbock and Black for the rachitic animals, except in series 1, where 1% alfalfa was added to the rachitic diet to insure an adequate supply of vitamin A. The alfalfa had to be discontinued as some factor prevented the rats from coming to constant weight. The rats of series 1 were killed at 88 and 100 days and those of series 2 at 65 and 70 days. For analysis the radius and ulna were combined with the humerus of the same side and called Humerus, and the tibia and fibula with the femur and called Femur. All results were given on the original weight of the bones.

The results of the bone analysis brought out the following points:

In general the bones of the first series showed a slightly lower percentage of moisture and a slightly higher percentage of ash than those of series 2. This is consistent with the findings of Hammett that moisture decreases and ash increases with age of rats.

*Abstract.

There was practically no difference between the males and females in series 2 or the normals in series 1, but there was a marked difference in the rachitic rats in series 2 in moisture and ash; the moisture being higher and the ash lower in the males than in the females.

In both series the humerus group shows a lower moisture content and a correspondingly higher ash content than the femur group. This is in accord with the findings of Hammett.

In both series, in both groups of bones, and in both sexes the percentage of moisture is higher in rachitic bones than in normal bones; and the percentage of ash is lower. Such findings of higher moisture and lower ash are consistent with the histological picture found in rachitic bones as described by Dodds and Cameron and others.

RETARDING RANCIDITY IN STORED BLACK-WALNUT KERNELS*

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THE PROBLEM OF RETARDING or preventing the development of rancidity in stored kernels of black walnut was studied by conducting storage trials at three temperatures including (1) unheated cellar storage, (2) storage slightly above freezing, (3) storage below freezing, and under various treatments of nitrogen, hydrogen, carbon dioxide, vapors of ethyl alcohol with air or nitrogen, vacuum, and partial desiccation prior to storage in air. The trials also included storage in ordinary screw-cap jars which were not air-tight and in sealed glass containers which were air-tight.

The results of the trials indicate that black walnut kernels may be stored satisfactorily for a period of two years if held in an atmosphere of nitrogen in sealed containers at temperatures near the freezing point. Vacuum, hydrogen, and carbon dioxide applied under similar conditions likewise delayed the development of rancidity but were somewhat less effective than nitrogen.

Storage in sealed containers gave better results than storage in screw-cap jars. This was true particularly for samples stored at ordinary cellar temperatures.

*Abstract.

The Geology and Mining Section

Note on a Mammoth Tooth from Gravels of the Monongahela River

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Gravel dredging operations along the Monongahela River near the mouth of Cheat River have on a few occasions brought up fragmentary mastodon and mammoth remains. In some instances these interesting finds have been reported but it is probable that more often their recovery has been unnoted. Many of these fossils undoubtedly have been found and destroyed by those not familiar with their scientific value.

The fossil vertebrate collection of the geology department at West Virginia University has been enhanced by the addition of two specimens contributed by their finders. The first of these was an upper left hindermost molar tooth of "*Mammut americanum* (Kerr)" previously described *(1)*. The second contribution of more recent date is that of a tooth of "*Elephas primigenius* Blumenbach" donated by Mr. John B. Conn. This specimen was found under similar circumstances as the former but at a point in the Monongahela about one-half mile north of the confluence of Cheat River with the Monongahela River. The condition of the tooth would imply considerable stream abrasion but this feature could hardly be considered indicative to any marked degree of the distance it was transported by either of these streams.

The reported discoveries of proboscidean remains of the Pleistocene Age in southwestern Pennsylvania and the adjacent portion of West Virginia are not numerous. A mastodon tooth was reported found near Stewartstown, Monongalia county, West Virginia *(2)* on the fifth and highest terrace along the Monongahela River. Numerous fragments of bones and teeth were found in the river bank at the junction of the Monongahela and Allegheny Rivers, Pittsburgh, Allegheny county *(3)*, and a tooth was found in Mount Pleasant Township, Washington county, Pennsylvania. Only two accounts are given of the occurrence of "Elephas primigenius Blumenbach" remains in this area. A portion of a lower jaw was found in Greene county and a tooth at Lone Pine, Washington county, Pennsylvania *(4)*.

LOWER RIGHT THIRD MOLAR, *ELEPHAS PRIMIGENIUS* BLUMENBACH

The grinding surface of this specimen shows a great deal of wear, being somewhat concave from the front to the hinder end. When oriented with the front end forward the outside lateral face is more concave than the inside lateral face. A few of the ridge-plates near the middle of the tooth have their outer ends curved backward. The greatest length along the basal portion of the ridge-plates is 225 mm.; the maximum width across the grinding surface is 98 mm. Six plates lie within a line 80 mm. long. In a similar tooth (No. 6564) in the U. S. National Museum *(5)* eleven plates are in a line 100 mm. long. The fangs of the root at the front end are broken or worn off and only small portions are still present at the rear. A sandy matrix fills the hollow portion of the single rear fang. This same matrix is wedged between the grooves along the lateral surfaces of the tooth.

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THE NATURAL OXIDATION OF PYRITIC SULFUR IN COAL

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Department of Chemistry, West Virginia University

THE PURPOSE of this paper is to discuss a chemical phenomenon of utmost importance to this state. This reaction is the attack of pyritic sulfur in coal by water and oxygen, and it is occurring constantly and continuously in the bituminous coal fields. The paper presents the salient results and conclusions of a study of this reaction which the writer is making under the direction of Dr. Stephen P. Burke of the West Virginia University.

The natural oxidation of iron disulfide is important for two reasons: first, the reaction is the most probable mechanism whereby acid-mine drainage from bituminous coal fields is produced; and, second, it is closely associated with the spontaneous ignition of coal. To emphasize to West Virginians the seriousness of the effects of mine-water pollution should be unnecessary. It destroys natural stream beauty, contaminates municipal water supplies, and ruins prospects for power plant utilization. Suffice it to say that acid-mine drainage is the greatest single source of stream pollution in the state. The Monongahela River is considered as an example of a major stream. Prior to 1901 it is doubtful if this river at Pittsburgh was ever known to be clear, but in that year the appearance of a clear greenish color characteristic of mine pollution was noted by Colonel Roberts *(2)*. By 1912 the river had reached a stage of pollution where it was difficult to produce potable water from it. It has been estimated *(8)* that, at the present time, in the 61,898,000 gallons of water which on the average flow down the river per day, there are contained 1,755,064 pounds of sulfuric acid calculated to the anhydrous condition.

Sulfur occurs in coal in four general forms *(14)*: pyritic sulfur, sulfate sulfur, resinic, and humus sulfur. The last two forms are characteristically organic, and are not involved in considerations pertaining to this discussion. Pyritic sulfur consists of the two iron disulfide minerals — pyrite and marcasite or modifications thereof. Often it happens that no differentiation between the two minerals is made in the literature, and both forms of pyritic sulfur are frequently referred to as "pyrite". The facts of the matter indicate *(13)* that marcasite is the chief form of iron disulfide present in stratigraphic bands in the coal beds, and pyrite is the common form in concretions along certain stratigraphic horizons in sedimentary deposits closely allied with the coal seam.

Whether a sample of pyritic sulfur from a coal mine is marcasite or pyrite is usually difficult to determine because of the microscopic size of the crystals. Pyritic sulfur in coal possesses often the grey color characteristic of marcasite, and nitric acid tests applied to the mineral give a distinct marcasite reaction with the separation of free sulfur. X-ray powder photographs, however, often fail *(2)* to show definitely the presence of marcasite, but indicate instead the presence of pyrite.

No definite statements can be made regarding the distribution of pyritic sulfur in the coal seams because of the great irregularity of its occurrence. In the bituminous fields, the lower coals — the Clarion and the Brookfield — are generally the most pyritiferous; the Lower Kittanning is higher in pyritic sulfur than the Freeport or the Upper Kittanning, while the Pittsburgh coal is pyritiferous in West Virginia west of the Monongahela River *(10)*. Depending upon its mode of occurrence, pyritic sulfur may conveniently be grouped into five divisions. These divisions are

(1) Pyritic sulfur in the form of rounded balls called "sulfur balls", irregularly occurring in the bed, but abundant in the top and bottom of the seam, particularly along certain horizons in the bone and black shales; the composition of these balls is nearly pure iron disulfide.

(2) Pyritic sulfur in the form of lenses, ranging in breadth from two inches to a foot or more and of variable thicknesses; they may occur both vertically and horizontally in the coal bed.

(3) Pyritic bands running often for miles parallel to the bedding plane of the coal; these bands are generally very uniform in thickness, and serve as partings and binders for the strata of bone coal or shale.

(4) Pyritic sulfur existing in the bituminous coal substance itself, in the form of microscopic crystals of iron disulfide (25-40 microns in size *(18* and *19)*), mechanically mixed in clusters; anthraxylon (that part of coal derived from woody substances) and resinous materials usually contain these clusters.

(5) Pyritic sulfur occurring as fillings or irregular plates within fractures in the seam structure.

The microscopic crystals of marcasite and the pyritic bands are generally supposed to have a syngenetic origin with that of coal, having been laid down as colloidal gels *(13)*; the sulfur balls, lenses, and joint fillings are ascribed to a secondary origin.

In the course of normal mining operations, the massive forms of pyritic sulfur, such as the sulfur balls and lenses, tend to accumulate in the floor of the tunnel. They are then either left there in a more or less shattered condition, or are removed to gob piles outside of the mine. The opening up of the coal seam is accompanied by a general lowering of the natural water table. This permits ready access to the pyritic sulfur of freshly aerated water and air itself, with the result that the following equations are said to take place *(3, 11, 12, 16, 17, 20, 21)*:

$$2\,FeS_2 + 7\,O_2 + 2\,HOH = 2\,FeSO_4 + 2\,H_2SO_4$$
$$4\,FeSO_4 + O_2 + 2\,H_2SO_4 = 2\,Fe_2(SO_4)_3 + 2\,HOH$$
$$Fe_2(SO_4)_3 + 6\,HOH = 2\,Fe(OH)_3 + 3\,H_2SO_4$$

The initial effect is the immediate formation of ferrous sulfate and sulfuric acid in the drainage issuing from the seam. The dissolved ferrous salt in the stream is oxidized to ferric sulfate which then hydrolizes to basic iron oxides of indefinite composition; these oxides being insoluble coat the bed of the stream, thereby giving the stream a reddish-brown color. The water assumes a clear, transparent appearance, due to colloidal precipitation of turbid matter along with the oxides. The natural alkalinity of the stream-bed is generally insufficient to overcome the acidity of the mine drainage, and the consequent coating over of the bed prohibits further natural neutralization. Consequently the stream builds up to a high sulfuric acid content. In many instances the acidity is sufficient to redissolve the oxides, and the water assumes in the later stages of pollution a splotched, reddish-brown color again.

The heat of reaction for the first equation accounting for the formation of acid drainage was at one time said to be the direct cause *(1)* of spontaneous ignition of coal. This view has been found within the past twenty years to have no basis of experimental proof *(4, 5, 6, 9,* and *15)*. Modern investigations show that heat necessary for ignition of coal is derived from the absorption of oxygen by the coal substance itself. Davis and Byrne, in fact, have estimated that if all the pyritic sulfur in 100 pounds of an ordinary bituminous coal were concentrated in one spot and there oxidized to ferrous sulfate and sulfuric acid, the heat liberated would barely be sufficient to raise the temperature of the coal to 100 degrees C. *(4)*. Because of two properties inherent in coal regarding its absorption of oxygen, the oxidation of pyritic sulfur does have *indirect* influences on factors contributing to spontaneous ignition. The two properties are: First, coal in a fine state of division absorbs oxygen much more rapidly than in massive forms: second, the increase in the oxygen absorption rate of a coal with rise in temperature, especially in the lower temperature ranges, is exponential. Pyritic sulfur in the microscopic clusters previously mentioned exhibits enormous expansive forces upon oxidizing in a humid atmosphere, due to the increased volume of ferrous sulfate crystals over that of the original disulfide. These forces tend to shatter the coal substance into particles of microscopic size. Unless the heat of pyritic dissociation is dissipated faster than the coal can absorb it, this heat, while not great, causes an abnormally rapid increase in the absorption rate of oxygen by the coal particles. Accordingly, we may conclude that the chief part played by the oxidation of pyritic sulfur in coal is that of a disintegrator and initial heater or primer for the coal, rendering the latter more permeable to air and exposing greater surfaces of the coal substance to oxygen, while simultaneously increasing the oxygen absorption through additive heat effects.

Investigations, which were begun preliminary to studies on pyritic oxidation now in progress at the University, early indicated that striking differences exist between pyritic sulfur from a coal bed and the purer crystalline varieties of the minerals. For example, crushed pure marcasite crystals failed to give positive tests for ferrous iron and sulfate after days in which oxygen bubbled through water covering the material. Yet a quantity of cleaned sulfur ball crushed to 80-mesh, when placed under identical conditions, gave positive tests for ferrous iron and sulfate within one-half hour. By placing some of the material in water in a system evacuated to the vapor pressure of water at room temperatures, no indication of iron or sulfate was received, but after the water over the material had come into contact with the atmosphere for a time, ferrous and sulfate ions were found in the solution. In addition to these observations, the presence of sulfur dioxide gas in noticeable quantities was found whenever the sulfur ball material was kept in a dry state, either in a dessicator over calcium chloride or phosphorus pentoxide, or in a tightly stoppered bottle; extremely finely crushed crystalline pyrite and marcasite failed absolutely to exhibit this phenomenon. An extraction for twelve hours of ten grams of the oxidized sulfur ball material with carbon disulfide in a ground-glass Soxhlet extractor gave, upon evaporation of the extracting liquid, a yellow resinous mass. Benzene dissolved some of this material but left several lumps which, upon testing by oxidizing them with a solution of bromine and aqua regia, proved to be originally free sulfur. Thus it became evident that sulfur ball material from a coal seam would be the proper substance to utilize in researches wherein a mechanism for the oxidation reaction was the objective.

The experimental method consists in measuring oxidation rates for pyritic sulfur from coal seams under various controllable reaction conditions. By slicing and polishing sulfur ball into cubes, the surface area of the pyritic sulfur is measureable; these cubes are cleaned and weighed. They are then subjected in a specially designed apparatus to conditions of oxidation wherein the aqueous film thickness on each cube, the oxygen content of the solution, the ionic concentrations, temperature, time of reaction, and surface exposure of the pyrite are measured and controlled at will. Re-weighing of the cubes after a determination affords a measure of the amount of oxidation; designing the apparatus to contain four such cubes permits four check results with each run.

The work on the problem of natural oxidation of pyritic sulfur is still in progress. Consequently, complete data and results are not available at this time. However, from present indications, the following conclusions are evident:

(1) The oxidation reaction can be prevented in the complete absence of water.

(2) When oxygen is removed from the reaction liquid the reaction is repressed.

(3) The presence of sulfur dioxide and the extraction of free sulfur with carbon disulfide indicates the presence of free sulfur in an abnormally unstable condition.

(4) Every repression of the oxidation rate is followed by an increased rate when the pyritic sulfur is re-submitted again to normal reference conditions.

On the basis of present indications, the following mechanism for the reaction is suggested: Pyritic sulfur is designated by the formula, FeS_{2+n}, where n is an exceedingly small number. Water serves to condition the surface or form a film complex, which may be represented by $(FeS_{2+n}.HOH)$ This film is the substance that is susceptible to natural oxidation by oxygen dissolved in the water or in the gaseous state, according to the following scheme:

$$FeS_{2+n} + HOH = (FeS_{2+n} \cdot HOH)$$

$$\downarrow 7(O)$$

$$nS + 2H^{+} + Fe^{++} + 2SO_4^{--}$$

$$2n\,(O) \downarrow$$

$$n\,SO_2$$

This mechanism, involving a ''conditioning'' of the surface or the formation of a film complex by water on the surface of pyritic sulfur, bears a vital relationship to the present program of mine-sealing. It predicts a production of abnormally high acid drainage, if mine-sealing maintenance were to be neglected, and the sealed seam were to be re-exposed to freshly aerated waters and air.

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STUDIES ON THE USE OF BITUMENS IN SOIL STABILIZATION AND FLEXIBLE PAVEMENT TYPES

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THIS STUDY was made with the primary purpose of developing suitable methods of soil stabilization and construction of low-cost roads. The work was done by the writer and N. S. Forman with the assistance of the laboratory force of the Division of Tests, State Road Commission of West Virginia, located at Morgantown.

Several years ago it was recognized that more information and laboratory work was necessary properly to maintain roads already built, and to devise new construction procedure so that the small amount of money available could be expended wisely. This became more important after July 1, 1933 when all the county roads were incorporated in the State Highway System, thereby increasing the State mileage by more than seven times. It was believed that the most economical way to solve the problem was by laboratory investigation with subsequent test roads in the field. For this reason the Testing Laboratory has studied the problem for the last two years and the following report is an outline of the work done. It is evident that in a brief report of this kind it is not possible to include analyses of materials, tables, and curves of results.

Two methods of construction were tried in the laboratory. In using the first, called the penetration method, the road would be shaped as desired, after which bitumen would be applied and allowed to penetrate. The second method would be a modified mix-in-place construction whereby the soil of the road-way would be loosened to a suitable depth, pulverized, mixed with bitumen, and compacted by roller and traffic. Results of laboratory tests indicated that the modified mixed-in-place method should be the more satisfactory.

PENETRATION METHOD

Three soils were secured that represented the extreme types we might expect to find in this state Samples of asphalt, tar, and asphalt-emulsion meeting our State Specifications were submitted by producers for our tests.

Procedure: 700 grams of oven-dried soil and varying percentages of water or solution were thoroughly mixed together and placed in 2″ x 4″, 3-gang, sand-mortar molds. The mixture was placed in the molds in three layers and each layer was tamped with a 3/8″ rounded point rod 8 inches in length. Each layer received fifty blows with this rod and the final layer was leveled off with a ¾″ flat-end tamping rod, using very light blows. Bitumen was applied on the surface at the rate of one gallon per square yard, and observations to determine the rate of penetration were made at 18 hours and 24 hours. After 24 hours the test specimens were sliced and examined for depth of penetration of bitumen.

In an effort to discover the total amount of bitumen which would penetrate into the soil and the total possible depth of penetration, the test specimens that had shown a complete penetration in less than 24 hours were prepared again. Bitumen was added in different applications at the rate of one gallon per square yard for each application until the bitumen had penetrated to the bottom of the specimen, or until the bitumen remained standing on the top of the specimen. Twenty-four hours was allowed between each application.

Analysis of Test Results: One feature noticed in the penetration test specimens was that the solvent oils penetrated much deeper than the bitumen. There was a crust formed on top of the specimens that was rich in bitumen, but underneath there was not sufficient bitumen to bind the soil and waterproof it. Unless the soil is loosened or the road prepared for maximum penetration, it is believed that this type of construction would result in pot-holes or in a soil road that would break up. However, for a very cheap type of construction that would adequately serve the intended purpose the penetration type should prove satisfactory, provided the proper bitumens are selected and the road is properly maintained.

The use of admixtures of calcium chloride, sodium silicate, ammonia, or soap solution to increase the depth of penetration or the speed of penetration does not appear advisable. Water alone gave results that compared favorably with any of the solutions.

The most important condition necessary for the bituminous penetration of soils is to have the proper moisture content present. In the three soils examined, each representing an extreme type, there was very little difference in maximum penetration results, so long as the moisture content was held below 15% by weight; and it was found that the maximum penetration on all three soils was obtained when the moisture content was held beween 5% and 10%. Our results show that the type of soil has very little bearing on the depth of penetration secured and that the maximum depth of penetration depends almost entirely upon the moisture content of the soil.

The bitumens used most successfully were light viscosity tars and asphalts. Asphalt emulsion gave zero penetration in all cases. It was found that asphalts and tars having semi-solid residues upon distillation would have some binding qualities, and should therefore give better results in actual use than those bitumens having liquid residues.

If the penetration type of construction is used, the bitumen should be applied in several applications. If more is added, however, a point will be reached at which the bitumen will merely remain on top and will not penetrate. Laboratory tests will determine both the rate of application and the total amount of bitumen to be used.

HUBBARD STABILITY TESTS

The same three soils used in the penetration tests were run through a series of stability tests using the Hubbard-Field Stability Apparatus. The Hubbard-Field Stability Testing Apparatus was developed by Mr. Hubbard and Mr. Field of the Asphalt Institute to test bituminous mixtures by measuring in pounds load the resistance of a bituminous mixture to internal shear. The mixture, compressed into a briquette six inches in diameter, is placed in a steel mold of the same diameter. By means of a load applied to a piston five and three-quarter inches in diameter, it is forced through a shearing ring of the same diameter fastened to the bottom of the mold.

Procedure: 2 000 grams of soil were mixed thoroughly with varying percentages of water and to this mixture was added different amounts of the various bitumens. The mixture was placed in the 6-inch mold in two layers and each layer was tamped with sixty blows of the #2 tamper. The briquette was compressed under a 10,000 pound load, removed from the mold, and weighed. It was then placed in the damp closet for 18 hours, weighed, measured, and tested for stability load. Curves were plotted showing the inter-relation between percent soil, percent bitumen, percent moisture, Hubbard Stability Load, percent voids, density ratio. and other relations, as will be shown in our completed report. By the use of these curves the mixtures giving the most satisfactory results in the laboratory could be selected.

KRIEGE TESTS

After determining the proper amounts of moisture and bitumen, and the correct proportioning of aggregates in mixes by the Hubbard Stability tests, the Kriege testing machine was used to test the final mixtures. These were compared with tests made on other premixed materials with known field results. The Kriege Testing Wheel was developed by Mr. Kriege of the France Stone Company for the purpose of measuring the structural strength of bituminous mixtures. It consists of a round steel plate twenty-four inches in diameter and one-quarter inch in thickness on which is clamped a circular band twenty-two inches in diameter. This assembly is attached to the rotating wheel of a Standard Dorry Hardness Machine. A bituminous mixture is spread evenly on the plate within the band and compacted by steel rollers five and three-quarter inches in diameter under loads of 200, 400 and 600 pounds.

After curing, the compacted mixture is tested for structural strength by the rolling action under load of two rubber tired wheels eight and three-quarter inches in diameter, having a tread of one-half inch. When the load is applied the wheels are placed in the first position, about two inches from the bands, and after rotating the plate for one minute the wheels are moved in one-half inch toward the center, to the second position. In all, the wheels are moved a distance of six inches or through twelve positions for each load. As before, loads of 200, 400, and 600 pounds are used, making 36 positions for each temperature. Temperatures of 75°F., 100°F., 125°F., and 140°F. are used in the order named, until the temperature is reached at which the mixture fails.

Procedure: The proper amounts of aggregates and bitumen were mixed and placed in the Kriege test form. In some cases a built-up base, and in other cases the metal base of the form was used to hold the final mixture compacted with the three loads on the solid metal rollers. After curing, loads were applied on the half-inch wheels at the progressive positions. That point was called failure at which the wheels had rutted to a depth of half the thickness of the compacted mixture, or when the mixture had shoved to the center to such an extent that failure was evident. Values were obtained for pavement types of known performance and used for comparison of our test mixtures.

Analysis of Hubbard and Kriege Tests Results: In our investigation of soil stabilization, we believed that if the proper moisture content could be held in the soil by the use of proper bitumens in a soil-water-bitumen mixture, and protected from either loss or gain of moisure, the resulting compacted mixture would be satisfactory at least as a base for low-cost road construction. We have found that in soils the moisture content which gives maximum shearing load is also the most satisfactory moisture content for pulverizing the soils and mixing them with the various bitumens. We have also found that it is possible, with the addition of suitable amounts of bitumens, to increase the resistance of these soils to internal shear. At the same time it has been found possible to decrease, even in some cases to nullify, the action of water on soils by forming a dense, compact mixture that to a greater or lesser degree is waterproofed by the bitumens. We have not found that all soils, when mixed with bitumens alone, will be suitable for a wearing surface; but we have found that one certain type of soil when mixed with bitumen will not require a wearing course as shown by comparative tests. The greater percentage of soils will need a wearing course but the soil-bitumen mixes will be suitable as a base over which higher types pavements may be laid. Our laboratory tests indicate that our method of soil stabilization will be suitable for any type of soil or road condition likely to be encountered in this state, and that the various bitumen types will be kept in competition. We will have an opportunity to try out our method on a test road in the near future. Laboratory tests for this test road have been completed and additional information will be secured and reported later.

DESIGN AND CONTROL

It was necessary to include in this investigation the study of existing road pavement types and also the study of the "Surface Area Theory," the "Theory of Minimum Voids" or stated conversely, the "Theory of Maximum Density," and other cement, concrete, and bituminous theories in order eventually to control the proportioning of aggregates and bitumens by formulae and curves. Not enough work has been done along this line to arrive at any definite conclusion but it is believed that further work will be justified. A "Surface Area Curve" consisting of surface area plotted against percent bitumen has been worked out using experimental data. Experimental formulae have also been evolved for use in the proportioning of aggregates. It is now believed possible to proportion aggregates and bitumens by formulae and curves to find the correct amount and kind of bitumen to use in any desired mix. We have found that when we make one mixture with known proportions of bitumen and aggregate it is possible, by the use of our formulae, to predict voids and density relations for any proportion of the same bitumen and aggregate.

OTHER EXPERIMENTAL WORK

The possibilities of the stabilization of soils and aggregates have been recognized to such an extent that practically every state is working on this problem, either by laboratory investigation or by experimental test roads in the field. Producers of the various stabilizing mediums have advocated soil stabilization in particular. An example of the producer's part in this work might well be given here.

About two years ago South Carolina officials had the thought that Portland cement might be used to stabilize soils. Following up their idea they constructed an experimental test road in co-operation with the Portland Cement Association. From the results obtained with this road the Portland Cement Association believed themselves justified in following this work with a series of experimental tests in their Chicago laboratory. Their laboratory tests were so successful that they are promoting the installation of experimental test roads using Portland cement as a stabilizer in each of the different states.

Experimental work is also being done by other associations such as the Calcium Chloride Association, the Asphalt Institute, and the Tar Association. Each is anxious to promote the use of his own material and so a great deal of soil stabilization in the various state may be expected.

It must be remembered that aggregates other than soils can be stabilized. The testing laboratory has considerable data on gravel stabilization. It is now working on waste and by-product materials such as "red-dog," cinders, and the like, in order to develop new methods of processing materials for use in the construction of low-cost roads. Another task is the attempt to improve existing types of road pavements. The final test, however, for any type of pavement developed in the laboratory will be its actual construction in a test road and its observed behavior under traffic.

At some later date we wish to try the experiment of drilling into earth-slides and pumping bitumens in sufficient quantity under pressure to waterproof and stabilize these plastic earth masses. For raising sunken pavements also a grouting mixture of bitumen and a suitable soil, used in a mud-jack, might be found more satisfactory than the method now in use.

The Mathematics and Physics Section

BIRATIONAL TRANSFORMATIONS DETERMINED BY PENCILS OF QUADRICS AND A RATIONAL CURVE

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Introduction: Transformations associated with the complex of secants of special space curves have been studied by various writers.* The present paper gives a generalization of such non-involutorial transformations with respect to the order of the curve. The generalization here given is much restricted in that only quadrics are admitted as the defining pencils.

1. *The Straight Line:* Consider the two projective pencils of quadrics

(1) $|H(x)| = sH_1(x) - rH_2(x) = 0,$

(2) $|H'(x)| = sH_1'(x) - rH_2'(x) = 0,$

and the straight line

(3) $r_1 : x_3 = x_4 = 0.$

We shall impose the additional condition on (1) and (2) that, for each value of the parameter r/s, the resulting H(x) and H′(x) contain the point O(r, s, 0, 0) of r_1. This gives

(4) $H_1(x) = b_{12}\, x_1^2 + a_{33}\, x_3^2 + a_{44}\, x_4^2 + a_{12}\, x_1 x_2 + a_{13}\, x_1 x_3$
$\qquad + a_{14}\, x_1 x_4 + a_{23}\, x_2 x_3 + a_{24}\, x_2 x_4 + a_{34}\, x_3 x_4,$

(5) $H_2(x) = a_{12}\, x_2^2 + b_{33}\, x_3^2 + b_{44}\, x_4^2 + b_{12}\, x_1 x_2 + b_{13}\, x_1 x_3$
$\qquad + b_{14}\, x_1 x_4 + b_{23}\, x_2 x_3 + b_{24}\, x_2 x_4 + b_{34}\, x_3 x_4.$

The $H_1'(x)$ and $H_2'(x)$ are identical with (4) and (5) respectively, except that all coefficients are primed.

Through a generic point P(y) of space passes one H(x) of (1). The line through P(y) and the point O of r_1 associated with H(x) cuts the associated H′(x) in one residual point P′, image of P(y) in the T thus defined. The equations of T^{-1} are thus found to be:

$$(6) \quad T_6^{-1} : \left[\begin{array}{l} tx_1 = y_1 R_5 - K_4 H_1, \\ tx_2 = y_2 R_5 - K_4 H_2, \\ tx_3 = y_3 R_5, \\ tx_4 = y_4 R_5, \end{array} \right.$$

(7) $K_4 = H_2 H_1' - H_1 H_2',$

(8) $R_5 = H_2 H_1'(y, H) - H_1 H_2'(y, H),$

(9) $H_i = H_i(y), \qquad H_i' = H_i'(y), \qquad i = 1, 2,$

and the

(10) $H_1'(y, H) = 2b_{12}'\, y_1 H_1 + a_{12}'(y_1 H_2 + y_2 H_1) + a_{13}'\, y_3 H_1$
$\qquad + a_{14}'\, y_4 H_1 + a_{23}'\, y_3 H_2 + a_{24}'\, y_4 H_2$

is the polar of H_1' with respect to its associated $O(H_1, H_2, 0, 0)$.

The $H_2'(y, H)$ is analogous to (10).

Since each point of the C_4

(11) $[H(O), H'(O)] = C_4 : O$

is invariant, it generates, as O varies, the pointwise invariant surface $K_4 : r_1$.

The tangent plane of H′(O) at O intersects H(O) in a conic $C_2 : O$. If P

* See references.

is any point on C_2, PO is tangent to $H'(O)$ at O, and P′ is at O. Hence under T^{-1},

$$O \infty C_2 : O.$$

As O generates r_1, its image C_2 generates $R_5 : r_1$.

The base of $|H'(x)|$ is a quartic s_4' of genus 1. For any point Q′ on s_4', Q′O meets $H(O)$ in one point P whose image is Q′. As O describes r_1, P generates a curve C_x, image in T^{-1} of Q′.

Since one $H(O)$ passes through Q′, this Q′ is one position of P, and C_x cuts a line Q′O of pencil (Q′, r_1) in two points Q′, P, hence $x=2$, and, under T^{-1},

$$Q' \infty C_2 : Q'.$$

By means of (6) we find

$H_1' \infty H_1 S_{10}$ hence, under T^{-1},

(12) $s_4' \infty S_{10}$.

The tangent plane of $H(O)$ at O meets $H(O)$ in two generators g_1, g_2, each of which passes through O. Since g_1 (or g_2) meets $H'(O)$ in one residual point P_1' (or P_2'),

$$P_1' \infty g_1, \qquad P_2' \infty g_2.$$

As O describes r_1, the points P_1', P_2' generate a curve t_{10}', and g_1, g_2 generate a surface T_5.

The image of any point on t_{10}' is a bisecant of s_4 which meets r_1.

The equation of T_5 may be obtained by eliminating the parameters r, s between the equations of $H(O)$ and its tangent plane at O. This gives

(13) $T_5 = H_2\, H_1(y, H) - H_1\, H_2(y, H)$.

Through each point of r_1 passes two generators of T_5, hence r_1 is double on it. Each generator contains the point of which it is the image, hence T_5 contains t_{10}'. Since (13) is quadratic in H_1, H_2, their intersection s_4 is double on T_5.

