TRANSACTIONS

of the

UTAH ACADEMY OF SCIENCES

VOLUME I (1908-1917)

FEBRUARY, 1918

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Historical

An announcement was made before the general assembly of teachers at the Provo meeting of the Utah Teachers' Association that all those interested in the formation of a Utah Academy of Science were requested to meet at 4 p. m., January 3, 1908, in Professor Hinckley's room, to take such action as seemed desirable. In accordance with this announcement, the following persons assembled: Dr. Ira D. Cardiff, University of Utah; Geo. W. Bailey, Ogden High School; Dr. S. H. Goodwin, Procter Academy; A. O. Garrett, Salt Lake High School; E. M. Hall, L. D. S. University; R. S. Baker, Eureka High School; C. G. Van Buren, B. Y. U.; C. C. Spooner, Salt Lake High School; W. D. Neal, Salt Lake City; Miss Olive E. Peck, Mt. Pleasant; Junius Banks, Lehi High School; J. F. Rawson, Eureka High School and Fred Buss, B. Y. U. At this meeting it was decided to perfect the organization. A committee was appointed on membership, and another on constitution. The committees were instructed to report at a meeting to be called by the President pro tem. in Salt Lake City in April. Moved and carried that all present as well as any who should be present at the April meeting should be invited to enroll as charter members.

The April meeting was held at the Packard Library Auditorium, beginning April 3, 1908. The committee on membership submitted a list of fifty-nine names of prospective members. The committee on constitution reported a draft for a constitution which after being acted on section by section was finally adopted. In all, three sessions of the first annual meeting were held.

Since this time, the Academy has held an annual convention during April of each year, except that in 1913, two conventions were held, one in April, and one during the Christmas holidays and none the following April.

List of Officers

OFFICERS FOR 1908-09.

Dr. Ira D. Cardiff, U. U.......................................President
Dr. John A. Widtsoe, U. A. C....................First Vice-President
Dr. S. H. Goodwin, Procter Academy..........Second Vice-President
A. O. Garrett, Salt Lake High School.......................Secretary
E. M. Hall, L. D. S. U.......................................Treasurer
Dr. John Sundwall, U. U....................................Councilor
Dr. E. D. Ball, U. A. C......................................Councilor
Dr. W. C. Ebaugh, U. U.....................................Councilor

OFFICERS FOR 1909-10.

Dr. W. C. Ebaugh, U. U.....................................President
Dr. E. D. Ball, U. A. C.........................First Vice-President
W. D. Neal, Salt Lake City...................Second Vice-President
A. O. Garrett, Salt Lake High School......................Secretary
Dr. Philena Fletcher Homer, Pleasant Grove...............Treasurer
Prof. J. L. Gibson, U. U. ....Councilor
Dr. S. H. Goodwin, Procter Academy........................Councilor
Prof. W. W. Henderson, Weber Academy.................Councilor

OFFICERS FOR 1910-11.

Dr. E. D. Ball, U. A. C.......................................President
C. C. Spooner, Salt Lake High School...........First Vice-President
Dr. S. H. Goodwin, Procter Academy..........Second Vice-President
A. O. Garrett, Salt Lake High School.......................Secretary
John B. Forrester, Salt Lake City..........................Treasurer
Prof. Marcus E. Jones, Salt Lake City....................Councilor
A. F. Greaves-Walker, Salt Lake City......................Councilor
Dr. C. T. Vorhies, U. U......................................Councilor

OFFICERS FOR 1911-12.

Dr. C. T. Vorhies, U. U......................................President
Dr. S. H. Goodwin, Procter Academy...........First Vice-President
Dr. Robert Stewart, U. A. C..................Second Vice-President
A. O. Garrett, Salt Lake High School......................Secretary
Prof. Marcus E. Jones, Salt Lake City....................Treasurer
Dr. E. G. Titus, U. A. C.....................................Councilor
Dr. Philena F. Homer, Pleasant Grove......................Councilor
W. D. Neal, Salt Lake City...................................Councilor

OFFICERS FOR 1912-13.

A. O. Garrett, Salt Lake High School......................President
Professor J. L. Gibson, U. U.....................First Vice-President
Dr. Philena Fletcher Homer, Pleasant Grove..Second Vice-President
Dr. E. G. Titus, U. A. C.....................................Secretary
Miss Gertrude Norton, Salt Lake City......................Treasurer
Dr. A. A. Knowlton, U. U....................................Councilor
Prof. Wm. Peterson, U. A. C................................Councilor
President W. W. Henderson, Weber Academy...........Councilor

OFFICERS FOR 1913-14.

Dr. E. G. Titus, U. A. C.....................................President
Dr. A. A. Knowlton, U. U..........................First Vice-President
W. D. Neal, Salt Lake City....................Second Vice-President
A. O. Garrett, Salt Lake High School.....................Secretary
B. Arthur Berryman, Bountiful............................Treasurer
Prof. Marcus E. Jones, Salt Lake City....................Councilor
Dr. Harvey Fletcher, B. Y. U.............................Councilor
Dr. Joseph Peterson, U. U................................Councilor

OFFICERS FOR 1914-15.

Prof. Marcus E. Jones, Salt Lake City......................President
Dr. Harvey Fletcher, B. Y. U...................First Vice-President
Dr. C. N. Jensen, U. A. C.....................Second Vice-President
A. O. Garrett, Salt Lake High School............Permanent Secretary
Dr. A. A. Knowlton, U. U.................................Councilor
Dr. Joseph Peterson, U. U................................Councilor
Dr. Frank L. West, U. A. C...............................Councilor

OFFICERS FOR 1915-16.

Dr. Harvey Fletcher, B. Y. U...............................President
Dr. Frank S. Harris, U. A. C...................First Vice-President
Dr. L. L. Daines, U. U........................Second Vice-President
A. O. Garrett, East High School, Salt Lake City..Permanent Secretary
Professor J. L. Gibson, U. U.............................Councilor
W. D. Neal, Salt Lake City...............................Councilor
Dr. W. E. Carroll, U. A. C...............................Councilor

OFFICERS FOR 1916-17.

Dr. Frank S. Harris, U. A. C...............................President
Dr. L. L. Daines, U. U.........................First Vice-President
Professor Carl F. Eyring, B. Y. U.............Second Vice-President
A. O. Garrett, East High School, Salt Lake City..Permanent Secretary
W. D. Neal, Salt Lake City...............................Councilor
Professor J. L. Gibson, U. U.............................Councilor
Dr. W. E. Carroll, U. A. C...............................Councilor

OFFICERS FOR 1917-18.

W. D. Neal, Salt Lake City.................................President
Dr. L. L. Daines, U. U.........................First Vice-President
Dr. W. E. Carroll, U. A. C....................Second Vice-President
A. O. Garrett, East High School, Salt Lake City..Permanent Secretary
C. Arthur Smith, East High School,
Salt Lake City..............................Assistant Secretary
Dr. Newton Miller, U. U..................................Councilor
Professor Carl Eyring, B. Y. U...........................Councilor
C. Arthur Smith, East High School, Salt Lake City........Councilor

Roster Utah Academy of Sciences,
October 25, 1917

LIFE MEMBERS.

BISHOP, FRANCIS MARION (1916)....................1642 Major Avenue, Salt Lake City

ASSOCIATE MEMBERS.

*BALL, DR. E. D. (Charter, 1908)................State Entomologist for Wisconsin, Madison
*CARDIFF, DR. IRA D. (Charter, 1908)....................................Yakima, Wash.
CLEMENS, MRS. MARY STRONG (Charter, 1908)................Mo. Bot. Garden, St. Louis
CUMMINGS, PROF. BYRON (1913)....Professor Archeology, University of Arizona, Tucson
GREAVES-WALKER A. F. (Charter, 1908).
HALL, E. M. (Charter, 1908)................................High School, St. George, Utah
HARTMAN, DR. L. W. (Charter, 1908).........Professor Physics, University Nevada, Reno
KNOWLTON, DR. A. A. (1911)..............Professor Physics, Reed College, Portland, Ore.
MATTILL, DR. H. A. (1912)...............Asst. Prof. Nutrition, Univ. California, Berkeley
MATTILL, DR. HELEN I. (Dec., 1913).......................................Berkeley, Cal.
PETERSON, DR. JOSEPH (1911).......Professor Psychology, Univ. Minnesota, Minneapolis
SMITH DR. FRANKLIN, O. (Dec., 1913)....Professor Psychology, Univ. Montana, Missoula
STEWART, DR. ROBT. (1910)..............Asst. Prof. Soil Fertility, Univ. Illinois, Urbana
*VORHIES, DR. CHARLES T. (1909).............Professor Zoology, Univ. Arizona, Tucson

FELLOWS.

CARROLL, DR. W. E. (1912)..................Prof. of Animal Husbandry, U. A. C., Logan
DAINES, DR. L. L. (1909)...............Associate Prof. Bacteriology, U. U., Salt Lake City
*EBAUGH, DR. W. C. (Charter, 1908)...Consulting Chemist, 809 Kearns Bldg., Salt Lake City
EYRING, PROF. CARL F. (April, 1913)...............Assoc. Prof. Physics, B. Y. U., Provo
*FLETCHER, DR. HARVEY (1912).......................................New York, N. Y.
FORRESTER, JOHN BRYCE (Charter, 1908)..Geologist and Min. Eng., 1634 9th E., S. L. C.
*GARRETT, A. O. (Charter, 1908).............Head Dept. Biology, S.L. H. S., Salt Lake City
GIBSON, PROF. J. L. (Charter, 1908)..Dean School Arts and Sciences, U. U., Salt Lake City
GOODWIN, DR. S. H. (Charter, 1908)...................President Procter Academy, Provo
*HARRIS, DR. FRANK S. (Charter, 1908)...........Director Utah Agr. Exp. Station, Logan
HILL, DR. GEO. R., JR. (Dec., 1913)....................Plant Pathologist, U. A. C., Logan
HOMER, DR. PHILENA FLETCHER (Charter, 1908).922 E. Second South St., Salt Lake City
JENSEN, DR. C. N. (1912)...................................President B. Y. C., Logan
*JONES, PROF. MARCUS E. (Charter, 1908)......270 W. South Temple St., Salt Lake City
MILLER, DR. NEWTON (1916)..................Professor Zoology, U. U., Salt Lake City
NEAL, W. D. (Charter, 1908)..............................528 Center St., Salt Lake City
PETERSON, DR. ELMER G. (1912)..............................President U. A. C., Logan
PETERSON, PROF. WM. (1911).......................Professor Geology, U. A. C., Logan
PORTER, DR. C. W. (1912).................................Univ. California, Berkeley
SMITH, C. ARTHUR (1916)..............Teacher Physics, East High School, Salt Lake City
SNODDY, DR. GEORGE S. (1916)........Assoc. Prof. of Psychology, U. U., Salt Lake City
SNOW, Dr. P. G. (Charter, 1908).............Dean of Medical School, U. U., Salt Lake City
*TITUS, DR. E. G. (Charter, 1908)..................Sugar Breeding Work, Idaho Falls, Ida.
WEST, DR. FRANK L. (1912)..Prof. Physics and Dir. School of Gen. Science, U. A. C., Logan
WIDTSOE, DR. JOHN A. (Charter, 1908).................President U. U., Salt Lake City

RESIDENT MEMBERS.

ALDER, BYRON F. (1912).................Asst. Prof. Poultry Husbandry, U. A. C., Logan
BENNION, PROF. MILTON (1916)........Dean School of Education, U. U., Salt Lake City
BERRYMAN, B. A. (1910)...................................Berg Apts., Tacoma, Wash.
BOND, MISS MARY ELIZABETH (1912)..........Principal Lincoln School, Salt Lake City
BONNER, DR. WALTER D. (1917)...........Professor of Chemistry, U. U., Salt Lake City
BRIGHTON, THOS. B. (April, 1913)..............Inst. in Chemistry, U. U., Salt Lake City
CAINE, GEORGE B. (1916)..................Assoc. Prof. Animal Husbandry, U. A. C., Logan
CAINE, PROF. JOHN T., III (1912)........Director of Extension Division, U. A. C., Logan
CORAY, PROF. GEO. (1917)....Professor of Economics and Sociology, U. U., Salt Lake City
CUMMINGS, N. W. (Dec., 1913)......................1461 S. Seventh East St., Salt Lake City
DIEHL, ISAAC E. (1915)...Mammoth, Utah
GARDNER, DR. WILLARD (April, 1913)....................Prof. Physics, B. Y. C., Logan

*Past Presidents.

GIDDINGS, L. A. (1917) .... Teacher Zoology, East High School, Salt Lake City
GODFREY, JAMES S. (1917) .... Murray
HAGAN, HAROLD R. (December, 1913) .... Assoc. Entomologist, U. A. C., Logan
HARWOOD, WILLARD R. (December, 1913) .... Teacher Nature Study, Salt Lake City
HAYES, JUNIUS J. (1912) .... Pleasant Grove
HENDERSON, DR. MARTIN P. (1916) .... Professor Biology, B. Y. U., Provo
HOGENSON, J. C. (1910) .... State Leader in Boys' and Girls' Club Work, U. A. C. Logan
IVERSEN, L. MOTH (1917) .... Salt Lake City
JONES, JAMES W. (1917) .... Agr. Expert, Salt Lake City
KEMP, JOHN H. (1909) .... B. Y. C., Logan, Utah
KERR, WALTER A. (1917) .... Asst. Prof Mod. Languages, U. U., Salt Lake City
KNOX, MISS FLORENCE (Dec., 1913) .... Teacher U. U. Training School, Salt Lake City
KORSTIAN, CLARENCE F. (1917) .... Forest Service, Ogden
LEDYARD, EDGAR M. (1916) .... Agr. Expert, U. S. Smelting Co., Salt Lake City
LYMAN, DR. RICHARD R. (1912) .... Professor Civil Engineering, U. U., Salt Lake City
MACFARLANE, WALLACE (1912) .... Oklahoma Agr. College, Stillwater, Okla.
MAESER, PROF. SHERWIN (1917) .... Asst. Prof. Physics, B. Y. U., Provo
MATTHEWS, A. L. (1916) .... Asst. Prof. Agr. Education, U. U., Salt Lake City
MAW, CHAS. E. (1915) .... Professor of Chemistry, B. Y. U., Provo
MAUGHAN, HOWARD J. (1915) .... Daniel, Wyoming
MERRILL, DR. JOSEPH F. (1917) .... Director of School of Mines, U. U., Salt Lake City
MOREHEAD, MISS MARY (1915) ...... Critic Teacher U. U. Training School, Salt Lake City
MORSE, MISS HAZEL L. (1916) .... Teacher Physiography, East High School, Salt Lake City
NORTON, MISS GERTRUDE (1909) .... Teacher Longfellow School, Salt Lake City
PACK, DR. FREDERICK J. (1917) .... Prof. of Geology, U. U., Salt Lake City
PAUL, DR. J. H. (Charter, 1908) .... Prof. of Nature Study and Geog., U. U., Salt Lake City
PHERSON, PROF. E. W. (1909) .... Asst. Prof. of Mathematics, U. U., Salt Lake City
REEVES, GEO. I. (April, 1913) .... Entomologist, 416 Vermont Bldg., Salt Lake City
SCHNEIDER, HYRUM (1917) .... U. U., Salt Lake City
SMITH, JAMES R. (1915) .... Teacher High School, Heber, Utah
SORENSEN, CHAS. J. (1917) .... Asst. Zoologist, U. A. C.
SPALDING, THOMAS (1917) .... R. F. D. No. 1, Box 274, Provo
SPERRY, SIDNEY B. (1917) .... Asst. in Chemistry, U. U., Salt Lake City
STEINER, PROF. CHRISTIAN D. (Dec., 1913) .. Prof. Agr. Education, U. U., Salt Lake City
SUGDEN JOHN W. (1917) .... Salt Lake City
TAYLOR, MRS. AMELIA R. (Dec., 1913) .... Box 94, Provo, Utah
TAYLOR, ESTES PARK (1916) .... Dir. of Extension, U. of Arizona, Tucson
TAYLOR, DR. FRED W. (Dec., 1913) .... Box 94, Provo
TAYLOR, J. EDWARD (April, 1913) .... 448 State Capitol Bldg., Salt Lake City
THOMAS, ELBERT D. (1917) .... Instr. in Anc. Languages, U. U., Salt Lake City
THOMAS, MATHONIHAH (April, 1913) .... 468 Seventh Ave., Salt Lake City
TUGMAN, DR. ORIN (1917) .... Assoc. Prof. of Physics, U. U., Salt Lake City
WEST, PROF. RAY BENEDICT (April, 1913) ..... Prof. Agr. Engineering, U. A. C., Logan
WILSON, C. OREN (1916) .... Teacher History, East High School, Salt Lake City

Constitution

ARTICLE I.