Under the transformation T_6:

$$p \infty F_6' : r_1^2\, s_4'^2\, t_{10}',$$
$$K_4 \infty K_4 : r_1\, s_4\, s_4'\, t_{10}\, t_{10}',$$
$$r_1 \infty R_5' : r_1\, s_4'\, t_{10}',$$
$$s_4 \infty S_{10}' : r_1^2\, s_4'^2\, t_{10}',$$
$$t_{10} \infty T_5' : r_1^2\, s_4'^2\, t_{10}.$$

The jacobian of T_6 is:

$$J_{20} = R_5\, S_{10}\, T_5.$$

The T and its inverse T^{-1} are symmetric. To obtain the one from the other, merely interchange the primed and the unprimed symbols.

2. *The Conic:* Consider the two pencils of quadrics (1) and (2), and the conic

(14) $r_2 : x_1 x_3 - x_2^2 = 0, \qquad x_4 = 0.$

Impose the condition on (1) and (2) that, for each value of r/s, the corresponding $H(x)$ and $H'(x)$ each contains the associated point $O(r^2, rs, s^2, 0)$ of r_2. This gives:

(15) $H_1(x) = b_{12} x_1^2 + (b_{23} - a_{13}) x_2^2 + a_{44} x_4^2 + a_{12} x_1 x_2 + a_{13} x_1 x_3 + a_{14} x_1 x_4 + a_{23} x_2 x_3 + a_{24} x_2 x_4 + a_{34} x_3 x_4,$

(16) $H_2(x) = (a_{12} - b_{13}) x_2^2 + a_{23} x_3^2 + b_{44} x_4^2 + b_{12} x_1 x_2 + b_{13} x_1 x_3 + b_{14} x_1 x_4 + b_{23} x_2 x_3 + b_{24} x_2 x_4 + b_{34} x_3 x_4.$

The $H_1'(x)$ and $H_2'(x)$ are identical with (15) and (16) respectively, except that all coefficients are primed.

The equations of the resulting T_8^{-1}, obtained as in Section 1, are:

$$(17)\quad T_8^{-1}: \begin{bmatrix} tx_1 = y_1 R_7 - K_4 H_1^2, \\ tx_2 = y_2 R_7 - K_4 H_1 H_2, \\ tx_3 = y_3 R_7 - K_4 H_2^2, \\ tx_4 = y_4 R_7, \end{bmatrix}$$

$$(18)\quad K_4 = H_2 H_1' - H_1 H_2',$$

$$(19)\quad R_7 = H_2 H_1'(y, H) - H_1 H_2'(y, H).$$

The $H_1'(y, H)$ is the polar of $H_1(y)$ with respect to $O(H_1^2, H_1 H_2, H_2^2, 0)$.

Proceeding as in Section 1, we find:

$$p \sim F_8' : r_2^2 s_4'^3 t_{12}',$$
$$K_4 \sim K_4 : r_2 s_4 s_4' t_{12} t_{12}',$$
$$r_2 \sim R_7' : r_2 s_4'^3 t_{12}',$$
$$s_4 \sim S_{14}' : r_2^4 s_4'^5 t_{12}'^2,$$
$$t_{12} \sim T_7 : r_2^2 s_4'^3 t_{12},$$
$$J_{28} = R_7 S_{14} T_7.$$

3. *The General Case:* The T is defined by means of (1) and (2) and a rational space curve r_m of order m. The coordinates of a generic point $O(z_1, z_2, z_3, z_4)$ of r_m are homogeneous polynomials of degree m in r, s.

As before, each quadric of (1) and (2) must contain its associated point O. The equations of the T^{-1}, obtained as in the special cases, are:

$$(20)\quad T_{2m+4}^{-1}: \begin{bmatrix} tx_1 = y_1 R_{2m+3} - K_4 Z_1, \\ tx_2 = y_2 R_{2m+3} - K_4 Z_2, \\ tx_3 = y_3 R_{2m+3} - K_4 Z_3, \\ tx_4 = y_4 R_{2m+3} - K_4 Z_4, \end{bmatrix}$$

where the Z_i are the z_i of O with the r, s replaced by H_1, H_2.

$$(21)\quad R_{2m+3} = H_2 H_1'(y, Z) - H_1 H_2'(y, Z).$$

The $H_1'(y, Z)$ is the polar of $H_1'(y)$ with respect to $O(Z_1, Z_2, Z_3, Z_4)$.

Mathematical induction from the tables of Sections 1 and 2 gives:

$$p \sim F'_{2m+4} : r_m^2 s_4'^{m+1} t'_{2m+8},$$
$$K_4 \sim K_4 : r_m s_4 s_4' t_{2m+8} t'_{2m+8},$$
$$r_m \sim R'_{2m+3} : r_m s_4'^{m+1} t'_{2m+8},$$
$$s_4 \sim S'_{4m+6} : r_m^4 s_4'^{2m+1} t'_{2m+8},$$
$$t_{2m+8} \sim T'_{2m+3} : r_m^2 s_4'^{m+1} t_{2m+8},$$
$$J_{8m+12} \sim R_{2m+3} S_{4m+6} T_{2m+3}.$$

4. *Discussion:* Pieri[1] discusses a $T_{n+2n'-3,\, n'+2n-3}$ associated with the special complex of lines meeting a fixed line. One of the three methods he gives for defining this T is by means of two pencils of surfaces $|F_{n-1}|$ and $|F'_{n'-1}|$. The T_6 obtained by setting $n = n' = 3$ in Pieri's T is identical with the T_6 discussed in Section 1 of the present paper. The T_6 obtained by setting $n = n' = 3$ in the $T_{n+2n'-3,\, n'+2n-3}$ discussed by Davis[2] differs from the present T_6.

The T_8 of Section 2 does not appear in Pieri's[3] discussion of the transformations associated with a conic. He obtains, in general, a T_{12}.

Caldarera[4] discusses a T_{15} associated with the twisted cubic. The present authors[5] discuss a related T_{13} associated with the same curve. The T_{10} obtained by setting $m = 3$ in Section 3 is of course distinct from both of these.

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SOME SPECIAL HOMALOIDAL SYSTEMS IN N-SPACE

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1. It is the purpose of this paper to present a class of rational varieties in space of n dimensions and to construct some Homaloidal systems of these varieties. In space of three dimensions, a quadric surface may be defined as the locus of the single infinity of lines which meet three fixed lines. We shall present here a ruled variety in space of n dimensions of which the quadric surface is a special case. This variety will be of order n—1 and dimensions n—1. It will be defined as the locus of the (n—2)—fold infinity of lines which meet n given (n—2) flats. For a rational variety these flats can not be generic. We shall choose them in such a manner that the resulting variety shall contain an (n—2) flat as an (n—2)—fold locus. Segre[(1)] has discussed this variety synthetically in space of four dimensions and Eiesland[(2)] has found its equation. The variety in five dimensions and its mapping on a space of four dimensions has also been presented by the present writer[(3)].

2. *The equation of the Variety:* The most general variety in n-space of order (n—1) and dimensions (n—1) with the (n—2) flat

(1) $F \equiv y_1 = y_2 = 0$

as an (n—2)—fold locus can be written as

(2) $V \equiv y_1^{n-1} + y_1^{n-2} U_1 + y_1^{n-3} y_2 U_2 + y_1^{n-4} y_2^2 U_3 + \; . \; . \; . \; . \; + y_2^{n-2} U_{n-1} + y_2^{n-1} = 0$

where the U_i are homogenous linear expressions in y_i (i=3, 4, . . . n—1).

Subject this equation to the projective transformation

(3) $\varrho\, y_1^1 = y_1 \qquad \varrho\, y_3^1 = y_1 + U_1 \qquad \varrho\, y_{n+1}^1 = y_2 + U_{n-1}$

$\varrho\, y_2^1 = y_2 \qquad \varrho\, y_i^1 = U_{i-2} \qquad (i = 4, 5, \; . \; . \; . \; n)$

and the variety (2) becomes, dropping the accents,

(4) $V \equiv y_1^{n-2} y_3 + y_1^{n-3} y_2 y_4 + y_2^2 y_5 y_1^{n-4} + \; . \; . \; . \; . \; + y_2^{n-2} y_{n+1} = 0$

Cut this variety by an (n—1) flat through the multiple flat F

(5) $y_1 = k\, y_2$

$k^{n-2} y_3 + k^{n-3} y_4 + k^{n-4} y_5 + k^{n-5} y_6 + \; . \; . \; . \; . \; . \; . \; + k\, y_n + y_{n+1} = 0$

Thus *on this variety lies a single infinity of (n—1) flats; n—2 of these meet at each point of the multiple space.*

The 2(n—1)—fold infinity of lines in n-space are given by the (n—1) equations

(6) $a_i y_1 + b_i y_2 = y_i \qquad (i = 3, 4, \ldots\ldots n+1)$

Requiring that these lines meet an (n—2) flat imposes one linear condition on the parameters. If we require the line to meet n of the flats (5), we impose n linear conditions on the 2(n—1) parameters of (6). There results a system of (n—2) parameters. Elimination of these gives the locus satisfying the incidence conditions. But these lines meet n of the flats of the variety (4) and hence lie on it. Thus *the variety* (*4*) *is ruled*, its generators being given by the (n—1) equations in (n—2) parameters.

The (n—1) equations giving the generators furnish a method of writing the surface in determinant form. They may be regarded after the manner of Bertini[4], as equations of projective pencils of (n—1) flats which, for any given set of values of the parameters, define a point of the variety. Thus the variety can be generated by (n—1) linear systems of (n—1) flats.

An easy calculation shows that every point of the multiple space is (n—2)—spacial, the locus of the m-spacial points being given by the algebraic manifolds (composite when $n>5$) of m dimensions immersed in F. The variety possesses its maximum number of multiple points, and the dual variety is composite, consisting of quadric hypercones of (n—1) dimensions.

3. *Projection of V from a point of F.* Since F is (n—2)—fold and V is of order n—1, a line through a point O of this space meets the variety again in only one point P, and the line OP meets a fixed (n—1) flat in one point P′. Then the correspondence P to P′ thus established is (1, 1), a point of the (n—1) flat in general corresponding to a point of V. This mapping will carry V into the (n—1) flat and its inverse will carry the (n—1) flat into V.

Choosing O as the point (O, O, O, ... O, 1) and the image flat as

$$E \equiv y_1 + y_2 + y_3 + \ldots\ldots + y_{n+1} = 0$$

then the transformation is given by

$$\varrho\, x_1 = y_1 y_2^{n-3} y_1 \qquad \varrho\, x_i = y_i y_2^{n-3} y_1 \qquad (i = 3, 4, \ldots\ldots n)$$

$$\varrho\, x_2 = y_2^{n-2} y_1 \quad \varrho\, x_{n+1} = y_2^{n-2} y_{n+1} - y_2^{n-3} y_1 E + (y_1^{n-2} y_3 + \ldots\ldots + y_1^2 y_2^{n-4} y_{n-1})$$

and the inverse transformation is

$$\sigma\, y_i = x_i x_2^{n-2} \qquad (i = 1, 2, 3, \ldots\ldots n)$$

$$\sigma\, y_{n+1} = x_2^{n-3} x_1 x_{n+1} + x_2^{n-3} x_1 E - (x_1^{n-2} x_3 + \ldots\ldots + x_1^2 x_2^{n-4} x_{n-1})$$

the quantity in parenthesis in the two equations above being the equation of V less the last two terms.

In $S_n(y)$ the general homaloid contains the flat F to a multiplicity (n—2) and also contains two other flats $y_1 = y_{n+1} = 0$ and $y_2 = y_3 = 0$. At the point O the varieties touch $y_2 = 0$ n—2 times. In $S_n(x)$ the F-system of the inverse transformation consists of the multiple flat F and the flat $x_2 = x_3 = 0$. The system satifies a rather complicated contact condition. All the varieties of the system touch $x_j = 0$ i—2 times along an (n—i) flat given by the i equations $x_j = 0$, $(j = 1, 2, 3, \ldots\ldots i)$ $3 \leq i \leq n-1$, and in addition the varieties touch $x_2 = 0$ n—3 times and $x_1 = 0$ once at O′. The first Jacobian of the system is

$$J = x_1 x_2^h$$

when $h = n^2 - n - 3$.

4. *A Second Projection of V upon an* (*n—1*) *flat:* If in the above type of projection we choose the image flat as one of those flats which cut V in an (n—2) flat, the equations of the transformation are changed. For example, let up map upon the flat $y_1 - y_{n+1} = 0$ by lines through O as before. The equations of T are found to be

$\varrho\, x_i = y_i\, y_1^{n-3}\, y_3 \qquad (i=1, 2, 3, \ldots\ldots n)$

$\varrho\, x_{n+1} = -y\,(y_1^{n-3}\, y_4 + y_2\, y_5\, y_1^{n-4} + \ldots\ldots\ldots + y_2^{n-3}\, y_{n+1})$

and the inverse

$\sigma\, y_i = x_i\, x_2^{n-2} \qquad (i=1, 2, 3, 4, \ldots\ldots n)$

$\sigma\, y_{n+1} = -x_1^{n-3}\, x_3\, x_{n+1} - V + x_1^{n-2}\, x_3 + x_2^{n-2}\, x_{n+1}$

The F-system in $S_n(y)$ is a composite variety of $(n-2)$ dimensions and order n^2-3n+2 consisting of F counted n^2-5n+6 times, the image flat counted $n-3$ times, the flat $y_2=y_3=0$ counted once, and the variety

$y_3 = y_4\, y_1^{n-3} + \ldots\ldots + y_{n+1}\, y_2^{n-3} = 0$

In addition the system satisfies the following contact conditions. At the point O_{n-1} the $n-2$ tangent flats all coincide with $y_2=0$. In the multiple space $n-3$ tangent flats along the line determined by O_3 and O_4 coincide with $y_1=0$; $n-4$ tangent flats at points of the plane $O_3\, O_4\, O_5$ coincide with $y_1=0$ and so on. The first Jacobian of the system is now

$J = (n-1)\, x_1^{n-3}\, x_2^{n(n-2)}\, x_3$

5. *An Involution Associated with V:* The simple quadratic involution in S_3, whose homaloid is of this form, may be written

$a_1\, y_2^2 + a_2\, y_1\, y_2 + a_3\, y_1\, y_3 + a_4\, y_2\, y_4 = 0$

From analogy we may write in S_n the equation of V as

$a_1\, y_2^2\, y_1^{n-3} + a_2\, y_2\, y_1^{n-2} + a_3\, y_1^{n-2}\, y_3 + a_4\, y_1^{n-3}\, y_2\, y_4 + a_5\, y_1^{n-4}\, y_2^2\, y_5$

$+ a_6\, y_6\, y_1^{n-5}\, y_2^3 + \ldots\ldots\ldots + a_i\, y_1^{n+1-i}\, y_2^{i-3}\, y_i + \ldots\ldots\ldots + a_{n+1}\, y_2^{n-2}\, y_{n+1} = 0$

The variety has been subjected to the following conditions. It contains two fixed flats, in addition to F, that is $y_2=y_3=0$ and $y_1=y_{n+1}=0$. It has an $(n-2)$—fold contact at a point, an $(n-3)$—fold contact along a line, and so forth, and finally a simple contact in an $(n-4)$ flat. These contact elements are all incident. Under the transformation a general flat is carried into V, and V is carried back to the flat, shedding the factor $x_1 (n-1)^2$ times and $x_2 (2n-4)$ times. The first Jacobian is

$J = (1-n)\, x^h\, x^s$

where $h = \frac{1}{2}(n^2+n-10)$ and $s = \frac{1}{2}(n^2-3n+6)$.

x_1 corresponds to $n-2$ incident F-elements of dimensions O to $(n-4)$, lying in the space $y_2=y_3=0$, which itself corresponds to x_1. Hence x_1 answers $(n-2)$ times for the contact elements, $\frac{1}{2}(n^2-5n+6)$ times for their incidence, and $2n-6$ times for the contact conditions.

6. *A Second Type of I in n-Space:* The symmetry that exists among the variables in even space may be preserved in extending the involution given above in 3-space. We let y_1 and y_2 enter into the conditions in the same way. Let the variety contain two simple flats besides F and let the contact elements lie symmetrically in the intersections of these flats with F. Other rather obvious conditions must also be imposed, but it is not necessary to present them here, as we are interested in the homaloidal system which we might just as well find purely from analogy. In even space the transformation can be written, putting $n=2m$,

$\varrho\, x_1 = y_1^{m-1}\, y_2^m, \qquad \varrho\, x_2 = y_1^m\, y_2^{m-1}$

$\varrho\, x_3 = y_3\, y_1^m\, y_2^{m-2}, \qquad \varrho\, x_4 = y_4\, y_1^{m-1}\, y^{m-1}$

$\varrho\, x_5 = y_5\, y_1^{m-2}\, y_2^m, \qquad \varrho\, x_6 = y_6\, y_1^{m+1}\, y_2^{m-3}$

$\ldots\ldots\ldots\ldots \qquad \ldots\ldots\ldots$

$\varrho\, x_{2l-1} = y_{2l-1}\, y_1^{m-l+1}\, y_2^{m+l-3}, \qquad \varrho\, x_{2l} = y_{2l}\, y_1^{m+l-2}\, y_2^{m-l}$

$\ldots\ldots\ldots\ldots \qquad \ldots\ldots\ldots\ldots$

The Jacobian of this transformation is

$$J = (1-n)x^h x^h$$

where $h = \frac{1}{2}(n-2)(n+1)$.

In odd space the transformation satisfying similar conditions, of which the quadratic involution is a case, is given by, putting $n = 2m-1$

$$\varrho x_1 = y_1^{m-2} y_2^m, \qquad \varrho x_2 = y_2 y_1^{m-1} y_2^{m-2}$$

$$\varrho x_3 = y_3 y_1^{m-1} y^{m-1}, \qquad \varrho x_4 = y_4 y_1^{m-2} y_2^{m-1}$$

$$\varrho x_5 = y_5 y_1^{m-3} y^m, \qquad \varrho x_6 = y_6 y_1^m y_2^{m-3}$$

$$\cdots\cdots\cdots \qquad \cdots\cdots\cdots$$

$$\varrho x_{2i-1} = y_{2i-1} y_1^{m-i} y_2^{m+i-3}, \qquad \varrho x_{2i} = y_{2i} y_1^{m+i-3} y_2^{m-i}$$

$$\cdots\cdots\cdots \qquad \cdots\cdots\cdots$$

and the Jacobian of this transformation is

$$J = (1+n)x^h x^s$$

where $h = \frac{1}{2}(n^2-n-4)$ and $s = n(n-1)$.

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THE PROJECTIVE FORM OF THE STROPHOIDAL CORRESPONDENCE

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1. Methods of defining and constructing strophoidal cubics have been many and varied. A strophoid is the non-linear part of the locus of a point P whence two fixed segments OA and OA′ are seen in equal or in supplementary angles. It might also be defined as the locus of the foot of a perpendicular drawn from a fixed point to a tangent to a fixed parabola. A well known construction is the following: Given a focus F, a pole O, and a line L through O, then for an arbitrary point K on L draw the circle with center at K and radius KO. Cut this circle in diamerically opposite points P and P′ by the diameter KF. As K traces L, the points P and P′ trace the strophoid.

This construction may be regarded as setting up a correspondence between each point K of the plane and a point pair P, P′. As K is allowed to trace a locus L, the points P, P′ trace a corresponding locus S, called the strophoidal curve of L. If L is of order n then S will be in general of order 3n. The correspondence was discussed by Barbarin[1], who found some of the elementary properties. Later Longchamps[2] discussed the construction of the tangents. In this paper it is proposed to set up the projective form for the correspondence as an aid to a further study of the curves.

2. The circle proper to each point K is a conic through three fixed points, the arbitrary point O, and the two circular points I and J at infinity. It is

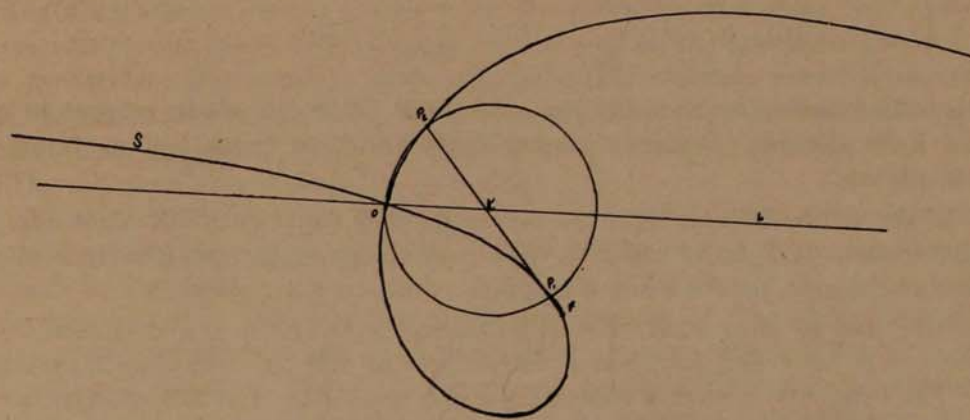

Figure 1

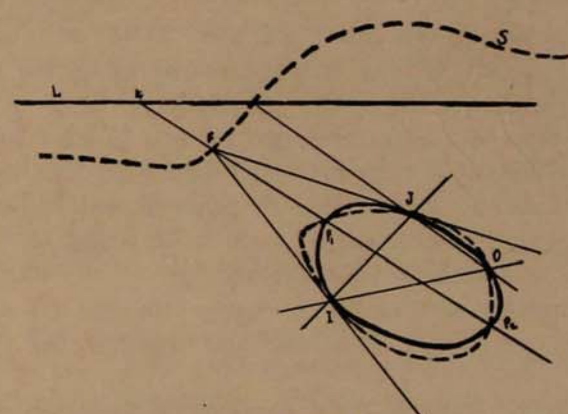

Figure 2

also noted that the tangents to the conic from I and J meet at the point K. Let the points O, I, J, be chosen as the vertices of the reference triangle, O, O′, O″. Then each point K of the plane will determine one conic on this triangle, for which KO and KO′ are tangents. This conic is cut by KF in two points P and P′ which correspond to K.

Now if we put $O=(1:0:0)$, $O'=(0:1:0)$, $O''=(0:0:1)$ any conic through O, O′, O″ is of the form

$$a_1 x_2 x_3 + a_2 x_3 x_1 + a_3 x_1 x_2 = 0$$

Now let $(y_1 : y_2 : y_3)$ be the coordinates of the generic point K. Since KO and KO′ are tangents to the conic, K is the pole of the line OO′. Then the conic corresponding to K is

$$y_1 x_2 x_3 + y_2 x_3 x_1 - y_3 x_1 x_2 = 0$$

Now if we take the coordinates of F as $(b_1 : b_2 : b_3)$ the line KF is

$$y_1 \begin{vmatrix} x_2, & x_3 \\ b_2, & b_3 \end{vmatrix} + y_2 \begin{vmatrix} x_3, & x_1 \\ b_3, & b_1 \end{vmatrix} + y_3 \begin{vmatrix} x_1, & x_2 \\ b_1, & b_2 \end{vmatrix} = 0$$

Solving the last two equations above for y_1, y_2, y_3 :

$$\varrho y_1 = x_1^2 (x_3 b_2 - x_2 b_3)$$

$$\varrho y_2 = x_2^2 (x_3 b_1 - x_1 b_3)$$

$$\varrho y_3 = x_1 x_3 (x_3 b_2 - x_2 b_3) + x_2 x_3 (x_3 b_1 - x_1 b_3)$$

These equations may be simplified by choosing F as the unit point $(1 : 1 : 1)$

$$\rho y_1 = x_1^2 (x_3 - x_2)$$
$$\rho y_2 = x_2^2 (x_3 - x_1)$$
$$\rho y_3 = x_1 x_3 (x_3 - x_2) + x_2 x_3 (x_3 - x_1)$$

These equations allow us to study the locus of P, P′ in the x's in respect to the locus of K in the y's. We may conveniently think of these loci as lying in different planes.

3. If the point K be on FO, the corresponding conic cuts FK at O and at one other point. If L be of order n, then S has a point of multiplicity n at O. For similar reasons, points I and J are also points of multiplicity n.

Let OF and IJ meet at H. Let E be harmonic to H for F and O, and D be harmonic to H for I and J. Then H is the pole of ED for every conic through OIJF. The tangents to such a conic at I and J meet ED. Let ED cut the curve L at K; then the corresponding conic cuts FK at F and at one other point. Thus F is a point of multiplicity n.

A general line through F will cut S at 2n points and n times at F. Thus S is seen to be of order 3n.

Each point K on FO gives O and one other point R. When K is at O, then R is also at O. Thus the multiplicity of O on S increases by unity for each time L passes throughO. For similar reasons the multiplicity of I or of J is increased by unity for each time L passes through such a point. Let L pass through F. The conic is determined as tangent to FI and FJ. F is the pole of IJ. The line KF is indeterminant. Every line through F will now cut this conic in two points Q and R which are harmonic to F (=K) and IJ. Thus the S curve consists of this conic and a curve of order 3n—2.

If F be a point of multiplicity r, then L, the conic through OI and J and tangent to FI and FJ, is r times a part of S, and the order of the remainder of S is then 3n—2r.

Let ED cut FI at K′. As K′ is on ED the corresponding conic must pass through F; and since K′ is on FJ, the conic is tangent to FI at I. Therefore it is degenerate, consisting of the lines FI and OJ. Each pair of points on FI which are harmonic to K′ and I satisfy the requirements for R and Q. Thus when L passes through K′, S degenerates into the line FI and a curve of order 3n—1. In general then, for each time the L curve passes through the intersection of FI and ED (or of FJ and ED), the order of S is reduced by unity.

Let L cut OI at K and let K′ be a neighboring point of L. The conic for K′ is tangent to K′I and K′J. When K′ comes to coincidence with K, then KI and KJ are tangents at I and J, and the conic still passes through O. It degenerates then into the two lines OI and KJ and cuts FK in two coincident points at K. This FK is a tangent. It can not be a double point, for S already cuts OI in 2n points at O and I, and there is a K point for each of the n points where L cuts OI. For similar reasons, S passes simply through each of the simple points where L cuts OJ simply, but S is tangent to FK at each such point.

As K and IJ are pole and polar for each conic when K lies on IJ, the conic consists of IJ and KO and cuts KF in two coincident points at K. Each is a simple point, for IJ already cuts S in 2n points at I and J.

If K is the point of contact of FK with L, then R and Q coincide and FK is a double tangent to S. Let L possess a double point D not lying at F, O, I, or J. As the ray through F approaches D, its intersections, K′ and K″, with L approach coincidence; and simultaneously Q′ and Q″ and R′ and R″ approach coincidence in the pairs as written. As the sequences of intersections of the ray with L are continuous through D, we find two double points on FD in general. If FD be one of the nodal tangents at D, then FD is a nodal tangent at Q and at R on FD. If D be an acnode, then FD possesses acnodes at Q and R. In case D is a cusp, the sequence of points K′ and K″ of the ray ends after the ray passes FD; and so we have cusps at Q and R.

Let KF cut IJ at C, OJ at A and OI at B. As K and IJ are pole and polar for the conic on OIJ that corresponds to K, the points K and C are harmonic with respect to the points in which the conic cuts FK. Again A and B are conjugate points for the intersections of FK and the conic. This follows from the theorem: If a triangle be inscribed in a conic, any line through the pole of one side cuts the other two sides in conjugate points. Thus by the act of drawing FK we can obtain two pairs, C, K and A, B, which determine on FK an involution whose double points are the intersections of the conic with that line. To construct these double points, we find the double lines of the radial involution O(AB, CK). Except when the lines come too close together, the circle circumscribed to OIJ can be used.

Figure 1 below shows the cubic curve S corresponding to a line L taken in general position. The I and J points are at infinity, giving the strophoid in the customary form.

Figure 2 shows the projective form of the correspondence, the line L and its companion conic are shown with heavy solid lines, while the corresponding strophoid S is the dotted curve.

4. The equations at the end of section 2 are linearly independent, for their Jacobian

$$6\, x_1 x_2 (x_3 - x_1)\ (x_3 - x_2)\ (x_1 x_3 + x_2 x_3 - x_1 x_2)$$

is not identically zero. When the coordinates of a point $(x_1 : x_2 : x_3)$ are given, the coordinates of a unique point $(y_1 : y_2 : y_3)$ can be calculated. On the other hand, when the equation of a locus in the y's is given, the equation of the corresponding locus in the x's is found at once by substitution. If the y-locus is of order n, then the x-locus is of order 3n. Thinking of the two loci as lying in different planes, let us refer to the plane of the x's as the plane E_x and the plane of the y's as E_y.

Each line in E_y

(1) $a_1 y_1 + a_2 y_2 + a_3 y_3 = 0$

corresponds to the cubic curve in E_x whose equation is

(2) $a_1 x_1^2 (x_3 - x_2) + a_2 x_2^2 (x_3 - x_1) + a_3 x_1 x_3 (x_3 - x_2 + a_3 x_2 x_3 (x_3 - x_1) = 0$

The several partial derivatives of the expression (2) are

$$2a_1 x_1 (x_3 - x_2) - a_2 x_2^2 + a_3 x_3 (x_3 - 2x_2),$$
$$-a_1 x_1^2 + 2a_2 x_2 (x_3 - x_1) + a_3 x_3 (x_3 - 2x_1),$$
$$a_1 x_1^2 + a_2 x_2^2 + 2a_3 (x_1 x_3 + x_2 x_3 - x_1 x_2).$$

It is easy to show that the cubic passes through $F = (1 : 1 : 1)$ and is tangent to $x_3 - x_2 = 0$ or OF at $O = (1 : 0 : 0)$, to $x_3 - x_1 = 0$ or O′F at $O' = (0 : 1 : 0)$, and also to $x_1 + x_2 = 0$ at $O'' = (0 : 0 : 1)$. Thus any two distinct cubics intersect in two points P and P′ besides those already named. As these two cubics in Ex correspond to two lines in Ey which meet in a point Py, then to each point Py there corresponds two points P and P′ in the plane Ex. To the net of lines in the y-plane there corresponds the net of cubics on O, O′, O″, each counted twice, and on F; each pencil in the net of lines corresponds to a pencil in the net of curves. The point correspondence is 1 to 2 from Ey to Ex.

5. It has appeared that the points of the plane Ex are paired under the correspondence. We will now determine the analytic relation. If the equations of the correspondence be solved for the x's in terms of the y's we get

$$x_1^2 : x_2^2 = y_1(y_3-y_1) : y_2(y_3-y_2)$$

$$x_3 = \frac{y_3 x_1 y_2}{x_2 y_1 + x_1 y_2}$$

The first of these equations gives two values of the ratio $x_1 : x_2$ which differ only in sign, while the second equation gives the corresponding ratio $x_3 : x_2$. Moreover, it is evident from the first that P and P′ lie harmonically with respect to the lines OO″ and O′O″. With these facts it is only a matter of algebra to show that P and P′ are collinear with F. If the coordinates of P be taken as $(x_1 : x_2 : x_3)$ then those of the companion point P′ are

$$x_1' : x_2' : x_3' = x_1(x_1-x_2) : x_2(x_2-x_1) : x_1(x_3-x_2)+x_2(x_3-x_1).$$

P and P′ correspond in this quadratic involution whose pole is F. The base conic is the line pair OO″, O′O″. The cubics of the correspondence are the isologous curves of this quadratic involution.

For special points in Ex the values of y in the correspondence become indeterminant, and for certain loci L on Ey the corresponding loci S are degenerate. The Jacobian of the correspondence set equal to zero is

$$x_1 x_2(x_3-x_1)(x_3-x_2)(x_1 x_3+x_2 x_3-x_1 x_2)=0$$

When P is on one of the component curves of this set, the equations of the correspondence are dependent, and the solutions are not uniquely 1 to 2.