Section 1. The name of this organization shall be "The Utah Academy of Sciences."

ARTICLE II.

Sec. 1. The objects of this Academy shall be to promote investigation and to diffuse knowledge in the various departments of science.

ARTICLE III.

Sec. 1. *Members.*—Any person interested in the promotion of science may become a member of this Academy upon nomination by the Council and assent of three-fourths of the members present at any regular meeting.

Sec. 2. Each applicant for life, resident or associate membership must be proposed in writing at a stated meeting of the Academy by two or more resident or life members. Except at the last session, names ratified by the Council shall be placed in the hands of the members at least one session before their election. A three-fourths vote of members present shall be required for election.

Every person elected to membership shall pay the initiation fee and the first annual dues within one month after receiving notice of his election and shall sign the Constitution.

Sec. 3. *Fellows.*—Fellows may be elected by the Council from the members upon presenting satisfactory evidence of having done original investigation.

Sec. 4. Fellows who have removed from the State may be transferred to associate membership.

Sec. 5. Honorary members shall be non-residents of the State. They may be elected on account of special prominence in science on the written recommendation of two members of the Academy. The elections shall be in the manner prescribed for resident members.

Sec. 6. *Patrons.*—Any person paying to the Academy the sum of one hundred dollars ($100.00) at one time shall be classed as a patron and shall be entitled to all the privileges of a member and to all publications of the Academy.

Sec. 7. *Fees.*—Resident members shall pay an initiation fee of one dollar and annual dues of one dollar; but the Secretary shall be exempt from the payment of regular dues during the years of his service.

Sec. 8. *Life Members.*—Any person who at one time shall contribute twenty-five dollars ($25.00) to the funds of the Academy may be elected a life member of this Academy and shall be exempt from all assessments therein.

ARTICLE IV.

Sec. 1. *Officers.*—The officers of this Academy shall consist of a President, two Vice Presidents and a Permanent Secretary. The President and the two Vice Presidents shall be chosen by ballot at the annual meeting, and shall hold office for one year, or until their successors are chosen. They shall perform the duties usually pertaining to their respective offices. All of the officers shall be elected from the fellows.

Sec. 2. *Permanent Secretary.*—The Permanent Secretary shall be elected by the Council to hold office during the pleasure of that body. The duties of the Permanent Secretary shall be those ordinarily pertaining to that office and in addition he shall have charge of all books, collections and other property of the Academy. The Permanent Secretary shall also perform the duties usually assigned to a Treasurer.

Sec. 3. *Council.*—The Council shall consist of the Past Presidents, the President, the Vice Presidents, the Secretary and three Councillors-at-large to be elected from the Fellows of the Academy at the time of the election of the officers.

Sec. 4. *Vacancies.*—In the event of a vacancy in the office of President, the First Vice President shall serve the unexpired term, and the Second Vice President shall succeed the First Vice President. The Council shall have power to fill any other vacancy in the offices.

ARTICLE V.

Sec. 1. *Place of Meeting.*—Unless otherwise directed by the Academy, the annual meeting shall be held in April of each year at such place as the Council shall designate. Other meetings may be called at the discretion of the Council.

ARTICLE VI.

Sec. 1. *Amendments.*—This constitution may be amended at any annual meeting of the Academy by a vote of three-fourths of attending members of at least one year's standing. No question of amendment shall be decided except at a regular session of the annual meeting, nor shall it be decided at the same session when presented. All proposed amendments shall be presented in writing.

By-Laws

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1. The first hour, or such part thereof as shall be necessary, in each session shall be set aside for the transaction of the business of the Academy. The following order of business shall be observed as far as practicable:

1. Opening.
2. Minutes of the last meeting.
3. Reports of Officers.
4. Reports of Standing Committees.
5. Appointing of Special Committees.
6. Unfinished Business.
7. New Business.
8. Reports of Special Committees.
9. Election of Officers.
10. Election of Members.
11. Program.
12. Adjournment.

2. The President shall deliver a public address on the evening of one of the days of the meeting, at the expiration of his term of office.

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

4. Members who allow their dues to remain unpaid for two years, having been annually notified of their arrearage by the Secretary, shall have their names stricken from the roll.

5. The Permanent Secretary shall collect initiation fees, dues and other moneys for the Academy and shall have charge of the distribution, sale and exchange of the published transactions of the Academy, under such restrictions as may be imposed by the Council.

6. Eight members shall constitute a quorum for the transaction of business.

7. No paper shall be entitled to a place on the program unless the manuscript, or an abstract of the same, will have been previously delivered to the Secretary.

8. Five members of the Council shall constitute a quorum.

9. In all points of parliamentary procedure not covered by this Constitution and By-Laws, Roberts' Rules of Order shall prevail.

10. These By-Laws may be amended by a two-thirds majority vote of the members present at any regular meeting, provided that the proposed by-law shall be submitted in writing to the Secretary.

FIRST ANNUAL CONVENTION, UTAH ACADEMY OF SCIENCES.

Packard Library Auditorium, Salt Lake City, April 4, 1908.

"THE PRIMORDIAL ELEMENT—A RECURRING HYPOTHESIS"..................By Dr. W. C. Ebaugh

"ORIGIN AND DISTRIBUTION OF THE FLORA OF THE GREAT PLATEAU"............By Marcus E. Jones

Published in Contributions to Western Botany, No. 13:46-68, 1910.

"NOTES ON NESTING HABITS OF THE GENERA BOMBUS AND OSMIA"..........By Dr. Philena Fletcher Homer

In the absence of the author, read by Geo. W. Bailey.

"THE ORIGIN OF THE HOMOPTEROUS FAUNA OF THE DESERT"........................By Dr. E. D. Ball

"RUSTS AND SMUTS OF SALT LAKE AND ADJACENT COUNTIES"........................By A. O. Garrett

Published in Mycologia 2:265-304, 1910.

"CONCERNING THE RADIATION FROM THE NERNST LAMP".......................By Dr. L. W. Hartman

"REFRACTORY CLAY AND THE EFFECTS OF INGREDIENTS UPON THE MELTING POINT"..By A. F. Greaves-Walker

"RECENT RESEARCHES BEARING UPON THE PHYSICAL BASIS OF HEREDITY"............By Dr. Ira D. Cardiff

"RESEARCHES ON GLAND CELLS".....By Dr. John Sundwall

NESTING HABITS OF BOMBUS AND OSMIA.

By Dr. Philena Fletcher Homer.

The nests of one of the most common of the western bumble bees, *Bombus morisoni,* are of peculiar interest in that they represent a complex type hitherto described only from Europe. Several kinds of nests have been described by American workers but all are of a simple type in which the eggs are deposited in masses of pollen and the only cells are the made-over cocoons of the pupae which are used for storing honey and pollen.

B. morisoni, however, not only uses the pupal cases as storage cells but in addition builds both brood cells and pollen tubes of wax.

The nest was taken in August, at Logan, Utah. It was situated in an old mouse nest under a strawy manure pile. The bees had evidently taken forcible possession of the nest as the mummified remains of the rightful owner were found in one side of the nest. At the time of its removal all the stages of bee life were represented, from the queen mother to the newly deposited eggs, through the young and mature larvae, pupae and the recently emerged queens and males.

The nest was very compact in form and composed of four tiers of cells. The lower ones were dark in color and mostly used as honey pots. Above there were the fresh cocoons containing the pupae and nearly mature larvae. These were light brownish in color with papery walls stiffened at the base with wax.

The majority of these cells bore near the apex a curious papilliform mass of soft wax which proved to be the breeding cells. From three to seven eggs were arranged in these cells, perpendicularly with the small end downward. A waxen cup is first formed in which the eggs are deposited and the cell is then capped over. No food was found in any of the brood cells and the young probably depend upon the ministrations of the nurse bees for their daily rations.

As the larvae increase in size the waxen cell is enlarged but they evidently remain in one cell until about ready to pupate. The waxen cells are then larger than the thumb and somewhat irregular in shape as the soft walls rather shape themselves around the larvae. In spinning their cocoons, however, each larva builds for himself an ample papery cocoon.

Besides the breeding cells, the nests contained two other kinds of cells not usually found in the nests of the common American species. These were the honey pots and the pollen tubes. The honey pots were round waxen cells open at the top and filled with honey. They differed from the old cocoons which were also utilized as honey pots in their form and size and in that they were composed entirely of wax.

The pollen tubes were long cylindrical cells of soft wax situated on the outside of the nest and extending from the bottom to the top of the nest like chimneys. This nest contained four of these placed about an equal distance apart. They were filled to within one-fourth inch from the top with pollen packed into a firm uniform mass.

The nest contained about sixty individuals and was remarkably free from parasites. The body of a mutilated Psithyrus was found under the nest where the bees had thrust her after tearing off her wings and the most of her legs and pubescence.

While the nests of the bumble bees are of particular interest in that they form an important link between the solitary and the permanently social bees, yet the bees of the genus Osmia are probably the master builders of the bee kingdom. In no other genus are the places chosen for the nest or the forms of the cells so diverse.

Only a few of these have as yet been studied but each one has its own method of building its home. Some dabble in clay, others form their nests of dainty hued vegetable fibres; but wherever the cells are placed the bee itself seldom makes the excavation but places them in some convenient cavity.

The mud-wasp Osmia is not at all averse to rented apartments and places her dainty brownish cells in the empty cell of the common eastern mud wasp. The cells are so arranged and shaped that they will exactly fill the cavity of the mud cell.

The cells are extremely dainty, being composed of chewed plant fibres and plant hairs of a reddish brown color. They are very firm in texture and will resist considerable pressure before bending. In leaving the cell the young bee may emerge either through the concave end of the cell or through the side of the cell. The adult closely resembles the Snail-shell Osmia.

The Pine Osmia is a pretty little greenish bee which builds its nest under the overlapping scales of the pitch pine. She does not waste extra labor in constructing a burrow for herself but finds the abandoned tunnel of a grub or wasp and places her tiny cocoons therein. These are placed end to end and are separated by thick partitions of chewed vegetable matter. The material used in the nests under observation was charcoal. The plug closing the burrow is likewise of charcoal and about half an inch long.

The burrows of the mud wasp which builds in similar situations are always supplied with mud partitions and their burrows are always closed with a plug of mud. The character of the partitions may be relied upon for determining the ownership of the nests.

The Snail-shell Osmia is, however, the aristocratic member of the family and while she has long been known in Europe has never before been described from America. They choose for themselves dainty houses of pearl, the deserted shell of Helix. The adults emerge early in the spring from the middle of April to the first of May in the vicinity of Ithaca, N. Y., the only locality from which they have been reported.

The adults spend the first two or three weeks in the shells and on cool days may be found there often four or five in one shell. The males are much smaller and usually occupy the inner spirals, often crawling into the third spiral of the shell. The larger females rest in the outer coils until settled warm weather in May calls them to nest building. At a place in the spiral where the diameter narrows to about one-fourth inch, the bee places a thin partition of vegetable matter, just thick enough to hold the pollen in place. About three cells are then constructed with their long axes following that of the spiral. Each cell is formed by the two partitions and is well supplied with pollen. By this time the mother bee has reached a place where the diameter has increased to one-half inch and she then places the cells across the lumen of the spiral. The opening into the shell is then closed by a plug of chewed plant fibres nearly half an inch thick. This differs from the plugs made by some members of the genus in that it is composed of a solid mass and is not made up of several layers or discs. This partition is placed more than half way around the first spiral so that the shell appears empty unless broken into. As a further safeguard against the depredations of predaceous and parasitic insects, the mother fills up the entrance with tiny pebbles.

The Stone Osmia possesses the most highly developed instinct for the protection of the young against their parasitic enemies. This exceedingly interesting bee is one of the larger members of the family and builds in the larger branches of the pithed plants. A long burrow is chosen not under one-fourth inch in diameter. In the bottom of this she stores a mass of pollen and deposits her egg. She then builds an ample partition of chewed vegetable fibres closely resembling that of *Alcidamea producta*. Next she places a few little pebbles in the burrow and constructs another vegetable partition. About three cells are thus formed, the partitions being invariably composed of alternate layers of vegetable fibres and stones.

When she has finished the partition for the last cell, the bee leaves an empty space about an inch long and fills it in with tiny pebbles from one-eighth to one-sixteenth of an inch in diameter. This stone-filled cell is then closed with five or six alternate layers of plant fibres and tiny stones which forms a plug one-half to three-fourths of an inch long.

But however efficacious her precautions may be against certain members of the parasitic hymenoptera, they are unavailing against her own relatives, little grey bees of the family *Stelididae* which enter the burrow while the bee is away after pollen and deposit their eggs in the mass of pollen intended for the Osmia larvae.

SECOND ANNUAL CONVENTION OF THE UTAH ACADEMY OF SCIENCES.

(Known as the "Darwin Centennial Meeting" of the Academy.)

Packard Library Auditorium, Salt Lake City,
April 9 and 10, 1909.

"DARWIN THE MAN"....By Prof. W. W. Henderson, B. Y. C.

"FACTORS IN ZOOLOGICAL EVOLUTION".By Dr. John Sundwall

"FACTORS IN BOTANICAL EVOLUTION"..By Dr. C. T. Vorhies

"THE ADAPTATION OF INSECTS WITH SPECIAL REFERENCE TO ARID CONDITIONS"..............By Dr. E. D. Ball

"THE ALFALFA LEAF WEEVIL"..........By Dr. E. G. Titus

"HONEY ANTS"........................By A. O. Garrett

"ORBITAL GLANDS OF AMPHIBIANS"........By P. G. Snow

"NOTE ON GEOLOGICAL SURVEY BULLETIN NO. 371"........................By J. B. Forrester

"HIGH TEMPERATURE MEASUREMENT"......................By Dr. L. W. Hartman

"POTTERY GLAZE COLORING"......By A. F. Greaves-Walker

"THE VALUATION OF FUEL ACCORDING TO ANALYSIS"........................By Dr. Wm. Blum

"PHILLIPINE BIRDS"................By Chaplain Clemens

THE HONEY ANTS.

By A. O. Garrett.

(Abstract).

A review is given of a paper by Professor William Morton Wheeler entitled "Honey Ants, with a Revision of the American Myrmecocysti."

There are two species of honey ants in North America, *Myrmecocystus melliger* (more abundant at lower altitudes of 300-1500 meters) and *M. mexicanus* (at higher altitudes of 2000-2500 meters). McCook discovered *M. horti-deorum* (a variety of *M. mexicanus*) in the Garden of the Gods near Manitou, Colorado, in 1882. This is nocturnal in its habits, while *M. melliger* is diurnal. The colony of *M. horti-deorum* consists of yellow workers, which are the nurses and feeders; of other yellow workers, which are the honey makers; and of black workers, which are the guards and purveyors.

The reasons for giving this review are stated as follows:

One day last autumn, Mr. Guy Hart, a senior in the Salt Lake High School, brought to me a box containing several repletes of honey ants. He had dug them up near Garfield. The abdominal walls of some had been broken, and the honey, a thick, viscous, rather dark-brown substance, had spread over the bottom of the box. The honey-chamber is about the size of a small currant. The measurement of that of one ant is 11 x 7.5 mm. I sent specimens to Professor Wheeler, who pronounced them as undoubtedly *M. mexicanus*, belonging to a variety very closely allied to *horti-deorum*. They are, however, apparently smaller than the repletes of that variety, the measurements of which he gives as 10-13 mm. in length.

Whether this is a new variety or not cannot be determined until a complete set of workers shall have been collected. However, the find is the first recorded for Utah, and Garfield is the farthest north and farthest west of any locality for any species or variety of the honey

ant. We find many ant-hills among the scrub-oaks of this region. Who knows whether they are those of honey ants? Here is a good subject for investigation by the zoologists of our Academy.

A SHORT COMMENT ON BULLETIN 371 OF THE U. S. GEOLOGICAL SURVEY.

By J. B. Forrester.

Having spent several years in close contact with the Book Cliffs Coal Field, and having studied the geology of that region through actual surveys, I believe that a short comment on Mr. Richardson's paper may not be out of place.

It is by a comparison of ideas advanced by different observers that the science of Geology has attained it present prominence, and mistakes as well as truths have given it a great impetus.

It will be unnecessary to go into the history of the literature concerning the Laramie and the Mesa Verde Formations, but we shall confine ourselves to the paper under consideration.

Since 1903 it has been my privilege to study and collect fossils in the Laramie, or Coal Bearing Series, of Eastern Utah; also those of southwestern Colorado, and the Mesa Verde in the same region. I have also run outcrop surveys from Sunnyside to the Beckwith Plateau and from Castlegate to Huntington Canyon. These, together with several geological profiles, cover farily well this portion of Utah.

I shall give a description of what has, until lately, been known as the Laramie formation. At Castlegate the Laramie consists of some 3000 feet of alternating sandstones and shales. The strata are thick and represent long periods of submergence. The conditions of deposition have been very uniform. However, the Castlegate sandstone which lies at the top of the coal bearing series, is materially different from the other sandstones in this formation. The lower sandstones weather into a honeycomb appearance. This is due to wind erosion. There are no joints, so all edges are rounded. Immediately under these sandstones, of which there are two, are shales, easily weathered and eroded. Thus the sandstones are undermined, the overhanging ledge breaks off and the operation commences anew. This is what Dutton named "Weathering by recession of cliffs" and is very characteristic of the whole formation.

The upper, or Castlegate sandstone, is very different. It attains a thickness of over 500 feet, is very compact and is broken by joints and cross joints into large blocks. One set of these joints is parallel to the bedding plane and the other at right angles to it. Consequently the talus from this stratum is formed of large angular blocks, while the talus of the lower strata consists of rounded boulders. The Castlegate sandstone is also underlaid by a layer of shale and this preserves the recession of cliffs uniform throughout the formation. Its general resemblance to cyclopean masonry makes it easy to identify.

Apart from its fauna the Laramie has strong lines of demarcation. The abrupt change from argillaceous to arenaceous at the bottom, and the gradual transition from arenaceous to calcareous at the top presents an unfailing index to its delimiting lines. These characteristic lines of demarcation, so I find, are coextensive with the Laramie exposures in other portions of Utah.

The Laramie is divisible into three natural zones, viz.,

Upper Zone	Heavy sandstones with a few beds of shale, and makes precipitous cliffs	1500 feet
Middle Zone	Thin beds of sandstone and shale, many seams of coal; makes talus-like slopes	500 feet
Lower Zone	Heavy bedded sandstones grading into thin argillaceous sandstones at the bottom, makes bluffs on top merging into talus-like slopes at base	1000 feet

Having thus described the general features and succession of the Laramie as it occurs near Castlegate and Sunnyside, I shall now give a general description of the Mesa Verde as it occurs at the type locality, where I have had two seasons of geological work.

The name Mesa Verde Group was applied by W. H. Holmes (U. S. Geol. and Geog. Surv. Terr., 1875, page 244) to the series of sandstones and shales which form the Mesa Verde. He included in the Group three divisions, viz.,

The lower Escarpment, sandstone	120	feet.
The middle Coal Group; shale, marl, and coal	800-900	feet.
Upper Escarpment, massive sandstone	190	feet.

This complex included the variable series, largely of sandstone, occurring between two strong shale formations —clearly the Mancos and Lewis Shales.

The fossil evidence presented by Cross (Folio No. 60, U. S. Geol. Surv.) shows that the Mesa Verde Formation is but a part of the Pierre division of the Montana Group. The following fossils were found by him in this formation.

Leda sp.
Ostrea pellucida.
Ostrea inornata.
Cardium speciosum.
Cardium bellulum.
Inoceramus cripsii var. barabini.
Mactra alta.
Callista pellucida.
Corbicula sp.
Baculites anceps var. obtusus.
Baculites compressus.
Placenticeras placenta var. intercalare.
Pinna sp.

According to T. W. Stanton, these forms range through both the Pierre and Fox Hills formations of the Montana Group of the Cretaceous. The list does not contain any exclusive Fox Hills species and there is, therefore, no ground from this fossil evidence to assign the Mesa Verde to the Fox Hills as was done by the Hayden Survey.

I shall now take up the faunas of the two series as collected by myself and identified by T. W. Stanton. First, I shall compare the faunas as found in southwestern Colorado where the succession is clearly shown from the Mancos Shale through the Mesa Verde and Lewis Shale to the Laramie. Then compare these with those found in Utah from the Beckwith Plateau to Ivy Creek.

LARAMIE.

Beaver and Yellow Jacket Creeks.
Anomia sp. related to A. micronema.
Modiola laticostata.
Corbiculas sp. related to C. subelliptica.
Corbicula occidentalis
Corbula undifera.
Melania wyomingensis
Ostrea sp.
Unio holmesianus.
Unio brachyopisthus.
Unio verrucosiformis.
Unio (two undescribed species.)
Campeloma sp.
Neritina sp.

MESA VERDE

In Strata between Durango and Hesperus.
Serpula sp.
Serpula sp.
Ostrea subtrigonalis.
Inoceramus cripsii var. barabini.
Pinna sp.
Lucina. sp.
Sphaeriola sp.
Cardium bellulum.
Cardium speciosum.
Callista deweyi.
Panopaea sp.
Dentalium sp.
Turrietella sp.
Lunatia sp.
Anchuria newberryi.
Fasciolaria sp.
Fusus sp.
Odontobasis sp.
Actaeon intercalaris.
Baculites anceps var. obtusus.
Baculites compressus.
Placenticeras intercalare.

It will be noticed that the Mesa Verde fauna has a distinct marine facies while that of the Laramie is fresh or brackish-water, and nowhere have we found the cephalopoda, such as Baculites and Placenticeras, distinct marine forms, in the series I refer to the Laramie; neither do we find such marine forms as Pinna and Inoceramus. So the point for us to keep in mind is, "The Mesa Verde fauna is marine, the Laramie, fresh or brackish-water."

Without going into detail, I will say that the Tertiary Eocene which lies conformable on the Laramie, contains characteristic fresh-water forms, such as *Viviparus paludinaeformis, Goniobasis tenera,* and *Unio mendax.* Thus the Laramie fauna as well as the strata form a transition series between the marine Cretaceous and the lacustrine Eocene Tertiary. The Mesa Verde, on the other hand, is overlain by marine Cretaceous strata, the Lewis Shale.

Now let us compare the fossils found by Richardson and myself in the Book Cliffs Coal Field.

COLLECTED BY

G. B. Richardson.	J. B. Forrester.
Anomia micronema.	
Anomia gryphorhyncus	Anomia propatoris.
Ostrea glabra	Ostrea glabra.
Ostrea sp.	Ostrea soleniscus.
Modiola laticostata	Modiola laticostata.
Corbula perundata	Corbula undifera
Corbula subtrigonalis	Corbula subtrigonalis
Corbula cytheriformis	Corbula nematophora.
Tulotoma thompsoni	Tulotoma thompsoni.
Unio sp.	Unio holmesianus.
Unio sp.	Unio mendax.
Unio sp.	Unio brachyopisthus.
Compeloma, sp.	
Goniobasis sp.	
Molluscan burrows in wood	
	Lingula sp.
	Cardium sp.
	Admetopsis subfusiformis.
	Viviparus trochiformis.
	Viviparus Panguitchensis.
	Planorbis planoconvexus.
	Physa copei.
	Sphaerium subellipticum.
	Melania wyomingensis.
	Cyrena securis.

On comparing these with the list obtained in southwestern Colorado one will see that there is a close agreement even to the species, thus showing that the fossils collected by Richardson and myself place the series of strata in the Laramie. In neither of these lists do we find any marine forms; on the contrary, such forms as Viviparus, show clearly the brackish-water nature of the fauna. Not only that, but also a transition to the fresh-water forms of the Tertiary.

Again, all these fossils will be found referred to the Laramie by Meek in his memoir on Cretaceous invertebrate palaeontology (Vol. 9 U. S. Geol. Surv. 1876). Dr. White also, through his more recent researches, corroborated the deduction of Mr. Meek, and it has been on these palaeontological grounds that I, as well as others, have referred the Book Cliff Coal Series to the Laramie.

Let us see now what reasons Mr. Richardson brings forth to lead him to relegate them to the Mesa Verde. In the type locality the Mesa Verde lies conformably between two marine Cretaceous formations, the Mancos and Lewis Shales. From the faunal relations, the Mesa Verde has been definitely placed in the Pierre division of the Montana Group. It is overlain by about 1800 feet of the marine Cretaceous strata. In the Book Cliffs, Richardson claims that there has been a long period of emergence, enough time, indeed, to wash 2000 to 3000 feet of Laramie and 1800 feet of Lewis Shale into the sea before the Eocene was deposited.

Does observation substantiate this? I think not. Near Castlegate the only unconformity that can be found is at the top of the Fox Hills Formation. From this line of demarcation the strata have been laid down with a succession so gradual that the upper delimiting line can only be found by palaeontological means with any degree of certainty.

This line has been found to correspond to a stratum of limestone that is persistent throughout the entire field. In Ivy Creek where the Tertiary is covered, in part at least, by a basic lava flow, I was enabled to locate the top of the Laramie by recognizing this limestone with its contained *Viviparus paludinaeformis*.

Mr. Richardson gives a good general section of the Laramie as I have found it. The only assignable reason for assuming that so great an unconformity exists, must be that he first assumed the series Mesa Verde and used this means to account for the seeming absence, to him, of the Lewis Shale. The main point which I think may have led to this condition is that the whole series which underlies the Laramie has been correlated with the Mancos Shale. Now the Mancos Shale, I find, agrees very well with the Colorado formation; and the Lewis Shale with the Montana. These two formations form the marine Cretaceous which underlies the series in question. Mr. Richardson knew that the Mesa Verde, as described by Holmes and Cross, was overlaid by marine Cretaceous strata. Not finding this the case here, he was obliged to use the unconformity hypothesis to account for this seeming irregularity in the Book Cliff Region. Then he shows a close lithological agreement, which, I find, is only true in a most general way, in that the coal bearing series is a complex of alternating sandstones and clastic rocks. Nowhere in the Mesa Verde do we find any such sandstone as that I have called the Castlegate Sandstone. (It was in this sandstone that a tibia of a *Claosaurus* was found some years ago by Robert Forrester in the vicinity of Castlegate). Most of the sandstones closely resemble those referred to as the Lower Sandstones.

The presence of the Lewis Shale has been conclusively proven, as a complete suite of fossils ranging from the bottom of the Colorado to the top of the Montana. The latter formation contains many characteristic Fox Hills Species. This taken together with the unconformity at the base of the series in question and the entire absence of any marine forms in the Laramie or overlying strata, I believe justifies me in calling attention to this paper; and in refusing to accept the new classification until it is based upon more complete paleontological and stratigraphical investigations. To base a conclusion of so much moment on thirteen specimens that are at home more in the Laramie than in the Mesa Verde seems to me rather hasty. Where what Richardson calls a close stratigraphical agreement, it seems to me that he would have tried to obtain more palaeontological data. He does not show a single specimen of *Viviparus* in his list, and I know that in Horse Canyon, south of Sunnyside, there is an abundance of these forms just above the lower seam of coal.

At some future time I expect to collaborate with Robert Forrester in a paper that will take up this whole section of Utah, and give a detailed study of the same. Taking the series as exposed from the Carboniferous to the Tertiary, we will try and give their faunal relations and a complete list of the fossils that we have found in this little studied section.

THIRD ANNUAL CONVENTION OF THE UTAH ACADEMY OF SCIENCES.

Room of the Utah Society of Engineers, 702 Newhouse Building, April 1 and 2, 1910.

Friday, April 1, 1910, 8 p. m.

"A General Survey of the Jurassic of Southeastern Utah"....By J. B. Forrester, Salt Lake City

"Mendelism"................By Dr. E. D. Ball, U. A. C.

Presidential Address.....By Dr. W. C. Ebaugh, U. of U.

Saturday, April 2, 1910. 2 p. m.

"Preliminary Report of the Animals of Great Salt Lake".......By Dr. Charles T. Vorhies, U. of U.

"Recent Analyses of Water from Great Salt Lake".........By Wallace Macfarlane, U. of U.

"Preliminary Report on the Plants of Great Salt Lake"................By L. L. Daines, U. of U.

"Recent Progress in Economic Entomology"...............By E. G. Titus, U. A. C.

"Efflorescence or Scum on Brick Work"....................By A. F. Greaves-Walker

"A Reported Occurrence of Native Iron in Utah"................By Dr. W. C. Ebaugh, U. of U.

"The Composition of Solids Precipitated From the Atmosphere During 'Salt Storms'"........By Dr. W. C. Ebaugh, U. of U.

A GENERAL SURVEY OF THE JURASSIC IN SOUTHEASTERN UTAH.

By J. B. Forrester.

I shall make no mention of the Jurassic west of the Wasatch Range. I do not wish to imply, however, that it is not to be found there. I shall limit my observations to the occurrence east of that Range, with special reference to that portion bounded on the north by the Book Cliffs, on the east by the Utah-Colorado Line, and on the south by the Utah-Arizona Line. I shall discuss it under the following heads: (1) Geographical Distribution. (2) Geology, and (3) Economic Features.

The exposure at the Uinta Mountains forms a fringe along the slopes, and partakes of the attending phenomena of the Uinta Uplift, namely faulting and folding. A good section and discussion of its occurrence in this region can be obtained from J. W. Powell's "Geology of the Uinta Mountains." With this note I shall pass on to the more extensive exposures farther south.