For every point P of the conic

$$x_1 x_3+x_2 x_3-x_1 x_2=0$$

we find that the corresponding y-point is $(1 : 1 : 1)$. On the other hand, any line through $(1 : 1 : 1)$ in the x-plane goes over into a line and the above conic. Thus the conic is the transform of the point $(1 : 1 : 1)$. If L passes r times through this point, with distinct tangents, then S will pass r times through F with distinct tangents, and will contain the conic r times as a redundant factor.

For every point K on $x_3-x_1=0$ the corresponding point D is $D=(1 : 0 : 1)$, so that D corresponds to the whole line. Likewise $E=(0 : 1 : 1)$ corresponds to the whole line $x_3-x_2=0$.

Let OO′ meet O″F at H. Then DE whose equation is $y_1+y_2-y_3=0$ cuts OO′ and O″F harmonically with respect to H. The line DE corresponds to the triangle of lines

$$(x_3-x_1)(x_3-x_2)(x_3+x_2)=0$$

6. As the point K traces the curve L of order n, the points P and P′ trace the curve S or order 3n. S may be prime, or it may be composite, consisting of curves of orders $n_1, n_2, \ldots n_r$ such that

$$n_1+n_2+n_3+\ldots\ldots+n_r=3n$$

The point K corresponds not only to P but also to P′. Now S may be such that for each point P it contains also its companion point P′. This means that S is invariant under the quadratic involution given in the last section.

The L curve can easily be constructed for a given S. Let P be a point of S. Construct with respect to O″O, O″O′ the harmonic conjugate of O″P to cut FP in P′. Let FPP′ cut OO′ in G; then K is harmonic to G for P, P′. As P traces S, P′ traces S′ and K traces L. S and S′ are companion curves, the sum of whose orders is 3n; unless S is invariant under the quadratic involution already mentioned. This will not generally be the case. Generally for every curve S there is a companion curve S′, both giving the same curve L, and each is the transform of the other under the quadratic involution. Then S is its own companion, or it has a distinct companion whose order is twice that of S, and which passes through O″ and F. As a product of the strophoidal correspondence, every curve S is to be regarded as consisting of itself and of its transform under the quadratic involution.

An arbitrary line in Ex is

$$S = a\,x_1 + b\,x_2 + c\,x_3 = 0$$

and its companion conic is

$$S^1 = a\,x_1(x_1 - x_2) + b\,x_2(x_2 - x_1) + c\,x_3(x_1 + x_2) - 2c\,x_1\,x_2 = 0$$

The product of the two equations gives the curve which is the transform of some curve in Ey. The equation of this product can be reduced to

$$a^2\,x_1^2(x^1 - x_2) - b^2\,x_2^2(x_1 - x_2) + 2ac\,x_1^2(x_3 - x_2) + 2bc\,x_2^2(x_3 - x_1)$$
$$+ c^2\,x_1\,x_3(x_3 - x_2) + c^2\,x_2\,x_3(x_3 - x_1) = 0$$

To find the corresponding curve L we note that

$$\varrho(y_3 - y_2) = (x_3 - x_2)\ (x_3\,x_1 + x_2\,x_3 - x_1\,x_2)$$
$$\varrho(y_3 - y_1) = (x_3 - x_1)\ (x_3\,x_1 + x_2\,x_3 - x_1\,x_2)$$
$$\varrho(y_1 - y_2) = (x_1 - x_2)\ (x_3\,x_1 + x_2\,x_3 - x_1\,x_2)$$

Multiplying the above product by $(x_3 - x_2)\ (x_3 - x_1)\ (x_3\,x_1 + x_2\,x_3 - x_1\,x_2)^2$ the transformed equation is

$$L = a^2\,y_1(y_3 - y_1)\ (y_1 - y_2) - b^2\,y_2(y_3 - y_2)\ (y_1 - y_2)$$
$$+ (y_3 - y_2)\ (y_3 - y_1)\ (2acy_1 + 2bcy_2 + c^2\,y_3) = 0$$

This is the initial cubic which, under the strophoidal transformation, gives the composite curve of order n consisting of (i) the desired line, (ii) its companion conic, (iii) the conic $x_3\,x_1 + x_2\,x_3 - x_1\,x_2 = 0$ counted twice, and (iv) the two lines $x_3 - x_1 = 0$, $x_3 - x_2 = 0$. When a curve passes through the focus F the Jacobian conic (iii) is always a complementary part, once for each branch through F. Evidently the above cubic has a node at F. And since the cubic above passes through D and E, the two Jacobian lines (iv) are accounted for.

Thus the arbitrary line in Ex is a part of the transform of the cubic in Ey which has a node at F and passes through D and E. We now proceed to find the conditions on such a cubic that it gives a line as a part of its transform.

The general cubic curve transforms into a curve of order nine, with triple points at F, O, O′, and O″. If the cubic have a node at (1 : 1 : 1) then this curve of the ninth order degenerates into the Jacobian conic counted twice and a curve of the fifth order. This will further degenerate if the original cubic is required to pass through D and E. Writing the general cubic in the form

$$y_1\,y_2\,y_3 + y_1^2(l_1\,y_1 + m_1\,y_2 + n_1\,y_3) + y_2^2(l_2\,y_1 + m_2\,y_2 + n_2\,y_3)$$
$$+ y_3^2(l_3\,y_1 + m_3\,y_2 + n_3\,y_3) = 0$$

and imposing the conditions above, the transformed equation is

$$x_3[x_1(x_3 - x_2) + x_2(x_3 - x_1)]\ (1 + m_1 + l_2) + (x_3 - x_1)\ (l_1\,x_1^2 + l_2\,x_2^2)$$
$$+ (x_3 - x_2)\ (m_1\,x_1^2 + m_2\,x_2^2) = 0$$

To find the conditions under which this cubic degenerates into a line and its companion conic, we may compare coefficients in this equation with those of the product of a line and conic given above. It has been found easier to compare coefficients of their L curves, cubics in Ey. These conditions take the form

$$a : b : c = (m_1 + l_1) : (l_2 + m_2) : 2(1 + m_1 + l_2).$$

[1] Barbarin, "Curbes Strophoidales," Revue de Mathematiques Speciales, II, pp. 298-299 (1892-1894).

[2] "Sur les Strophoidales," Mathesis (2) IV, p. 138 (1894).

NOTES ON THE CHARACTERISTIC AND ASYMPTOTIC LINES OF A SURFACE AND ITS SPHERICAL IMAGE

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1. *Introduction:* In a recent issue of the Mathematical Monthly there appeared a problem[3] proposed by A. D. Wallace, dealing with a certain relationship between the total curvature of a surface along a characteristic line and the arc lengths on the surface and its spherical image. Becoming interested, the author has found a number of relationships between various properties of a surface and its spherical image along the characteristic, asymptotic and minimal lines, and the arc lengths. It is the purpose of this paper to present the original problem in an extended form and to discuss several of the more interesting relationships which, so far as can be ascertained, are new.

2. The equation of the characteristic lines of a surface, when referred to any lines whatever as parametric, is[2]

$$[D(GD-ED'')-2D'(FD-ED')]du^2+2[D'(GD+ED'')-2FDD'']dudv$$
$$+[2D'(GD'-FD'')-D''(GD-ED'')]dv^2=0.$$

Let us refer the surface to the lines of curvature as parametric. The necessary and sufficient condition that this be true is that

$$F=D'=0.$$

Referred to these lines, the equation of the characteristic lines becomes

$$D''=D\frac{du^2}{dv^2} \qquad (1)$$

Making use of relationship (1) the total curvature of the surface along a characteristic line is found to be

$$K(c)=\frac{DD''-D'^2}{H^2}=\frac{D^2\,du^2}{EGdv^2}$$

The square of the ratio of the arc length on the spherical image to the arc length on the surface is, when referred to the lines of curvature, given by

$$\left(\frac{d\sigma}{ds}\right)^2=\frac{\mathcal{E}du^2+\mathcal{G}dv^2}{Edu^2+Gdv^2}$$

For a point on the characteristic line

$$\mathcal{E}=\frac{1}{H^2}\left[GD^2-2FDD'+ED'^2\right]=\frac{D^2}{E}$$

$$\mathcal{G}=\frac{1}{H^2}\left[GD'^2-2FD'D''+ED''^2\right]=\frac{D^2}{G}\left(\frac{du^2}{dv^2}\right)^2$$

and the ratio becomes

$$\left(\frac{d\sigma}{ds}\right)^2=\frac{D^2\,du^2}{EGdv^2}=K(c)$$

Again, the equation defining the asymptotic lines of a surface

$$Ddu^2+2D'dudv+D''dv^2=0$$

becomes

$$D'' = -D\frac{du^2}{dv^2} \qquad (2)$$

when referred to the lines of curvature. Making use of this relationship in the same manner as was done above we find

$$K(a) = -\frac{D^2\,du^2}{EGdv^2} \quad \text{and} \quad \left(\frac{d\sigma}{ds}\right)^2 = \frac{D^2\,du^2}{EGdv^2}$$

We have thus established the

THEOREM: The total curvature of a surface along a characteristic line is equal to the square of the ratio of the arc length on the spherical image to the arc length on the surface. Along an asymptotic line the total curvature is minus the square of this ratio.

Incidentally, we note that the curvature along a characteristic line and an asymptotic line differs only in sign.

3. Again using the lines of curvature as parametric, let us calculate the radii of geodesic torsion of the characteristic and asymptotic lines. For characteristic lines we have, using (1),

$$T(c) = \frac{\sqrt{EG}\,(Edu^2 + Gdv^2)\,dv^2}{D\,(Gdv^2 - Edu^2)}$$

and for asymptotic lines, using (2),

$$T(a) = \frac{\sqrt{EG}\,(Edu^2 + Gdv^2)\,dv^2}{D\,(Gdv^2 + Edu^2)}$$

The ratio of these radii of geodesic torsion is then

$$\frac{T(c)}{T(a)} = \frac{Gdv^2 + Edu^2}{Gdv^2 - Edu^2}$$

The mean curvature of the surface along these lines is then found. For characteristic lines this is

$$K_m(c) = \frac{D\,(Gdv^2 - Edu^2)}{EGdv^2}$$

and along an asymptotic line it is

$$K_m(a) = \frac{D\,(Gdv^2 - Edu^2)}{EGdv^2}$$

The ratio of the mean curvatures along these lines is seen to be

$$\frac{K_m(c)}{K_m(a)} = \frac{Gdv^2 + Edu^2}{Gdv^2 - Edu^2} = \frac{T(c)}{T(a)}$$

thus proving the

THEOREM: The ratio of the mean curvature of a surface along a characteristic line to that along an asymptotic line is equal to the ratio of their radii of geodesic torsion to within sign.

4. We have previously found the mean curvature of a surface along a characteristic line to be

$$K_m(c) = \frac{D\,(Edu^2 + Gdv^2)}{EGdv^2}.$$

Referred to the lines of curvature as parametric, the radius of normal curvature of the surface along a characteristic line is

$$R(c) = \frac{Edu^2 + Gdv^2}{2Ddu^2}.$$

The ratio of these quantities is then

$$\frac{K_m(c)}{R(c)} = \frac{2D^2\, du^2}{EGdv^2} = 2K(c)$$

thereby demonstrating the

THEOREM: The ratio of the mean curvature of a surface to its radius of normal curvature, taken along a characteristic line, is equal to twice the total curvature along that line.

5. The minimal curves

$$Edu^2 + 2Fdudv + Gdv^2 = 0$$

of a surface, when referred to the lines of curvature as parametric, become

$$G = -E\frac{du^2}{dv^2}.$$

The square of the arc length of these curves on the spherical image of the surface is

$$d\sigma^2 = \frac{E(D''^2\, dv^4 - D^2\, du^4)}{EGdv^2}$$

while the mean curvature of the surface itself along these curves is

$$K_m(m) = \frac{E(D''dv^2 - Ddu^2)}{EGdv^2}.$$

The ratio of these two quantities is

$$\frac{d\sigma^2}{K_m(m)} = Ddu^2 + D''dv^2$$

and there follows the

THEOREM: The ratio of the square of the arc length on the spherical image of the minimal curves of a surface to the mean curvature of the surface itself along these lines when equated to zero defines the asymptotic lines of the surface.

6. The Casorati curvature[1]

$$K_c = \frac{1}{2}\left(\frac{1}{\varrho_1^2} + \frac{1}{\varrho_2^2}\right)$$

when referred to the lines of curvature as parametric is

$$K_c = \frac{1}{2}\left(\frac{D^2\, G^2 + D''^2\, E^2}{E^2\, G^2}\right).$$

Using relationships (1) and (2) it is found that the Casorati curvature of a surface along both the characteristic and the asymptotic lines is

$$K_c(c, a) = \frac{D^2(E^2\, du^4 + G^2\, dv^4)}{2E^2\, G^2\, dv^4}.$$

We have previously calculated (paragraph 3) the value of the mean curvature of a surface along these lines. Squaring these values and adding we obtain

$$K_m^2(c) + K_m^2(a) = \frac{2D^2(E^2\, du^4 + G^2\, dv^4)}{E^2\, G^2\, dv^4} = 4K_c(c, a)$$

giving us the

THEOREM: The sum of the squares of the mean curvatures of a surface along a characteristic and an asymptotic line is the Casorati curvature of the surface along either line multiplied by 4.

(1) Casorati, 1890. Acta Mathematica, 14, p. 95.

(2) Eisenhart, A Treatise on the Differential Geometry of Curves and Surfaces, Ginn, 1909, p. 131.

(3) Wallace, A. D. 1936. Problems, American Mathematical Monthly, 43: p. 190.

FLAT SPREAD-SPHERE GEOMETRY IN NON-EUCLIDEAN N-SPACE

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1. In a former paper by the author[1] a development of flat spread-sphere geometry in non-Euclidean odd dimensional space was discussed. As this present paper is chiefly concerned with the intersection of flats of the same set which are tangent to the absolute surface and the corresponding relations in an image space of the same dimensions, only so much of the above mentioned development as will serve our purpose will be given in section II.

II. We take the quadric (1) $\Sigma x_i y_i = 0$, $i = 1, 2, \ldots, n/2$, as the absolute in a space $\overline{S}_{n-1}$ of odd dimensions, and find the representation of configurations of that space in an image space S_{n-1} with homogeneous coördinates $\vee_i$, S_i.

We have two sets of ∞^{n-1} self dual flats of $\frac{n-2}{2}$-dimensions in $\overline{S}_{n-1}$ which are tangent flats to (1), each set having contact with it along an $\frac{n-4}{2}$-flat. The equations of these flats are

$$(2)\quad X.\begin{cases} \vee_m^2 x_i + (\vee_i \vee_m + S_i S_m) X_m + S_i \Sigma S_k y_k = 0 \\ \vee_m^2 y_m + S_m^2 X_m - \Sigma y_k (\vee_k \vee_m - S_k S_m) = 0, \quad i = \ , 2, \ldots, \frac{n-2}{2}, \ m = n/2 \end{cases}$$

and the flats Y obtained by making the following substitutions in (2):

$$\begin{array}{cccccccc} -y_i & -x_i & X_m & y_m & S_i^1 & \vee_i^1 & S_m^1 & \vee_m^1 \\ x_i & y_i & X_m & y_m & \vee_i & S_i & \vee_m & S_m \end{array}$$

By an orientation process[2] we may cover the two tangent complexes of the absolute by two sheets, with the generating flats of this surface as the branch manifold.

In the image space we have, corresponding to these oriented tangent flats, points which are harmonically separated by the coördinate flats $(\vee_i : O)$ and $(O : S_i)$.

We write (2) in the form:

$$(3)\quad P.\begin{cases} x_m \vee_i + X_i \vee_m - Z S_i = 0 \\ x_m S_m + \Sigma y_i S_i + Z \vee_m = 0 \\ Z S_m + \Sigma y_i \vee_i - y_m \vee_m = 0 \end{cases} \qquad i = \ , 2, \ldots, \frac{n-2}{2}, \ m = \frac{n}{2}$$

and Y may be changed in a similar manner into Q. Interpreting x_i, y_i, Z as coördinates in a space S_n, these equations represent two sets of flat generators of $\frac{n-2}{2}$-dimensions on the quadric

$$(4)\quad M_{n-1}^{(2)} : \Sigma x_i y_i + Z^2 = 0$$

A central projection of the quadric $M_{n-1}^{(2)}$ on the space $Z = 0$ will project these generators into the tangent flats X and Y.

The equations of P and Q together with the corresponding equations in u_i, v_i coördinates, i. e. flat coördinates, give us the corresponding system of the system derived by Study[3], which gives in non-Euclidean 3-space what Lie and others expressed by the Lie line-sphere transformation[4][5][6].

We now have:

S_n	$\overline{S}_{n-1}$	$\underline{S}_{n-1}$
Generator P of $M_{n-1}^{(2)}$	Oriented tangent flat X	Point $\vee_i$, S_i
Generator Q of $M_{n-1}^{(2)}$	Oriented tangent flat Y	(n—2) flat
∞^{2n-3} surface elements (P, Q intersecting)	∞^{2n-3} surface elements	∞^{2n-3} surface elements

and the principal flat-sphere correspondence:

$\overline{S}_{n-1}$	$\underline{S}_{n-1}$
Sphere. Section of $M_{n-1}^{(2)}$ by (n—1) -flat.	Flat (ϱ_i, σ_i)
Null-sphere. Section of $M_{n-1}^{(2)}$ by (n—1)-tangent to $M_{n-1}^{(2)}$.	Flat of principal complex $\varrho_m = \sigma_m$
Flat oriented sphere. Section of $M_{n-1}^{(2)}$ containing center of projection.	Flat of adjoint complex $\varrho_m + \sigma_m = 0$
Null flat.	Flat of absolute congruence $\varrho_m = \sigma_m = 0$

III. We will now investigate the case where a tangent flat X′ intersects one of the same kind X″. We will treat this question from the standpoint of the space S_n.. Consider any two generators P′ and P″ of $M_{n-1}^{(2)}$:

$$(5)\quad \left[\begin{array}{l} X_m \vee_i^{1} + X_i \vee_m^{1} - Z S_i^{1} = 0 \\ X_m S_m^{1} + \Sigma y_i S_i^{1} + Z \vee_m^{1} = 0 \\ Z S_m^{1} + \Sigma y_i \vee_i^{1} - y_m \vee_m^{1} = 0 \end{array}\right.$$

$$(6)\quad \left[\begin{array}{l} X_m \vee_i^{11} + X_i \vee_m^{11} - Z S_i^{11} = 0 \\ X_m S_m^{11} + \Sigma y_i S_i^{11} + Z \vee_m^{11} = 0 \\ Z S_m^{11} + \Sigma y_i \vee_i^{11} - y_m \vee_m^{11} = 0 \end{array}\right. \qquad i = 1, 2, \ldots, \frac{n-2}{2} \qquad m = \frac{n}{2}$$

In general these generators do not meet. However, we find that they intersect in an $\frac{n-6}{2}$-flat and lie in an (n—1)-flat, if the relation

$$\text{I.}\quad \frac{Z}{X_m} = \frac{\vee_i^{1} \vee_m^{11} - \vee_m^{1} \vee_i^{11}}{S_i^{1} \vee_m^{11} - \vee_m^{1} S_i^{11}} = \frac{\vee_{m-1}^{1} \vee_m^{11} - \vee_m^{1} \vee_{m-1}^{11}}{S_{m-1}^{1} \vee_m^{11} - \vee_m^{1} S_{m-1}^{11}}$$

and thus the relation $\Sigma(\vee_i^{1} \vee_m^{11} - \vee_m^{1} \vee_i^{11} + S_i^{1} S_m^{11} - S_m^{1} S_i^{11}) = 0$ holds.

We now find the conditions imposed if P′ and P″ lie in an (n—2)-flat, such as is given by the equations

$$(7)\quad \left[\begin{array}{l} Z = \Sigma a_i X_i + \Sigma b_i y_i + d X_m \\ y_m = \Sigma c_i X_i + \Sigma d_i y_i + e X_m \end{array}\right. \qquad i = 1, 2, \ldots, \frac{n-2}{2}.$$

If P′ and P″ lie in (7) we find

$$(8)\quad b_i = \frac{S_i^{1}[\Sigma a_i S_i^{1} - \vee_m^{1}]}{\vee_m^{12}} = \frac{S_i^{11}[\Sigma a_i S_i^{11} - \vee_m^{11}]}{\vee_m^{112}}$$

$$(9)\quad d = \frac{\Sigma a_i(\vee_i^{1} \vee_m^{1} + S_i^{1} S_m^{1}) - S_m^{1} \vee_m^{1}}{\vee_m^{12}} = \frac{\Sigma a_i(\vee_i^{11} \vee_m^{11} + S_i^{11} S_m^{11}) - S_m^{11} \vee_m^{11}}{\vee_m^{12}}$$

$$(10)\quad d_i = \frac{V_i^1}{V_m^1} + \frac{S_i[\Sigma c_i S_i^1 - S_m^1]}{V_m^{12}} = \frac{V_i^{11}}{V_m^{11}} + \frac{S_i^{11}[\Sigma c_i S_i^{11} - S_i^{11}]}{V_m^{112}}$$

$$(11)\quad e = \frac{\Sigma c_i (V_i^1 V_m^1 + S_i^1 S_m^1) - S_m^{12}}{V_m^{12}} = \frac{\Sigma c_i (V_i^{11} V_m^{11} + S_i^{11} S_m^{11}) - {}_m^{112}}{V_m^{112}}$$

From (8) we obtain the following relation among the S_i's

$$\text{II.}\quad S_i^1 S_{m-1}^{11} - S_{m-1}^1 S_i^{11} = 0,\ i = \ , 2, \ldots, \frac{n-4}{2} \qquad m = \frac{n}{2}$$

We write (10) and (11) in the form

$$(12)\quad \frac{V_i^1}{V_m^1} - \frac{V_i^{11}}{V_m^{11}} = \frac{S_i^{11}}{S_m^{11}} K^1 - \frac{S_i^1}{S_m^1} K$$

$$(13)\quad \Sigma c_i \left(\frac{V_i^1}{V_m^1} - \frac{V_i^{11}}{V_m^{11}} \right) = K^1 - K$$

where $K = \dfrac{\Sigma c_i S_i^1 S_m^1 - S_m^{12}}{V_m^{12}}$, $K^1 = \dfrac{\Sigma c_i S_i^{11} S_m^{11} - S_m^{112}}{V_m^{112}}$

Multiplying (12) by c_i and summing we have

$$\Sigma c_i \left(\frac{V_i^1}{V_m^1} - \frac{V_i^{11}}{V_m^{11}} \right) = K^1 \Sigma c_i \frac{S_i^{11}}{S_m^{11}} - K \Sigma c_i \frac{S_i^1}{S_m^1} = K^1 - K$$

$$\therefore \frac{\Sigma c_i S_i^1 - S_m^1}{S_m^1} K = \frac{\Sigma c_i S_i^{11} - S_m^{11}}{S_m^{11}} K^1$$

$$\frac{V_m^{12}}{S_m^{12}} K^2 = \frac{V_m^{112}}{S_m^{112}} K^{12}$$

$$\text{i. e.}\quad \frac{V_m^1}{S_m^1} K = \frac{V_m^{11}}{S_m^{11}} K^1$$

Substituting in (12), and setting $i = m-1$ on both sides we find for the values of K and K':

$$K = \frac{S_m^1}{V_m^1} \left(\frac{V_{m-1}^1 V_m^{11} - V_m^1 V_{m-1}^{11}}{V_m^1 S_{m-1}^{11} - S_{m-1}^1 V_m^{11}} \right)$$

$$K^1 = \frac{S_m^{11}}{V_m^{11}} \left(\frac{V_{m-1}^1 V_m^{11} - V_m^1 V_{m-1}^{11}}{V_m^1 S_{m-1}^{11} - S_{m-1}^1 V_m^{11}} \right)$$

Substituting these values in (12) and adding $\dfrac{S_i^1 S_m^{11} - S_m^1 S_i^{11}}{V_m^1 V_m^{11}}$ to both sides of the equation, we have by using II:

$$(14)\quad V_i^1 V_m^{11} - V_m^1 V_i^{11} + S_i^1 S_m^{11} - S_m^1 S_i^{11}$$
$$= \frac{S_i}{S_{m-1}} \left(V_{m-1}^1 V_m^{11} - V_m^1 V_{m-1}^{11} + S_{m-1}^1 S_m^{11} - S_m^1 S_{m-1}^{11} \right)$$

Since the left side of this equation is zero by relations obtained from (5) and (6), and since $\Sigma y_i S_i$ is not equal to zero, we have

$$V_{m-1}^1 V_m^{11} - V_m^1 V_{m-1}^{11} + S_{m-1}^1 S_m^{11} - S_m^1 S_{m-1}^{11} = 0$$

and therefore also

$$\text{III.}\quad V_i^1 V_m^{11} - V_m^1 V_i^{11} + S_i^1 S_m^{11} - S_m^1 S_i^{11} = 0$$

$$\text{If}\quad V_i^1 V_m^{11} - V_m^1 V_i^{11} = 0, \qquad S_i^1 S_m^{11} - S_m^1 S_i^{11} = 0$$

the generator P' intersects P" on the absolute and thus the tangent flats X' and X" of the absolute, into which P' and P" project, will intersect on the absolute.

Thus the generators P′ and P″ lie in an (n—2)-flat and intersect in an $\frac{n-4}{2}$-flat if the above conditions are satisfied. The equations of the $\frac{n-4}{2}$-flat are:

$$(S_i^1 V_m^{11} - S_i^{11} V_m^1) X_i - (V_i^1 S_i^{11} - S_i^1 V_i^{11}) X_m = 0$$
$$(V_i^1 V_m^{11} - V_i^{11} V_m^1) X_m - (S_i^1 V_m^{11} - S_i^{11} V_m^1) Z = 0$$
$$(S_m^1 V_m^{11} - V_m^1 S_m^{11}) y_m + \Sigma y_i (V_i^1 S_m^{11} - V_i^{11} S_m^1) = 0$$
$$(S_m^1 V_m^{11} - V_m^1 S_m^{11}) X_m + \Sigma y_i (S_i^1 V_m^{11} - S_i^{11} V_m^1) = 0,$$
$$i = 1, 2, \ldots, \frac{n-2}{2}$$

We will now attend to the (n—2)-flat (7). Its projection on the space $\overline{S}_{n-1}$ is the (n—2)-flat

$$y_m = \Sigma c_i X_i + \Sigma y_i \left(\frac{\Sigma c_i S_i^{12} + \Sigma (V_i^1 V_m^{11} - S_i^1 S_m^{11})}{V_m^{12}} \right) + X_m \left(\frac{\Sigma c_i (V_i^1 V_m^{11} + S_i^1 S_m^{11}) - S_m^{12}}{V_m^{12}} \right)$$

There is a single relation, namely (10), between the constants c. Hence there are ∞^{m-2} surface elements on the two flats X′ and X″ with the $\frac{n-4}{2}$-flat as nucleus.

We shall now find the corresponding configurations in the image space S_{n-1}.

In S_{n-1} we have two points (V_i^1, S_i^1) and (V_i^{11}, S_i^{11}) which we shall denote by p′ and p″, V_i, S_i being used as running coördinates.

We find that the conditions that a flat of the complex $\varrho_m = \sigma_m$ shall pass thru p′ and p″ to be the same conditions as for the intersection of the generators P′ and P″ in an $\frac{n-6}{2}$-flat; i. e.

$$\text{I.} \quad \frac{V_i^1 V_m^{11} - V_i^{11} V_m^1}{S_i^1 V_m^{11} - S_i^{11} V_m^1} = \frac{V_{m-1}^1 V_m^{11} - V_{m-1}^{11} V_m^1}{S_{m-1}^1 V_m^{11} - S_{m-1}^{11} V_m^1}$$

and $\Sigma (V_i^1 V_m^{11} - V_i^{11} V_m^1 + S_i^1 S_m^{11} - S_i^{11} S_m^1) = 0$

Thus we have the correspondence:

$\overline{S}_{n-1}$	S_n	S_{n-1}
Tangent flat of absolute, X′	Generator P′ of $M_{n-1}^{(2)}$	Point p′ (V_i^1, S_i^1)
Tangent flat of absolute, X″	Generator P″ of $M_{n-1}^{(2)}$	Point p″ (V_i^{11}, S_i^{11})
X′, X″ intersecting in an $\frac{n-6}{2}$-flat	P′ P″ lying in an (n—1)-flat, intersecting in $\frac{n-6}{2}$-flat	A flat of complex $\varrho_{\frac{n}{2}} = \sigma_{\frac{n}{2}}$ passes thru p′, p″.

Now we shall investigate the case where conditions II and III hold in S_{n-1}.

Let the equations of a flat f_1 be written

$$(15) \quad \begin{cases} \sigma_o V_i - \sigma_m S_i + \varrho_i V_m = 0 \\ \sigma_o S_m + \Sigma \sigma_i S_i + \varrho_m V_m = 0 \\ \sigma_m S_m + \Sigma \sigma_i V_i - \sigma_o V_m = 0 \end{cases} \qquad i = 1, 2, \ldots, \frac{n-2}{2}, \quad m = \frac{n}{2}$$

The equations of a flat $f_2^{(7)}$, conjugate to f_1, with respect to the complex $\varrho_m=\sigma_m$ are:

$$(16)\quad \begin{cases} \sigma_o\, V_i - \varrho_m\, S_i + \varrho_i\, V_m = 0 \\ \sigma_o\, S_m + \Sigma\, \sigma_i\, S_i + \sigma_m\, V_m = 0 \\ \varrho_m\, S_m + \Sigma\, \sigma_i\, V_i - \varrho_o\, V_m = 0 \end{cases} \qquad i=1, 2, \ldots, \frac{n-2}{2}$$

Let p' (V_i^1, S_i^1) be a point on f_1, and the equations of a flat of the complex thru p' be:

$$(17)\quad \begin{cases} \bar{\sigma}_o\, V_i - \bar{\sigma}_m\, S_i + \bar{\varrho}_i\, V_m = 0 \\ \bar{\sigma}_o\, S_m + \Sigma\, \bar{\sigma}_i\, S_i + \bar{\varrho}_m\, V_m = 0 \\ \bar{\sigma}_m\, S_m + \Sigma\, \bar{\sigma}_i\, V_i - \bar{\varrho}_o\, V_m = 0 \end{cases}$$

where $\bar{\varrho}_i = \dfrac{\bar{\sigma}_m\, S_i^1 - \bar{\sigma}_o\, V_i^1}{V_m^1}$, $\bar{\varrho}_m = \dfrac{-\bar{\sigma}_o\, S_m^1 - \Sigma\, \bar{\sigma}_i\, S_i^1}{V_m^1}$, $\bar{\varrho}_o = \dfrac{\bar{\sigma}_m\, S_m^1 + \Sigma\, \bar{\sigma}_i\, V_i^1}{V_m^1}$

This flat intersects f_2 in the points p'' whose coördinates are:

$$(18)\quad \begin{cases} V_i^{11} = V_i^1 + \dfrac{\lambda\, \bar{\alpha}\, S_i^1}{\varrho_m - \bar{\alpha}\, \sigma_o} \\ S_i^{11} = S_i^1 + \dfrac{\lambda\, S_i^1}{\varrho_m - \bar{\alpha}\, \sigma_o} \\ S_m^{11} = S_m^1 + \dfrac{\lambda(S_m^1 + \bar{\alpha}\, V_m^1)}{\varrho_m - \bar{\alpha}\, \sigma_o}, \qquad V_m^{11} = V_m^1 \\ \qquad \lambda = \sigma_m - \varrho_m, \quad \bar{\alpha} = \dfrac{\bar{\sigma}_m}{\bar{\sigma}_o} \end{cases}$$

A flat of the complex thru p'' of f_2 intersects f_1 in the points p' whose coördinates are:

$$(19)\quad \begin{cases} V_i^1 = V_i^{11} - \dfrac{\lambda\, \bar{\alpha}\, S_i^{11}}{\sigma_m - \bar{\alpha}\, \sigma_o} \\ S_i^1 = S_i^{11} - \dfrac{\lambda\, S_i^{11}}{\sigma_m - \bar{\alpha}\, \sigma_o} \\ S_m^1 = S_m^{11} - \dfrac{\lambda(S_m^{11} + \bar{\alpha}\, V_m^{11})}{\sigma_m - \bar{\alpha}\, \sigma_o}, \qquad V_m^1 = V_m^{11} \end{cases}$$

which may be obtained by taking the inverse of (18) or by interchanging the points p' and p'', and at the same time exchanging the parameters of f_2 for those of f_1.

We thus obtain the conditions

$$\text{II.} \quad V_i^1\, V_m^{11} - V_i^{11}\, V_m^1 + S_i^1\, S_m^{11} - S_i^{11}\, S_m^1 = 0, \qquad i=1, 2, \ldots, \frac{n-2}{2}$$

$$\text{III.} \quad S_i^1\, S_{m-1}^{11} - S_i^{11}\, S_{m-1}^1 = 0, \qquad i=1, 2, \ldots, \frac{n-4}{2}$$

for p', p'' to lie on conjugate flats with a complex flat thru them. In S_n, corresponding to the above, we had the flats P' and P'' lying in an $(n-2)$-flat and intersecting in an $\dfrac{n-4}{2}$ -flat.

As $\bar{\alpha}$ varies the point p'' (18) describes a straight line g_3 in f_2 and we thus have a pencil of lines thru p′ intersecting f_2 in this line. If p′ and p″ and fixed, $\overline{\alpha}$ is fixed, and $\overline{p' p''}$ will, as axis, be the carrier of ∞^{m-2} flats of the complex. All the complex flats thru p′ intersect f_2 in the line g_2. Similiarly, to a point p″ on g_2 corresponds a straight line g_1 on f_1.

The equations of the line $\overline{p' p''}$ are:

$$(20)\quad \frac{V_1 V_m' - V_1' V_m}{\overline{\alpha}\, S_1''} = \frac{S_1 V_m' - S_1' V_m}{S_1''} = \frac{S_m V_m' - S_m' V_m}{S_m'' + \overline{\alpha}\, V_m''}$$

where $$\overline{\alpha} = \frac{V_1' V_m'' - V_1'' V_m'}{S_1' V_m'' - S_1'' V_m'} = \frac{V_{m-1}' V_m'' - V_{m-1}'' V_m'}{S_{m-1}' S_m'' - S_{m-1}'' S_m'}$$

$\overline{\alpha}$ being constant.

To the ∞^1 points $V_1 = \lambda V_1' + \mu V_1''$, $S_1 = \lambda S_1' + \mu S_1''$ of this line $\overline{p' p''}$ correspond a pencil of ∞^1 flats $\lambda X' + \mu X'' = 0$ in $\overline{S}_{n-1}$, which pass thru the $\frac{n-4}{2}$ -flat common to $X' = 0$, $X'' = 0$. To the ∞^{m-2} flats of the complex having this line as axis correspond the ∞^{m-2} points of the $\frac{n-4}{2}$ -flat which is the locus of intersection of X′ and X″.

The equations of the lines g_1 and g_2 respectively, are:

$$(21)\quad \begin{cases} V_1 V_m' - V_1' V_m + S_1 S_m' - S_1' S_m = 0 \\ S_1 \rho_m - V_1 \sigma_0 - \rho_1 V_m = 0 \end{cases}$$

$$(22)\quad \begin{cases} V_1 V_m'' - V_1'' V_m + S_1 S_m'' - S_1'' S_m = 0 \\ S_1 \sigma_m - V_1 \sigma_0 - \rho_1 V_m = 0 \end{cases}$$

and the equations of the plane pencil thru p′ intersecting f_2 in the line g_2 are:

$$(23)\quad \gamma : \begin{cases} V_1 V_m' - V_1' V_m + S_1 S_m' - S_1' S_m = 0 \\ S_1 S_{m-1}' - S_1' S_{m-1} = 0 \end{cases}$$

Those of the corresponding pencil thru p″, intersecting g_1, are obtained by substituting the coördinates of p″ for those of p′ in (23).

If p′ moves along g_1, the plane γ_2, determined by g_2 and p′, turns about g_2 as an axis, and reciprocally, if p″ moves along g_2, the plane determined by g_1 and p″ turns about g_1 as an axis.

Since the equations of γ_1 and γ_2 do not contain the flat coördinates ρ_1, σ_1 they establish a reciprocal relation between the points and planes of S_{n-1}. To a point p′ corresponds a plane γ_2 passing thru p′, and to a point p″ corresponds a plane γ_1 passing thru p″; and since the system γ_2 may be obtained from the system γ_1 by merely interchanging the coördinates of p′ and p″, it follows that the correspondence is involutory. The two systems are thus reducible to a single bilinear system.

Table of correspondence between the spaces $\overline{S}_{n-1}$, S_n, S_{n-1}.

$\overline{S}_{n-1}$	S_n	$\overline{S}_{n-1}$
X', X'' tangent flats of absolute, in $(n-2)$-flat, intersecting in $\frac{n-4}{2}$-flat, F_1-nucleus.	P', P'' generators of $M_{n-1}^{(2)}$ lying in $(n-2)$-flat and intersecting in an $\frac{n-4}{2}$-flat.	Points p', p'' on conjugate flats where a flat of $\varrho_m=\sigma_m$ intersects them.
∞^1 flats of pencil $\lambda X^1+\mu X^{11}=0$ with common locus of intersection the $\frac{n-4}{2}$-flat F_1.	∞^1 generators of pencil $\lambda P^1+\mu P^{11}=0$ with common locus of intersection the $\frac{n-4}{2}$-flat in which P' and P'' intersect.	∞^1 points $\left\{\begin{array}{l}\surd_i=\lambda\surd_i^1+\mu\surd_i^{11}\\ S_i=\lambda S_i^1+\mu S_i^{11}\end{array}\right.$ of line $\overline{p'\,p''}$.
∞^{m-2} points of F_1.	∞^{m-2} points of $\frac{n-4}{2}$-flat of intersection of P', P''.	∞^{m-2} complex flats with $\overline{p'\,p''}$ as axis.
∞^1 $\frac{n-4}{2}$-flats, F_1 nuclei on tangent flat X'.	∞^1 $\frac{n-4}{2}$-flats on the $\frac{n-2}{2}$-flat P'.	Plane pencil of lines γ_2 thru p' and g_2.
∞^{m-1} points of the tangent flat X'.	∞^{m-1} points of the generator P'.	∞^{m-1} complex flats with lines of the pencil as axis.
∞^{n-2} points of $(n-2)$-flat containing tangent flats X', X''.	∞^{n-2} points of $(n-2)$-flat $(P'\,P'')$.	p' moves along g_1, plane γ_2 turns about g_2 as axis. ∞^{n-2} complex flats with lines joining points of g_1, g_2 as axis.

If we let p' be a point consecutive to p we have

$$\surd_i^1=\surd_i+d\surd_i,\quad S_i^1=S_i+d\,S_i,\quad \surd_m^1=\surd_m+d\surd_m,\quad S_m^1=S_m+d\,S_m$$

which when substituted in (23) gives us the system of Pfaff's equations

$$(24)\quad \left[\begin{array}{l}\surd_i\,d\surd_m-\surd_m\,d\surd_i+S_i\,d\,S_m-S_m\,d\,S_i=0\\ S_i\,d\,S_{m-1}-S_{m-1}\,d\,S_i=0\end{array}\right.$$

Among the integral curves of (24) there are ∞^{n-1} straight lines which belong to a linear line complex in S_{n-1}, and thru any point will pass ∞^1 such lines forming a pencil (23). This complex will be called the associated line complex[8]. The flat complex $\varrho_m=\sigma_m$ determines a line complex whose line elements satisfy the equations (24), and conversely, the line complex determines uniquely the flat complex $\varrho_m=\sigma_m$[9].

Let the point p' have coördinates $\surd_i^1$, S_i^1. The equation of the element $(n-2)$-flat is

$$(25)\quad S_m\surd_m^1-S_m^1\surd_m=\Sigma\,p_i(\surd_i\surd_m^1-\surd_i^1\surd_m)+\Sigma\,q_i(S_i\surd_m^1-S_i^1\surd_m)$$

If a flat, not necessarily a complex flat, lies in the element and passes thru p' we must have

$$\propto p_1 + q_1 = \frac{\quad}{\sigma_0}, \quad \propto = \frac{\sigma_m}{\sigma_0}$$

hence ∞^1 flats, corresponding to the infinity of values of $\propto$, pass thru p′ and lie in the element.

If the flat belongs to the principal complex $\varrho_m = \sigma_m$, $\propto$ must have the value

$$\propto = \frac{S_m^1 - \Sigma q_i S_i^1}{\Sigma p_i S_i^1 - V_m^1}$$

Hence only one flat of the complex passes thru p′ and lies in the element (n—2)-flat E p^1.

The condition that the line (20), which belongs to the associated line complex, shall lie in the surface element is the same as the above. Thus the flat complex $\varrho_m = \sigma_m$, with its associated line complex determines in every surface element E_{p1} a self dual flat element f_{p1} and an associated line element λ_{p1}.

We may now state the following, the proof of which follows from a theorem in a paper on flat geometry[10].

The flat complex $\varrho_m = \sigma_m$ establishes a reciprocal relation between the surface elements of S_{n-1} of such a nature that to a given surface element E_{p1} corresponds a conjugate surface element E_{p11}. The point p″ is the vertex of ∞^1 complex flats which lie in E_{p1} and p′ is the vertex of ∞^1 complex flats which lie in E_{p11}. The two surface elements have a flat of the complex in common, which passes thru p′ and p″, and the line which joins these two points belongs to the associated line complex.

Associated with, and imbedded in, the conjugate surface elements E_{p1}, E_{p11} are two conjugate plane elements, whose planes γ_1 and γ_2 are determined by g_1, p″ and g_2, p′ respectively. ∞^1 lines of the associated line complex pass thru p″ and lie in γ_1, and ∞^1 lines pass thru p′ and lie in γ_2. γ_1 and γ_2 intersect in the line λ joining p′ and p″.

Now we will discuss the correspondence of surface elements in the three spaces $\overline{S}_{n-1}$, S_n, and S_{n-1}.

In S_{n-1}, E_{p1} and E_{p11} have a complex flat in common which passes thru p′ and p″. Thus for each of the ∞^{m-2} complex flats with the line $\overline{p' \, p''}$ as axis there will be two conjugate surface elements E_{p1} and E_{p11}.

If in S_n we take generators $\overline{P'}$, $\overline{P''}$ of $M_{n-1}^{(2)}$, which are obtained from those of P′, P″ by merely changing S_i into $-S_i$, we see that the conditions I, II, III are unaltered. Thus we have, as was stated before, ∞^{m-2} surface elements on the flats P′, P″ with the $\frac{n-4}{2}$ -flat of intersection as nucleus; and also ∞^{m-2} surface elements on the flats $\overline{P}'$ and $\overline{P}''$. Thus we have a 1—1 correspondence between these surface elements and the elements E_{p1}, E_{p11} in S_{n-1}.

In the space of the absolute there are ∞^{m-2} surface elements on the flats X′, X″ with the $\frac{n-4}{2}$ -flat F as nucleus. And, when we consider these tangent flats as being oriented, we obtain a 1—1 correspondence between the surface elements in $\overline{S}_{n-1}$ with the surface elements in S_n and S_{n-1}.

In the case where

$$V_1^1 \, V_m^{11} - V_1^{11} \, V_m^1 = 0, \qquad S_1^1 \, S_m^{11} - S_1^{11} \, S_m^1 = 0$$

the tangent flats X′ and X″ intersect in an $\frac{n-4}{2}$ -flat on the absolute. Since each tangent flat X has contact with the absolute along an $\frac{n-4}{2}$ -flat, the so-called F_1-nucleus with equations

$$X_m \vee_i + X_i \vee_m = 0, \qquad \Sigma y_i \vee_i - y_m \vee_m = 0, \qquad X_m S_m + \Sigma y_i S_i = 0$$

we see that the $\frac{n-4}{2}$ -flat of intersection of X′ and X″ on the absolute must be the common F_1-nucleus where these two flats touch the absolute surface.

The (n—2)-flat containing X′ and X″ becomes

$$y_m = \Sigma c_i X_i + -\frac{\Sigma \vee_i y_i}{\vee_m} + \frac{\Sigma S_i y_i [\Sigma c_i S_i - S_m]}{\vee_m^{2}} - \frac{S_m^{2}}{\varepsilon^{m} \Lambda} X_m$$

In S_{n-1} we have two points p′ and p″ and the line joining them has the equations

$$\vee_i \vee_m^{1} - \vee_i^{1} \vee_m = 0, \qquad S_i \vee_m^{1} - S_i^{1} \vee_m = \frac{S_i^{11}}{\vee_m^{11}} (S_m \vee_m^{1} - S_m^{1} \vee_m)$$

since $\alpha = 0$.

To the ∞^{1} points of this line correspond a pencil of ∞^{1} flats $\lambda X^{1} + \mu X^{11} = 0$ which pass thru the $\frac{n-4}{2}$ -flat common to X′=0, X″=0, on the absolute. To the ∞^{m-2} flats having this line as axis correspond the ∞^{m-2} points of the $\frac{n-4}{2}$ -flat, which is the locus of intersection of X′ and X″, and lies on the absolute surface. In this case α cannot vary being always zero, and the conjugate flat f_2 coincides with f_1 in S_{n-1}.

Two generators of the absolute surface belonging to the same set a) intersect in an $\frac{n-6}{2}$ -flat:

$$X_m \vee_i^{1} + X_i \vee_m^{1} = 0 \qquad X_m \vee_i^{11} + X_i \vee_m^{11} = 0$$

$$\Sigma y_i \vee_i^{1} - y_m \vee_m^{1} = 0 \qquad \Sigma y_i \vee_i^{11} - y_m \vee_m^{11} = 0$$

The condition for intersection is

$$\vee_i^{1} \vee_m^{11} - \vee_i^{11} \vee_m^{1} = 0$$

To the generators a′ and a″ of the absolute there corresponds two points p′($\vee_i^{1}$, 0) and p″($\vee_i^{11}$, 0) which lie on one of the directricies of the absolute congruence $\varrho_m = 0$, $\sigma_m = 0$. To the ∞^{m-3} flats of the congruence which have the line $\overline{p' p''}$ as axis there corresponds the ∞^{m-3} points of the $\frac{n-6}{2}$ -flat, which is the locus of intersection of the generators a′ and a″ of the absolute.

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(1) Given at a meeting of the Mathematical Association of America, March 1934, at Pittsburgh, Pa.

(2) Study, E., Math. Ann., 91; 87, (1924).

(3) Study, E., Math. Ann., 91; 94 (1924).

(4) Lie, S.—Engel, F., Theorie Der Transformationsgruppen, III; 138, B. G. Teubner, Leipzig (1894).

(5) Lie, S.—Scheffers, G., Vorlesungen Ueber Continuirliche Gruppen; 245, B. G. Teubner, Leipzig (1893).

(6) Eiesland, J. A., Amer. Math. Jour., 35, 217 (1930).

(7) Eiesland, J. A., Tôhuku Math. Jour., 16, 185, 1919.

(8) Eiesland, J. A., Tôhuku Math. Jour., 16, 185 (1919).

(9) Eiesland, J. A., Tôhuku Math. Jour., 17, 295 (1920).

(10) Eiesland, J. A., Tôhuku Math. Jour., 17, 300 (1920).

The Social Sciences Section

De Quincey on the Eleusinian Mysteries and the Greek Oracles

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In August and October 1847 De Quincey published in Tait's Magazine an essay entitled "Secret Societies" wherein he attacked the Eleusinian Mysteries and Freemasonry as the greatest humbugs of the ancient and modern world respectively. We are concerned here only with what he has to say concerning the Eleusinian Mysteries. "The great and illustrious humbug of ancient history was The Eleusinian Mysteries . . . The Eleusinian humbug was for centuries the opprobrium of scholars . . . The interest which attaches to the Eleusinian shows is not properly an interest in *them,* but an alien interest in accidents indirectly connected with them. Secret there was virtually none; but a mystery at length begins to arise — how it was that this distressing secret: viz., of there being no secret at all, could through so many generations pass down in religious conservatism of itself from all profane curiosity of outside barbarians. There was an endless file of heroes, philosophers, statesmen all hoaxed, all of course incensed at being hoaxed and yet not one of them is known to have blabbed." *(1).* De Quincey approaches his subject by reviewing Warburton's "Divine legation of Moses." Analyzing Warburton's thesis as composed virtually of a syllogism, De Quincey says "Suppose the *major* proposition to be this: That no religion, unless through the advantage of divine inspiration, could dispense with the doctrine of future rewards and punishments. Suppose the *minor* proposition this: That the Mosaic religion *did* dispense with that doctrine. Then the conclusion will be, ergo, the Mosaic religion was divinely inspired. The monstrous tenor of this argument made it necessary to argue most elaborately that all the false systems of false and cruel religions were affectionately anxious for maintaining the doctrine of a future state; but, secondly, that the only true faith and the only pure worship were systematically careless of that doctrine. . . . The Bishop had, therefore, to prove — it was an obligation self-created by his own syllogism — that the Pagan religion of Greece, in some great authorized institution of the land, taught and insisted on the doctrine of a future state as the basis on which all legal ethics rested. . . . The doctrine of immortality, he insisted, was the chief secret revealed in the mysteries. And thus he proved decisively that, because it taught a capital truth, Paganism must be a capital falsehood" *(2).* De Quincey concludes this section on the Eleusinian Mysteries thus: "But all this is superfluous. Let the reader study the short essay of Lobeck on this subject, forming one section in three of his *Aglaophamus,* and he will treat, with derision, all the irrelevant skirmishing, and the vast roars of artillery pointed at

(1) *DeQuincey's Writings,* Boston, Houghton Mifflin (1956), 1777, vol. 8, pp. 159, 160.

(2) *Ibid.,* pp. 165-166.

shadows, which amuse the learned, but disgust the philosophic in the "Divine Legation." Much remains to be done that Lobeck's rustic seclusion denied him the opportunities for doing; much that can be done effectually only in great libraries. But I return to my assertion, that the most memorable of all secret societies was the meanest. That the Society which made more people hold their tongues than ever the Inquisition did, or the Mediaeval Vehm-gericht, was a hoax; nay, except Freemasonry, the hoax of hoaxes" *(3)*.

The basis of De Quincey's argument, therefore, is that Lobeck proves that the Eleusinian mysteries did not teach the immortality of the soul, and that therefore they were, with the excepion of Freemasonry, the hoax of hoaxes.

If the Eleusinian mysteries did not teach the immortality of the soul as a *doctrine*, they did not do so for the very natural reason that the Greek people already believed in immortality and therefore, in this matter, did not need indoctrination *(4)*. The mysteries merely sought by expressive symbolism — by an appeal to the eye and the imagination — to make the initiate realize the blessedness of this immortality in which he already believed *(5)*. But if Lobeck had proved that the Eleusinian mysteries did not teach the immortality of the soul or even that they had nothing whatever to do with the question of immortality, this does not at all preclude the possibiliy of their having been an uplifting moral agency, as De Quincey assumes. On the contrary, that these mysteries were elevating and beneficial we have abundant evidence. Professor E. G. Sihler, who also cited Lobeck as an authority on this point, says, "On the whole there was, as Plutarch and Plato suggest, very little of genuine spirituality, or of a deeper reaction on the soul, in these secret and far-famed rites. The 'circle of life' there was; the symbolism of the endless succession of seed and fruit, of germ and growth, there was some taking hold of and appropriating of all this; but as the fundamental weakness of Greek religion, so called, remained unchanged here, I cannot see that there was any very material elevation above, or any radical emancipation from nature-cult to be observed here. . . . The question remains whether the Greek people did not after all attach their piety to these idols or simulacra, without any elevation of soul toward a more spiritual or adequate object of worship" *(6)*. We are today in a much better position to investigate the real nature and moral effect of the Eleusinian mysteries than was Lobeck in 1829.

(3) *Ibid.*, p. 168.

(4) Some of the most important evidence on this point may be found in the following works: James Adam, *The Religious Teachers of Greece*, Edinburgh, 1908, pp. 58ff., 131ff., 135, 136, 173; L. Campbell, *Religion in Greek Literature*, 1898, p. 253; L. R. Farnell, *The Higher Aspects of Greek Religion*, pp. 139-140; R. D. Archer-Hind, *The Phaedo of Plato*, pp. xxiv ff.; K. S. Guthrie, *The Philosophy of Plotinus*, 1896, p. 39. Cf. also Hesiod, *Works and Days*, 166-173; *Aeschylus, Eumenides*, 312 322, 910-915; Plato, *Phaedrus*, BDE; Laws, 894-895; *Timaeus*, 41A.

(5) Farnell, Ar., *Mystery*, Ency. Brit., Eleventh ed., vol. XIX, p. 121.

(6) E. G. Sihler, *Testimonium Animae, or Greek and Roman Before Jesus Christ*, 1908, p. 156.

We can well realize why the pagan writers themselves tell us nothing about the essential secrets of the mysteries. De Quincey says that the reason they did not "blab" was that they had nothing to "blab". Having been hoaxed themselves, they in turn hoaxed others, as illustrated by the formerly popular academic sport of "snipe-hunting". This could not account for the fact, however, that many Pagan writers have testified to the beauty and moral value of the rites, and that so far as we have any knowledge, no divulgence of any of the secrets was ever made. The writings of the Christian fathers can have little weight as evidence, for none of the fathers spoke from personal knowledge except in a few instances where as Pagan youths they had been initiated. Besides, the Christian fathers wrote with too strong a bias against Paganism to give to their charges against the mysteries any high degree of reliability. The evidence of the Pagan writers themselves is to the effect that the Eleusinian mysteries were beneficial in their effects. Campbell says , "One thing may be certainly affirmed — that high authorities whose gravity and depth of mind cannot be disputed bear witness with one voice to the elevating influence of the Eleusinian mysteries." He then cites the ancient authorities *(7)*. Fairbanks says, "Because they vivified the belief in a future life, while at the same time they met the religious needs of the individual, the Eleusinian mysteries were perhaps the most important form of worship in ancient Greece" *(8)*.

The Essay on Pagan Oracles was published in Blackwood, March, 1942 *(9)*. De Quincey begins by remarking that "oftentimes under a continual accession of light important subjects grow more and more enigmatical," and cites as an example the Pagan oracles. "Much has been accomplished," he says, "chiefly of late years; and, confining our view to ancient history, almost exclusively amongst the Germans -- by the Savignys, the Niebuhrs, the Otfried Muellers. And if that much has left still more to do, it has also brought the means of working upon a scale of far accelerated speed" *(10)*. De Quincey shows that the Christian fathers wrote with a deep-seated prejudice upon this subject. "They, like all their contemporaries, were besieged by errors, ancient, inveterate, traditional; and incidentally, from one cause especial to themselves, they were not merely liable to error, but usually prone to error. This cause lay in the polemic form which so often they found a necessity, or a convenience, or a temptation for assuming, as teachers or defenders of the truth" *(11)*. De Quincey then discusses Van Dale's "De Oraculis veterum ethnicorum Dissertationes duae," which he says was published *at least* as early as the year 1682 *(12)*. It was the contention of Van Dale, first, that the Christian fathers were mistaken as to the cause of the oracles; second, that the oracles were not inspired

(7) L. Campbell, *Religion in Greek Literature*, p. 264.
(8) Arthur Fairbanks, *A Handbook of Greek Religion*, p. 137.
(9) *Op. cit.*, vol. 8, pp. 465-532.
(10) *Ibid.*, p. 467.
(11) *Ibid.*, 470.
(12) The date was 1684 according to Winkler Prins, *Geilustreede Encyclopaedie*, Amsterdam, 1907, vol. 5, p. 765.

by evil spirits, as the Christian fathers taught, but that "from the first hour to the last of their long domination over the minds and practice of the Pagan world, they had moved by no agencies whatever, but those of human fraud, intrigue, collusion, applied to human blindness, credulity, and superstition" *(13)*. De Quincey says that Van Dale won an easy victory over the Fathers in the first point, but denies the validity of the second. He takes the Delphic oracle as the best type of Greek oracle and shows that it had begun to wane several centuries before Christianity had attained to great influence. He argues that this decline was accelerated by the Roman emperors who would see in the Delphic oracle a potential peril. "Prudence, therefore, it was, and state policy, not the power of Christianity, which gave the final shock to the grander functions of the Delphic oracle" *(14)*.

De Quincey shows that these facts, as presented by Van Dale, overthrew the error of the Christian fathers who wished to represent the victory of Christianity over Paganism as a sudden miracle instead of a gradual change, and he further points out *a fortiori* that if Christianity could not have tolerated oracles, it could not have tolerated Paganism, which, however, did persist five centuries and in some localities considerably longer. De Quincey shows that Constantine not only did not overcome Paganism, but could not have done so *(15)*. He now disagrees with Van Dale's solution of the second problem, that is, "How and by what machinery, did the oracles, in the days of their prosperity, conduct their elaborate ministrations?" "To this problem no justice at all is done by the school of Van Dale. A spirit of mockery and banter is ill applied to questions that at any time have been centres of fear, and hope, and mysterious awe, to long trains of human generations. And the coarse assumption of systematic fraud in the oracles is neither satisfactory to the understanding, as failing to meet many important aspects of the case, nor is it at all countenanced by the kind of evidences that have been hitherto alleged" *(16)*. De Quincey's statement of this problem is as follows: "I. What was the relation of the oracles (and we would wish to be speaking particularly of the Delphic Oracle) to the credulity of Greece? 2. What was the relation of that same Oracle to the absolute truth? 3. What was its relation to the public welfare of Greece?" *(17)*. De Quincey notices the different agencies at work that naturally tended to arouse suspicion. "They were", he says, "skeptical bon-mots, refusals to consult the oracle, failure in the prophecy, and acting in collusion with criminals." These, for the most part, he explains justly and in a manner largely to vindicate the oracle. The last case, that of actual corruption, De Quincey says would be true probably of only a few poverty-striken oracles. The Delphic Oracle, however,

(13) *Op. cit., pp.* 467-477.
(14) *Ibid.,* p. 479.
(15) *Ibid.,* pp. 495ff.
(16) *Ibid.,* pp. 496-497.
(17) *Ibid.,* p. 503.

was bribed according to Herodotus *(18)* and Plutarch *(19)*. De Quincey then states that the Delphic oracle in ninety-nine cases out of one hundred did not exercise strictly prophetic functions, but that it "discharged the office of a central bureau d'administration, a general dépôt of political information, an organ of universal combination for the counsels of the whole Grecian race. And that which caused the declension of the Greek oracles was the loss of political independence and autonomy. After Alexander, still more after the Roman conquest, each separate state, having no powers and no motive for asking counsel on state measures, naturally confined itself more and more to its humbler local interests of police, or even at last to family arrangements" *(20)*. The influence of the Delphic Oracle in Greek colonization De Quincey discusses rather incidentally (*(21)*. He seems to have omitted entirely the treatment of his second point, "What was the relation of that same Oracle to the absolute truth?" One can easily infer from the general tone of the essay along what lines such a treatment would have proceeded. De Quincey believed that the oracle had very little connection with the Greek religion, and since in his mind that religion was fundamentally and radically false, the oracle would, to the extent of this slight connection, be also tainted with falsity. He does not at least anywhere suggest that the oracle in its religious aspect as a shrine of Apollo would do more than reflect the popular religion. That it did merely reflect and did not seek to elevate the religious standards is the view generally held today as distinguished from the view of Curtius *(22)*.

The Christian fathers were then totally in error in the hostility which they assumed to exist between Christianity and the Oracles. The source of this error, De Quincey states, was two fold. "First, most falsely they supposed prophecy to be the main function of an Oracle; whereas it did not enter as an element into the main business of an Oracle by as much as once in a thousand responses. Second, not less erroneously they assumed this to be the inevitable parent of a collision with Christianity. For all prophecy and the spirit of prophecy, they supposed to be a regal prerogative of Christianity, sacred, in fact, to the true faith by some inalienable right. But no such claim is anywhere advanced in the Scriptures." De Quincey justly states that prophecy as used in the New Testament is much broader than the prediction of future events. It referred rather to exegetical powers. "As rationally might Christianity be supposed hostile to post-offices, or jealous of mail steamers, as indisposed to that oracular mission, which the noble purpose, stated in the briefest terms, was — to knit the extremities of a state to its centre, and to quicken the progress of civilization" *(23)*. This contribution of the Delphic oracle to Pan-Hellenism is also main-

(18) V. 63; VI, 66.

(19) *Lysander*, 25, 447. As to charges of charlatanism, *cf.* Farnell, *The Cults of the Greek States*, vol. IV, p. 189.

(20) *Op. cit.*, pp. 514-515.

(21) *Op. cit.*, pp. 508 ff. Cf. Farnell, Op. cit., p. 200,

(22) Farnell, op. cit., p. 197.

(23) *Op. cit.*, p. 527.

tained by Professor Campbell *(24)*. The essay closes by showing that in the general fall of the independent Greek states the oracles suffered correspondingly and finally "went out — lamp after lamp — as we see oftentimes in some festal illumination that one glass globe of light capriciously outlives its neighbor" *(25)*.

This essay treats of the nature and cessation of the Greek oracles in a generally fair, liberal and interesting manner. De Quincey's attitude here is in marked contrast to that which he exhibited in the two preceding essays on "Christianity and Paganism" and "Secret Societies" The political influence of the oracles forced the historians to recognize their services, and the prejudice which has sometimes attended the study of Greek religion has not in this instance been operative. The fact that the Christian Fathers took such a radical and untenable position with regard to the oracles doubtless had its influence in according to the treatment of this subject a larger measure of impartial consideration. The authorities whom De Quincey followed in this instance made it practically impossible for him to take that narrow view which renders his treatment of Plato and of Greek religion so unsatisfactory *(26)*.

CURRENT OPINIONS REGARDING THE BLOND TYPE IN CLASSIC GREECE AND ROME

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AT THE MEETING of The West Virginia Academy of Science held at Elkins in 1935 I read a paper containing some of the most important opinions of modern scholars concerning the blond type in prehistoric Greece and Rome. This paper is published in these *Proceedings*, vol. 9 (1935) pp. 141-150. Therefore I shall omit these prehistoric peoples in the present paper. I give the following opinions in a more or less chronological order and, as far as possible, in the words of the authors themselves. Full discussion of these opinions is reserved for my forthcoming book. In the notes to this paper will be found anything I have to say at present.

Concerning the Homeric Greeks and the Hellenic peoples, we find the opinions expressed by modern scholars even more conflicting and diverse than the opinions on the prehistoric peoples of Greece.