The Jurassic strata constitute the greater part of Emery County, Grand County south of the Denver and Rio Grande Railroad, Wayne County, west half of Garfield and Kane Counties and practically all of the large county of San Juan. This makes a total of about twenty thousand square miles. In this area there are small isolated regions covered with strata of earlier or later age. A small area of Upper Aubrey is found in the western end of Wayne County, also in the Cataract Canon of the Colorado River. The famous Natural Bridges in San Juan County occur in the northern extremity of an exposure of Upper Aubrey that extends south to the San Juan River.

GEOLOGY.

For convenience I have divided the Jurassic into three series, Upper, Middle, and Lower. This division is based upon lithological characters. The characteristic rocks of each are as follows:

Lower, 1205 feet of sandstone, massive and cross-bedded.

Middle, 1866 feet of Argillaceous strata and Limestones.

Upper, 492 feet of Conglomerates.

The typical section was taken a few miles west of the town of Rochester, Emery County.

Lower:		
Conglomerates	100 feet	
Red Arenaceous Shales	4.5	
Sandstone	2.0	
Red Arenaceous Shales	6.5	
Red Fossiliferous Conglomerate	3.3	
Red Shales	54.5	
Sandstone	1.5	
Shale	1.0	
Red Sandstone	13.2	
Red Shale	6.0	
Sandstone	1.0	
Shale	5.0	
Coarse Grained Sandstone	1006.0	
		1204.5 feet
Middle:		
Limestone	40.0	
Shale	57.0	
Sandstone	6.0	
Limestone	2.0	
Shale	34.0	
Fossil Sandstone	3.5	
Limestone and Shales	60.0	
Gypsiferous Red Shales	834.0	
Red Argillaceous Sandstone	110.0	
Shale	10.0	
Fine Grained Conglomerate	2.0	
Green Arenaceous Shales	45.0	
Massive Green Sandstone	63.0	
Green Arenaceous Shales	138.0	
Dark Red Aren. Shales	462.0	
		1866.5 feet
Upper:		
Siliceous Conglomerate	42.0 feet	
Variegated Arg. Conglomerate	450.0	
		492.0 feet
Total		3563.0

These lithological characters I have found to be coextensive with the Jurassic of Southeastern Utah. Whether or not they exist in other localities of our State only time and research will reveal. But in the absence of paleontologic evidence, I believe the above division will serve for the present purpose, as I shall not try to correlate the several series with those known from other sections of the United States. For the solving of a problem of such moment, the fauna so far collected is too meager. I shall have occassion to speak of this phase later.

From our present knowledge of the distribution and faunal relations in this Western Interior Region, it is highly probable that the strata were laid down in a narrow embayment of the Northern Pacific Ocean. It also appears that near the beginning of the Middle Jurassic this embayment was broken up into many lagoons.

From the character of the Lower Jurassic strata in Utah, it appears that we had to do with a comparatively shallow bay. This may be accounted for by the fact that this region was at the extreme southern end of the embayment. The subsidence and deposition must have proceeded apace, as evidenced by the even graining of the lower massive 500 feet of the Jurassic Sandstone.

The next 500 feet changes greatly in character. One of two things took place; either the deposition became greater than the subsidence or a slight rise occurred. As a result the succeeding sedimentation was brought within the sphere of activity of currents and eddies, and the second 500 feet of the Jurassic Sandstone is characteristically cross-bedded.

During the time necessary for the deposition of this one thousand six feet of sandstone, the conditions were remarkably uniform. There were few and slight oscillations with no orogenic movements. The period seems to have been one of repose. However the conditions were not favorable to the sustenance of life. I have searched diligently for any evidence of a flora or fauna in this extensive sandstone, but have been rewarded with negative results.

The end of the Lower Jurassic is marked by sudden subsidence and the Middle Jurassic first makes its appearance with Limestone strata. Thus far no unconformity has been found between this and the preceding strata. For a short period conditions were favorbable for sustaining the fauna that had migrated from the Northern Pacific south, in the Jurassic Sea, but these conditions were not long lived. As I said before the evidence is that the southern end, at least, of this bay was disconnected and broken up into lagoons. Through concentration by evaporation the environment became unsuited for the maintenance of living organisms, and the meager fauna which had migrated so far from its origin died out during the first two hundred feet of strata of the Middle Jurassic series, never to appear again in this locality.

The fossils found in this two hundred feet are as follows:

Pentacrinus asteriscus.
Ostrea strigilecula.
Camptonectes stygius.
Camptonectes pertenuistriatus.
Camptonectes platessa.
Camptonectes platessiformis.
Trigonia quadrangularis.
Trigonia montanaensis.
Trigonia sp.
Pinna kingii.
Tancredia inornata.
Astarte packardi.
Modiola subimbricata.
Pholadomya kingii.
Cyprena sp.
Pseudomonotis (Eumicrotis) curta.
Pleuromya subcompressa.
Pleuromya sp.
Gervillia montanaensis.
Cyprinus sp.
Lima (Plagiostoma) occidentalis.
Liman. sp.
Neritina phaseolaris.
Cardioceras sp.
Belemnites densus.
Serpula sp.

Out of a total of twenty-six individuals there are twenty-one Pelecypoda, one Gastropoda, two Cephalopoda, one Articulata, one Crinoideae. The Pelecypoda greatly outnumber all the rest. There are nineteen different genera, all indicative of a marine habitat, the Crinoid and Cephalopoda especially characteristic of such. Of these, seventeen species are characteristic of the Jurassic, while the remainder either begin in the Jurassic or earlier.

It is plain then that our strata in Utah are Jurassic, but the data is insufficient to say with assurance that they are the Middle Jurassic as found in other areas. The exact correlation of the subdivisions of the Jurassic of Utah with those of identified localities is a problem yet to be solved, and a worthy field for original research.

After this subsidence and the deposition of the Limestone series, a slight rise seems to have occurred and a red arenaceous shale was deposited in these lagoons. Along with them ferric oxides were thrown down, with one exception. In the case of the Green Sandstone and Shales, Glauconite took the place of the oxides. As concentration proceeded, Gypsum, a characteristic of the lower half of the period, was deposited. However, the process of concentration did not continue long enough to deposit any salt in this locality, at least. The Upper portion of the Middle Jurassic became more and more arenaceous, and the lagoons gradually filled up with a sandstone-shale complex.

As this filling continued we find shore deposits, and it is here that I have drawn the line between the Middle and Upper Jurassic Series.

The base of the Upper Jurassic is a siliceous conglomerate, consisting of water-worn pebbles seldom larger than a good sized hen's egg, and grading from that down to sand grains. Immediately overlying this is a calcareous, argillaceous conglomerate. This is characteristically variegated. The pebbles are small, waterworn, and generally coated with a thin flim of a black manganese oxide. It is in the lower part of this conglomerate that the majority of the vertebrate remains of the Jurassic are found. These remains are found more or less throughout this Complex.

The strata are colored red, green, white, and purple, with here and there great blotches of a brilliant red. Seen from a distance, they certainly present a striking appearance.

The conglomeritic nature is most prominent on the western exposure, but toward the east the strata lose more or less of this character, and in places become simply variegated marls. In a few places, for instance, two miles and a half west of Cliff Siding, Emery County, the siliceous portion, at the base contains fragments of trees. These are the only evidence of plant life found in the Jurassic in this region. In several of the siliceous pebbles I have found crinoid stem plates, which seem to indicate a land area (probably Carboniferous) to the west, in the vicinity of the present Wasatch Range.

Just a word here as a comment on the foregoing. In the first place I wish to draw attention to the lower delimiting line of the Jurassic. At present I have preferred placing it at the base of the heavy massive sandstone, as it appears to me that this whole one thousand six feet of sandstone, regardless of the cross-bedding of the upper portion, is a unit. Powell calls the cross-bedded portion the White Cliffs formation, and the lower portion the Vermillion Cliffs and the red arenaceous shales immediately underlying, the Upper Shinarump. It may be that the White Cliff Formation is stratigraphically the same as the La Plata formation in Southwestern Colorado. If this be true then the series underlying them down to the base of the lower conglomerate will be the Dolores of the same locality and consequently of Triassic age.

The Middle Jurassic as here outlined, is the same as Powell's Flaming Gorge group and corresponds with it both lithologically and paleontologically.

The Upper Jurassic agrees very well with the Morrison formation both lithologically and paleontologically as is evidenced by its variegated appearance and contained Allosauri. If this is correct then it will share the fate of these beds, which according to Marsh are placed at the top of the Jurassic, and according to Emmons, Cross, and

Eldridge, who base their classification on the Orogenic Movements in the Denver Basin, are placed in the Lower Cretaceous. If the latter classification is right, then these beds are the only ones in the Western Interior Region that belong to the Lower Cretaceous as known from the typical localities.

EROSIONAL FEATURES.

I shall now give the erosional features of the three series as I have outlined them. The massive five hundred feet of sandstone of the first or Lower series forms perpendicular cliffs with exceedingly smooth faces. Because of the absence of joint planes there are no rocky talus slopes to cover the underlying Triassic strata. These straight walled cliffs are everywhere capped with pinnacles, domes, and beehives, which belong to the upper five hundred feet, and are the results of the elements on the intricately cross-bedded structure. The effect of wind erosion on this cross-bedding is most peculiar. Great caves or alcoves, as they may be called, are worn out of the face of the cliffs, their walls as smooth and round as if done by the hand of man. In other places are worn hundreds of smaller holes, about from a few inches to three or four feet in diameter and very close together. This gives the appearance of a huge honeycomb, only lacking the bees to make the comparison complete.

Wherever a stream has cut its way through this sandstone the walls are vertical and the canyons are very tortuous. A characteristic bit of weathering is found in the North Salt Wash, Emery County. Following the wash one comes up against a straight wall seven hundred feet high. Near the top is a hole through which the blue sky shows like a mirror. The canyon then turns abruptly to the east and after a detour of some five miles the hole is again seen from the other side, not over a mile and a half from the first observation point. This winding back and forth with very little progress in a straight line is characteristic of all canyons in this stratum and the parapets and domes breaking the sky line at a distance remind one of some Moroccan City.

In Emery County, on the west reef of the San Rafael Swell, some of these domes assume immense proportions. One of these particularly large and perfect is called the Copper Globe, another one the Temple and still another St. Peter's Dome.

The Bad Land appearance of the Middle Jurassic is strongly contrasted with the above. It weathers into low hills covered with a light sand which is blown about by the winds forming ever changing ridges and hollows. These dunes keep the eastern portion of Emery County barren of vegetation. And the whole country has a barren, monotonous landscape. In places these dunes and clay ridges have been made permanent by the cementing action of the gypsum, which causes them to appear as though they had been subjected to folding of a high order. The scenery presents a general somber appearance due to the ever present ferric oxide. The lower portions are bright red while the upper portion is almost a maroon separated by a comparatively narrow band of faint green.

A siliceous conglomerate caps this and forms the floor for the bad lands of the upper Jurassic. The difference between this series and the preceding is that all the hills in the Middle Jurassic are generally flat-topped while in this they are rounding knolls with smooth, gently sloping sides. Around the base of all these small knolls are wagon-loads of black water-worn pebbles, the origin of which is not at first apparent.

In weathering, this conglomeritic series parts with its quartz pebbles, which roll to the foot of the slopes and leave the calcareous material to protect the remainder. When dry this finely divided calcareous residue is very light and one will sink into it from four to six inches, making progress exceedingly difficult. It contains very little grit and feels like an impalpable powder. When rain wets it, it shows its clayey nature and sticks together, very little of it being washed away unless the rain be exceedingly severe. When in this condition one had better keep to the hard siliceous floor at some distance lest he become too heavily loaded, for it is no light task to carry ten pounds of this material on both feet sinking to one's shoe-tops with each step.

From a distance the brilliant coloring, red, green, white, and purple, is certainly a sight one will never forget. All the lines are smooth curves with no broken jagged contours to displease the eye. And every change of position brings in more pleasing combinations. No wonder the gigantic Allosauri chose this for their Mecca and burying place. For everywhere you will see piles of bones, now ornamenting the top of some knoll of many colors, now scattered about on some small flat. Truly it is a sight worth seeing.

But of present day life, either animal or plant, there is a woeful lack. A few stunted pines and cedars here, some greasewood there, while in the more sandy places one will see a small area of sand-grass waving gently in the hot breeze. The animal life, what there is of it, partakes of the color scheme of the country. Lizards, for that is about all one can find, are generally brilliantly colored. Very few snakes can be seen as they seem to need a respite from their basking habit, while here this would be impossible, for the atmosphere hardly gets time to cool before the sun again appears over the horizon to clinch his conquest of the day before.

ECONOMIC FEATURES.

This phase of the Jurassic will be easily disposed of. Still this period gives a good example of syngenetic ore deposits. The ores found have proved to be of little economic value. Chief among them are copper, manganese, iron, uranium, vanadium, sulphur, gypsum, and limestone. Of these copper occurs as malachite; manganese as psilomelane; iron as hematite; and uranium and vanadium as carnotite. The copper and manganese ores occur in lenses laid down with the arenaceous shales at the base of the gypsiferous series. Sometimes they form pockets sufficiently large to obtain a few carloads of ore. These pockets appear to be scattered through the territory covered by the Middle Jurassic strata. The copper has, in places, been subject to secondary concentration as is shown at the Copper Globe. At which place it has been redissolved by descending waters, carried through the cross-bedded sandstone, and deposited at its base on a thin shale stratum, in sufficient quantities to work for a short period, and to keep up the hope of the locators.

The manganese deposits east of Green River and south of Little Grande Station, have likewise received a secondary concentration. This unlike the copper, has been concentrated along a fault plane. They were worked for several years in a small way by the Colorado Fuel and Iron Co. Here also the deposits are too small and distributed over too much territory to be of much commercial value.

The carnotite occurs in thin films along cracks in the sandstone. In the eastern portion of the district these films occasionally develop small pockets in which there is from 50 to 60 per cent carnotite.

Sulphur occurs very sparingly; in fact the only locality of which I know is in Sulphur Canyon north of the Cedar Mountain, Emery County. The gypsum, for the deposits are in the gypsiferous series, is coated with a thin film of this mineral for a distance of half a mile, which has apparently come up through an open fissure that still emits carbon dioxide gas.

Lime occurs throughout this territory in thin beds, but is too impure to be of any commercial value.

This leaves only the gypsum which is widespread and very abundant. It is found throughout the entire region. The purer beds are so far from the railroad that they could not compete with the deposits on the west side of the Wasatch Range. However, while at Green River recently, I heard considerable talk of their developing the deposits at that place. In time the many other deposits will be opened up as the transportation facilities reach out to the virgin territories.

On account of its topography and drainage system the Jurassic of this region is of little value to agriculturists.

Unfairly, it would seem, an otherwise fertile soil has been deprived of a most important assistant, water. The soil is not to blame for the barren condition in which it is found. Plenty of water is at hand, but it is hemmed in by walls that are from one thousand to five thousand feet high. Several small villages have sprung up along the larger rivers where their otherwise narrow channels have widened out for a short distance, also at places along their courses before they enter their deep gorges. If this land is ever reclaimed it will be through the assistance of artesian water, as is being done at Bluff City at present. Through my studies in this district I reached the conclusion that the Jurassic sandstone acts as a large conduit and conducts the water that it absorbs at its upturned edges along the Uinta Mountains, Rocky Mountains, La Sal and the other localities in that portion of the state, to the many points where it is cut by the deeper canyons, and there issues out as the best water to be found throughout southeastern Utah.

FOURTH ANNUAL CONVENTION OF THE UTAH ACADEMY OF SCIENCES.

Science Building, Salt Lake City High School,
April 7 and 8, 1911.

Friday, April 7, 1911. 8:15 p. m.

"EUGENICS (THE SCIENCE OF RACE BETTERMENT)" Presidential Address ......By Dr. E. D. Ball, U. A. C.

"EARTH MOVEMENTS OF THE WASATCH" (Illustrated by the stereopticon)
By Prof. Marcus E. Jones, Salt Lake City

Saturday, April 8, 1911. 10 a. m.

"FROST AND KILLING TEMPERATURES,"
By Dr. Philena Fletcher Homer, Pleasant Grove

"ALKALI INJURY TO LEAVES OF THE APPLE"......................By E. P. Hoff, U. A. C.

"SOME PRESENT DAY FOREST PROBLEMS"....By E. R. Hodson, Forest Service, Ogden

"SOME INTRODUCED WEEDS".......By Prof. Charles Piper Smith, U. A. C.

Saturday, April 8, 1911. 2:15 p. m.

"THE CENTENARY OF AVOGADRO'S HYPOTHESIS"..........By Dr. W. C. Ebaugh, U. of U.

"RELATION OF PARASITES TO THE DESTRUCTION OF INSECT PESTS"...................By A. H. Kirtland

"FIXATION OF FREE NITROGEN"..........By Dr. Robert Stewart, U. A. C.

"MAGNETIC ALLOYS OF THE NON-METALLIC METALS"............By Dr. A. A. Knowlton, U. of U.

Saturday, April 8, 1911. 8:15 p. m.

"THE PLANETESIMAL HYPOTHESIS AS A SUBSTITUTE FOR THE NEBULAR HYPOTHESIS"
By Prof. Wm. Peterson, U. A. C.

"VERTICAL DISTRIBUTION OF TEMPERATURE"
By A. H. Thiessen, U. S. Weather Service, Salt Lake City

SOME PRESENT DAY PROBLEMS IN FORESTRY.

BY E. R. HODSON.

Forestry is a very comprehensive term, for it embraces both an art and a science or rather several sciences. With so broad a field and so varied an application, there have arisen many questions connected mostly with its practice. The short time in which it has developed in this country has only intensified these problems. In Europe forestry grew up through a long course of time, was interwoven with the development of States and followed the fortunes of war and social changes. In this country to a certain extent, limited by our conditions both economic and forest, we can profit by that experience. For while really a response to the economic conditions of tomorrow, forestry has apparently come to us so suddenly as to arouse distrust in some quarters. Its purpose has been questioned, the need of it doubted, and there has been a general tendency to discredit its claims. Happily this is fast passing away. Public spirited people in every walk of life are interested. Forestry is recognized as a part of the national work and its progress and standards are jealously watched.

The region on which this discussion is principally based includes the forest areas adjacent to the Great Basin and at the headwaters of the Snake River, in Utah, Nevada and southern Idaho. For the purposes of government forest administration, it is known as District 4.

Over this whole region the general climatic conditions may be characterized as arid or semi-arid. Sufficient precipitation for tree growth is confined to the higher elevations of the mountains, and, as a rule, the important forest areas are still further restricted to northern exposures.

Another broad general distinction is the coniferous character of the forest. With the exception of aspen and a few other minor broadleaf species, this type of forest is unrelieved by deciduous species. This uniformity is largely the product of climatic conditions, mainly temperature.

While District 4 is not heavily timbered comparatively, there is approximately 50,000,000,000 feet B. M. of timber of which 30,000,000,000 is saw timber. As only a fraction of this amount is now accessible, the present cut of 35,000, 000 board feet per annum falls on a small part of the total area. The District is but little developed with a consequent weak demand. Large operations are also hindered by the lack of large continuous timber bodies. For these reasons it is likely that for a long time the greater part of the lumber business will be mostly local and supplied by small scale operators.

The following problems are at the present time the most important: Forest fires, Reforestation, Forest taxation, Grazing in relation to Forestry, Agricultural versus Forest land values, Utilization, and Silvicultural problems.

FOREST FIRES.

It is an old story that forest fires have done great damage and one that has been emphasized by the past year. The reduction and ultimate prevention of this source of loss is an enormous and pressing problem. It is mainly one of organization and improvement of the forest. To prevent fires gaining headway an extra patrol is necessary during the danger season. Telephone lines, roads, trails and fire lines are indispensable to make the patrol efficient. An equipment of tools and storehouses distributed over the forest for emergency use is also necessary to control small fires at the start.

This work cannot all be accomplished in a year or two even were the money available. It must be the result of a steady growth and building up of the forests along the line of permanent improvement. Wonders can be accomplished in fire protection by concentration of effort in a bad season, as evidenced by the past year's experience, but a well planned means must be provided beforehand if the protection is to be complete.

Of first importance in eliminating forest fire is care with camp fires and other sources of fire. Much carelessness is due to the fact that the danger is not generally appreciated by the public. There is malicious intent in but very few cases. Therefore, an educational campaign on the danger of fire to the valuable mature timber and the young growth is productive of much good. After fires start the best thing is to be in a position to attack them before they gain headway. Rapid means of communication and transportation are essential as well as adequate amount of men and firefighting tools.

The hopeless features of forest fires receive most notice because it is the large conflagrations which attract attention. A large fire with a wind behind it can rarely be stopped during the day with any amount of men and tools but it can often be narrowed down and at night when low can be surrounded. The damage from large fires is reduced and countless small fires which are never known are prevented from gaining headway.

Another side of the fire problem is the effect on the forest. Two great changes in conditions are made by fire: 1st, light; 2nd, seedbed. The complete light favors, temporarily, pure stands of light demanding species while the changed seedbed conditions favor still other species. A profound change may therefore be made in the composition and quality of the forest by fire. This change of forest types has been little studied and our virgin forests offer a fascinating field for original investigation.

REFORESTATION.

Perhaps the most popular and easily understood branch of forestry is reforestation or tree planting. In some quarters forestry really means little else. The reproduction of future stands is a vital problem and in this region a difficult one. It is accomplished by two methods, natural and artificial. The first by systems of cutting at proper times merely aids and accelerates what takes place naturally in the virgin stands. The second deals with sowing and planting—strictly artificial means. It is the latter which is the most important in the popular conception and concerns us chiefly here.

Because of the arid climate in District 4, forest planting is much more difficult than in a humid region. Broadcast seeding is an inexpensive method being thoroughly tried in this District, which if successful will greatly facilitate the work. The seed spot method is a still more intensive one where the seed is covered in prepared spots; sometimes cornplanters are used. Both are direct seeding methods.

As there are places where direct seeding has little chance, nursery stock is needed. For this purpose three large nurseries, with an ultimate capacity of 12,000,000 plants, are maintained in the District. Last year 1,000,000 seedlings were field planted and 700 acres sown.

Fall work so far promises best and it has been found that underbrush protection increases the chances of success in both sowing and planting.

It is expected that two or three million plants, depending on development in the nurseries, will be field planted next fall and also direct seeding done on a large scale.

Since about 5,000,000 acres in the District require artificial reforestation, it is necessary to push this work to the limit of funds. Artificial reforestation is therefore one of the immediate practical problems.

Now a word as to natural reproduction. Many details are connected with securing this kind of reproduction. Special methods of removing the mature stand by successive cuttings are practiced to favor natural restocking. The composition of the stand and the character of its species have a direct bearing since a pure stand or one composed of a single species must have different treatment than a mixed stand. Also light demanding trees are handled differently from shade endurers and a mixture of both still another way.

As in each of these cases the result will depend on other minor and often complex factors of soil and local climate the problem is difficult and will require much patient effort. It varies with the type of forest, density of stand, favorableness of situation, indeed with every single factor in a forest community.

FOREST TAXATION.

While taxation does not affect the government forests it is important in private forestry. A fundamental difference between forestry and most other business is the fact of long delayed returns. One hundred or two hundred years must elapse before the crop is mature. Now to tax a forest annually on the basis of the growing crop merely spurs the desire to get immediate returns by lumbering before the crop is mature and to cut over the ground more completely. The forest is slaughtered to cut down the burden of a yearly taxation. With an equitable tax on the basis of productivity at the time the crop is harvested there would not be the temptation, or in some cases the necessity, of realizing immediate returns, nor would the cut need to be so complete. The stands would be left to grow to their full value at maturity and would then be cut in such a manner as to keep the yield of the forest at the maximum. The state would not lose but in the long run would gain by the increased wealth made possible. The only change would be the time of collection which is adjusted to the needs of forestry and its involved time element.

Although the National Forests are not directly taxed, such a system is really in operation through the 25 per cent of proceeds paid the state. This is, of course, paid only when the crop is harvested and on the basis of the actual yield.

The present incongruous system of taxation and the fire menace are the two greatest drawbacks to private forestry. With a just system of taxation in application, much may be expected of private forestry.

THE GRAZING QUESTION.

If a forest were fully stocked and uniform over its area there would, of course, be no grazing to consider. In humid regions in the east, particularly the north, the density of the stand and absence of forage makes grazing impossible. But with the scattered open stands of the intermountain country, grazing within the forest limits is exceedingly important. All of the grazing land cannot be eliminated from the forests without crippling their administration since much of it is in small areas scattered among the timber bodies. Moreover, in the open stands, the forage is even among the trees themselves.

For these reasons it has been found impractical to separate entirely forest land and grazing land. In this region it is necessary to handle much of the summer range, at least, along with the forests with which it is so intimately connected.

Now grazing has some effect on the timber areas. This effect will depend on several things, chiefly amount and kinds of grazing, the forest type, the stage of development of the stand, character of soil, slope, etc. Grazing on cut-over and burned areas where small reproduction is present does a great deal of damage where at later stage of development but little injury would be done. Some species, notably Douglas Fir, on account of the tender foliage, are very susceptible to browsing while other species, as Engelmann Spruce, are more liable to injury from trampling; the latter species is practically uninjured by browsing on account of the stiff foliage of spiny needles.

The problem here is to adjust the two industries in such a way that the forage may be used and at the same time the timber protected at critical stages.

AGRICULTURAL VERSUS FOREST LAND VALUES.

Some forests are on absolute forest land, that is, land which will produce little else. This may be due to elevation, rugged topography, stony and ledgy surface, etc. But there are forests on land which is also more or less valuable for growing crops. Here is where the problem enters. What factors shall be considered in determining how far the agricultural development shall crowd the forest? Shall this be done at once or distributed over a long period of time? There is the precedent of magnificent forests swept away in the Middle West to make farms and villages. These settlements have proved permanent. There is the desire for immediate returns which has had its way and will continue to do so where the agricultural value promises permanency. That an attempt may be made to cultivate forest land which cannot have permanent agricultural value is a danger not altogether impossible, the Jack Pine Plains of Central Michigan may be given as an illustration. There may be seen whole communities with schools and churches completely deserted. They were prosperous for a time but when the first flush of fertility of the soil had gone, it was impossible to get sufficient returns and abandonment was compelled. This land had also once borne a splendid forest which might now under forest management be a constant source of revenue instead of an unproductive waste.

This problem is confused by a short sighted public opinion. There is some danger that the forest area of a community may shrink unduly before a keen demand for land of any kind. Where the agricultural value remains permanent, there is a gain on that side. But where the forest is merely destroyed without creating permanent agricultural values, there is an economic waste. The solution lies in securing a better understanding by the public of the value of forests; and in a liberal policy where the land is of unquestioned farm value. The border line between land which should be used for forest purposes and that which should be released to agricultural use, is different in different localities and varies with the development of communities and of new methods. For instance, dry farming in some sections has changed the balance to the agricultural use. Therefore to devise a just and consistent policy in the proper use of land will require constantly more specific information and will tax the resources and ingenuity of administrative officers.

UTILIZATION.

Forest products are very wastefully used throughout the country, due to the supposed inexhaustible supply. There is incomplete utilization in the woods and through the mill with carelessness in handling and shipping. Only the best parts of the trees are used and this wasted in the slab and sawdust. Improper seasoning also causes much deterioration and waste.

Aside from this form of waste which takes place everywhere, there is another kind not so apparent. It is the use of high grade species for low grade uses. For instance, a valuable species of saw timber size may be used for firewood or a durable species used where durability is not required as in packing boxes. Species with great strength are used where this quality is not necessary. The uses of the different woods have not therefore been adjusted to conserve the most valuable qualities of species now becoming scarce. Recently the Government has done a great deal along this line. The Forest Service has established a laboratory at Madison, Wisconsin, to study the different problems connected with wood utilization as pulp woods, wood distillation, etc. The strength of different species in different conditions is also tested.

Such problems as these have not received attention until recently because of abundance of material of all kinds. With the growing scarcity of timber, closer and more economic utilization becomes imperative and better methods of manufacture and distribution of uses are seen to be practical.

SILVICULTURAL PROBLEMS.

Under this head comes a number of the more technical forest problems. Marking timber for cutting is one of the most intricate, since both practical and theoretical considerations are involved. The success of the logging operation often depends upon securing a certain amount of scale from a given area. The maturity of the trees, soil protection, reproduction, injured and diseased trees are also factors in marking. The principal aim is to keep the yield of the forest at the maximum in both quantity and quality. Mixed stands present very different marking problems than pure stands, dense stands than open ones, while uneven aged stands must be considered still differently. As a general statement all the trees of a stand which are mature should be marked for cutting so far as their removal does not injure the soil and lessen the chance for reproduction. As many as possible of the diseased and dwarfed trees should also be marked. In the average virgin forest an improvement cutting is the one first needed. The aim of this cutting is to leave the forest with an even stand of well distributed thrifty growing trees.

Thinning is another problem of intensive forestry. It is concerned with immature stands while improvement cuttings are made in mature stands. The aim of thinnings is to keep the stand in the younger stages at the greatest rate of growth without deterioration of the form or quality of the trees. In mixed stands the better species are favored so far as possible. In detail thinning is an intricate problem and has been much elaborated in Europe. They are, however, too expensive to be applied in this country at the present time, although information derived from a study on a small scale, will be useful later.

The substitution of valuable foreign forest tree species for less valuable native ones is another important problem. While great care is necessary and not too much should be expected, yet there is some chance of success. The Eucalyptus in certain parts of California and the Norway Spruce in the Adirondacks are examples. In the latter locality it is expected that the foreign spruce will eventually take the place of the native red spruce because of its more rapid growth and consequently shorter rotation period.

Douglas Fir has been introduced from this country to Germany where it is valued highly and stands almost old enough to yield seed have been produced. White Pine, the great lumber tree of Michigan, has also been introduced into Germany much earlier and stands 150 years old are now seen.

In this successful interchange of foreign and native species there is much encouragement that patient and persistent effort in this line will increase the value and usefulness of our forests.

TO SUMMARIZE.

1. In order to insure forestry, fires must be reduced to the minimum through eliminating the causes and being

prepared with men and equipment to reach and combat them when first started.

2. Where natural restocking cannot be expected or is too slow, artificial reforestation is neccessary if the forest is to be fully stocked and kept at its highest productive capacity.

3. To prevent wasteful cutting of forest crops, a system of taxation should be devised on the productivity and collected only when the crop is harvested.

4. Where grazing and forest land are so intermingled that both industries must be carried on together a system which will permit the full use of the forage and at the same time protect forest reproduction in the early stages is necessary.

5. On areas where agricultural use and forest use of the land overlaps, the problem is so to adjust the uses that the greatest constant values are produced.