The earliest of the moderns to pronounce upon the physical features of the Greeks, so far as I have been able to find out, was Scaliger. In

(24) *Op. cit.*, p. 26.
(25) *Op. cit.*, p. 531.
(26) The modern writers upon whom he principally relies are Van Dale, Fontenelle, and the German historians.

a work published in 1590 A. D. he thought that the Greeks were dark, "*subfusci*", which he equates with the Greek word μελίχρους.[1]

Bulwer-Lytton in his novel *Zanoni,* which appeared first in 1842, connects the Greeks with the Nordics. He writes: "The pure Greeks, the Hellenes, whose origin has bewildered your dreaming scholars, were of the same great family as the Norman tribe, born to be the lords of the universe and in no land of earth to become the hewers of wood. Even the dim traditions of the learned which bring the sons of Hellas from the vast and undetermined territory of Northern Thrace, to be the victors of the pastoral Pelasgi, and the founders of the line of demi-gods; which assign to a population bronzed beneath the suns of the West the blue-eyed Minerva and the yellow-haired Achilles (physical characteristics of the North); which introduce among a pastoral people warlike aristocracies and limited monarchies, the feudalism of the classic Greece; even these might serve to trace back the primeval settlements of the Hellenes to the same regions whence in later times the Norman warriors broke on the dull and savage hordes of the Celt and became the Greeks of the Christian world."[2]

In 1853 Felton delivered the second series of his Lowell *Lectures on Ancient and Modern Greece.* He had consulted the Greek physiognomonist Adamantius, and in his first lecture he gives a brief sketch of the complexion of the Greeks as he thought it to have been. Like Lapouge,[3] he is of the opinion that Greek art did not represent an ideal but the actual type of the Greeks as they were. Further on he says, "The same type of beauty has remained in those regions under all the changes of circumstances which have since taken place. The facial angle and the straight nose .... In detail, a white skin, yellow hair in waving locks, well-formed extremities, a round head[4] of moderate size, delicate (281) lips, a straight nose never surmounted by spectacles, and deep blue eyes. . . . Among the Southern Greeks a darker complexion, hair, and eyes presented frequent exceptions in those individual points; while the type of figure, height, and outline remained the same."[5]

Gladstone thought that the 'Pelasgians' were like the Celts while

1. J. Scaliger, *Manili etc., Commentaries,* 341, 34, on Manilius, 4, 721 (Heidelbergae, 1590) note 2. He continues: "*Is color dicitur a Ptolemaeo et Theocrito* μελίχρους." This word is discussed in an appendix to my dissertation, *Studies on the Blond Type in Ancient Greece,* 116-124 (Univ. of Illinois, 1926). See also note 100 below. An abstract of a paper on μελίχλωρος *and* μελίχρους etc. appeared in *Proceedings of the American Philological Association,* vol. 63 (1932) p. 46.
2. E. Bulwer-Lytton, *Zanoni,* Chapter 18, p. 196. The reference is to the edition of 1874 (G. Routledge), Knox, quoted immediately below (note 8), takes the same view.
3. See quotation from Ripley below, note 64.
4. The ancient Greeks are generally considered as long-headed or dolichocephalous. This topic will be treated in my chapter on anthropological measurements, but see Ripley, quoted below, note 64.
5. C. C. Felton, *Greece, Ancient and Modern,* I, 280-281 (Boston, J. Osgood, 1877, 2 vol. in one).

the Hellenes were like the Germans. "Observe, then," says he, "how the differences noted by Strabo (vii, 2 p. 290) between Celts and ' "Germans" ' correspond with the Homeric differences between Helli and Pelasgi. First as to ἀγριότης let us call to mind the history of the name Ἀργεῖος the use of Ἄγριος as an early Hellic proper name; the absence of names of this class among the Pelasgians; the rude manner of the Helli and the Pheres; the pacific habits, wealth, and advanced agriculture of the Pelasgian populations. Then as to stature: note how this gift has Diana for its goddess; how it is a standing and essential element of beauty for women as well as men; how the Greek chiefs in the Third *Iliad* are distinguished from the crowd by size . . . And lastly, the auburn hair, which was with Homer in such esteem. Menelaus is ξανθὸς; <also> . . . Meleager . . . Rhadamanthus . . . Agamede . . . Ulysses . . . <and> . . . lastly Achilles . . . But never once, I think, does Homer bestow this epithet upon a Pelasgian . . . None of the Trojan family, so renowned for beauty, are ξανθὸς; none of the Chiefs, not even Euphorbus, of whose flowing hair the Poet has given us so beautiful and even so impassioned a description. Nothing Pelasgian but Ceres, the καλλιπλόκαμος is admitted to the honor of the epithet. It could hardly be denied to the goddess of the ruddy harvest."[6] Elsewhere he notices that among the ancient Greeks "the olive hue of the skin kept down the play of the white and red; the hair tended much more uniform than with us to darkness."[7]

Knox would bring the Achaeans to Greece about 1600 B. C. He makes them blond. Speaking of the Achaean women he thinks that they had "blue eyes". Says he: "Fair and flowing locks, full-bosomed, fleshy, and large-limbed, seemed to have been the character of Grecian women: look at the Niobe, the Venus of Nidos, and a hundred others. All these show Scandinavian blood . . . The Maid of Athens had blue eyes, a divine and matchless colour."[8]

Curtius describes the Greeks without mentioning their color. He says: "Their physical constitution shows itself in plastic art, which native as it was to the people could find in the people alone its peculiar conception of human form. Apollo and Hermes, Achilles and Theseus, as they stand before our eyes in stone and painting, are after all merely glorified Greeks. Their noble harmony of the members of their bodies, the mild and simple lines of the face, the large eye, the short forehead, the straight nose, the fine mouth, belonged to the people, and were its natural characteristics . . . Their height rarely surpassed the right mean. Excessive fleshiness and fattiness of body were equally rare."[9]

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6. W. E. Gladstone, *Studies on Homer and the Homeric Age*, I, 151 and 153 (Oxford Univ. Press, 1858). See also note 101, below.
7. *Ibid.* 3, 487; also 481 and 488. See Scott, below, and note 89.
8. Robert Knox, *The Races of Man*, 403 (London, Renshaw, 1862). See also 405, where he lists as Scandinavian Pyrrus, Pericles, Aristotle, Plato, Socrates, Demosthenes, Iskander (?), etc., and those "who carved the immortal Venus and Niobe." It is hard to see on what evidence he classifies these men as "Scandinavians."
9. E. Curtius, *The History of Greece*, I, 37, (translated by A. W. Ward, (Scribners, 1871).

Says Paley: "The light flaxen hair of the Teutonic type, so common in those of Saxon descent in our country, but so rare among the black-haired and olive-complexioned natives of the south of Europe, was greatly admired by both Greeks and Romans."[10]

Mahaffy on the other hand is of the opinion that "the pure Greek was often fair in color and of very regular and beautiful features."[11]

Becker espouses the opposite view in saying: "Black was probably the prevailing color of the hair, though blond is frequently mentioned."[12]

Guhl and Köner agree with Becker in thinking that "the usual color of the hair being dark, fair hair was considered a great beauty. Homer gives yellow locks to Menelaos, Achilles, and Meleagros; and Euripides describes Menelaos and Dionysos as fair-haired."[13]

"As to ancient Greece," says Stephanos, "one could also affirm the relative rarity of blonds, according to the testimony of the ancient authors. It is only among the gods and mythical persons that one finds (*connait*) many blonds."[14]

Evans thinks that "in Greece and Italy blonde hair was so much prized as dark hair was among the northern nations.[15] Hence Helen, Achilles, Meleager . . . and others are all ξανθὸς The ladies therefore prided themselves as much as the men on the personal beauty of their attendants."[16]

Lapouge draws the somewhat unwarranted conclusion that "the Homeric poetry and the Egyptian paintings agree in showing us a tall blond people with white skin and blue eyes, the destroyers of Troy and the Achaean invaders of Egypt[17] . . . All scholars have arrived at the same conclusion that the classical people of free birth (*de condition libre*) presented with greater or less purity the specific characters of the *Homo*

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10. F. A. Paley, *Sexti Aurellii Propertii Carmina*,[2] 55 (Cambridge, Deighton, Bell and Co., 1872).
11. J. P. Mahaffy, *Old Greek Life*, 8 (History Primers, Am. Book Co., no date, but about 1875). The same views of the author are expressed in his *Rambles and Studies in Greece*, 26 and 338 (The Chautauqua Press, 1913). On p. 27, Mahaffy states that "the Greeks came from their Eastern homes." The above references may also be found in his second edition of *Rambles* etc. (Macmillan, 1878), 15, 383, and 16 respectively.
12. W. A. Becker, *Charicles* 456 (translated F. Metcalf, London, Longman, 1874).
13. E. Guhl and W. Köner, *The Life of the Greeks and Romans* 173 (translated by Hueffner, London, Chay Windus, no date).
14. C. Stephanos, *La Grèce au point de vue . . . ethnique*, etc. *Dict. Encyclopedic des Sciences Medicales.* Section 4, volume 10, (1884) 439. See under Von Luschan, who assumes "a great number of individuals with fair complexion and blue eyes" (note 35).
15. I am not aware that the northern nations as a rule admire dark hair, dark skin, and dark eyes, although some of them do admire dark hair or eyes and a white skin. Blond is the ideal type of the Nordic peoples, dark of the Egyptians, the Assyrians and the Aryans in India. The Chinese take pride in being "the people with the black hair." This topic will be discussed at a future time.
16. L. Evans, *The Satires of Juvenal, Persius*, etc., 51, (London, The Bohn Library, 1890).
17. G. V. de Lapouge, *Les Selections Sociales*, 413 (Paris 1896).

europaeus. Among the lower classes one finds a greater variety of types, as the numerous representations of slaves indicate. If one goes through the great collections of classical archaeology or the history of art, and if one compares them with the plates (*se reporte aux planches*) one is struck with the considerable number of persons represented with the dolichocephalous blond type[18] . . . Likewise the study of the Hellenic pantheon shows us that the gods properly Greek are all of them blond.''[19]

''We read of the olive tint,'' says Grosvenor, ''the ebon hair, the cold and coal-black eye, the shapely head, the forehead broad and low . . .''[20]

Palmer asserts that ''the southern nations admired blondes, as brunettes were the predominant type.''[21]

Brinton states the same opinion: ''Though both Greeks and Egyptians were of the dark type of the Mediterranean peoples, their noblest gods, Apollo and Osiris, were represented 'fair in hue and with light or golden hair'.''[22]

''Indeed,'' says Ridgeway, ''it is not unlikely that the distinctive epithet 'fair-haired' is applied in Homer to the Achaean chiefs because they were thus marked off from the mass of their subjects . . . These fair-haired Achaeans were but newcomers into Greece[23] . . . There are strong reasons for holding that the Greeks of classical times had hair and eyes of the like color,'' *i. e.,* like that of the modern Greeks.[24]

Sergi affirms that ''the two classical civilizations, Greek and Latin, were not Aryan, but Mediterranean. The Aryans were savages when they invaded Europe; they destroyed in part the superior civilisation of the Neolithic populations, and could not have created the Greco-Latin[25] civilisation.'' ''The disappearance of the Germanic type among the Mediterranean populations, assumed by Penka,[26] is a necessity imposed by the fact that this type is sought in vain where it is supposed to have dominated, except as a sporadic element easy to explain through the course of ages by the immigration of races or families or individuals.[27] The Homeric Greeks, too, Sergi considers to have been dark. The gods and goddesses are not blond.[28] ''Achilles, however, is ξανθὸς like

18. *Ibid.* 414.
19. *Ibid.* 415.
20. E. A. Grosvenor, *The Permanence of the Greek Type,* 19 (Worcester, Mass. 1897). His latest views are found in the *National Geographic Magazine,* 34 (December, 1918) 450-59. On 450 he calls the Greeks the ''dark-whites of Huxley.''
21. A. Palmer, *P. Ovidi Nasonis Heroides,* 487, 20, 57. (Oxford Univ. Press, 1898).
22. D. S. Brinton, *Races and Peoples,* 42. (Philadelphia, D. McKay, 1901). The quotation is from C. P. Tiels, *History of the Egyptian Religions,* 93 and 95.
23. W. Ridgeway, *The Early Age of Greece,* volume I, 284 (Cambridge Univ. Press, 1901).
24. *Ibid.* 282.
25. G. Sergi, *The Mediterranean Race,* VI (Scribners, 1901).
26. Karl Penka, *Origines Ariacae* (1883). I have no access to this book.
27. *Ibid.* 18.
28. Compare Scott below and notes 91 and 92.

Rhadamanthus; but ξανθὸς means not only fair, but also chestnut brown; and bees are ξανθαὶ ".[29]

Ujfalvy asks the question whether the Greeks and the Macedonians — "their near relations" — were "Pelasgians", and replies thus: "We answer affirmatively for the mass of the people, negatively for the ruling class, namely, the Macedonian aristocracy."[30]

Says Tucker: "The tall fair-haired race . . . also passed down through the Balkan peninsula into Greece. What became of it in these various regions depended on what it met with. It of course met with some other peoples already established; and its own subsequent history would depend on the numbers and characters of these peoples and the degree in which it absorbed them."[31]

Hawes, speaking of pre-Dorian Greece, thinks that "ethnical Greece of those days must then have presented a picture whose background in the main showed dark and short types, relieved here and there by blondness and good stature. Such a partially mixed people seems more probable at this era; and the inroad of a people, the Dorians, sharing these very characteristics, if we are to judge by the Albanians of today, would yield no contrast to the picture."[32]

Woodruff believes that by 500 B. C. the Nordics had died out in Greece and left the Mediterraneans the sole survivors.[33] He calls the former people "Aryans" in contradistinction to the Mediterraneans whom he calls "Semites".[34]

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29. *Ibid.* 20. See also note 101 below.
30. C. De Ujfalvy, *Le Type Physique d'Alexandre le Grand,* 166, footnote, (Paris, 1902).
31. T. G. Tucker, *Life in Ancient Athens,* 6 (Macmillan, 1906).
32. C. H. Hawes, "Some Dorian Descendants", *Annual British School at Athens,* 16 (1909-1910), 265: "The Albani are a tall, dark, broad-headed race with a sprinkling of the lighter element." *Ibid.* 275. Compare also 279: "We found among such of these peoples (Albanians, Tsakonians, and Sphakiots) a varying minority of a short, dark, long-headed type (Mediterranean race) but the main type is broad-headed and inclined to be of a more than average stature; and though in the main dark, has a considerable percentage of lighter eyes and a sprinkling of light or medium-haired." For the Albanians see further Sir Rennel Rodd, *The Customs and Lore of Modern Greece,* 22 (London, Stott, 1892); and E. Pittard, *Race and History,* 293 (New York, Knopf, 1925), who contradicts Rodd, finding only four percent of fair hair among the Albanians, while Rodd gives the impression that the Albanians are blond in the main. Says the latter: "The eyes are light and often blue, the nose is straight and high, the cheek bone inclined to be prominent, and the face generally open, with a fair and healthy complexion. But the type varies considerably, and different travelers have gathered the most contradictory impressions." See also Reinach's statement, quoted below, note 58, and compare Dixon, below, and notes 80 and 81.
33. Woodruff's statement is absurd, like most of his ethnological statements. There never ceased to be, both in ancient and in modern Greece, individuals of Nordic race or type.
34. C. E. Woodruff, *Expansion of Races,* 340 (New York, Rebman, (1909). See also *Ibid.* 325, 327, 333, etc.

Von Luschan declares that "as in ancient Greece a great number of individuals seem to have been fair, with blue eyes, I took great care to state whether this were the case with the modern Greeks in Asia."[35]

"The occurrence," says Myres, "even in the islands, and from the earliest times, of more or less 'Alpine' types, thickset (but often also tall), broadfaced, and round-headed, suggests that this very different breed already held all the adjacent sections of the Mountain Zone, and was able to intrude itself into the Cycladic islands, and into both ends of Crete. The proportion of more or less 'Alpine' individuals mounts up perceptibly in the latter half of the bronze age, and again at its close . . .[36] the Achaeans, blond, fair-skinned giants, 'tamers of horses', shepherds of the people."[37] "The same clear-eyed, chivalrous horse tamers".[38]

According to Marrett, "at the other end of Europe the round-headed peoples, the so-called Alpine race, affected Greece by way of steady though limited infiltration; whilst in Asia Minor they issued forth from their hills as the formidable Hittites, the people by the way to whom the Jews are said to owe the characteristics, yet non-Semitic noses. But are these round-heads all of one race? . . . in the very long run round-headedness goes with a mountain life."[39]

Ogle observes that "many of the Greek gods and goddesses, heroes and heroines are described as golden-haired by Homer, Hesiod, and Pindar; and they continued to be so described by succeeding writers in spite of the fact that the Greeks of the classical period had dark hair and dark eyes."[40]

Beloch gives a somewhat longer description: "As to their Indo-Germanic race relations, as in particular their neighbors the Thracians, the Greeks were also, to begin with, a blond race. Homer attributes blond hair to his favorite heroes, Achilles, Odysseus, and Menelaus; blond were the Laconian maidens whom Alcman celebrated in his *Partheneia,* and the Boeotian women were for the most part blond even in the Third Century B. C. In general, blond hair had been considered throughout the entire antiquity as of particular preference . . . . . At least in later time dark hair predominated in Greece, as is also the case today, and probably in a still greater degree[41] . . . The greater number of Greek women must have been short,[42] and that can only go back to the mixing with the original population."[43]

35. F. Von Luschan, "The Early Inhabitants of Western Asia", *Journal of Royal Anthropological Institute,* 41 (1911), 239. See under Stephanos (note 14) who speaks of the rarity of blonds.
36. J. L. Myres, *The Dawn of History,* 171 (New York, Holt, 1911).
37. *Ibid.* 209.
38. *Ibid.* 217.
39. R. R. Marrett, *Anthropology,* 107 (New York, Holt, 1911) .
40. H. B. Ogle, The White Hand as a Literary Conceit, *Sewanee Review,* 20 (October, 1912), 469.
41. K. J. Beloch, *Griechische Geschichte,*[2] Vol. I, 93 (Strassburg, Trubner, 1912).
42. This topic will be taken up at another time.
43. Beloch, *op. cit.* 94.

Haddon considers the Achaeans to have been a "mixed people of Northern and Alpine descent in which the Northern blood predominated . . . The ancient writers indiscriminately termed them Keltoi,[44] and described them as tall, fair-haired, and gray-eyed. The earliest historical movement of this stock was that of the Achaeans, who about 1450 B. C.,[45] with their iron weapons mastered the bronze-using inhabitants of Greece."[46]

In Beddoe's opinion "the Achaeans, a militant Aryan-tongued race from the north of Central Europe, were at least partly blond and probably also long-headed. On them followed the Dorians, probably of Illyrian race, and broader in head than the Achaeans or their Minoan predecessors[47] . . . You will remember that almost all of Homer's heroes are *Xanthous*-blond or chestnut-haired — Minerva was grey-eyed, but Juno βοῶπις ox-eyed — probably with dark as well as large eyes . . . The earlier subject races, Pelasgic or what not, may have been dark . . . That the Hellenes proper were a race of the type we most of us call the long-headed Aryans, there seems no doubt . . . Next come the palmy days of the Greeks, even then a mingled strain, of which the ruling element seems to have been long-headed and largely blond, while the subordinate ones may have been dark . . . And blond coloration was common and admired among the Greeks, at all events in the early historical period."[48]

Bury once thought that "the Greeks were a people of blond complexion,"[49] but in his later years he changed his mind. Says he:[50] "There is no reason to suppose that the Achaeans were fair-haired because Homer calls Menelaus ξανθὸς (which means probably brown).[51] Among the later Greeks there were two marked types distinguished by light and dark hair. The fair complexion was rarer and more prized. This is illustratrated by the fact that women and fops used sometimes to dye their hair yellow or red — the κόμης ξανθίσματα mentioned in the *Danai* of Euripides."[52]

Cotterill is of the opinion that the Achaeans were "fair-haired", related to the Bhryges, or Phrygians[53] . . . "The Hellenes were mainly of this Indo-Germanic race and . . . when their northern ancestors first pushed southward into Greece they found there a race of quite a different kind — a dark-haired, lithe-limbed race. . . ."[54]

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44. Compare also the views of Lytton and Gladstone above and notes 2 and 6 and 7.
45. See also under Knox, Murray, and notes 8 and 87.
46. A. C. Haddon, *The Wanderings of Peoples*, 41 (Cambridge Univ. Press, 1912).
47. J. Beddoe, *The Anthropological History of Europe*, 49, (Paisley Alexander Gardner, 1912, being the Rhind Lectures for 1891, revised to date).
48. *Ibid.* 82.
49. J. B. Bury, *History of Greece*, 44 (Macmillan, 1913).
50. *Ibid.* 44, note 1 (1924). See also *ibid.* (1913), 57 and 59.
51. Compare notes 29 and 101 and note 6.
52. Euripides, *Tragicorum Graecorum Fragmenta*,[3] edited by August Nauck, Fragment 322 (Leipzig, Teubner, 1889).
53. H. B. Cotterill, *Ancient Greece*, 7 (London, Harrap, 1913).
54. *Ibid.* 4.

Miss Harrison states that "long ago Mr. Gladstone (*Studies in Homer*, I, 553) pointed to Dodona as that early home in Greece and noted also the clear analogies between the Germans[55] of Tacitus and the Hellenes,[56] their great stature, their ruddy hair, their blue eyes. In all these details Homer's Achaeans closely resemble the large-statured, fair-haired, blue-eyed populations of the North whose blood is in our own veins. They — the Achaeans — are but an early off-shoot of those tribes of northern warriors who, later as Dorians or Gauls, again and again invaded the South and blended with the small dark, indigenous peoples, blended with them and, it may be, saved them from being submerged in the great ocean of the East."[57]

"The Albanians on the one hand," says Reinach. "and the Tsakonians or the Mainotes of Laconia on the other, and the Sphakiots of Western Crete; these are all tall brachycephalic blondes. As it is certain that the Sphakiots and Tsakonians descended from the Dorians, this similarity cannot be explained except one admits that the Albanians are the representatives of the Illyrians, the people of which the Dorians were but one branch."[58]

Says Miss Garnett: "One may meet in Greece with a type of quite classical purity — the broad low forehead, the straight nose, dark lustrous eye, and finely-rounded chin and throat of ancient statues."[59]

Davis describes the typical Athenian youth as follows: "His limbs are graceful but vigorous and straight . . . His hair is dark-blonde; his profile very 'Greek' — nose and forehead joining in unbroken straight line."[60]

After an extended study Ripley declares: "All authorities agree that the ancient Hellenes were decidedly long-headed, betraying in this respect their affinity to the Mediterranean race." He continues: "Stephanos[61] gives the average cranial index of them as about 75.7, betokening a people like the present Calabrians in head form; and, for that matter, about as long-headed as the Anglo-Saxons in England and America. More than this concerning the physical traits of these ancient Greeks we cannot establish with any certainty. No perfect skeleton from which we can ascertain their statures remains to us. Nor can we be more positive as to their brunetteness. Their admiration for blondness in heroes and deities is well known. As Dr. Beddoe[62] says, almost all of Homer's leaders were blond or chestnut-haired, as well as large and

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55. Jane E. Harrison, *The Religion of Ancient Greece*, 27 (London, Archibald Constable, 1913. It appeared first in 1906).
56. See Gladstone's own statement above, note 6.
57. *Ibid.* 28.
58. A. Reinach, *L'Hellenisation du Monde Antique*, 18, note 1 (Paris, Felix Alcan, 1914). For the Albanians see note 32 above.
59. Lucy M. Garnett, *Greece of the Hellenes*, 2 (New York, Scribners, 1914).
60. W. S. Davis, *A Day in Old Athens*, 162 (New York, Allyn and Bacon, 1914.) This youth is supposed to have lived about 300 B. C.
61. C. Stephanos, *opera citata*, 432.
62. J. Beddoe, *opera citata*, 82. See also the passage quoted above, note 47.

tall. Lapouge[63] seems inclined to regard this as proof that the Greeks themselves were of this type, a broad interpretation which is scarcely justifiable. As we shall see, every characteristic in their modern descendants and every analogy with the neighboring populations leads us to the conclusion that the classical Hellenes were distinctly of the Mediterranean racial type, little different from the Phoenicians, the Romans, or the Iberians.''[64]

Ferriman, speaking of the modern Greeks, quotes loosely with approval About's[65] description of some modern Greek youths: ''These tall youths of simple gait, oval face, bright eye and lively spirit . . . are undoubtedly of the same family from which Phidias took his models. About's own words are significant. Says he: ''The Greek race has very little degenerated and those tall young men with a slender waist, oval face, quick eye, and ready wit, who fill the streets of Athens, are surely of the family that furnished models to Phidias.''[66]

Inge considers the Spartans as being almost pure Nordics, the Athenians as almost pure Mediterraneans.[67]

Bottsford thinks that ''there was no typical Greek.''[68] A little before that remark he states: ''We find among the ancient Greeks as great difference as among civilized men of the whole world today.''[69]

Says Peake apropos of the Homeric Greeks: ''It is noticeable that all the people mentioned by name — *sc.* in the *Iliad* — are captains of the host, or members of the nobility. The *Iliad* . . . records the doings of the Achaean heros. One exception only is there to this rule. At one moment the host, composed no doubt of Alpines and Mediterraneans, thinks of revolting.''[70] The classic peoples he considers to have been ''tall, dark people, with small but broad heads.''[71]

Günther asserts that ''the Achaeans were 'bright-eyed' as Homer[72] named them''.[73] ''The ideal of beauty (*Shönheitsbild*) of Greece is entirely Nordic. The Greek statues show repeatedly the pure Nordic race. The gods and heroes are distinguished (*gekennzeichnet*) through their

63. G. V. De Lapouge, *opera citata,* 414. See the passage quoted above, notes 17, 18, and 19.
64. W. Z. Ripley, *The Races of Europe,* 407 (New York, D'Appleton, 1915).
65. Z. D. Ferriman, *Greece and Tomorrow,* 6 (New York, Oxford Univ. Press, 1918).
66. Edmond About, *Greece and the Greeks of the Present Day,* 21. Translated by authority; no translator's name given. (Edinburgh, Thos. Constable, 1855).
67. W. R. Inge, ''Religion'' in *The Legacy of Greece,* edited by R. W. Livingston, 25 (Oxford, Clarendon, 1921).
68. G. W. Botsford, *Hellenic History,* 6 (New York, Macmillan, 1922).
69. *Ibid.* 6.
70. H. Peake, *The Bronze Age and the Celtic World,* 113 (London, Benn Brothers, 1922).
71. *Ibid.* 108. He classifies them as belonging to the ''Eastern Alpine or Dinaric Type.''
72. In *Iliad,* I, 389; III, 190; XVI 569; XVII 274, etc. He has in mind Ἑλίκωψ For references to the discussion of this work see note 96 below.
73. H. F. K. Gunther, *Rassenkunde des deutschen Volkes,* 28[2] (Munchen, Lehmann, 1923). See also *Ibid.* 305, where he speaks of the Persians: ''Sie waren fast

high stature, light skin, and light hair." And in a more recent work he gives a more full description: "Homer and Hesiod call gods and heroes blond, blue-eyed, and tall. Dark hair is in Homer characteristic of non-Hellenes. The Trojan Hector is called (*Iliad*, Book 12) black-haired.[74] Greek sculptures are always showing the pure Nordic race. The ever-recurring phrase 'fair and tall' applied to men, women, and children (often, for instance, by Homer and Herodotus) goes to show that only the tall Nordic fulfilled the conditions of the Hellenic ideal of beauty."[75]

Harland sums up the current belief about the Achaeans: "From the fact that Achilles, Menelaus, Odysseus,[76] etc., were called 'yellow-haired' in the *Epos*, it is generally believed that the 'Achaeans' were a light-haired people.[77] The tradition that the Dorians found a Hellenic people already in Peloponnesos of course applies to the 'Achaeans' who might as well be called Dorians. As Beloch[78] has shown, the term Dorian as an ethnic name did not come into general use until the eighth or seventh century . . ."[79]

Dixon thinks that "the blond type of the Homeric heroes has apparently long since been absorbed."[80] The Dorians he believes to have been of Alpine type[81] "primarily", "although perhaps under leaders who were largely of Caspian type."[82]

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alle hell blond oder rot blond wie die Griechen."

74. *Iliad*, XII 463.
75. *Idem*, *The Racial Elements of European History*, 157 (translated by C. C. Wheeler, New York, Dutton, no date but about 1928). Gunther devoted another effort to the subject in his *Rassengeschichte des hellenischen und des römischen Volkes*, Munchen, Lehmann, 1929).
76. Compare *Iliad* I, 197 (of Achilles); III, 284 (of Menelaos); Odyssey XV, 133 (of Menelaos); XIII, 399 (of Odysseus). The description of Odysseus however is complicated. In the *Odyssey* XV, 174, he is represented as dark. Later Greek writers, too, represent him sometimes as blond and at others as dark. Shewan. *Classical Philology* 24 (1929), 340-342, takes Odysseus for a dark; while Myres in his *Who Were the Greeks?* 569 note 77 (Univ. of California Press, 1930), takes him for a blond. Myres misunderstands the passage in Homer.
77. J. Harland, The Peloponnesos in the Bronze Age, *Harvard Studies in Classical Philology*, 34 (1923) 57,
78. K. J. Beloch, *opera citata*, 141. But see C. D. Buck, "Language of Greece", *Classical Philology*, 21 (1926), 1-26, especially 3 and footnote. This view of Beloch's is untenable.
79. *Idem*, *opera citata*, 51, note 2.
80. O. R. B. Dixon, *The Racial History of Man*, 96 (Scribners, (1923). Elsewhere Dixon thinks (p. 35) that only a few non-Alpine persons came into Greece with the Dorian invasion. He calls these Caspian. For the meaning of this term see *ibid.* 17, 21, and 317. It is discussed in my article, "The Pre-Hellenic Inhabitants of Greece and Italy", in Volume 9, p. 147, note 55, these *Proceedings* (1935).
81. *Ibid.* 35, Dixon, 497, describes the Alpine as follows: "In skin they are probably fair, the hair being straight and dark, the eyes without the Negroid fold. They appeared in Europe during the end of the Palaeolithic period." The Mediterranean type according to him (486) "appeared in Western Europe first in the Aurignacian period of later Palaeolithic times."
82. *Ibid.* 35.

Grant's view is somewhat like that of Peake, quoted above:[83] "Both Trojans and Greeks were commanded by large blond princes, the heroes of Homer, — in fact even the gods were fair-haired — while the bulk of the armies on both sides was composed of little brunette Pelasgians,[84] imperfectly armed and remorselessly butchered by the leaders on either side. The only common soldiers mentioned by Homer as the same race as the heroes were the Myrmidons of Achilles."[85] He is of the opinion that the "true Greeks" were blonds.[86]

Murray thinks there came to Greece, "probably well before 2,000 B. C., an immigration of people who afterwards became the main Greek stock and who spoke a language that is the parent of Greek."[87] Speaking of the Achaeans he states: "The invaders seem to have been, to a preponderant extent, tall and fair, warlike, uncivilized. Authorities differ as to the shape of the head."[88]

Scott argues that "if the Achaeans were a light-haired race, and this color was a matter of racial pride, it seems strange that their chief divinities should have been dark. The reason for calling Demeter[89] golden is simple for she was the divinity of golden harvests; and she is the only divine being thus named in Homer.[90] It is a striking fact that no Greek is said to have had dark hair[91] and no Trojan light hair; also that the three powerful deities, Zeus, Hera, and Poseidon, should have been dark".[92]

Weigall, speaking of Cleopatra, comments: "The color of her eyes and of her hair is not known; nor can it be said whether her skin was white as alabaster, like that of many of her Macedonian fellow countrywomen, or whether it had that olive tone so often observed among the Greeks."[93]

Hamilton, speaking of the Homeric Greeks, says: "They were fair-haired, blue-eyed men."[94]

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83. See note 70, above.
84. A. H. Keane, *Ethnology*, 364 (Cambridge Univ. Press, 1896), considers the Pelasgians to have been "blue-eyed and light-haired, as the Teucrians, Hellenes, Itali and Etruscans."
85. Madison Grant, *The Passing of the Great Race*,[4] 159 (Scribners, 1924). "No Trojan is described as blond." See also Gladstone, note 6, and Scott below, note 92.
86. *Ibid.* 34, 60, 138, 139, also 143-144.
87. Gilbert Murray, *The Rise of the Greek Epic*,[2] 40 (Oxford: At The Clarendon Press, 1924).
88. *Ibid.* 41.
89. See Gladstone, above, notes 6 and 7.
90. Aphrodite is called golden by Homer, and Athena grey-eyed.
91. Scott's statement is somewhat too strong. Odysseus had dark hair for at least part of the time. See note 76 above; and compare Sergi's statement, notes 26 and 27; also Gladstone, note 6.
92. John Scott, "The Complexion of the Achaeans," *The Classical Journal*, 20 (1925), 367. See also note 85 above. J. L. Myers, *Who Were the Greeks?* 192 (Univ. of Calif. 1930) considers Zeus a blond.
93. Arthur Weigall, *The Life and Times of Cleopatra*,[2] 6 Putnam, 1925).
94. M. A. Hamilton, *Greece*, 4 (Oxford: At the Clarendon Press, 1926).