6. In utilization of forest products, waste of all kinds must be eliminated by a more exact knowledge of the qualities and uses of woods as well as of the market and manufacturing conditions.

7. In the strictly technical silvicultural problems a well organized policy of research work is desirable in order that better methods may be available as rapidly as economic conditions permit their practice and that proper advance may be made in the scientific phase of forestry.

NOTES ON VERTICAL DISTRIBUTION OF TEMPERATURE.

BY A. H. THIESSEN.

In the older text books on meteorology we find the general statement that the temperature of the air decreases with the altitude. This statement was justified by experiment, observation, and deductions from theory.

The observations were made on mountains, with kites, and manned balloons. Within the past few years with increased facilities, new observations have been secured, causing the meteorologist to modify his views and reconstruct his theory to some extent.

In studying the distribution of temperature, it is not enough to carry on observations at any single place. The vertical distribution of temperature may be different over land than over the ocean, may vary with the latitude, with the season, and finally with the changing atmospheric condition at any one place.

The forecaster in the Weather Bureau can not hope to improve the accuracy of his forecasts greatly unless his knowledge of the mechanism of the air is greatly increased. As far as observations on the surface of the earth are concerned, the data are very complete, so in the past few years attention by experimental meteorologists has been directed to the upper portions of the atmosphere.

To obtain data from this region they have resorted to the use of free balloons. The balloons used have varied greatly in size. They are made of india rubber and filled with the lightest available gas-hydrogen. An instrument called a meteograph is attached to this balloon. This instrument records either temperature and air pressure, or air temperature, pressure, wind velocity and humidity. They are tied to the balloon which when filled with gas is allowed freely to rise. As it rises higher and higher in the air, it continually comes into regions of less and less air pressure and the balloon in turn continually expands until a limit is reached when the rubber breaks and the instruments fall to the earth. In order to protect the instrument in its falls so that the record and instrument will not be greatly injured, two devices are used. Either the larger balloon contains a smaller balloon which is large enough greatly to lessen the fall, or a parachute is used which opens as soon as the instrument commences to fall. In addition a basket work is arranged around the instrument to ease up the shock. These plans have all been successfully carried out, the instruments receiving little or no injury. The instrument, of course, is carried up into regions of very low temperatures and the record is secured in two ways: first, an ink is used which does not evaporate or freeze, and is made of glycerine with an aniline dye. A second way is by using a sheet similar to those used on a seismograph. The sheet as you know has a deposit of soot on it and instead of an inked pen a stylus is employed.

The rate of increase or decrease in temperature as higher altitudes are reached is called the temperature gradient. Air is cooler as higher altitudes are attained, and it is the custom to say that the decrease is at the rate of 1 degree for every 183 feet, but this is the adiabatic rate. By adiabatic heating and cooling we mean the increase or decrease in heat due to change in pressure, that is without gain from or loss to outside space. When a quantity of air rises it expands and does work which consumes a certain amount of heat energy; and conversely when it descends work is done upon it and it regains the heat that was lost.

This rate varies greatly according to the constituents of the atmosphere. Water vapor causes a considerable change from the dry adiabatic.

The changes due to day and night and to the various seasons are felt in the upper as well as in the lower atmosphere, but not to such a great extent. In the free air about 3 or 4 thousand feet high no changes are felt due to the rotation of the earth on its axis.

The seasonal change, however, is more pronounced, and is about half as great in the upper as in the lower atmosphere.

Observations taken on mountains side or tops are very different from observations taken in the free air. The atmosphere is cooler over mountain tops than in the free atmosphere at the same altitude. This is due probably to the fact that air cools as it rises, and as air is generally in motion, there is a current of air being constantly forced up the mountain side and over its top, which is cooled by expansion and in addition by the free radiation from the mountain peak.

For purposes of study the atmosphere may be divided into three portions: or layers:

The first includes that portion extending from the earth to 3000 m.

The second from the 3000 m. level to the 10000 m. level.

The third all above the 10000 m. level.

In the first layer, or all that below the 3000 m. level is a region of considerable atmospheric turmoil. Here the winds are irregular in direction and vary considerably in speed. It is the storm layer, although the vortical action of a cyclone or anticyclone extends into the next higher level. Here the temperature frequently, especially in summer, rises with increase in altitude, and the temperature condition is controlled almost entirely by the passing of highs and lows over a place.

The second layer, or that between the 3000 m. and 10000 m. is a region of uniform temperature changes. This region is comparatively free from clouds, the temperatures fall with the adiabatic rate. There is an absence of atmospheric turmoil characteristic of the first layer. The vortical action due to cyclones and anticyclone extends into this layer, but as a rule its normal condition is one of stability and usual freedom from clouds.

The thin layer or that above the 10000 m. level is a region which is particularly interesting. Here the temperature gradient is positive—a fact which was unknown up to a short time ago. Occasional observations indicate an isothermal condition and for this reason it is called the isothermal layer.

We have then two atmospheres which intermingle but slightly. The first below the 10000 m. level. Here we have a negative temperature gradient, with the exception that below the 3000 m. level in summer time there is occasionally a positive temperature gradient, that it is hotter as one ascends. Then in the upper we have a positive temperature gradient, freedom from water vapor and no convectional current. It is physically impossible to have convectional currents in this layer as a mass of air would be continually rising in regions of greater density which is not possible.

IRREGULARITIES WHICH NEED EXPLANATION.

We have what we call the morning inversion in the lower atmosphere, that is the temperature is colder near the earth than at the adjacent higher levels. This is due to the fact that the earth radiates its heat more quickly than does the atmosphere. There are wide changes in temperature on the earth due to the over and underrunning of warm and cold masses of air, and also the amount of insolation at different points on the surface differ considerably due to cloud layers.

Just the opposite condition prevails during summer and winter when a place is under the influence of high and low barometer regarding its temperature.

In summer during high barometer the sky is generally clear and conditions are favorable for storing up heat, when the barometer is low the sky is overcast and no heat can get to the earth and the air is generally cool and below the seasonal average.

In winter, however, during a period of high barometer the sky is also clear but the period of sunshine is short, radiation takes place freely and it is usually colder than during a period of low barometer when the sky is overcast.

At higher altitudes, however, say 4 kilometers, both in winter and summer it is colder during low barometer than during high barometer. That is due to the fact that during low barometer the air is moist and radiates heat more rapidly than dry air which accounts for the observations. But in the isothermal region the conditions are reversed; here the air is being warmed by radiations from the moist air below when the barometer is low. But when the barometer is high, and the air relatively dry, it will conserve its own heat and allow the upper air in the region of the upper inversion to become cold.

CAUSE OF THE UPPER INVERSION.

There have been all kinds of explanations of the cause of this upper inversion.

Mechanically we have divided the atmosphere into three parts or layers, the first of which is the region of terrestrial disturbance. The second, that lying between the 3000 m. and the 10000 m. which is the region of uniform temperature changes; the third, that lying above the 10000 m. level, or the region of the upper inversion.

Spectroscopically we have three layers corresponding to these mechanical layers. The first the black body portion which comprises all below the 3000 m. level where most of the water vapor exists. Second, the diathermous or dry air above that containing most of the water vapor. Third, the selectively absorptive, or the air of the isothermal layer, presumably rich in ozone.

Solar radiation ranging from 2.5 mu. down, the maximum intensity between .4 mu. and .5 mu. Now what extent of these radiations are absorbed by the atmosphere and the earth is not easy to say as it depends upon many things, the wave-length, kind of gas or substance, the amount of gas through which it passes, which is the same thing as saying its partial pressure, and even to the total pressure to which the gas is subjected, and to probably more.

In the lower levels there are about 5 to 12 per cent of the energy absorbed, the remainder is either absorbed or reflected by the clouds, dust or the earth itself. That portion of the radiant energy which is simply reflected is returned with its wave length unchanged. That part which is absorbed has its wave-length changed into waves of great length relatively. Water vapor absorbs a large amount of these long wave radiations; and carbon dioxide and other constituents of the lower also absorbs them readily. The heat radiations do not escape readily from the earth and lower atmosphere then, but only step by step until they reach the diathermous layer, where the radiations are relatively unimpeded.

It is thought that the air in the upper inversion layer gets its heat by radiations from the earth and from the layer of water vapor.

Now, the upper air is composed of part oxygen which absorbs a large part of the ultraviolet and a small part of the red. Besides causing heating, chemical and electrical effects are produced. The air there is ionized, and both ozone and nitrogen pentoxide are formed, and as ozone absorbs energy from a large portion of the spectrum the air there is heated both by radiations from the sun and also those from the water-vapor below which does not happen with the diathermous region as that is not rich in ozone.

FIFTH ANNUAL CONVENTION OF THE UTAH ACADEMY OF SCIENCES.

Science Building, Salt Lake City High School.

April 5 and 6, 1912.

Friday, April 5, 1912. 8 p. m.

"THE PRESENT STATUS OF SALVERSAN"
(Erlich's 606) . . . . By Dr. R. L. Byrnes, U. of U.

"ANIMAL BEHAVIOR WORK AND ITS SIGNIFICANCE"
(Presidential Address)
By Dr. Charles T. Vorhies, U. of U.

Saturday, April 6, 1912. 9:30 a. m.

"ONE-PIECE SIDEWALK CONSTRUCTION" . . . . By H. M. Jones, Salt Lake City

"THE RUSTING OF IRON" . . . . By Prof. C. W. Porter, U. A. C.

"THE CELLULOSE FERMENTS" . . By Dr. J. E. Greaves, U. A. C.
(Read by title.)

"PHYSICAL PROPERTIES OF SOME ORGANIC AMALGAMS" . . . . By Dr. Frank West, U. A. C.

"SOME EUGENICS DATA" . . . . . . By Dr. E. G. Titus, U. A. C.

"NOTES ON THE DISTRIBUTION OF THE SUGAR BEET LEAF HOPPER AND SUGAR BEET BLIGHT" . . . . By Dr. E. D. Ball

Saturday, April 6, 1912. 2 p. m.

"THE UNMET NEEDS OF INDIANS IN UTAH" . . . . By Rev. G. W. Martin, Manti
(In the absence of the author, read by Prof. M. E. Jones.)

"THE KINETIC HYPOTHESIS AS APPLIED TO MAGNETIC MATERIALS" . . . . By Dr. A. A. Knowlton, U. of U.

"BOTANISTS OF UTAH" . . . . By Prof. M. E. Jones, Salt Lake

"GLACIATION IN UTAH" . . . . By Wm. D. Neal, Salt Lake

"FUNGOUS FLORA OF THE SOIL, AND ITS PROBABLE ROLE".................By Dr. C. N. Jensen, U. A. C.

"THE EFFECT OF SOIL MOISTURE ON THE MORPHOLOGY OF CERTAIN PLANTS"......By Prof. F. S. Harris, U. A. C.

Saturday, April 6, 1912. 8 p. m.

"EARTHQUAKES IN UTAH"....By Dr. Fred J. Pack, U. of U.

"METABOLIC INFUENCE OF WATER DRINKING WITH MEALS"*...................By Dr. H. A. Mattill

"THE DEVELOPMENT OF THE EUGENICS MOVEMENT"..By Miss Amey B. Eaton, Salt Lake City

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*Published in Jour. Amer. Chem. Soc., **33**:1978-2032. Dec., 1911.

THE RUSTING OF IRON.

By C. W. Porter.

(Abstract.)

A discussion of the chemical and electro-chemical theories of corrosion. The chemical composition and physical properties of paints and other protective coverings intended to retard corrosion—The catalytic influence of certain paints accelerating rather than retarding rusting. An exhibit of iron in contact with other metals was presented with an explanation of the electro-chemical effects of various couples on the rate of corrosion of the iron.

THE CELLULOSE FERMENTS.

By J. E. Greaves.

(Summary.)

A critical review of the work which has been done with the cellulose decomposing organisms of the soil. It indicates the part played by these ferments in soil fertility and their relationship to the nitrogen-fixing organisms, especially the part which they play in rendering assimilable the plant residues to the non-symbotic nitrogen fixers.

The article points out the rich field that is open to the investigator in a study of the inter-relationship existing between various species of soil organisms.

THE EFFECT OF SOIL MOISTURE ON THE MORPHOLOGY OF CERTAIN PLANTS.

By F. S. Harris.

(Summary.)

Experiments reported gave the following conclusions:

The number of stomata was decreased and the number of small hairs increased on the leaves of corn by increasing the soil moisture.

Corn, wheat, and peas growing a number of weeks in sand containing different amounts of moisture showed a proportionately greater root growth in the drier sand.

Corn grown in glass tubes 75 days showed a relatively greater root growth where the level of free water was a considerable distance below the surface.

Different roots of the same corn plant grown in very wet and in moist sand showed a greater root growth with the lower amount of water.

Tests with corn and wheat showed that the ratio of tops to roots was affected by soil moisture even during the germination stage.

Wheat harvested at different stages showed relatively more roots during early stages of plant growth than later.

Wheat grown to maturity showed a greater relative root growth with low than with high soil moisture, and the moisture during the early stages of growth had the greatest influence on that ratio.

SIXTH ANNUAL CONVENTION OF THE UTAH ACADEMY OF SCIENCES.

Science Building, Salt Lake City High School.

April 4 and 5, 1913.

Friday, April 4, 1913. 8 p. m.

"Reality of the Kinetic Theory"..........By Dr. Harvey Fletcher, B. Y. U.

"The Influence of Biological Investigations Upon the Other Sciences" (Presidential Address)
By A. O. Garrett, Salt Lake High School

Saturday, April 5, 1913. 9:30 a. m.

"Chemical Composition of Utah Hydro-Carbons,"
By Carlos Bardwell, B. A. Berryman, T. B. Brighton, F. D. Kuhre., U. of U. (Read by B. A. Berryman.)

"Non-Symbiotic Fixation of Nitrogen by Soil Bacteria and Other Soil Organisms"............By Dr. L. L. Daines, B. Y. C.

"The Intensity of Nitrification in Arid Soils".............By Dr. R. Stewart, U. A. C.

"Physical Relations of Subjective and Objective Combination Tones". By Dr. Joseph Peterson, U. of U.

"Nitrogen Fixation by Bacteria in Utah Soils"............By Dr. E. G. Peterson and E. Mohr

Saturday, April 5, 1913. 2 p. m.

"Some Problems of Utah Botanists"
By Prof. M. R. Porter, Weber Stake Academy, Ogden

"Recent Advances in Our Knowledge of Protein Metabolism"..........By Dr. H. A. Mattill

"The Egg Record of a Flock of Six-Year-Old Hens"..................By Dr. E. D. Ball, U. A. C.

"BLOSSOM INFECTION BY SMUTS" . . . . By Dr. C. N. Jensen, U. A. C.

"COMPARATIVE VALUE OF FIRST, SECOND AND THIRD CROP ALFALFA HAY FOR MILK PRODUCTION"
By Prof. W. E. Carroll, U. A. C.

"PROGRESS IN CEREAL IMPROVEMENT AT NEPHI SUBSTATION" . . . . By P. V. Cardon, U. S. Dept. Agr.

Saturday, April 5, 1913. 8 p. m.

"ALLOY STEELS AND THEIR PHYSICAL PROPERTIES"
By E. H. Beckstrand and Dr. A. A. Knowlton, U. of U.

"GERMAN AND AMERICAN UNIVERSITIES—A COMPARISON" . . . . By Dr. W. C. Ebaugh, U. of U.

THE INFLUENCE OF BIOLOGICAL INVESTIGATIONS UPON THE OTHER SCIENCES.

By A. O. Garrett.

Modern biological science begins with 1859—the date of the publication of Darwin's epoch-making "Origin of Species." We of the present day can have little conception of the storm of protest raised by the appearance of this book at a period in the world's history when the acceptance of a new theory must be absolutely dependent upon how well the theory fitted in with the current theological opinions; at a period of history still dominated by the spirit of ecclesiastical intolerance which had persecuted Galilee. The schools were not independent factors to investigate freely and then publish broadcast the results of their researches, for the benefit of other investigators. They must first submit their conclusions to the one test: Do they conflict in any way with the ecclesiastical beliefs of the day?

No wonder that such a doctrine as that enunciated by Darwin in the "Origin of Species" literally took the breath away from those who heard it promulgated! No wonder that theologians bitterly attacked the so-called heresy! And in this attack they were joined by many noted scientists. But there were also firm defenders. In England, Huxley, Spencer, Hooker, and Lyell; in Germany, Ernst Haeckel, and in America Asa Gray were enthusiastic in their support. Of these, none has exerted a stronger influence than Dr. Asa Gray. Referring to Dr. Gray's influence, Dr. Farlow has said: "His simple and attractive style enabled him to reach an audience which would have been repelled by the dryness generally supposed to be characteristic of scientific writings. He was also known to be a member of the orthodox church and the good religious people of the country said: 'If the orthodox Gray sees in evolution nothing inconsistent with revelation, why may we not also accept it?' Furthermore Gray did not go too far in his views, whereas some of the evolutionists started off on a wide sea of speculation whither the public would not be expected to follow". Little by little the belief in Darwinism grew; and when Darwin died in 1882, well could Huxley say of him: "He found a great truth trodden under foot. Reviled by bigots, and ridiculed by all the world, he lived long enough to see it, chiefly by his own efforts, irrefragably established in science, inseparably incorporated with the common thoughts of men, and only hated and feared by those who would revile, but dare not". And so, in the language of a current writer, "organic evolution became the most stupendous scientific structure of the nineteenth century", profoundly influencing the thoughts and the methods of all the sciences. But its greatest gift to the sciences is the fact that through it the shackles of ecclesiastical bondage were stricken from scientific investigation; and thus freed, so wonderful an impetus was given to research along all lines of science that the nineteenth century has been aptly nicknamed "The Century of Science".

So much for the general debt owed by all sciences to the results from biological investigation. In tracing the history of medicine, chemistry, geology, agriculture, we find all of them have been influenced to a greater or less extent by results obtained in biological research.

Let us take the case of medicine. Previous to the last quarter of the nineteenth century, we find that nearly every botanist was also a physician. The main reason for this was that one could hardly expect to earn a living as a botanist. Positions in colleges were extremely few, and there was not the opportunity offered in government work that exists to-day. And so it is not surprising to find the vast influence of botany upon medical science. Many of the drugs used came from plants, and the botanist-physician did much toward making the plants of the world known to science, and in founding a materia medica. But in other important ways did the biologist aid in influencing medical science. In outlining this influence, let us begin with the year 1668, and with the work of Francesco Redi—poet, physician, scholar, naturalist. Redi lived at a time when the teachings of Aristotle were still believed in—that living things were created from non-living matter. As Lucretius expressed it, "With good reason the earth has gotten the name of mother, since all things are produced out of the earth. And many living creatures, even now, spring out of the earth, taking form by the rains and the heat of the sun." Huxley says, "the axiom of ancient science 'that the corruption of one thing is the birth of another' had its proper embodiment in the notion that a seed dies before the young plant springs from it; a belief so wide spread and so fixed that St. Paul appeals to it in one of the most splendid outbursts of his splendid eloquence: 'Thou fool, that which thou sowest is not quickened, except it die.' "

Among other examples of spontaneous generation, it was held that maggots were spontaneously generated from putrefying meat. Now, on several occasions had Francesco Redi noticed large flies buzzing around the meat before the maggots appeared; and it occurred to him that possibly the maggot was merely an immature stage of the fly. This hypothesis he proceeded to test as follows: He placed pieces of meat in a bottle, and covered the mouth of the bottle with paper; but although exposed to the air, and although in due time the meat putrefied, there were no flies around the bottle, and no maggots. The paper, of course, kept the odor of the meat from being conveyed to the flies. Then he repeated the experiment, except that he substituted gauze for the paper. Now the flies swarmed above the gauze, and laid their eggs upon it; and the eggs were soon transformed into maggots. Thus by a simple and easily understood experiment did Redi disprove one statement regarding spontaneous generation. The method shown, other investigators took up other instances of so-called Spontaneous Generation and one by one showed their falsity. The dictum "Omnum vivo ex vivo" had about come to be an accepted fact among scientific men. Then came improvements in the microscope; and there was made visible a world of living forms the existence of which was previously not even dreamed of. In connection with the study of these minute organisms it was observed that when vegetable infusions apparently free from any sign of life were allowed to stand for a few days and then examined microscopically, millions of these micro-organisms were present. The theory of spontaneous generation was resurrected. I need not go into detail as to the arguments advanced and the experiments tried by its supporters, nor by those who defended the theory of biogenesis; suffice it to say, that the "Discontinuous Heating" experiments of Tyndall gave the death-blow to the scientific heresy of "Spontaneous Generation".

In the meantime, convinced that "all life comes from preceding life", and therefore that bacteria could not be generated from the flesh of the body, the great Pasteur had begun his epoch-making discoveries. He had shown that fermentation is always caused by an organism; that the silkworm disease which in seventeen years in France had caused a loss of $250,000,000, and indeed even threatened the destruction of the industry, also was caused by a micro-organism, and that it could be absolutely prevented. He initiated the researches in the subject of serum therapy by developing sera for chicken cholera, anthrax and hydrophobia. Commenting upon the results of Pasteur with the silk-worm disease, Huxley said in 1870: "There can be no reason, then, for doubting that, among insects, contagious and infectious diseases, of great malignity, are caused by minute organisms which are produced from pre-existing germs, or by homogenesis; and there is no reason, that I know of, for believing that what happens in insects may not take place in the highest animals. Indeed, there is already strong evidence that some diseases of an extremely malignant and fatal character to which man is subject, are as much the work of minute organisms as is the silk-worm malady". Notice especially in this quotation the words "minute organisms that are produced from pre-existing germs." The great stumbling block to the study of parasitic organisms had been removed.

In England, also, the death of the Spontaneous Generation theory had produced results; for Dr. Joseph Lister had reasoned that if putrefaction is always due to bacterial development, this must apply as well to living as to dead tissue. Hence the putrefactive changes which occur in wounds and after operations on the human subject, from which blood-poisoning and gangrene so often follow, might be absolutely prevented if the injured surfaces could be kept from the germs of decay. So he began experimenting to find a drug that would kill the germ without injuring the patient. As we know, the results of his experimentation were crowned with success.

I need not discuss further the investigations which have led to the development of the science of Bacteriology. Francisco Redi's simple experiment has borne a wondrous fruitage. We realize the important role played by bacteria not only in medicine, but in agriculture as well, where they cause destructive plant diseases, aid in fertilizing the soil, and give characteristic flavors to various products.

But not only in a true understanding of the nature of bacteria has the explosion of the Spontaneous Generation theory aided medical science.

In 1833 an English medical student noticed little glistening specks in the muscular tissues of a human subject. His professor of comparative anatomy classified them as being the cocoon of a minute "insect", and gave it the name of *Trichina spiralis*. In 1847, the cysts of Trichina were found in pork by the American anatomist, Dr. Joseph Leidy. Some time elapsed before the life cycle of the Trichina had been worked out by German zoologists. This discovery stimulated investigation as to the part played by animal parasites in diseases of the human body. One of the most striking cases of animal parasitism has only recently been brought to light as occurring in the United States; only recently, I say, notwithstanding the fact that it affects over two million people: Affects, did I say? Rather, it makes them useless citizens, with life a burden to themselves. I refer to the hook-worm disease, discovered in May, 1902, by Charles Wardell Stiles. At the time of the announcement of his discovery Dr. Stiles was a zoologist at the Bureau of Animal Industry, Washington. In December of the same year Dr. Stiles addressed the Pan-American Sanitary Congress on the subject of his discovery.

To the hook-worm alone he attributed the "laziness" and general shiftlessness of the poor whites in the sand-lands and pine-barrens of the South. It is said that physicians laughed at his "theory", as they called it; but finally became convinced of its truth. And when we consider that fifty cents worth of medicine will cure a man who has been a life-long sufferer from this terrible affliction, and that by proper sanitary measures it can be absolutely prevented; when we consider that Dr. Stiles' discovery will regenerate certain portions of the South, and give health and happiness to one-fiftieth of the population of the United States, we surely must conclude that biological science has added its share to the peace and prosperity of the world, notwithstanding the fact that many of our friends on the outside would look on with a good natured smile at the work of collecting, classifying and studying the various kinds of worms found in the intestines of dogs, sheep, badgers, foxes, etc.

Another prolific line of recent investigation has been that of insects as carriers of disease. The discoveries of the last few years in regard to the connection between the mosquito and malarial fever, yellow fever, and certain tropical fevers are still fresh in the mind. As to the practical results of these studies we have but to turn to Havana, a hot-bed of yellow fever for over two centuries, but now free from the disease; or we have but to compare the overwhelming death-loss at the Panama canal during the De Lesseps regime with the extremely low mortality existing there now.

And so, as the biologist discovers the life history of these various animal and plant parasites, the physician extends applied knowledge along his own special lines; until we may hope that in the not far distant future, a certain class of diseases will become extinct. Among these diseases, none gives more promise of early extinction than typhoid fever. In the year 1890, 2.2 per cent of all deaths in the registration area of the United States had been caused by this disease. In 1900, this had been reduced to 1.9 per cent, and in 1910 to 1.6 per cent.

Chemistry and Physics also have been profoundly influenced by investigations that were initiated at least as purely biological. In 1827 the botanist Robert Brown noticed that minute particles suspended in a liquid were in a continual state of agitation. This observation has given meat to the physicists ever since. It was not until 1889 that the explanation was offered which is accepted to-day: that the motion is caused by molecular bombardment. Again, in 1877 the botanist Pfeffer wished to discover some of the facts associated with the rise of sap in plants, and began a series of experiments to measure the osmotic pressure. He constructed an apparatus to simulate as nearly as possible a plant cell. The results of his researches were published as a monograph. This monograph opened a new field to the physiological botanists; and when Van't Hoff at the age of 24 was called to the Chair of Chemistry at Amsterdam, his colleague the botanist Hugo De Vries called his attention to the work of Pfeffer, and requested Van't Hoff to continue certain parts of Pfeffer's investigations. As a recent writer says, "This was the introduction of Van't Hoff to the work of Pfeffer, and this introduction marks an epoch in the development of Chemistry." Here too the biological influence ends; but the result of the influence is so great not only to Chemistry and Physics, but to all sciences, that I am tempted to continue. Van't Hoff discovered that a constant relation exists between the osmotic pressure and the per cent of concentration of the cane-sugar used in his experiments. In this he saw an analogy to the law of Boyle for gases. Then "if," said he, "there is any real relation between solutions and gases, the other laws of gas pressure must apply to the osmotic pressure of solutions." Proceeding with this theory, he showed that the law of Gay-Lussac, and finally the law of Avogadro for gases, applied for most solutions. Since the discoveries of Van't Hoff we really know something about matter in solution, but this raises the question, "Why is it so important to deal with solutions by the exact scientific method, or by any method whatsoever? Why is a knowledge of solutions so fundamental, not only for chemistry but for so many of the other branches of natural science?" Harry C. Jones of Johns Hopkins University aptly answers these questions. He says: *"We know matter in three states of aggregation, solid, liquid and gas. A solution is a homogeneous mixture of matter in the given state of aggregation with matter in the same or a different state of aggregation; the component parts of which cannot be separated mechanically. In terms of this definition we can have solid, liquid or gas acting as a solvent, and every state of aggregation dissolved in its own or in any other state of aggregation. We would consequently have nine types of solution. Bearing in mind this broader definition of solution, the whole science of chemistry is only a branch of the science of solutions. Think of all the chemical reactions you can, and see how many do not take place in solutions in the broader sense of the term. Of course, all reactions that take place at high temperatures between fused masses are reactions in solution, because the term solution does not raise any question as to temperature".

"But let us turn to geology. The rocks are either precipitated from aqueous solutions or aqueous suspensions, colloidal or otherwise, or else crystallized from molten magmas—and the latter are as true solutions as the former; the difference being chiefly a difference in temperature. Thus, solutions underlie geology." But what would geology be without the aid it has received directly from the biologist? How far can the geologist go in the proper placing of his strata without being able to classify his fossils? And as biological knowledge is developed, how soon do we find its application in historical geology! Only within the past decade has the botanist discovered that the most of the so-called ferns of the paleozoic era were not ferns at all, but really plants more closely allied to the Gymnosperms. To this group of plants has been given the name Cycado-filicales. What were formerly thought to be fern sporangia on the leaves are now known to be the microsporangia of

*The Bearing of Osmotic Pressure on the Development of Physics and Chemistry. Harry C. Jones in The Plant World **16**:79. 1913.

the Cycadofilicales! Even the winged pollen-grains so characteristic of Gymnosperms have been found! Think of the effect of this discovery upon historical geology, and upon plant evolution, if you will!

But it is in agricultural science where we find the greatest effect of the biological influence. Indeed, agriculture may aptly be called "Applied Biology".

The entomologist has worked out the life-history of insects, and discovered how to control the injurious species, either by spraying with mineral poisons or by the introduction of other insects as parasites. The ornithologist has told us which birds are valuable, and which are harmful. The botanist has suggested the possibilities of new species of plants for cultivation. As an example of this, it might be interesting to note that commercial rubber is to-day obtained from over two hundred different species of plants. He has studied plant diseases, and has shown how to save millions of dollars annually from their depredations. Thirty years ago, plant pathology was practically unknown; but in this brief period, it has grown to be an independent science. Its importance from the practical side can well be judged when it is considered that the loss to the farmers of the United States from grain rusts alone is estimated at between $20,000,000 and $60,000,000 annually; from oat smut at $18,000,000 and from corn smut at $2,000,000. And Plant Pathology has already shown how some of these losses can be prevented, and it is but the matter of a short time until the rest of the problem will be solved.

The physiological botanist has shown the laws governing the growth of plants—their relation to water, light, drainage, soil-treatment, both mechanical and chemical, and so forth. But perhaps the most interesting phase of agricultural biology of the past decade or so is that associated with plant and animal breeding and researches into the laws of heredity. As is well known to this audience, Gregor Mendel in 1865 was the pioneer in plant breeding; but his work on this subject was published when the scientific world was in the vortex of the storm of Darwinism; and hence it received no serious attention until thirty-five years later. Then it was independently discovered by other biological investigators. Mendelism is but the introduction to a series of brilliant experiments of world-wide interest yet to come. Eugenics is its natural outcome, and from Eugenics we hope to see the regeneration of the human race. Surely biological investigations have played no mean part towards making the world, mentally, physically, morally, a better place in which to live!

CHEMICAL PROPERTIES OF UTAH HYDROCARBONS.

By Carlos Bardwell, Benjamin Arthur Berryman, Thomas Bow Brighton, Kenneth Drown Kuhre.

INTRODUCTION.