Brandes thinks that the ancient country people of Greece were brunettes. Says he: "He whose eyes have rested on the dark, slender men of modern Greece, and on their peasant girls, with their free, elastic tread, and on their little ones with their fiery black eyes — these children that still bear the names Aristidi and Aristoteli — has had a glimpse at the appearance of the ancient Greek country-dwellers."[95]

Of the persons quoted above, Lytton, Gladstone, Knox, Lapouge, Ridgeway, Tucker, Woodruff, Ogle, Beloch, Haddon, Cotterill, Harrison, Günther, Harland (?), Murray, and Hamilton consider the Homeric Greeks to have been blond or predominantly blond. Brinton, Sergi, Hawes, and Scott consider them to have been dark. To this class may be added the opinions of scholars cited under ἑλίκωψ (the Homeric word which is treated in my article, 'Ελίκωπες 'Αχαιοὶ: *A Lexicographical Study*).[96] Myres, Marrett, Beddoe, Bury, Peake, Dixon, and Grant consider the Achaeans only partly blond, the mixture varying according to each writer's idea, most of these writers postulating that only the Homeric leaders were blond. Myres would have the Achaeans more or less Alpine. With him agree Marrett and Haddon. Hawes, Marrett, Beddoe, Reinach, and Dixon consider the Dorians to have been Alpine. Inge thinks the Spartans were "almost pure Nordics".

Lytton, Felton (in part), Knox, Mahaffy, Lapouge, Luschan, Woodruff, Beloch (in part, for the earlier Greeks like Woodruff), Beddoe, Cotterill, Harrison, Davis, Günther, and Grant consider the later Greeks to have been more or less blond. Scaliger, Gladstone, Paley, Becker, Guhl and Köner, Stephanos, Evans, Grosvenor, Palmer, Brinton, Ridgeway, Sergi, Ujfalvy, Ogle, Bury, Garnett, Ripley, Ferriman, About, Dixon, and Weigall consider them brunette.

I should like to touch upon the question whether like admires like; whether the Greeks, in admiring blond hair, admired what they themselves were, or whether they admired what was rare; but it is impossible to do so within the limits of this paper. I have gathered information from a number of sources and from a questionnaire, and hope to present the results of this study in the near future.

It would carry us far beyond the limits of the present paper to do other than to indicate that there are many problems to be solved before we are able to pronounce with authority upon the complexion of the ancient Greeks. That they were a mixed people goes beyond saying. Archaeology is helping to solve the problem, and in the near future we shall be able to distinguish more clearly the different migrations. Meanwhile, I mention only three of the views held by scholars. De Morgan[97]

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95. George Brandes, *Hellas, Travels in Greece*, 3 (translated by J. Hartmann, Adelphi, 1927).
96. The article mentioned here is published in *West Virginia University Studies: III, Philological Papers* (Vol. 2), May, 1937. For an abstract of a paper entitled 'Ελίκωψ: Its Meaning and History in Homer and Classic Greek Literature," see *P. A. P. A.*, vol. 61 (1930) pp. 27-28.
97. Jacques de Morgan, *Pre-historic Man*, 294 (Knopf, 1925).

postulates Asiatic immigrants in the course of the fourth millennium. Afterwards appeared the Pelasgians "bringing with them in this environment new conceptions foreign to Asia." Then came a new element known as the Aegean. Two physical types were in evidence from somewhere about the second millennium before our era. The earlier of the two was dolichocephalic, which furnished the Minoan civilization; the other and more recent, brachycephalic, which must have been the creator of Mycenaean culture and was related to the tribes who in those times inhabited Thrace and the banks of the Danube. Kretchmer[98] distinguishes in Greece three strata of population: the non-Indo-Germanic; the prot-Indo-Germanic which he considers to have been the author of the Minoan civilization; and the Indo-Germanic or Hellenic. Blegen[99] also distinguishes three strata, though these are not like those of Kretchmer. They are the Mediterranean race, "from undatable beginnings to shortly after 3000 B. C.," the early Helladic, an Anatolian, non-Indo-European race. This stratum he supposes to have "overrun and absorbed the remnants of the first, continuing in power until 2000 B. C.;" and the Middle Helladic, which was "the first of many successive waves of Greeks."

The author of this paper has gathered[100] all the literary, the philological, the historical, and, as far as possible, the archaeological and anthropological evidence and hopes to be able to complete his studies soon. But some problems are raised in this paper that should not be passed over: *e. g.*, the portrayal of persons and the coloration of hair, skin, and eyes in art. How far is the coloration owing to convention? For instance, we know that the Aegeans borrowed from the Egyptians the convention of representing the skin of the men as brown and that of the women as white. The Greeks in turn borrowed this convention from the Aegeans. In Greek art we find the eyes sometimes painted red, often brown or auburn like the hair. How far did the original paint discolor? How far did the Greeks as well as the Aegeans apply the colors realistically? For instance, we have the Cretan *Blue Boy* and the Athenian *Blue-Beard*. How far like preferred like? Of late, too, scholars have begun to think that ξανθὸς does not necessarily mean blond but may mean brown as well.[101]

98. Paul Kretchmer, "Die Protindo-germanische Schicht," in *Glotta* 14 (1925), 319.

99. C. W. Blegen, *American Journal of Archaeology*, 27 (1923) 157. See also these *Proceedings*, Vol. 9 (1935), 148.

100. In 1926 he submitted part of the results of his study of the literary evidence in his doctoral dissertation entitled, *Studies on the Blond Type in Ancient Greece* (Univ. of Illinois), which he wrote under the direction of Prof. W. A. Oldfather. See *Proceedings*, Vol. 9 (1935) p. 141.

101. See Bury above, notes 6, 21, and 50. The words *xanthos* and *xouthos* will be discussed in another paper in the near future.

NEGRO MIGRATION TO THE MINING FIELDS OF WEST VIRGINIA

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IN AN ARTICLE in the American Journal of Sociology for November 1931 Ross and Truxal[1] pointed out the distinction between primary and secondary migration. As related to interstate migration, a direct movement of natives of one state into another is termed primary migration, and the movement of migrants into an area from other than their native states is termed secondary or indirect migration. They criticize the frequent inference of writers on population movements that an an increase in one state of natives of another state is due to direct migration between the two areas. and show that these increases may be indicative of both primary and secondary migration. In other words, an increase in West Virginia of Virginia-born Negroes does not necessarily mean that there has been so much movement of people between Virginia and West Virginia. It may mean that the movement has been between Pennsylvania and West Virginia.

The purpose of this paper is to suggest a conceptual approach, both quantitative and qualitative, to the study of migration in its primary and secondary aspects which will not only point out the main currents in the stream of migration but will indicate something of the little eddies, undercurrents, whirlpools, and backwashes, and their relative importance to the totality of migration toward certain focal points. This approach was used by the writer in a schedule study of 600 Negro miners in West Virginia in which the effort was made to study the causes, amount, and directness of the movement of migrant Negroes to the mining fields, and in addition to answer the question of how they came to West Virginia. The term "directional types" was coined in the attempt to give at least a partial answer to this last question. Folkways and their relationship to population movements have long been the subject matter for the sociologist. The point of emphasis here, however, is not so much folkways as pathways.

The Negro miners of West Virginia are largely a migrated group. Only 14.0 percent of the 600 miners interviewed were born in this state; 47.8 percent came from Virginia, 11.8 percent from North Carolina, 11.2 percent from Alabama, 4.5 percent from Tennessee, 3.3 percent from Georgia, 2.5 percent from South Carolina, and the remaining 4.9 percent from five southern and six northern states. From the standpoint of both direction and numerical importance Negro migration to the mining fields may be thought of as coming from three main sources: Virginia, southern states other than Virginia, and northern states. From these areas came respectively 55.6 percent, 41.7 percent, and 2.7 per cent of the migrants.

A comparison of the number of miners claiming a particular state as a place of birth and the number claiming it as a last place of residence

[1]Ross, Frank A., and Truxal, Andrew G., **Primary and Secondary Aspects of Interstate Migrations**, A. J. S., Vol. xxxvii, Nov. 1931, pp. 435-444.

prior to coming to West Virginia indicates that not all of the movement to West Virginia is of the primary type. The more northern states, along the pathways of the migratory movement from the south, appear in greater numbers as the last residence of the migrants than do their native states. Of the southern points of origin of the movement, on the contrary, the reverse is true. Virginia was the native state of 287 of the 516 migrants, while 289 gave Virginia as the state of last residence. Kentucky likewise claimed only 7 as natives, but was the last residence of 20. Two chief factors account for the greater number of Negroes claiming Virginia as a place of last residence than as a native state. There is a decided intermigration between Virginia and North Carolina with the balance greatly in favor of Virginia.[2] In addition, the ship yards, furniture factories, tobacco factories, coal mines, and other industries of Virginia, have constituted a "pull" for Negroes from states in the deeper south. The coal mines of Kentucky have similarly served as stopping points for numbers of southern Negroes who eventually found their way to West Virginia.

Most of the Negro migration, however, into the West Virginia mining fields is probably of the primary or direct type. Of the 516 migrated miners 444 or 86.1 percent came directly and only 72 or 13.9 percent came from other than their native states. The directness of the movement varies somewhat inversely with the distance of the state of the migrant's birth from West Virginia. Of the Virginians 92.6 percent came directly, while of those from states south of Virginia only 77.2 per cent came in that way.

DIRECTIONAL TYPES

1. *Primary directional types*

The pathways of migrant Negroes to the mining fields of West Virginia may be classified into ten directional types; three of which are primary and seven secondary. The most important directional type is a direct movement from Virginia to West Virginia. Of the 287 who came from Virginia 266 or 92.6 percent came directly. This type constitutes 51.6 percent of all migration indicated by the study. This movement, starting with emancipation, has continued in large numbers since the completion of the Chespeake and Ohio Railroad which connected Virginia with southern West Virginia in 1872. This railroad, which was built largely by Negro labor from Virginia,[3] was the occasion for the opening of the rich New River coal field. Many of the railroad workers remained to work in the mines. This transition from railroad workers to miners was duplicated in the building of the Norfolk and Western Railroad from 1883 to 1892, the Virginian in 1909, and their later extensions. Many of these Virginia negroes owned farms in Vir-

[2] *Ibid.*, p. 437.

[3] It may be of interest to observe here that the Negro legendary hero, John Henry, was supposed to have been one of the workers at the Big Bend Tunnel on this road. See Guy B. Johnson, **John Henry**, Univ. of N. C. Press, 1929.

ginia and worked in the mines only a few moths each year, using coal mining as a sort of "money crop."

The next directional type in numerical importance is a direct movement from states south of Virginia. Of the 215 miners from these states 166 or 77.2 percent came directly. This group constituted 32.2 percent of all migrated miners interviewed. This type, like the one already mentioned, is as old as the mining fields; for it is traditional for coal operators to look to such states in addition to Virginia for a labor supply and to get it through labor agents sent by them for that purpose.

Migration of northern Negroes to West Virginia is numerically unimportant, only 13 or 2.2 percent of the 600 miners being natives of northern states. Twelve or 92.3 percent of these came directly, constituting a directional type representing only 2.3 percent of all migrants. This north to south movement is not very extensive, coming largely from states like Pennsylvania, Ohio, and Indiana which also have extensive coal mining operations. These migrants are usually miners who have come to West Virginia in order to secure the advantages of higher wages or a more prosperous market.

2. Secondary directional types

Among the secondary migration pathways of those who have come to West Virginia indirectly it is possible to issolate several well-defined directional types. As has been pointed out, 92.7 per cent of the native Virginia Negroes came directly to West Virginia. The other 7.3 percent form a secondary migration group which came to West Virginia in two general directions, one dominant, the other of minor importance. The main movement is to the states north of Virginia and then to West Virginia. A typical movement of this kind is to Baltimore, Pittsburgh, and the mining fields of West Virginia. Sometimes the movement is entirely cyclical, ending in a return to Virginia. Eighteen Virginians came to West Virginia by this northern route, constituting 3.5 percent of all migrants and 6.3 per cent of all Virginians. The other secondary movement from Virginia is first to Kentucky and then to West Virginia. While only three of those interviewed, constituting only .6 percent of all migrants, took this western route before coming to West Virginia, it forms a definite directional type — like the former, sometimes cyclical in its nature. The proximity of the extreme western counties of Virginia to the rich coal fields of Kentucky largely accounts for this movement.

A noticeable pathway from states south of Virginia, followed particularly by natives of North Carolina, South Carolina, and Georgia, is a two-direction type — first south and later north-ward to West Virginia. The southern magnet which draws many natives of these states is the coal and iron mining centers of Birmingham, Alabama. Negroes in the coal mines of Alabama constitute more than 50 percent of the entire population of the industry,[4] although their numbers are less

[4]See Allen, G. E., **The Negro Coal Miner in the Pittsburgh District**, unpublished M. A. thesis, University of Pittsburgh, 1927.

than one-third those in West Virginia. Seven of the 215 southerners, exclusive of Virginians, or 3.3 percent came to West Virginia by way of Alabama. This group, already accommodated to mining, usually turns northward because of the higher wage scales of West Virginia. They constituted only 1.3 percent of the migrated miners.

Another direction followed more frequently by natives of all the southern states south of Virginia is a one-direction northward and eastward movement with one or more stops, the last one in Virginia from which state the migrant would come to West Virginia. Seventeen or 7 9 percent of the southerners came in this way. Virginia, with its ports, factories, and mines, has attracted some migration not only because of its own "pull" but but because it lies directly in the pathway to the northern sates. The type of migrant who wanders from his native state by means of short moves often stops in Virginia. Here he is likely to be influenced by teh traditional Virginia-West Virginia movement so that it is not surprising that a considerable number, come from the south in this way. This type constituted 3.3 percent of the movement into West Virginia. Many of them were, to use their own terms, "just venturing out" and "just wandered" to the mining fields.

The type of movement just described might be termed "the Virginia way" of coming to West Virginia. Another "way" that is also followed by numbers of southerners might also be called "the Kentucky way" or the "Tennessee-Kentucky way." A good many natives of Alabama, Mississippi, and the Carolinas take a more westerly route, making their first stop or stops in Tennessee or Kentucky or in both. Eight, or 3.7 percent of those coming from the states south of Virginia took this direction. Tennessee miners quite often go to Kentucky and later to West Virginia. Miners following this direction constituted only 1.5 percent of the migrated group.

A very important secondary movement to the West Virginia mining fields comes as a sort of backwash of the movement to the northern urban centers. The migration of Virginia natives to these northern cities has already been mentioned. Another type of this two-direction migration is a direct movement from one of the southern states to a northern state, such as Pennsylvania, Illinois, or Ohio, and then a return from there to West Virginia. Fifteen or 6.9 percent of those from states south of Virginia followed this direction, constituting 2.9 percent of the migrated group. According to a reliable source,[5] there are to be found among this type of migrant a number who have run afoul of the law in the north and come to the mining fields to hide for a time. It is likely, however, that most of them have simply been unable to make a satisfying adjustment in northern urban life.

Finally, another type of migration, which was much more important 20 or 25 years ago than now,[6] was a movement from the southern states in a northwestern direction, particularly to the states of Kansas and

[5]Interview with Mr. T. L. Felts of the Baldwin-Felts Detective Bureau, Bluefield, W. Va.

[6]See **Abstracts of Reports of the Immigration Commission**, Senate Document 747, 2 vols., passim.

Missouri, and then east to West Virginia, sometimes directly, sometimes directly, sometimes with intermediate stops. Only two, or less than one percent, of the southerners came in this way. Such a movement, only 0.4 percent of the total, illustrates clearly an historical and quantitative change in directional types.

We may summarize our findings concerning the ten directional types of Negro migration to the mining fields of West Virginia as follows: 1. A direct movement from Virginia to West Virginia. 2. A direct movement to West Virginia from states south of Virginia. 3. A direct movement from northern states to West Virginia. 4. A movement from Virginia to northern states and thence to West Virginia. 5. A movement from Virginia to Kentucky and thence to West Virginia. 6. A movement from certain southern states north of Alabama to that state and thence northward to West Virginia. 7. A movement north from the southern states with one or more stops, the last of which was in Virginia from which state the migrant came to West Virginia. 8. A movement from the southern states with one or more stops, the last being Kenucky from which state the migrant came to West Virginia 9. A movement from the states south of Virginia direct to the north and thence back to West Virginia. 10. A movement from the southern states to the West, to such states as Kansas and Missouri, and thence to West Virginia.

PUBLIC WELFARE IN WEST VIRGINIA

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THE PRIMARY OBJECT of this paper is to set forth some of the significant facts concerning the origin, development, and present status of public welfare activities and problems in the state of West Virginia; also, to consider some of the basic conditions out of which our problems have grown. It would be inappropriate to attempt, within the limits of this paper, any *detailed* consideration of the plans and methods for dealing with the problems and situations referred to. From the viewpoint of scientific procedure we can not legitimately undertake to propose *remedies* before we know, at least fairly well, the nature and causes of conditions to be remedied. In other words, this paper is a brief excursion into a study of those phases of human life in our state which are coming to be called *social welfare* or *public welfare* problems. Our procedure is chiefly that of *descriptive* and *analytical* sociology, *not* that of *applied* sociology.

"Public Welfare" was a phrase little known to our West Virginia citizens of the early days. There were no large cities with so-called slums, very few unassimilated foreign-born, and very few negroes except a small number of pre-civil war farm slaves and domestic servants, with their descendants.

Until about 1890, except for the industrialized section of the Northern Panhandle around Wheeling, West Virginia was almost entirely a state of peaceful and quiet land-owning farmers and small town dwellers. The public highways and the free public schools were about the only important common welfare functions in early days, and even they were relatively slightly developed. The absence of compulsory school laws and of inadequate educational personnel, and the old-fashioned neighborhood way of caring for public highways, helped make civic welfare and group effort for the common good to be decidedly casual, individualistic, and relatively ineffective. It was the day of rugged individualism "par excellence"; and our state motto (inscribed on the University College of Law building) was a vital reality. This motto, "Montani semper liberi" (mountaineers always free), meant more than the right of every man who so desired to make and sell moonshine whiskey and carry a gun in his hip pocket. It meant that, barring the outright criminals and the dangerously insane, to a *very* large extent, every man literally free. He sent his children to school if he felt like it, if they wanted to go, and if he didn't need them to help work in the corn and tobacco fields. He took his own sweet time to do a little work on the road which passed his home, and he voted on election day, generally. These were about the extent of his community interests and activities except those connected with the church and spontaneous neighborhood social life.

The bitter and bloody family feuds of West Virginia's early days, also the conscientious and vigorous protests of mountaineer farmers against government interference with home production and sale of liquor, were both perfectly natural expressions of the primitive individualism fostered by isolated living and independent thinking.

In the relatively short period of the last half century, West Virginia has changed tremendously; and is still in the process of change and evolution from a relatively simple rural to a more complex and more industrialized community. In the 1880's and 90's valuable oil and gas resources were discovered and rapidly developed. During this same period the virgin forests of the state yielded enormous quantities of high grade lumber, and made many multi-millionaires, including one unsuccessful candidate for the vice-presidency.

Just a little later the bituminous coal resources were located and developed, making West Virginia in these later years a close rival with Pennsylvania for first place in national coal production. In addition to furnishing cheap fuel to the industries of *other* states, low-priced gas, oil, and coal greatly stimulated the manufacturing industries within the state. Glass manufacturing, steel and iron production, potteries, and the chemical industries have become genuinely significant, to say nothing of many other smaller industries. There are three large population centers in the state with the conditions and problems of urban groups: Wheeling, Charleston, and Huntington. One hundred thousand men and at least 400,000 people are directly or indirectly dependent upon the ups and downs of the coal-mining industry. In short, to a large extent, West Virginia has become, in the last three or four decades, an industrialized state, where unemployment, labor and capital conflict, assimilation of foreign-born, and illiterate southern negroes, have become realistic social problems. Agriculture has also become more specialized and more productive; but there are about 20,000 of our 95,000 farm families now either on relief or near the border-line of dependency. S ome of these (or their ancestors) worked in the saw mills and in the gas and oil fields of the 1890's With most of our forests already used up, with the exploiting stage of oil and gas development largely a thing of the past, and with our hillside farms partially ruined by soil erosion and neglect, these 20,000 farm families are now in the phraseology of our National Relief Administration, "stranded". The Rural Rehabilitation Organization in West Virginia is attempting to deal with this very large problem of families on submarginal farms (meaning those people who are unsuccessfully trying to make a living on cut-over lands or other worn-out soils).

Like other nations and states which grow relatively wealthy, West Virginia is now confronted with the very large problem of caring for those who have been left behind in the severe competitive struggle of modern life. Even much larger and richer states have the very same problems. It may be true that, with exercise of more forethought and social control, *some* of these recent and present unfortunate conditions could have been prevented.

Because of its early isolation and sectionalism, and because of the rapidity with which these are now being broken down, West Virginia probably gives us a more clear-cut present-day example of the *transition* from rugged rural individualism to modern social or public-welfare viewpoints, attitudes, and policies than most of our 48 states. It is with an account of some of the high spots in the problems of working out and putting into practice these newer public-welfare ideas and programs in our state that the remainder of this paper is concerned. The developments of our manufacturing and mining industries from 1890 to the present time have brought into the state large numbers of foreign-born peoples and southern negroes who, in prosperous times, were valuable citizens and profitable producers :but who, even under normal conditions, made large problems of assimilation and adaptations. In times of depression *especially*, these groups have added greatly to the numbers of our unemployed and dependents. In December, 1932, 29% of our state's population was partly or entirely dependent upon public charity; only the state of Florida had a higher proportion of its people on relief. West Virginia's public-welfare problem, during the last six years, has been tremendous, and will continue to be with us for some time to come, perhaps indefinitely. It is indeed fortunate that at least *some* very worth while forward steps to deal with the situation have been taken. To these we now give our attention.

1. About 1920, the State Board of Children's Guardians came into existence. This was the pioneer public welfare program in West Virginia; and the Board not only performed valuable functions in the more adequate care of dependent and neglected children, but it was also the "germ-plasm", so to speak, out of which developed other philanthropic interests and activities. Under the three successive directors

or executive secretaries, it gradually built up a personnel and an organization that reached into every county of the state. The executive staff at Charleston and the local district agents were active and effective, to the benefit of thousands of needy children. The functions of the board extended *beyond* the discovery, care, and placement of homeless children. It helped to create public opinion in behalf of state-supported and state-directed welfare work; it carried on appropriate publicity, both through its own publications and through the newspapers. The Board of Children's Guardians was one of the chief agencies in carrying on the annual state conferences of social workers. These conferences considered, in at least a *semi-professionay* way, the technical problems of social welfare. They included in their membership many men and women who, as rank and file citizens, wanted to learn more about the increasingly difficult problems of child welfare and the problems of the dependents, defectives, and delinquents in our state population.

Much credit for organizing and carrying on the work of the Board of Children's Guardians must be given to the first West Virginia State Board of Control, especially to its president, Mr. James S. Lakin. This group of three men gave much thought and earnest activity to the problem of bringing West Virginia up to a standard somewhere near the standards of those states which had been doing public welfare work many years. The Board visited some of the most progressive states, like Massachusetts and New Jersey, and carefully studied the objectives, methods, and results of child welfare work. They persuaded the legislature to appropriate the necessary funds, which was no easy task. They secured the cooperation and active interest of capable and public-spirited men and women who, without salary, guided the actual program and policy of the child welfare workers. One of these many unselfish and socially minded men who served on the Board of Children's Guardians was Harry L. Snyder, of Shepherdstown, the veteran newspaper man of the Eastern Panhandle.

2. State work for *crippled* children. Perhaps the chief credit for stirring up interest in crippled children, which interest led to action, should go to one of our Men's Civic Clubs, although many other persons and groups were helpful. Among these other groups should be mentioned the Kiwanis and Lions clubs and the State Federation of Women's clubs. The Rotary Clubs of West Virginia, for a good many years, had aided crippled children as they located them in the respective communities. This aid consisted of financing surgical treatment, necessary hospitalization, and convalescent care; and by the middle of the 1920's, this work had become fairly extensive throughout the state. As surveys, made through the public schools and in other ways, began to show that there were at least 10,000 needy crippled children in the state, the Rotary Clubs took the wise step of petitioning the legislature to make this greatly needed philanthropic work a sate wide and tax-supported enterprise. After a few years this goal was attained; and about 1930, care and treatment of indigent crippled children became a regular public-welfare function in West Virginia. Soon thereafter the new state department of public welfare, (mentioned later in this paper),

made work for crippled children one of its three main divisions. It is a noteworthy fact that, even during the period of the economic depression, the appropriations for this work have been maintained, and, at one legislative session, substantially increased. Evidently our state legislators believe that public opinion in West Virginia is increasingly conscious of the state wide human welfare problems; and that the tax payers are willing to support well-planned programs along these lines.

3. The West Virginia State Department of Public Welfare. In some respects, we may think of the creation of the Department of Public Welfare in 1931 as a climax of several different activities and interests along social welfare lines. As has been prviously stated, the Board of Children's Guardians for *dependent* children and the work for *crippled* children had been under way for some time. The state conferences of social work had been fostering the ideas and practices leading towards a more definite and professional program in behalf of both children and adults who were physically or mentally deficient or socially mal-adjusted. Public opinion in1931 reached the point where it supported the legislature in making a modest appropriation for this new branch of our state government, the Department of Public Welfare.

Under the leadership of Captain Calvert Estill, its organizer and first director, and of Major Francis W. Turner, the present director, our new state department has a record of substantial achievement. It is organized in 3 divisions — one for dependent and neglected children, one for crippled children, and one for state aid of a non-financial character to World War Veterans.

During these recent years of nation-wide relief problems, the work of the state department of public welfare and of its county units has been overshadowed by the State and Federal Relief Administration, which has had ten times as much money and personnel. There is definite prospect, however, that in the near future, when the new social security program of the federal government goes into operation, the departments of public welfare in *all* of our states will resume former functions. They will probably be given *larger* functions and greater financial support, when the systems of old age pensions, child and maternity welfare, and other social service programs go into operation.

4. Public Health. It may be that, in the future, we shall consider the great expansion of public health functions a valuable by-product of the great depression of the of the 1930's At least it has been so in West Virginia. As a matter of dire necessity for one- fourth of our total population, publicly supported medical and surgical work has developed rapidly, including hospitalization, various kinds of immunization, pre-school nutrition classes, nursery schools, and tuberculosis and venereal disease clinics. Even though all these services are still inadequate, the results of the expanded services in effective control of epidemics and in holding down infant mortality rates to approximately normal have been a real achievement. Three state hospitals for tuberculosis patients and three general state hospitals are a vital part of the public health program.

In the 1935 summer session of West Virginia University, 94 Nursery

School teachers from various sections of the state were taking semi-professional training to better fit them for their work in 30 or more counties. It is a constructive *criticism* of our relief program in health and nutrition that it is legally limited to those actually on relief. This regulation necessarily leaves out many persons on the *border-line* of dependency, who can not afford adequate medical care because they are making a heroic struggle to *stay off* the public relief rolls. Some more socialized form of group medical and dental services that would, for small annual fees, enable self-respecting wage-earners to have their health adequately cared for would be a much needed forward step.

5. Privately-supported welfare agencies. Even though an independent social work agency receives its financial support from personal gifts and bequests rather than tax revenues, the *work* it does is of a public nature and is a part of the general social welfare program. We should therefore not omit the contributions which have been made to relief needs and to the maintaining and developing of standards, by the well organizzed city family welfare societies in Wheeling, Huntington and Charleston. The activities of the West Virginia Tuberculosis Association in educating the public in methods of care and prevention of this disease are a constant process of real value in a state where physical conditions are more than ordinarily favorable for the spread of tuberculosis.

The Monongalia County Preventorium for children is a distinct step forward. The only regretable fact in this connection is that there are four times as many tubercular children in the county as can be cared for in this Preventorium. Not only governmental officials have been concerned with the public health developments in West Virginia, but large numbers of rank and file citizens have interested themselves in this work, helping raise money to supplement insufficient government funds. While these unofficial citizens have been *working* together, they have been *learning* at least *something* concerning the complex *causes* of social maladjustments; they have also had it borne in upon them that the attack upon these causes cannot successfully be made by one person or a few persons. The united efforts of *all* socially minded citizens and public officials are essential. The children's aid society of Monongalia county, an entirely voluntary group, is giving indispensable support to the governmental relief work in this county.

6. The Development of Community Recreation. In its beginning community recreation was almost entirely a voluntary, privately supported enterprise. The Lions Club in Charleston made possible the beginnings of what has come to be an all-around recreation program in Kanawha county, for adults, young people, and children. Wheeling had the first recreation system maintained and directed by the Municipal government. Perhaps the fact that Wheeling, in its earlier days, had a large German element in its population has been a significant factor in its community life. The German immigrants of the 1850's, 60's and 70's were sturdy people seeking greater political, economic, and social freedom. They came from communities in Germany where harvest festivals, folk-music, and various sorts of group recreation were an integral part

of their lives. Naturally, they transplanted these interests to the new world, with modifications and adaptations. It is quite to be expected, therefore, that our American cities which have large numbers of Germans, like Milwaukee, Wisconsin, St. Louis, Missouri, Cincinnati, Ohio, and Wheeling, West Virginia, are not only musical centers, but also have spread their interest in play, music, and outdoor pageantry, to the populations round about them. In our own state the later and more professionalized recreation developments have been definitely stimulated by the pioneer, voluntary activities in the City of Wheeling.

Parkersburg, Clarksburg, and Morgantown have effective set-ups for community recreation. The systems are now mostly on a *county* basis, following the new county unit system of our state for both education and unemployment relief.

For the last two years, under a liberal interpretation of the Federal Emergency Relief Law, the State Relief Admiinstration at Charleston has allotted substantial sums of money for the personnel of recreation systems and for the purchase of limited amounts of material and supplies. The personnel must be selected from persons otherwise on relief rolls, although the interpretation of this provision of the law is also somewhat liberal. The county and city *supervisors* are, for the most part, professionally trained persons who are *not* paid from relief funds. Evidently our state and federal relief administrators believe that public recreation has now become so essential in the physical and social development of our people that it is distinctly worth while to aid its functioning as a part of our public welfare program. Well-organized recreation is making a genuine contribution in dealing with some of the *results* of prolonged unemployment and increased leisure due to the machine age.

The Works Progress Administration of West Virginia during the current year has about a quarter million dollars for the various county recreation units in West Virginia. There is probably no social welfare project that has more solid support of the people, and so little criticism, as recreation; for nearly every one likes to play, and great numbers of our citizens, young and old, are largely *without* group play facilities and play leaders, unless these are provided by the public. All of our professionally trained recreation directors encourage to the utmost individual and home play and relaxation; but in the nature of the case, recreation is largely a *group* or *community* function, and hence a signnificant element in any well integrated public welfare program.

7. The hampering effects of sectionalism. "A house divided against itself can not stand;" also a *state,* too much encumbered with sectionalism, can not bring the public-welfare spirit and practice to full fruition. All who *know* West Virginia know that here lies one of her great problems; also, all who *love* West Virginia are doing what they can to understand and to decrease this sectionalism. Before the development of modern methods of transportation, especially paved highways and the automobile, the rugged topography and scarcity of railroads inevitably isolated many sections or population areas from one another. The accidents of peculiar state boundary lines were significant. The Eastern Panhandle was, socially and culturally, a part of Virginia; the Northern

Panhandle was a part of Ohio and Pennsylvania. The *early* population growth and industrial development was in *northern* West Virginia; the *later* growth has been, and is, in *southern* West Virginia. It is little wonder that only fifteen years ago it was an easier and quicker trip from Bluefield, West Virginia to New York City, than from Bluefield to Morgantown. It was in those days and earlier that most of the young men of our southeastern counties who wanted a college education went to Washington and Lee University at Lexington, Virginia, or to the University of Virginia at Charlottesville. Those were the days when, in the southern part of our state, West Virginia University was referred to as the "Morgantown College."

8. Some processes contributing to the development of state-wide public spirit, and the elimination of sectionalism. During the last 15 years — and the processes are still continuing — a number of fortunate developments, physical, social, economic and governmental, have taken place. These are substantially reducing the sectionalism of the first 40 years of West Virginia's statehood. We shall briefly describe some of these developments without attempting an evalution of the *relative* significance of each.

The state-wide road-building program got under way in 1920 with a $50,000,000 bond issue, emphatically approved by vote of the people. This project continued, with practically no interruption, for ten years. In spite of the fact that it costs twice as much per mile to build roads in West Virginia as in more level areas, the *people* and the *government* of our state drove ahead with unified enthusiasm to make every county and section of the tsate accessible to trade and travel from other sections. This goal has been almost completely attained.

Another very effective agency in helping our people realize that state-wide activity is often more effective than halting and separated local efforts, has been the extension program of the College of Agriculture and of the School of Mines of West Virginia University. Adult farm men and women and 20,000 farm boys and girls in all sections of the state are having their occupational pride and efficiency increased, and their civic and cultural life stimulated, by the work of the county agents. home demonstration agents, 4-H club agents, and the technical specialists — all these being a part of the College of Agriculture of West Virginia University. The 4-H camp at Jackson's Mill, not far from the population center of the state, has become a center of year-round activity for training farm leaders, and for recreation and culture. Not *only* farm people but civic clubs, religious organizations, and business organizations make increasing use of Jackson's Mill State 4-H Camp.

The Mining Extension work for the training of men for foremen's jobs in the local mining communities, and for the all-round improvement of one of the state's chief industries, is accomplishing substantial results. Safety campaigns and competitive tournaments between teams from different mines have aroused genuine interest in this vital aspect of West Virginia life. The governmental department of Mine Inspection at Charleston has also had a large part in this work.

The annual conference of newspaper editors and publishers, held under the auspices of the West Virginia University Department of Journalism, is a distinctly contributing factor towards a broader, more intelligent interest in public affairs. This conference is decidedly *not* a local or regional affair. Editors and publishers of country weeklies and city dailies, reporters and other workers in this field, from all parts of the state, are invited to participate. Higher standards of journalistic effort are distinctly encouraged and appropriately recognized. The larger community and public-welfare viewpoints are emphasized in this conference in contrast with a too exclusive interest in the profit aspect of newspaper make-up and in the more personal and local aspects.

Additional factors which, consciously or unconsciously, make it a part of their function to develop the state-wide, public welfare idea are such enterprises as the West Virginia Review — a unique monthly publication at Charleston — the movement for a state Chamber of Commerce, and the annual Forest Festival, held at Elkins, on the edge of the Monongahela National Forest.

CONCLUSION

In West Virginia, as elsewhere, the *individual* person and the *local* neighborhood or community *are* permanent and important parts of a well-rounded society. But it is *also* true that, in our present era of the *increasing interdependence* of persons, groups and communities, we need a vital, intelligent *common* life; in other words, the promotion of *public* welfare and the learning to work *together* effectively and happily are a necessity. West Virginia is a state in sociological transition; it seems to be on its way *out* of pioneer individualism and on its way *toward* a new social order, which will more harmoniously merge the *personal* and the *public welfare* elements of modern society. We may say, with approximate correctness, that this era of transition began about 1920 with the state-wide action taken on two matters of vital concern — the beginning of the state-supported public highway system and the establishing of the first public-welfare activity, the State Board of Children's Guardians. The significant processes of sociological transition then set in motion are still continuing.

The Toll of Eroded Lands

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Future generations are likely to have standards of living far below ours, and to meet problems of scarcity unknown to us, unless we are able to protect our agricultural lands against the destruction of wind and water.

We have thought of our heritage as a continent of abundance, rich in land, minerals, timber and opportunities. Once settled on the Atlantic coast, our ancestors advanced rapidly westward attracted by an inexhaustible wealth of natural resources. The great abundance led already among the most severely eroded areas of the whole United States.

to ruthless exploitation, which has continued until our timber, minerals, and wild life have been vastly reduced; and the land itself is rapidly going. The top soil of literally millions of acres is being washed into streams or blown by the wind where it is lost forever.

The early pioneers soon began clearing the land of timber, exposing it to the wind and rain. No hillside was too steep for some kind of cultivation. Over-grazing followed when the rich soils began to show signs of depletion. This destructive policy has continued until soil specialists tell us that more than one hundred million acres of our once fertile farm land — an area seven times the size of West Virginia — are no longer fit for profitable farming. Another hundred million acres are seriously eroded, and still other large areas are beginning to show the destructive effects of uncontrolled water and wind.

In our great haste to occupy the land of our nation, we have given almost no thought to the conservation of one of our most valuable natural resources — the soil. A new policy must be formulated with a definite objective for conserving the soil or our once prosperous region will be reduced to waste land and poverty must inevitably result.

For more than 100 years the process of soil erosion has been going on, yet little has been said or done about it. Soil depletion due to continuous cropping of land has been given no little attention. Crop rotations have been worked out with a view to conserving plant food, yet it has been shown that erosion accounts for 21 times the yearly net loss of plant food by all crops removed. The Mississippi River alone carries to the sea each year enough soil from the most fertile part of America to cover an area of 350 square miles one foot thick. The other rivers of the country are just as busy as the Mississippi.

Erosion resulting from gullies, formed from the run-off of water after heavy rains, is readily noticeable and of course destructive; but the slower process of land washing somewhat uniformly over a whole field is a much greater source of soil loss. It goes on to some extent wherever there is enough slope for water to run downhill. With no capacity for absorbing rainfall the barren soils turn the water away as floods. Careful measurement has shown a loss of 40 tons of soil removed from an acre with 27 inches of rainfall on a two percent slope. Probably 75 percent of the cultivated area of the United States is at least this steep. Some soils are somewhat more difficult to erode than others, but there is a serious loss on all unprotected slopes. The normal rainfall in Missouri carried away 40 tons of soil per year on a six percent slope, while in North Carolina under similar conditions 25 tons were lost. In the middle west it has been definitely shown that 86 percent of the upland area had lost from 8 to 40 inches of soil during the 40 years since the land was cleared. On the east side of the Applachian Mountains from New York to Alabama careful estimates indicate that a layer of soil from 4 to 18 inches deep has been washed from 65 percent of the area — and this area comprises some 50 million acres. The comparatively new farming sections of the country also are already affected. Oklahoma was opened to settlement in 1890, and became a state in 1907 — not 30 years ago; but in so short a time this state is

In parts of eight states in the middle west, wind has caused as great a loss by erosion as water has in other sections. Since May, 1934, it has been estimated that wind erosion has transformed 5,000,000 acres of formerly good land into waste areas and sand dunes. More than 60,000,000 additional acres are in immediate danger of the same fate. The dust storms of 1934 and 1935 in these states followed severe drought and the plowing of great stretches of land, where the soil originally was anchored by only a scant vegetation. Unless this land is anchored again by vegetation, no relief from wind may be expected and desert conditions will certainly result. Such conditions are sign-posts of the misuse of land. It seems regretable that these huge and unnecessary soil losses should be permitted to go on year after year unchecked. The cost to our farmers is about $400,000,000 annually from this source alone, while they pay out approximately $180,000,000 for commercial fertilizers to replenish their soils in the same period. Estimates ranging from 58 to 150 years at present rates of soil depletion portray the United States in such a condition that self-sustained agriculture will be impossible.

The United States has no national agricultural policy; instead we have a confusion of conflicting plans. The Adjustment Administration aims at restriction of acreage and production; the Reclamation Service fosters reclamation projects for greater expansion. The Department of Agriculture is ably fostering efficiency in production and at the same time aiding farmers in lowering their volume of output. A comprehensive national agricultural policy would contribute to the economy of the entire nation.

Many farmers in West Virginia as well as elsewhere are living on small farms which are becoming less fertile year after year. If these submarginal farms are taken over by the government within a few years, as has been frequently suggested, a problem arises of relocating the farmers. The State could well afford to buy the lands which cannot support their occupants and turn them to forestry, game, recreation, and flood control. Technical Bulletin 303, U. S. Department of Agriculture, says of two counties in West Virginia, "It would be well if the State could purchase the scattered farms that are too few to support roads and schools, particularly where the maintenance of such facilities could be discontinued." The Federal and State governments have already bought large areas of the less valuable mountain land in the State. In the two counties mentioned more than 80 farmers living on the small mountain farms were asked if they would be willing to move to other locations, where there were opportunities for better farming, and bandon their present locations. Almost invariably the response was that they were satisfied and not interested in locating elsewhere — another problem in dealing with present owners of submarginal land.

Problems are gradually growing more acute as conditions become worse, and under present policies they are likely to continue. Floods and wind storms have caused more damage and laid waste larger areas in recent years than formerly. In 1890 the greatest flood stage of the Mississippi River at Memphis was 35.6 feet, in 1916 it was 43.4 feet, and 45.8 feet in 1927. Checking stream flow by use of dams and reforesting will help, but competent authority predicts, "There can be no permanent flood control until soil conservation is practiced over entire watersheds." This means that the knowledge we have of forests and crops and their relation to erosion must be put to use.

A start at solving erosion problems has been made in West Virginia. State and federal authorities cooperating are bringing the findings of science to an eroded and depleted soil in an effort to rebuild more than 150,000 acres of farm land in ten areas of the state. There are eight Civilian Conservation Corps camps in as many counties devoting their time to soil erosion activities. Other states are doing as much or more. It now remains to educate the farmers of the nation to the advantages of soil-protective types of agriculture and the citizenry to the losses sustained by preventible floods and dust storms. This can be done whenever the nation decides to adopt methods which call for the use of land according to its adaptability and fitness and for the efficient protection of all cultivated slopes.

A PEACE PLANK FOR 1936

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SINCE PEACE is an essential condition to the maintenance and continuance of democracy, and since individual as well as national security and prosperity depend on its preservation, the ———— Party pledges itself to exert its utmost endeavors to prevent wars and to promote the blessings of peace.

Mindful of the fact that war and peace are as much the result of prevailing conditions at home as they are of international relations, and that some form of machinery is necessary for the peaceful adjudication of international disputes, we shall, if entrusted with the powers and responsibilities of government, give our support to the following measures and policies:

1. *Adherence to the World Court of International Justice.*

Since international disputes do arise it is to the interest of the people of the United States to have some tribunal which has the power to investigate questions that may be transmitted to it and to pass upon the legality or illegality of the same. We have little to lose and much to gain from such an institution.

2. *Cooperation with the League of Nations — short of commitments to application of sanctions.*

A people as rich, as populous, and as civilized as we are cannot indefinitely shirk the responsibility of actively cooperating with other peoples in the building of better and happier relations among the nations of the earth. We shall cooperate with the League of Nations, but we shall not commit ourselves to the application of any economic or military sanctions that may be imposed by it.

3. A permanent neutrality policy.

Historical scholarship and congressional investigations have made quite clear what forces and influences drew our country into the wars of 1812 and 1917. To avoid a repetition of these previous sad experiences, the American people will have to choose between the traditional doctrines of laissez-faire and the open sea on one hand and a new neutrality policy on the other. With the unstable conditions prevailing in the world, the decreasing importance of foreign trade, and the intensification of national rivalry for markets and raw materials, it is evident that the true interests of the American nation demand a new policy. The present temporary neutrality law shall be strengthened and made permanent.

4. Reorganization of foreign policy and national defense.

The "founding fathers" meant to establish upon this continent a system under which the military branch of the government should be subordinate to the civil branch. As things have developed we now have a war department and a naval department, each with a secretary in the cabinet. Of late we have heard much from generals and admirals over the radio and through the press. The country has been flooded with military propaganda and military budgets have climbed by leaps and bounds. In spite of all this agitation we are still without a clear military or naval or diplomatic policy. Nobody seems to know what a navy is for. What we need to do is to crystallize a rational policy and to reorganize our national defense. Foreign policy and national defense must be recognized as parts of the same thing.

We pledge ourselves so to reorganize our federal administration that all those branches of the federal government which have to do with determining foreign policies and policies of national defense will be brought together in one body. The war and navy departments will be abolished, and in their place a Division of National Defense will be created in the State Department. This Division will contain a War Bureau and a Navy Bureau. Since there has always been a close relationship between foreign trade and foreign policy, all foreign trade will be placed under the supervision of the State Department. In the two houses of Congress joint committees on foreign affairs and on military affairs will be established, and these will be represented on a Council for Foreign Affairs. On the Council will also sit the President of the United States, the Secretary of State, the head of the Division of National Defense and the chiefs of the bureaus of the army, the navy, and of foreign trade.

Such a reorganization will centralize power, will eliminate bickerings and contradictory policies among the various branches of the government, will tend to develop national policies for foreign affairs and national defense, and as a result, will minimize the dangers of war while increasing our ability for defense.

5. Improvement of our economic and social conditions in order to prevent domestic disorder and civil war.

How can anybody imagine that peace is secure as long as we have ten million workers who are unemployed and more than twice that many people on relief rolls? Since the problems of relief and unemployment are treated elsewhere in this platform, it must suffice here to state that they will be dealt with honestly and constructively. In no case shall the military forces of the federal government be employed in domestic or economic disputes, unless it be to protect the interests of both the workers and the employers.

6. *The international war debts shall be liquidated in a manner most likely to promote world peace and security.*

7. *The armament and munitions industries shall be placed under the control of the Council for Foreign Affairs.*

8. *The "good neighbor" policy shall be maintained and promoted among the peoples of the Western Hemisphere.*

These measures and policies, we believe, will make it possible for us to keep out of wars with all their grief, destruction, and demoralization, and to build here a civilization in which peace, justice, prosperity, and beauty shall have a permanent place.

STUDENT JUDGMENTS CONCERNING FACULTY PERSONALITY TRAITS

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ON MOST COLLEGE CAMPUSES the term "bull-session" probably needs no explanation. Such a casual gathering of students, who so freely proclaim the merits, expose the weaknesses, and verify the alleged assinine qualities of their instructors, is as a rule merely an indulgence in a popular college sport. Sometimes it is more serious; and it becomes evident that college teachers sometimes unfortunately arouse in their students a feeling of ill-will that may persist indefinitely. Such a feeling is not conduciive to good work on the part of the student. It is obvious that any teacher's efficiency is materially lessened by unfriendly student-teacher relationships. The fault may frequently lie with the student, but not always. Too often college teachers are found who feel but little responsibility for the welfare of their students, and who believe no improvements in their instructional procedures are possible.

In order to reveal student opinion and stimulate self-examination on the part of teachers, this investigation was made. The procedure was as follows: A blank sheet of paper was handed to each student in several classes with the request that he list on one side of the sheet all the displeasing traits he had observed in his teachers and on the other side the pleasing traits he had observed in them. About two hundred such lists were submitted by the students.

The traits disliked and listed by the students were classified and tabulated under a considerable number of headings. Groups of related traits were next combined under heads of more general traits in order to reduce the number. With the aid of three members of the faculty and two senior students a list of eleven most frequently mentioned traits was selected for further study.

An attempt was then made to secure reliable student judgment as to (a) the prevalence of these eleven alleged faults among the faculty members as a whole and (b) the relative undesirability of the traits. The eleven traits were arranged and mimeographed in miscellaneous order with respect to the number of times mentioned in the original lists made by the students. Blank spaces were provided along the left margin for the "a" judgments and along the right margin for the "b" judgments. Copies of this sheet were next distributed at the same hour to the students of several subject-classes, along with carefully mimeographed directions for ranking the traits listed. Two hundred ninety-eight usable "a" rankings and two hundred ninety-four usable "b" rankings were obtained.

By adding all the ranks assigned to each trait, arranging the sums in a decreasing order and giving the rank "1" to the smallest sum, new ranks representing the combined judgment of all the students were derived. The traits and the ranks thus assigned by the students are listed below. Trait No. 1 was judged as being most prevalent, trait No. 2 next to most prevalent, etc.

Prevalence of trait: "a" ranking	*Name of trait*	*Undesirability of trait: "b" ranking*
1	Partiality	1
2	Fault-finding	2
3	Egotism	3
4	Unpleasantness of voice	8
5	Grouchiness	4
6	Unfriendliness	7
7	Lack of sense of humor	10
8	Untidyness	9
9	Lack of promptness	11
10	Display of temper	5
11	Indifference	6

In the same manner as for the whole group, combined rankings were obtained for men, women, seniors, juniors, sophomores, and freshmen separately. All these groups agreed rather closely on the first three traits listed above.

To test the reliability of the judgments, correlations were made between the entire group and each sub-group separately, and likewise between the sub-groups — eleven correlations in all. The rank-difference formula was used, and the results were converted into the usual Pearson "r" correlation by use of a table. On the "a" ranking the correlations ranged from + .53 to + .96; all but three were above + .70. On the "b" ranking the correlations ranged from + .77 to + .98; only three of the eleven were below + .84. Considering the highly subjective nature of the judgments asked for, the groups appear to have agreed surprisingly as to the occurrence and the undesirability of the traits. Among individuals who ranked the trait's however, a much wider variation occurred.

A Critical Analysis of a Supervisory Program for West Virginia

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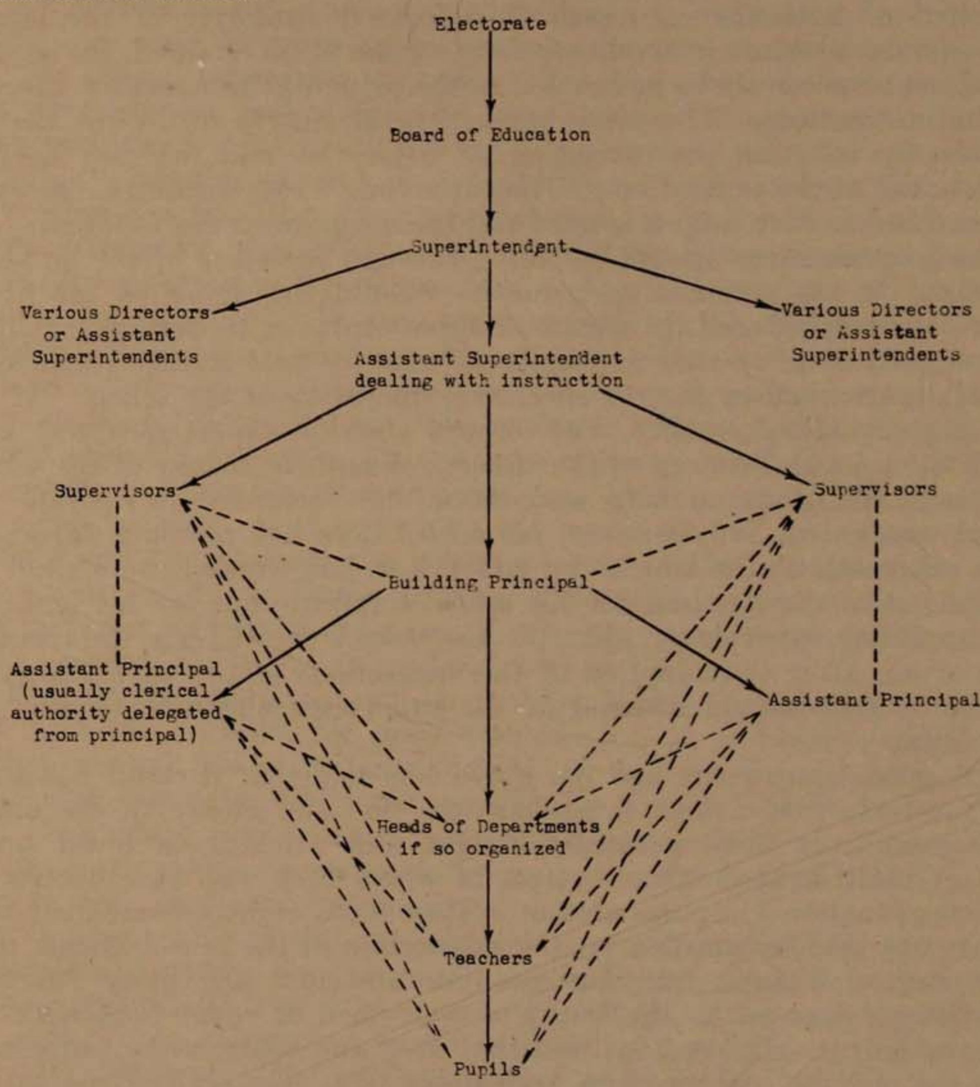
When West Virginia adopted the County Unit plan of school organization she went on record as favoring a form of elementary school principalship of an order superior to her former one. Under the old set-up the matter of teaching was largely in the hands of supervisors and the duties of clerkship and policeman were left to the principal. The abolition of supervisors, *but not supervision,* established the elementary principal on the basis of a supervising principalship, greatly magnifying his job. He was elevated in prestige which created a situation demanding additional preparation, broader vision, and increased efforts. Regardless of personal feelings concerning the bill as enacted, we must admit that in this bill the school principal attained the object which for decades the leaders in their fields had been demanding. They are now in the enviable position of chief executive within the segment of the school system which they direct. Prior to this the elementary school had been distinctly dual-headed, and constant friction was brewing between supervisor and principal in their control and direction of teachers. From this unsatisfactory situation developed confusion in the school and doubts in the teacher's mind. This greatly undermined efficiency. In short, the situation in some sections at least had almost reached an impasse which might have, but had not, been changed by other methods The point to note is that at present the elementary principal has an opportunity to show what he can do towards developing a good school.

It has ever been an observed fact that with increased opportunity and prestige go increased responsibilities. Failure to accept these added responsibilities has in the past meant that others would be secured to do them. No longer can the inefficient principal be like Adam of old when he said, "It's the woman thou gavest me" who is at fault. We are clearly establishing a direct line of authority between the superintendent, his assistants, and the principal. If this group fails to accept this challenge to leadership, principals may be abolished and an administrative supervisor created. If supervising principals are a possibility, then administrative supervisors can be. The world waits for no one who refuses to accept his share of duties and responsibilities or who fails to fulfil them with dispatch and efficiency. Being thrust into the enviable position of leadership, is it not wise that principals should study themselves and their jobs with added stimulus, in order to see its proper perspective?

When the legislature abolished supervisors it did not and could not abolish supervision. Education demanded supervisory oversight but could not function under the old dual-headed set-up of superintendents, district supervisors, principals, and departmental supervisors. Friction and inefficiency placed supervision in such bad repute that the layman could see in it no possibilities and the profession was willing to see its abolition. We are now facing the need for a re-study of the problem in the hope of filling the vacancy its abolition created.

Any attempt to discuss this subject must start with a definition of two terms. For the purpose of this paper it is understood that the term "special supervisor" includes all those specially trained and expert teachers found in a system who have been assigned the specific task of improving other teachers in the system. They are assumed either to have prepared specially for the task or to have demonstrated special aptitude or ability in the classroom. They are in the position of staff officers assigned by the superintendent to a special task. In a sense the supervisor fulfilling the function of supervision is the superintendent in action.



The building principal is also a direct representative of the superintendent and, in his official capacity, is in the same sense the superintendent in action. This obviously raises the vexing question, "Who is in direct command?" The building principal, in addition to being a representative of the superintendent, is more than a staff officer. He is an executive officer — a line officer if we follow out the military analogy. Instead of being assigned to assist the superintendent, he is assigned to carry out his orders. As such he is responsible to the superintendent and is entitled to aid and assistance in return. Following this reasoning no one will question which officer is in command. One is assigned to assist while the other is to execute orders.

The acceptance of the philosophy implied in the above analogy and chart practically answers the question raised by this paper. A restatement of the implications will not be out of order. The special supervisor, being a staff officer or expert, will work in the building subject to the call and direction of the building principal. Any directions which the supervisor might issue to the teachers must come through the principal or with the expressed or delegated authority of the latter. They should be made in triplicate form — one to be retained, the second and third respectively to be handed to the principal and teacher affected by the instructions. The principal will be at liberty to decline the assistance by refusing the invitation or, after the visit, he may decline to make use of the suggestions. The supervisor's responsibility, however, will end unless such help is sought and the suggestions are followed. All supervisory meetings should be called through the office of the building principal at his sanction or request. Should the principal see fit to ignore the help offered by a staff of supervisors, or to decline to follow the suggestions after they are made, he must be held rigidly responsible to his superior officer for the successful operation of the school. If his school compares favorably with others without supervisory aid why waste the time and energy of the supervisor and the money of the school patron? He needs no help and should be permitted to operate the school unassisted. If, however, his school does not compare favorably with other schools in which the supervisor has worked, he should be challenged to show reason for his school's failure and for his ignoring the proffered supervisory aid. If the school showed an unfavorable comparison after the adoption of the suggestions of the supervisor, the superintendent should demand of the supervisor adequate reasons for this failure.

A good many years ago the world was told that it could not serve two masters; that a man must hate the one and cleave to the other. Superintendents have generally fought any attempt to build up a dual or multi-headed school system in which they will have control of but one function: i.e., instruction. They have rightly contended that if they are held responsible for the instruction of the school system they must control finance, building and grounds, and any other function sometimes delegated by the board to other men of equal rank with the superintendent. It has been said that he "who controls the purse controls the output," which is an undeniable fact. Generally these superintendents have been successful in establishing a single-headed school system with themselves as heads but subject to the board of education. They have not generally been so willing to carry out this same philosophy throughout their system. Frequently they have set up dual assistants of equal rank which they have called supervisor and principal.

This sets up in each school building a dual-headed system with as much chance for inefficiency and friction as the superintendent might have experienced in his own office with a group of directors each responsible to the board for his own department and in no way interconnected with other directors. If a single head is good for the entire system, it must also be good for the integral parts.

The policy outlined above makes each building have but one head. All the teachers know to whom they must answer. The placing of all such authority in the building principal makes for harmony, efficiency, and satisfaction among the teachers. This is obviously the acme of good teaching conditions. The superintendent should learn a lesson from the commercial word — i.e., if responsibility is demanded from an individual, he must be given authority to carry out the thing commanded.

The special supervisor may ask. "Yes, but where do we come in?" This arrangement makes for the healthiest situation under which a supervisor may hope to work. When the principal calls the supervisor, the latter knows that she is welcome and wanted. She knows that a task is awaiting her, and that the principal and teachers will eagerly carry out the suggestions made. Executive duties have been removed leaving the supervisor free to exert her time to the improvement of teaching and the teaching act. It also removes one of the real reasons why teachers hesitate and rebel at supervision. The supervisor does not come as a "snoopivisor" looking for troubles and inefficiencies. These are admitted in the invitation. She comes to help correct them, and she receives a hearty welcome. This scheme removes completely, or at least reduces to a minimum, the chances for shifting responsibilities and blame for failures. It shows where the credit should go for successful teaching and management. A principal who half-heartedly carries out suggestions and fails blames the supervisor and is in turn blamed by the supervisor under the old plan. Under this plan the superintendent knows to whom the blame or credit should go.

Finally, the question might be raised, "How can the superintendent know and place credit for good teaching?" Is it possible to know which principal has a good and which one has a poor school, as compared with others? While the question is outside the realm of this paper, the writer would like to point out a few techniques without discussion which are being successfully used to measure good school management and teaching. Most school systems have a department of research answerable to the superintendent which administers tests and measurements, carries on investigations, and rates teachers, principals, and supervisors. This work goes on as a function of the superior officers and, even where antagonism exists, will still function at the orders of the superintendent. The contentment of teachers, the activity of the pupils, the success of the school in curricular and extra-curricular activities — these also are valid indications of good management and good teaching. Where it is the policy for the superintendent to compare each school in his system with every other, or with accepted norms, and to publish such reports for the profession and the patrons alike, one will find a rare principal who will ignore the possibilities of good supervision. Similarly, supervisors who are poorly equiped for their task will be found and removed from the system, thus making room for the well-trained supervisors.

Capable principals and supervisors alike will welcome this single headed school organization. The duties of each one are well defined and authority and responsibility are balanced. Each will be able to do what is required of him and be able to show his degree of success. That such a scheme is definitely needed in our state can hardly be denied. Under shady legality we now have it in some localities. It seems desirable to advocate openly its legalization.

THE SURVIVAL (AND MORTALITY) OF STUDENTS IN BETHANY COLLEGE AS RELATED TO THEIR SCORES ON FRESHMAN PSYCHOLOGICAL EXAMINATIONS

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THE FRESHMEN CLASSES entering Bethany College in September, 1930, 1931, and 1932, were made the basis of the following study, partly because these classes all took highly comparable tests and also because these are our most recent graduating classes, (1934, 1935, and 1936).

The class entering in 1930 was given the American Council on Education Psychological Examination, 1930 edition, and the Ohio State University Intelligence Test, form 16. The freshmen in 1931 were given the 1931 edition of the American Council test, and form 17 of the Ohio State U. test. In 1932 the American Council test, 1932 edition, and form 17 of the Ohio State were used. These two types of tests will hereafter be symbolized as Am.C. and O.S.U. respectively.

On any particular test the scores were arranged in rank order and grouped into deciles and quartiles. Percentiles were also computed from the norms furnished with the Am.C. and O.S.U. tests. Each student had therefore for each of the two tests a percentile, a decile, and a quartile rating — six ratings in all. In the following study only decile and quartile ratings are utilized.

From permanent records in the registrar's office the length of time that each student remained in Bethany College was tabulated. The data were grouped according to decile and quartile standing, and the length of time in college was computed according to the college year completed — freshman, sophomore, junior, and senior. For example, one student in a tenth decile was in college during all four years, and one in the first decile was in college during freshman and sophomore years only.

The total number of those who began as freshmen in the various deciles and quartiles and who remained as sophomores was then counted and tabulated. The same was done for the juniors and seniors. For example, in 1930, 15 freshmen ranked in the tenth decile of the Am.C. test. Of this original group, 13 of them remained as sophomores, 8 of them as juniors, and 8 as seniors. On the same test 36 freshmen ranked in the fourth quartile. Of this group 29 remained as sophomores, 20 as juniors, and 19 as seniors. The complete data for the Am.C. test for 1930 are presented in Tables 1 and 2.

TABLE 1—*The survival of the 1930 freshmen ranked according to deciles on the Am.C. test, 1930 edition*

Decile	No. of Freshmen	No. of Sophomores	No. of Juniors	No. of Seniors
10	15	13	8	8
9	14	10	9	8
8	15	12	6	5
7	14	11	7	6
6	15	10	6	5
5	15	12	6	5
4	15	11	6	6
3	14	8	5	4
2	15	10	6	5
1	14	5	2	2
	N = 146	N = 102	N = 61	N = 54

TABLE 2—*The survival of the 1930 freshmen ranked according to quartiles on the Am.C. test, 1930 edition*

Quartile	No. of Freshmen	No. of Sophomores	No. of Juniors	No. of Seniors
4	36	29	20	19
3	37	27	16	13
2	36	27	15	13
1	37	19	10	9
	N = 146	N = 102	N = 61	N = 54

Similar tables were prepared for the numbers surviving in the various deciles and quartiles of both tests in each of the three years. There were twelve tables in all. Table 1 and 2 above are the only ones of these twelve which are presented here, although the data from all twelve are utilized in the results to follow.

In order to give a more typical picture of academic survival and mortality in Bethany College, the data for the three classes entering in 1930, 1931, and 1932 were combined for the Am.C. and for the O.S.U. tests separately. This gave two tables of composite results for each test — one for the quartiles and one for the deciles. The complete combined data for the Am.C. tests of these three years are presented in Tables 3 and 4.

The two tables of combined data for the O.S.U. tests are omitted here, although their results are utilized in later tables.

From these combined tables the percentage of the original groups remaining in the sophomore, junior, and senior years was computed. For example, a total of 36 students in the years 1930, 1931, and 1932 ranked in the tenth decile of the Am.C. tests. Of these, 23 or 64% of them remained as sophomores, 17 or 47% as juniors, and 16 or 44% as seniors. The two following tables give the percentages remaining in college during the various years, ranked according to deciles and quartiles on the Am.C. tests only. Two similar tables were prepared for the O.S.U. tests, summaries from which appear later in this report.

TABLE 3—*The number of freshmen entering Bethany College in 1930, 1931, and 1932, remaining in college during successive years, ranked according to deciles on the Am.C. Tests for those years*

Decile	No. of Freshmen	No. of Sophomores	No. of Juniors	No. of Seniors
10	36	23	17	16
9	36	21	20	19
8	36	20	11	10
7	36	30	22	17
6	39	23	14	11
5	39	25	12	12
4	36	22	15	13
3	36	15	9	7
2	36	21	12	12
1	36	8	4	3
	N = 366	N = 208	N = 136	N = 120

TABLE 4—*The number of freshmen entering Bethany College in 1900, 1931, and 1932, remaining in college during successive years, ranked according to quartiles on the Am.C. tests for those years*

Quartile	No. of Freshmen	No. of Sophomores	No. of Juniors	No. of Seniors
4	91	59	43	39
3	92	59	36	34
2	91	55	34	29
1	92	35	23	18
	N = 366	N = 208	N = 136	N = 120

TABLE 5—*The percentages of freshmen entering Bethany College in 1930, 1931, 1932 remaining in college during successive years, ranked according to deciles on the Am.C. tests for those years*

Decile	Freshmen	Sophomores	Juniors	Seniors
10	100%	64%	47%	44%
9	100%	58%	55%	52%
8	100%	55%	30%	27%
7	100%	86%	61%	47%
6	100%	58%	35%	28%
5	100%	64%	30%	30%
4	100%	61%	41%	36%
3	100%	41%	25%	19%
2	100%	58%	33%	33%
1	100%	22%	11%	8%

TABLE 6—*The percentages of freshmen entering Bethany College in 1930, 1931, 1932, remaining in college during successive years, ranked according to quartiles on the Am.C. tests for those years*

Quartile	Freshmen	Sophomores	Juniors	Seniors
4	100%	65%	47%	43%
3	100%	64%	38%	36%
2	100%	60%	37%	31%
1	100%	34%	25%	19%

From the complete tables data were compiled indicating the comparison between the survival of students in the tenth and first deciles on each test, and also between the fourth and first quartiles. This material is presented in the four tables following:

TABLE 7—*A comparison of the percentages of students remaining in college, from the 10th and 1st deciles of the Am.C. tests — years 1930, 1931, and 1932*[1]

Decile	Freshmen	Sophomores	Juniors	Seniors
10	100%	64%	47%	44%
1	100%	22%	11%	8%

TABLE 8—*A comparsion, of the percentages of students remaining in college, from the 10th and 1st deciles of the O. S. U. tests — years 1930, 1931, and 1932*[1]

Decile	Freshmen	Sophomores	Juniors	Seniors
10	100%	66%	51%	49%
1	100%	45%	15%	10%

[1]Similar to that in Table 7.

The results of these two tables agree fairly closely, indicating that the survival through four years in the 10th decile is approximately five times as great as that in the 1st decile.

TABLE 9—*A comparison of the percentages of students remaining in college from the 4th and 1st quartiles of the Am.C. tests — years 1930, 1931, and 1932*[2]

Quartile	Freshmen	Sophomores	Juniors	Seniors
4	100%	65%	47%	43%
1	100%	34%	25%	19%

[2]Similar to that in Table 7 and 8.

These two tables also agree in the main, indicating that approximately twice as many remain through four years in the fourth quarter as in the first.

Tables 5 to 10 together indicate that academic mortality among students, in the sense of dropping out of college, is progressively greater as we pass from the highest to the lowest ranking of the freshmen tests. The chances of remaining in college for four years are five times as great in the tenth decile as in the first, and twice as great in the fourth quartile as in the first. Judging from these results, if a college were limiting enrollment by restricting the size of its freshman class and were interested in selecting those students who would remain in college the full four-year academic period, the psychological tests would be a very important criterion for admission.

TABLE 10—*A comparison of the percentages of students remaining in college, from the 4th and 1st quartiles of the O. S. U. tests — years 1930, 1931, and 1932*[3]

Quartile	Freshmen	Sophomores	Juniors	Seniors
4	100%	67%	51%	47%
1	100%	52%	31%	27%

[3]Similar to that in Table 9.

THE VALIDITY OF THE THURSTONE PERSONALITY SCHEDULE

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THE THURSTONE PERSONALITY SCHEDULE occupiees an important position in the chain of development from Woodworth's Psychoneurotic Inventory to some of the best of the personality questionnaires now in use. The Bernreuter Personality Inventory, for example, was standardized in part by correlation of its items with the Thurstone Schedule. The validity of this instrument: i. e., the accuracy with which it measures emotional adjustment or neurotic tendency, is a question of importance. This paper discusses the validity of the Thurstone Schedule, reporting some of the weaknesses and presenting some suggestions for improvement.

CONSTRUCTION

From some 600 items, the 223 of the present Schedule were selected by the authors and subjectively scored by them, the list being compiled largely from lists of Woodworth, House, Laird, Freyd, and Allport. The Schedule was then given to 694 freshmen at the University of Chicago in Setpember, 1928, and these were tentatively scored. The 50 most neurotic subjects and the 50 least neurotic subjects were selected by means of this scoring and for each question the frequency of neurotic answer in the two groups was compared. Thus the consistency of each item with the schedule as a whole was checked, with the result that only one case was found where the tentative scoring of the authors was inconsistent with the Schedule as a whole, as measured by these two extreme groups. It has been assumed by Thurstone that the validity of the scale can not be adequately determined by correlating it with oustide criteria unless there is a criterion of maladjustment which is better than the scale. May *(3)* thinks correlation with an outside criterion of little use, and urges validation by the method of internal consistency. Accepting the tenative assumption that validation by correlation with an outside criterion is at least not at present practicable, the question still remains, "How adequate is the validation of the Thurstone Schedule?" This question will be discussed in the following sections.

I. THE CONCEPT OF MALADJUSTMENT IMPLICIT IN THE SCHEDULE

The 223 items of the original Thurstone Schedule were not selected and classified according to any stated scheme of classification and do not refer to any stated theory of maladjustment. Even supposing that the 223 items were classified and selected with reference to some unstated concept of maladjustment, the frequencies of neurotic response by the extreme neurotic group, as compared with the extreme adjusted group, indicate that items play very variable roles in contributing to the total neurotic score. Compare the following frequencies:

Item No.	Question	Number Making Neurotic Responses from the 50 in the: Adjusted Group	Neurotic Group
16	Do you worry too long over humiliating experiences?	1	40
152	Do you often feel just miserable?	0	40
177	Do you often experience periods of loneliness?	1	39
201	Are you troubled with feelings of inferiority?	0	36
60	Did you ever have St. Vitus' dance?	0	2
65	Have you ever seen a vision?	2	5
165	Has any of your family had a drug habit?	0	0
136	Are you often in a state of excitement?	0	1

The first four of the above items contributed to the scores of the neurotic group 155 units, to the adjusted group, 2, whereas the last four items contributed to the scores of the neurotic group 8 units, to the adjusted group, 2. The average number of the neurotic group would have received a score on these 8 items of 3 or 4, all contributed by the first 4 items, and the modal number of the adjusted group would have scored on these 8 items a 0. The differentiating power of the first four is thus over 19 times that of the second 4, when the schedule is observed in actual operation, and unless each classification of items in the schedule has the same total differentiating power as each other classification, the relative functioning importance of the classification is different from their numerical proportion in the schedule.

That the differentiating powers of these classifications are not equal is indicated by Harvey's study reported in the Journal of Social Psychology, May 1932, pages 240-251. In this study he gave the schedule to 146 students and selected on the basis of these scores the 30 best items on the grounds of *(1)* discrimination percentage between neurotic and adjusted groups; and *(2)* frequency of neurotic response. This selection of items greatly changed the relative importance of his ten categories, leaving four categories — family relations, sex, childhood, and sleep, with no best items; and leaving four others — *drive, ascendancy, consistency,* and *sociality,* with nine-tenths of the best items.

So far as published material indicates, the Thurstone Schedule seems to lack relationship to a stated theory of personality and maladjustment, and functions in haphazard variation from any plan implicit in the methods of its construction. May *(3)* that the validity is determined by the extent to which the instrument fulfills the original definition of the behavior that is being sampled. Surely then we need a defiinition of maladjustment and a careful relating of the instrument as it functions.

II. FALSIFICATION OF RESPONSE

The Thurstone Schedule was given to the Chicago freshmen on the same day on which they took their intelligence tests. In the directions for the schedule the freshmen were told that only two or three persons would know the individual responses, that it was in order that their adviser might help them, and that there would be a short report to the dean.

Surely this must in some cases have intensified the human tendency to try to make a good impression on those who have authority, and increased the occasions of concealment and falsification, conscious or unconscious. On such a question as No. 163, "Do you get tired of work quickly?" a self-conscious freshman might be careful to make his response acceptable, and not one of the top 50 answered *yes* to this question. On No. 165 no one of either group of 50 said *yes* to "Has any of your family had a drug habit?" It is a common characteristic to hide bad qualities in ourselves from others, and sometimes from ourselves. Surely there are such things as "masked neurosis," "over-compensation," and "manic" states of excitement with euphoria; and when it was emphasized to the Chicago freshman that not many persons would see his blank other than his adviser and his dean, we may well suspect that the over-conscientious student would tend to be self-critical on such questions as No. 204, "Have you any physical defects?" or No. 91, "Do you allow people to crowd ahead in line?" Only 39% of the two groups say *yes* to this latter question, though observation indicates the proportion must be far higher. Granted that there will inevitably be some distortion, concealment, or falsification on such a questionnaire, it seems desirable first that the conditions of standardizing the questionnaire should be purged of items on which falsification tends to occur frequently.

Validation of items by the criterion of internal consistency indicates merely that persons who describe themselves as well adjusted on most items tend also to describe themselves as well adjusted on the item in question, and vice versa. It is hard to see how this method alone could reveal falsification, whereas investigation through case study and interview, or correlation studies with externai criteria, might help on these points.

III. ITEMS REFERRING TO PAST EXPERIENCE

Some 46 of the 223 items on the schedule refer to the past experience of the subject in such a way that a truthful response would depend primarily on the past, as in No. 1, "As a child did you like to play alone?", or No. 131, "Have your friends ever turned against you?" In some 29 other items the past experience *may* play a dominant part in determining the response as in No. 37, "Are you usually cool and composed in a dangerous situation?" According to my count at least 75 of the 223 items: i.e., 34%, depend on past experience. This has an important bearing on the meaning of the score for persons who had many unfavorable conditions and attitudes existing in the past, but who have recently become well adjusted despite these past factors. Such a person, theoretically perfectly adjusted today, might receive solely because of these items referring to the past, a score of 50 or 75 which would place him in the group described as emotionally maladjusted, and it might require but five other unfavorable answers to put him with those who should have psychiatric advice. The inflexibility of the Thurstone Schedule caused by this large element is a distinct obstacle to its efficient functioning as a measure of present conditions.

IV. ORIGINAL SCORING OF THE QUESTION RESPONSE

A subject responding to an item on the Thurstone Schedule by marking the question mark is not given an unfavorable score for it. In the standardization, however, a question response was scored unfavorably "in those questions in which the doubtful answer was thought to mean the avoidance of some unfortunate fact," such as No. 157, "Is your mother dissatisfied with her lot in life?" or No. 8, "Do you get on well with your brothers and sisters?" Of course it is quite possible that a question response in these items means the avoidance of some unfortunate fact, but there is also the situation where one's mother or brothers and sisters, if any, die, and one must mark the question response since neither *yes* nor *no* is correct. Also, it has been by experience that frequently the marking of the question indicates doubt as to the meaning of the question or a sense that its ambiguity allows interpretations which prevent either *yes* or *no* from being comprehensively correct. There is small probability that this factor of scoring the question response greatly affects the validity of the schedule as a whole, since the number of question responses is seldom large. Only casual reference is made to this practice which strikes me as being rather inconsistent with scientific method.

V. USE OF EXTREME GROUPS AS VALIDATING CRITERION

Thurstone has published response frequencies for only the extremes of the distribution of Chicago freshmen, and it is on these frequencies that the items of the schedule have been validated. This process justifies our saying that a particular response is more typical of one extreme than the other, but we are not justified in assuming an even progression of frequencies from one end through the intervening 86% to the other end. Various sorts of progression are possible and probable, and the assumption of a regular progression may be quite unjustified by the facts. On item No. 142, "Are you usually in good spirits?" none of the extreme adjusted responded *no*, while 18% of the extreme neurotic did so.

It is quite conceivable that many of the extremely maladjusted either through lack of insight or in a pain-evading pollyannaism said *yes*, while a group three quarters of the way toward the neurotic extreme might show a frequency of say 30% of *no* responses. The *no* response in this case would be typical not of the extreme neurotic but of a group nearer the middle. That there are such disorderly progressions has been found by Harvey. It is possible to suggest several possible explanations. Suffice it that until we know what sort of a total distribution exists we should no make assumptions based on a mere 7% at each end. Ideally each response should be evaluated according to the mean criterion score given those persons making the response. This would afford an adequate basis for judging the differentiating power of an item, one indication of which is the difference between these mean criterion score values for the various responses to the item.

VI. RESPONSE SIGNIFICANCE AND INDIVIDUAL DIFFERENCES

An instrument designed to show differences in personality between individuals designed to show differences in personality between individuals should recognize differences between types of adjustment made by individuals. The importance of the response to No. 192, "Do you usually plan your work ahead?" may depend on the kind of work a person does. To answer *yes* to No. 215, "Were you considered a bad boy?" may mean one thing if there were good grounds for being considered bad, and another thing if there were not. The significance of an item depends on the constellation or picture of the particular personality. The purpose of the Thurstone Schedule is stated to be "to obtain a single numerical index of the neurotic tendency of the subject." This hardly allows room for variously weighting items according to the particular personality type; and the limitations of the Schedule in this respect should be clearly pointed out, in order to guard against its misuse by those who are looking for a numerical index of personality adjustment by which individuals may be classified and rated.

VII. FAILURE TO CHECK RESULTS ON ANOTHER GROUP

A fundamental principle of test construction is that hypotheses drawn from experimentation on one group must be checked by application to a second group. This particular Schedule was the result of a certain amount of subjective selection of items experimentally checked by the Chicago group. Adequate standardization requires further experimentation with another group, for it may be urged (1) that the subjective selection was made with conscious reference to the Chicago group, thus invalidating the results of different groups, and (2) that despite the statement in the instructions that "all of the frequencies of maladjusted answers in (the extreme neurotic group) are considerably greater than the frequencies for (the extreme adjusted group)," there are in the schedule several items for which the difference in frequency between the two groups is slight or significant. In 12 items the difference is 2 or less. That in many cases these differences would not remain under experimental application of the schedule to a new group is strongly to be suspected. Our own use of the Schedule with Bethany College students indicates very different frequencies for the various items, and though there are undoubtedly real personality differences between the two groups, the differences found suggest that not all changes were due to the real differences between groups. Harvey (2) makes such a report from his study of 144 Texas students.

CONCLUSION AND SUMMARY

The validity of the Thurstone Personality Schedule has been questioned, and this paper makes the following points:

1. The Schedule as it functions lacks relation to a stated theory of personality adjustment.

2. Partly owing to the particular conditions under which it was standardized, there is an unacertained amount of falsification of response, conscious or unconscious, which is not revealed by the method of validation by internal consistency.
3. Such a large proportion of the items of the Schedule (34%) is dependent to some degree on the past experience of the subject that in some cases the Schedule's picture of present conditions may, owing to this factor, be quite invalid.
4. The scoring of the question response in the the process of validation was subjective and open to criticism on subjective grounds and was not fully reported. It was not retained in the 1929 edition now on the market.
5. The use of the only two extreme groups of 50 each in validating the responses is quite inadequate, and response values should be calculated on the basis of the entire distribution rather than 14.4% of it.
6. The variable significance of a response relative to the type of personality and maladjustment of each subject should be carefully pointed out instead of being hidden by the scoring method which provides a single numerical index.
7. The failure to check with a second group the hypothetical values derived from the Chicago freshman group seems indefensible.

In making these criticisms the writer has attempted to stress practices which could be improved. The writer believes that these criticisms in sum constitute an indictment of the methods of construction of the Thurstone Personality Schedule and of such methods in the construction of any personality tests or questionnaires.

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INTELLIGENCE AND SCHOOL MARKS

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THE OTIS Self-Administering Test of Mental Ability[1] and the Detroit Advanced Intelligence Test[2] were administered to the freshmen entering Fairmont State Teachers College, September, 1933. The point scores made by the various members of the class were converted into I.Q's. The mean of the I.Q's obtained from the two tests for each individual was taken as his Estimated Learning Rate (E.L.R.). The writer believes that while the term I.Q. is a rather definite measure of the native mental ability of children, it cannot appropriately be used to indicate the learning ability of college students; hence the use of the term E.L.R.

After the test results were determined, a form letter was sent to each freshman who had taken the two tests. In this letter he was given his E.L.R. with the explanation which follows.

The E.L.R. is a comparatively accurate measure of ability to succeed in college work. While the marks made by college students depend upon many other factors than learning rate, such as physical health, industry, study habits, attitude, interest, likes and dislikes, in general the E.L.R. and marks should correspond approximately as follows:

E.L.R.	*MARKS*
120 and above	A's and B's in most of the college work
105-119	B's and C's predominating
90-104	C's predominating

A comparison of each of the 161[3] freshmen's E.L.R. was made with the mean of the marks that he receivd in all courses at the end of the semester. The standards for comparison were defined thus:

If a student with an E.L.R. of 120 or higher had 51 percent of his credit hours A's and B's, he was counted as making his anticipated attainment. A student with an E.L.R. of 105-119 who had 25 percent of his credit hours B's and 51 percent of them B's and C's was counted as reaching the standard predicted for him. One with an E.L.R. of 90-104 was counted as meeting the expected goal for him if the mean of all his marks was equivalent to a C, or if 51 percent of them were C's. The standard for one with an E.L.R. of 75-89 was a mean of D, or D on 51 percent of the hours attempted. F was the expected mark for a student whose E.L.R. was below 75. The results of the comparisons are shown in Tables 1 and 2..

As shown in the preceding table approximately two-thirds of the class made marks that corresponded to the attainment predicted for

[1]Form D.
[2]Form V.
[3]Only those students who enrolled and took the tests on the first day of the enrollment period have been considered in this study.

TABLE 1—*Predicted and Actual Record of the Freshmen Entering Fairmont State Teachers College in September 1933 for One Semester*

E.L.R.[4]	No. of Correct Prediction	No. Exceeding Predicted Achievement	No. Falling Below Predicted Achievement	Total
120-134	4	0	1	5
105-119	47	6	11	64
90-104	50	8	15	73
75- 89	8	7	3	18
74	1	0	0	1
Total	110	21	30	161
Percent	68+	13+	19+	100

them. However, it is clearly observable that the standard used in making the predictions is a filexible one. A somewhat more definite comparison was made by assigning a specific letter rating for certain levels of intellectual ability. This was done as follows:

A for E.L.R.'s of 120 or above
B for E.L.R.'s of 105-119
C for E.L.R.'s of 90-104
D for E.L.R.'s of 75-89
F for E.L.R.'s lower than 75

Numerical values were then assigned to the letters. These values are: A = 4; B = 3; C = 2; D = 1;[5] F = 0.

By the use of the numerical values the mean of the achievement mark was calculated for each student. Then the letter corresponding to the mean was used as his academic attainment. The necessity for some such procedure as this is obvious, and surely indicates the need of a marking system in which the individual marks have a more specific meaning than is the case with the one now in use. It is because of the element of subjectivity that entered into the determination of the original letter marks, and the arbitrary values given to them as well as to the E.L.R. ratings, that we are using the coefficient of contingency instead of the coefficient of correlation. The method of handling the results as shown in the tables presented here will probably help to avoid a pretense to a degree of accuracy which, owing to the nature of the data, cannot exist.

Table 2 shows that only one of the five students of "A" ability made an A in achievement, while two of the five dropped to C. No student lower than "A" ability made an A in achievement. Three of "C" ability made a B in achievement. Forty students of "C" ability made C in achievement. Thirty students of "C" ability made an achievement lower than C, but only three of "C" ability made an achievement higher than C. Thirty-seven percent of the members of the class made achievements corresponding exactly to their mental ratings in achievement,

[4]The teachers did not have the E.L.R.'s of the students in any group.

[5]One taken to mean anything from .9 to 1.9. In all probability it would have been better to have considered 1 as ranging from .5 - 1.5.

TABLE 2—*A Contingency Table Showing the E.L.R. and Achievement of Freshmen Entering Fairmont State Teachers College in September 1933 with a Letter Rating Substituted for the E.L.R. Intervals*[6]

		Achievement Marks					
		F	D	C	B	A	Total
E. L. R.	A	..	..	2	2	1	5
	B	1	16	35	12	..	54
	C	5	25	40	3	..	73
	D	3	10	5	..	..	18
	F	1	..	..	..	..	1
	Total	10	51	82	17	1	161

while only nine percent, exceeded their mental ratings in achievement.

By the use of Table 2, the coefficient of contingency was found to be .53. The application of the approximate method of correction gave us a coefficient of .596. This is roughly comparable to the coefficient of correlation and is large enough enough to be significant, yet small enough to imply that there are other factors than intelligence that have great influence in determining academic achievement.

The same tests had been administered to the freshmen enrolling in September 1932 and were administered to the class entering in 1934. The same explanations were made to the students, when the results of the tests were given to them, as were made to those enrolling in 1933. The same comparisons of the E.L.R.'s and Achievement marks were also made. The results are given in Tables 3 to 6.

TABLE 3—*Actual and Predicted Record of Class Entering in 1932 for Three Semesters*

E.L.R.	No. of Correct Predictions	No. Exceeding Predicted Achievement	No. Falling Below Predicted Achievement	Total
120-134	7	0	2	9
105-119	97	9	7	113
90-104	69	13	11	93
75- 89	14	5	0	19
60- 74	..	..	..	..
Total	187	27	20	234
Percent	80—	12—	9+	100

Table 3 reveals a much large percentage of correlation between expected and actual achievement for the group entering in 1932, than is shown in Table 2 for the class entering in 1933. It should be borne in mind that the record of the 1932 entrants is for three semesters, the record for the entrants of 1933 being for only one semester.

TABLE 4—*Contingency Table Showing the E.L.R.'s and the Achievement of the class entering in 1932 with Letter Marks Substituted for the E.L.R. Intervals*[7]

		Teachers' Marks					
		F	D	C	B	A	Total
E. L. R.	A	1	2	5	7	1	16
	B	0	20	72	15	0	107
	C	0	38	50	4	1	93
	D	3	9	6	..	..	18
	F	..	..	0	0	0	0
	Totals	4	6	133	26	2	234

[6]Same group as Table 1.
[7]Same group as Table 3.

From an inspection of Table 4 we learn that out of 16 students of "A" ability, only one has an achievement of A. Half of the sixteen have an achievement of C or lower. Sevventy-two students who are rated as having "B" ability have an accomplishment of C. Twenty of them have only D in accomplishment. Only 15 of the 107 students of "B" rating in mentality made a corresponding rating in subject matter achievement. Four of "C" mental rating have ratings in achievement of B and one of "C" ability has to his credit an achievement of A. In such cases as this it is self evident that one or both of the ratings are wrong.

Approximately 32% of this class made for three semesters an achievement corresponding to their mental ratings, while 63% ranked below and 5% above. In other words, more than half of the class have done an inferior quality of work in comparison with their intellectual quality; or else they have been rated too low by their teachers.

From the data given in Table 4, the coefficient of contingency was found to be .47. The application of the approximate correction formula gives .52. This is but slightly different from the results obtained from Table 2. Contrary to indications from Tables 1 and 3, the coefficient of contingency is less in this case than in the case of the class entering in the year of 1933. A study ofTables 1 and 4 shows that this is due mainly to great variations from expectancy on the part of students of superior ability. We surely have evidence here that we are failing to utilize our intellectual resources.

TABLE 5—*Actual and Anticipated Achievement for the Class Entering in 1934 for the First Semester*

E.L.R.	No. Making Anticipated Attainment	No. Exceeding Anticipated Attainment	No. Falling Below Anticipated	Total
120-134	6	0	1	7
105-119	57	7	6	70
90-104	47	10	4	61
75- 89	10	1	0	11
60- 74	1	1	..	2
Total	121	19	11	151
Percentage	81—	13—	7	100

Table 5 gives results almost identical with the results of Table 3. As in the case of the other two classes a more definite comparison is shown in the contingency table which follows:

TABLE 6—*Contingency Table Showing the E.L.R.'s and the Achievement of the Class Entering in 1934 with Letter Marks Substituted for the E.L.R. Intervals*[8]

		Teachers' Marks					
		F	D	C	B	A	Total
E. L. R.	A	..	..	1	4	..	5
	B	1	6	47	18	..	72
	C	..	17	38	5	..	60
	D	2	6	3	1	..	12
	F	..	2	..	..	..	2
	Totals	3	31	89	28	..	151

[8]Same group as Table 5.

Table 6 reveals that for the 1934 entrants there is, as in the case of those for the two preceding classes, a slightly larger proportion of students of "C" ability making marks corresponding to their abilities than there is of any other ability group.

The majority of the students above normal ability in this class have made higher marks than they were expected to make. Approximately 41% of this class have an achievement record corresponding to their E.L.R.'s, 52% have achievement ratings below, and 7% have achievement ratings above their intelligence ratings.

The coeffiicient of contingency between intelligence ratings and achievement marks for this group is .66. The application of the correcting formula gives .73. This is higher than for either of the other classes. The data of Table 6 portray a silghtly more satisfactory relationship between intelligence and scholarship for this class than was found to exist for either of the other classes, yet we have evidence of profligacy in connection with our "intellectual capital."

Views of the scholarship achievements of the members of the three classes combined are given in Tables 7 and 8. The reader is here reminded that the data for the first and third classes are for one semester and for the second class three semesters. This may have made the general results slightly different to what they would have been if the data for all three classes had been obtained for the same period of time.

TABLE 7—*Predicted and Actual Record of the Three Freshmen Classes Entering Fairmont State Teachers College in September 1932, 1933, and 1934*

E.L.R.	No. of Correct Predictions	No. Exceeding Predicted Achievement	No. Falling Below Predicted Achievement	Total
120-134	17	0	4	21
105-119	201	22	24	247
90-104	166	31	30	227
75- 89	32	13	3	48
60- 74	2	1	0	3
Total	418	67	61	546
Percentage	77—	12+	11+	100

Table 7 furnishes testimony that clearly emphasizes the value of intelligence rating in predicting success in college work. The consistent results, in Tables 1, 3, and 5, which are brought together in Table 7 can not be due entirely to chance. In Tables 1, 3, and 5, the percent of correct predictions in scholarship records based on the E.L.R. ratings vary from 68 to 81 percent, that is, a variation from approximately two-thirds to four-fifths. Table 7 shows that a little more than three-fourths of the forecasts for the three classes were correct.

Table 8 indicates, in even a more vivid way than do Tables 2, 4, and 6 separately, that students of mediocre and superior mentality have not made achievement in scholarship corresponding to their capacity, and that those in the lower brackets of mentality have been awarded higher marks in scholarship than their E.L.R. ratings indicate they are capable of earning. One naturally asks: Does this clearly imply that the su-

TABLE 8—*Contingency Table for the E.L.R. and Scholarship Ratings for the Classes Entering Fairmont State Teachers College in 1932, 1933, and 1934*

		Scholarship Marks					
		F	D	C	B	A	Total
E. L. R.	A	1	2	8	13	2	26
	B	2	42	154	45	0	243
	C	5	80	128	12	1	226
	D	8	25	14	1	0	48
	F	1	2	0	0	0	3
	Total	17	151	304	71	3	546

perior students are not as industrious as the slow ones? Do the teachers under-estimate the accomplishment of the stronger students, and over-estimate the achievement of the weaker ones? Are the teachers exacting with those in the upper range of mentality and lenient with those in the lower ranges? Is it the result of a defective marking system? Is it the result of inadequate educational guidance? Or finally, is it due to a combination of two or more of these and other causes? The writer is inclined to believe that it is the result of a combination of two or more of the above or other causes, but large contributing factors to the situation are:

1. Lack of application on the part of many of the students of average and superior ability.
2. Lack of sufficient educational guidance.
3. The marking system.

SUMMARY

This study was begun with 161 students who enrolled in Fairmont State Teachers College in September, 1933. The main purpose of the study was to get evidence as to the value of the mental testing program that has been carried on in this college for several years. The results, obtained by making a comparison of the intelligence rating of each member of the class with the marks assigned by the teacher, gave positive evidence as to the value of intelligence ratings in predicting scholastic success in college. Since the group used in this study included only a part of the freshmen class, it was decided to extend the study to include those students of the freshmen class who had taken the intelligence tests in September, 1932, and those who ook the tests in September, 1934. The achievement records we have used, therefore, are for one semester for the 1933 and 1934 entrants and extend over three semesters for the class entering in 1932. Two methods of comparing mental and acievement ratings were used. The first was simply counting the actual numbers and computing the percent of each class that made a certain predicted attainment The standard set up permitted considerable range in each category of achievement. Notwithstanding the range allowed in making each of the standards of achievement, they were perhaps as specific as those generally employed by school superintendents and principals in rating teachers as to ability and achievement. The second method was that of arranging both the intelligence and scholastic rating into categories. By this technique the number was ascertained and the percent of those in each class making scholarship marks corresponding

to their intelligence ratings was computed. Likewise the number and percent. of those making achievement marks higher or lower than their mental ratings were determined.

Correct predictions made by the first method ranged from 68 to 81 per cent. For the three classes combined it was 78%. While the standard used was an indefinite one, the percent. of correspondence between the E.L.R. ratings and the marks assigned by teachers is too high and too consistent to be the result of chance.

In making a more reliable comparison, on account of the marking system in use, we were compelled to resort to a "round-about" method of handling the "data". Contingency tables were constructed. From the tables it was ascertained that the percent of students falling in the same category, both in intelligence rating and scholasic marks, varied from 32 to 41 percent. For all three taken together, 37 percent were in the same category both in intelligence and scholastic rating. Fifty-four percent were in lower categories scholastically than mentally. Nine percent were in higher categories in achievement than in intelligence. The coefficient of contingency ranged from .52 to .73. For the three classes combined it was found to be .573.

This is about the usual correlation[9] found to exist between intelligence and achievement in the elementary and secondary school. In general, this study produced results similar to those obtained from a recent study at Purdue University.[10]

CONCLUSIONS

1. After making due allowance for inaccuracies in rating both intelligence and scholarship, the data used in making this study implies clearly that intelligence ratings are great aids in predicting scholastic success.

2. So far a sthe groups used in this study are typical in ability and scholastic attainment, a large proportion — at least one-half — of the student body in Fairmont State Teachers College should be making a much higher scholarship attainment than they are making at present.

3. The marking system in use in this institution is very indefinite. Consequently data obtained by its use are bound to be lacking in validity and reliability.

RECOMMENDATIONS

1. That the college establish a personnel education guidance plan in which every member of the faculty who is willing to assume the responsibility, and who is willing to study guidance problems and techniques, shall participate.

2. That the letter marking system, now in use, be replaced by the percentile ranking sysem.

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[9]See Davis, Robert A., Psychology of Learning, New York, McGraw-Hill Book Co., 1935, p. 43.

[10]See Walters, J. E., Individualizing Education, New York, John Wiley and Sons, 1935, chapters I and VI.