About fifteen kinds of hydrocarbons occur in Utah; the five of those occurring most abundantly—gilsonite, tabbyite, wurtzellite, ozokerite, and rock asphalt—are the ones selected for investigation.

Gilsonite or uintaite was first described by W. P. Blake[1] in 1885. He gave it the name uintaite because of its occurrence in the Uinta mountains. Later the name gilsonite was adopted because S. H. Gilson of Salt Lake City brought it into prominence as an article of commerce.

The deposits of gilsonite are limited to the Uncompahgre Indian reservation in Uinta County, being found in an area extending from about four miles east of the Colorado line westward along the fortieth parallel about 60 miles.

Gilsonite occurs as a filling of vertical fissures, which strike quite regularly 40 degrees west. The geological formation is the "Green River" of the Eocene period of the Tertiary, here at an altitude of from 5,000 to 6,000 feet. The "Green River" formation consists of a series of calcareous shales and limestones intercalated with thin sandstone members.

Tabbyite is so named from an Indian chief Tabby. It occurs in fissure veins in the shales and sandstones of the upper Tertiary. The deposits are in Tabby canyon, a branch of the Duchesne and are about 8 to 9 miles south and west of Theodore, Uinta County. It is being mined by the Salt Lake and Pittsburg Oil Co., tabbyite being the trade name of their product.

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[1]E. & M. J. Vol. 40, p. 431.

Elaterite, wurtzellite, or mineral rubber from Utah was first described by Dr. Henry Wurtz, who showed that it is a distinct mineral. The name elaterite had been used previously by Dana and other mineralogists to describe three different minerals of specific gravities ranging from 0.905 to 1.223.

The region in which wurtzellite is found covers an area of about 100 square miles between Indian Canyon and Sam's Canyon, branches of Strawberry Creek. This is about 30 miles due north of Price, Utah.

Like gilsonite and tabbyite, wurtzellite occurs in vertical veins ranging in width from 1 to 22 inches and with a maximum length of 3¼ miles. It also is found about midway in the "Green River" formation of the Eocene. The veins strike from N. 66 degrees E. to N. 80 degrees W.

Ozokerite or mineral wax has been known for many years on account of the economic value of the large deposits in Galicia, Austria. It has its name from two Greek words, meaning "I smell" and "wax," alluding to its odor. The only known deposits of ozokerite of commercial value are those in Utah and those of Galicia.

The area known to contain ozokerite begins about two miles west of Colton, Utah County, and extends westward to about four miles west of Soldier Summit, a distance of twelve miles. The belt is two miles wide. This area may be divided into three parts; [1]near Colton, on the north side of Price River Valley, [2]near and at the east of Soldier Summit where the railroad crosses the crest of the plateau, [3]near Midway station on the north side of the canyon, near the source of Soldier's Creek and west of Soldier's Summit.

The ozokerite deposits occur in shales, shaly sandstones and limestone strata in the lower part of the "Wasatch" formation of the Tertiary. The mineral has been found at various positions through a section of about 150 feet of strata. The shales are soft and friable and variously tinted. The sandstones are moderately soft, the limestones thin and brittle.

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[1]E. & M. J. Vol. 40, p. 431.
[2]17th Annual Report U. S. G. S.
[3]E. & M. J. Jan. 11, 1890, p. 59.

Where the ozokerite occurs the strata are intersected by fissures, zones of brecciation and parallel jointing. Those fissures and spaces between the brecciation contain the ozokerite, usually as thin sheets but sometimes as dike —like bodies several inches thick. The fissures are nearly vertical and strike from N. 10 degrees W. to N. 60 degrees W. The thickness of the deposit is variable both laterally and vertically.

In the past rock asphalt has been called bituminous sandstone, but the name rock asphalt is gradually being adopted, especially in Utah. The largest deposits in the state lie south and east of Vernal, north of the White River and between Ashley and Uintah Valleys[5]. This deposit attains a thickness in places of twenty feet but at present is too far from a railroad for successful commercial exploitation. Another deposit occurs south-east of Thistle in Spanish Fork Canyon, and still other immense deposits are found (a) in the tributaries of Whitmore Canyon, near Sunnyside, having a bituminous content of from 10 to 12 per cent, rather evenly distributed; (b) at the head of Willow Creek, a tributary of the Green River in the Book Cliffs Mountains; (c) in the Laramie sandstones near Jensen on the Green River.

A deposit of bituminous limestone occurs at the head of the right hand fork of Tie Fork, a canyon entering Spanish Fork Canyon two miles west of Clear Creek Station. This deposit occurs in horizontal veins of from two to four feet in thickness and carries 12 to 20 per cent of asphalt.

An area underlaid by bituminous limestone about 50 miles long east and west, by 10 miles wide north and south, lies just north of Colton and south of Strawberry Creek from Antelope Creek on the east to near Thistle on the west[6].

In reviewing the literature of the work done on these products, one finds that considerable has been published concerning gilsonite and ozokerite but not much about wurtzellite, tabbyite, and rock asphalt. Day[7] attempted to

[5]E. & M. J. Vol. 17, p. 115.
[6]U. S. G. S. 17th Annual Report, p. 332.
[7]Journal of Franklin Institute, Sept. 1895.

show the real nature of gilsonite. He first outlined preliminary work done by Boussingalt and by Kayser. Kayser gave formulae for a number of distillates obtained from various asphalts but Day doubts their correctness.

To quote from Day's article, "The present investigation of gilsonite had for its object the isolation of such single hydro-carbons or their derivatives, as would give some information as to the real nature of the material itself."

He gives an outline of the physical characteristics, solubility in alcohol, ether, glacial acetic acid, carbon bisulphide, and petroleum ether and describes the character of the residues from each solvent as well as the character of the dissolved portion. Then follows some analyses, both proximate and ultimate. He found the most satisfactory method of determining sulphur to be a combination of the Carius and Eschla method, dissolving first in concentrated nitric acid, pouring into cold water, drying the precipitate formed, then heating it with magnesium oxide, etc.

Next follow the results of distilling gilsonite, description of the distillates and their action with steam distillation, with sulphuric acid and with nitric acid. From its action his conclusion is that the oil obtained belongs to the paraffin series and is a complicated mixture of different hydro-carbons just as is highly refined petroleum.

From the distillate volatile with steam he obtained oils which seemed to correspond to those described by Peckham[8] obtained from California bitumens. This had an odor similar to quinoline and to him was evidence of the relationship of California bitumens and gilsonite and of their animal origin.

Day gives the results of the treatment with nitric acid and description of the products and their properties. From these he concludes that some members of the naphthalene series are present.

Eldredge[9] describes the location of the hydrocarbon deposits and the geology of the district as told previously in

[8]American Journal of Science. III. Vol. 48, p. 250.
[9]17th Annual Report U. S. G. S., p. 330.

this paper. He holds to the idea that the cracks in which the gilsonite is found were formed by the gentle folding that produced the Uinta Valley syncline. He describes the appearance and properties of the gilsonite coming from near the surface where, through atmospheric agencies, it has lost its luster and become "pencillated" in structure (columnar at right angles to the wall). Sometimes a cuboidal structure is developed.

Then follow descriptions of several important veins, the Duchesne, Bonanza, Cowboy, Culmer and smaller ones. Those range in thickness from that of a knife blade to 18 feet. From a study of conditions he concludes that the gilsonite found its way into the fissures as a plastic mass, coming from below under pressure, and though of high viscosity, sufficiently fluid to be pressed between the grains constituting the wall rocks. He frankly confesses his lack of ability to suggest the condition under which the gilsonite existed prior to its flow into the cracks.

Eldredge quotes from Day an analysis of gilsonite as follows:

Volatile matter	56.46 per cent
Fixed carbon	43.43
Ash	.10
	99.99 per cent

Ultimate composition.

Carbon	88.30 per cent
Hydrogen	9.96
Sulphur	1.32
Ash	.10
Oxygen and Nitrogen, undetermined	.32
	100.00 per cent

Locke[10] quotes the description analysis, etc., given by Blake[11], then add further details. He notes the fact that it is an insulator, that it appears to be composed of two in-

[10] A. I. M. E. Vol. 16, p. 162.

gredients, one of which is more soluble in some solvents than in others and that a part of it when heated undergoes destructive distillation. He considers asphaltums to be composed of a volatile oily portion, petrolene, and a non-volatile, asphaltene, which is decomposed by heat. The article closes with descriptions of some experimental mixes made with gilsonite for paving, roofing, varnish, etc.

Blake[11] describes gilsonite, giving it the name uintaite from its place of occurrence and treats briefly of its fusibility, solubility in oils, melted wax, tallow, ozokerite, turpentine, naphtha, etc. He gives an analysis made by Fristol and Sawyer as follows:

Carbon	78.43 per cent
Hydrogen	10.20
Nitrogen	2.27
Oxygen	8.70
Ash	.40
	100.00 per cent

Raymond[12] describes gilsonite but pays more attention to the occurrence of it and other hydrocarbons in eastern Utah than to its chemical properties and composition.

He gives an analysis by T. M. Brown as follows:

Carbon	80.88 per cent
Hydrogen	9.76
Nitrogen	3.30
Oxygen	6.05
Ash	.01
	100.00 per cent

The earlier analyses of asphalts gave rather large percentages of oxygen but this was probably because the sulphur content had not been recognized and the oxygen was supposed, with the carbon and hydrogen, to make up the ash free bitumen. Still some analyses which report sulphur and nitrogen also report small amounts of oxygen.

[11] E. & M. J. Dec. 26, 1885.
[12] T. A. I. M. E. Vol. 17.

[12a] By some authorities as Richardson and Peckham, oxygen is considered as foreign to natural asphalts.

A similar article by Henry Wurtz[13] gives a description of gilsonite as well as some solubilities and properties.

In the first reference to wurtzellite Blake[14] describes it from a physical standpoint, noting its occurrence, hardness, color, specific gravity, fusibility, electrical properties, etc. In giving to it the name "wurtzellite" he said he wished to compliment his friend Dr. Henry Wurtz of New York.

Blake[15] explains the difference of wurtzellite from gilsonite and at some length shows that the Utah wurtzellite is an entirely distinct mineral from the elaterite of Dana and other mineralogists. He takes up its form, fracture, toughness, color, luster, elasticity, hardness, specific gravity, fusibility, solubility, and electrical characteristics. He notes that 4.17 per cent is soluble in ether, the soluble portion being a yellow oil of unpleasant odor. The removal of this oil does not materially affect the properties, however. Most of his article deals with the substances that are known as elaterite. These he shows are certainly not the same as wurtzellite. He also compares gilsonite, albertite, grahamite, and other asphaltums but does not bring out anything new about the Utah product.

Wurtz[17] gives more comparisons to show that wurtzellite is a distinct mineral.

The Utah ozokerite is very similar in properties to that of Galicia, but as it contains less oily material and is firmer, it is more valuable. Plenty of popular[18] accounts as to its mode of preparation, uses, etc., are to be found, but we could find nothing as to work on its chemical composition, distillation products, etc.

With the exception of an occasional reference to the fact that bituminous sandstones occur in Utah and their location, nothing was found about rock asphalt.

[12a] Jour. of Industrial and Eng. Chem. May 19, 1913, p. 393.
[13] E. & M. J. Aug. 10, 1889, p. 114.
[14] E. & M. J. Dec. 21, 1889, p. 542.
[15] T. A. I. M. E. Vol. 18, p. 497.
[17] E. &. M. J. Vol. 49, p. 106.
[18] The Salt Lake Mining Review, Oct. 15, 1912; Salt Lake Tribune Dec. 29, 1912; U. S. G. S. Bulletin 285, p. 369.

USE OF UTAH ASPHALTS.

An investigation into the uses which are made of the asphalts of Utah shows them to me surprisingly numerous and varied. That there are large deposits of rock asphalt in Utah is known by comparatively few, and to still fewer is known the extended use which is made of them. Many of our most common articles are products of Utah asphalts. Their use has increased enormously during the last few years, yet the supply is still short of the demand. Before the discovery of gilsonite in Utah, European and Asiatic asphaltum was shipped into the United States; now, because of its abundance and purity, large quantities of the Utah asphalt are shipped to the foreign countries.

The production of gilsonite in the last two years has increased rapidly due to the greater number of articles made from it. In 1910 the production was 30,000 tons[19]; in 1912 over 50,000 tons. This is worth about $20.00 per ton f. o. b. Utah, which would mean an annual income of $100,000.

Ozokerite is of still greater value, the price in New York being 15 to 28 cents per lb.[20] The only available data as to production is that of the Soldier Summit mine. Here the total production to date has been 300 tons of the refined black ozokerite marketing at from $400 to $500 per ton, or a total value returned of between $120,000 and $135,000.

Wurtzellite is little used because of its insolubility. There are about 1000 tons produced annually.

Perhaps the most extended use which has been made of Utah asphalts is in the paving industry. Yet the value of gilsonite and ozokerite for other purposes are so great as to make it impractical to use them for paving. Gilsonite has been used in paving the streets of many important cities. Among these is a long stretch of Michigan Avenue Boulevard, Chicago[21], where it is giving entire satisfaction under the most exacting requirements.[21] Rock asphalt has

[19]H. L. A. Culmer, Address, Nov. 15, 1912.
[20] Salt Lake Mining Review, Oct. 15, 1912.
[21] H. L. Culmer, Address, Nov. 15, 1912.

also been used in the paving industry, especially in Salt Lake City. Second South between West Temple and First West was paved with rock asphalt in 1896. It has had no repairs and is in fair condition after sixteen years of service.

Another very extensive and at present no doubt the greatest use of Utah asphalts is in the manufacture of varnishes and paints. Only the purest and best asphalts are used for this purpose. Gilsonite and glance pitch are used for the best grades, and Trinidad and Bermudez for the cheaper grades. The asphalt is refined and then mixed with turpentine and linseed oil to make a varnish. Wurtzellite has been used in the manufacture of a varnish in which the particles are held in suspension, not entering into solution.

Asphaltum is practically imperishable[22]. The ancient Egyptians knew of this property and made use of it to preserve their dead. This property has been made use of in modern times by coating metal and wood to preserve them from decay[23]. Reservoirs and aqueducts as well as all manner of water-carrying appliances are lined with Utah asphalts. For this purpose they are better than coal tar because they will not crack after heating or aging. Since they are acid proof they find an extensive use in acid factories and in industries where acids are employed. As roofing compounds they are employed extensively and are said to be better for the purpose than coal tar products.

Some of the uses of the individual hydrocarbons of Utah are as follows:

GILSONITE:

Manufacture of varnishes.

Paving industry.

Electrical insulator[24]. For this purpose it is compounded with ebonite. Its non-absorbent property makes it valuable as a covering for underground conduits for electrical wires.

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[22] H. L. Culmer Address, Nov. 15, 1912.
[23] New International Encyclopedia, May.
[24] T. A. I. M. E. Vol. 16, p. 162

Manufacture of roofing compounds and roofing papers[25].

For coating of wooden and steel pipes and masonry aqueducts[26].

The U. S. Geological Survey gives the following uses of gilsonite[27]:

For preventing electrolytic action on iron plates of ship bottoms, coating barb wire fencing, coating sea walls of brick and masonry, covering paving brick, and proof lining for chemical tanks, roofing pitch, insulating electrical wires, smokestack paint, lubricants for heavy machinery, preserving iron pipes from corrosion and acids, coating poles, posts, and ties, toredo-proof pile coating, covering wood-block paving, a substitute for rubber in the manufacture of garden hose, and as a binder pitch for culm in making briquetes and eggette coal.

OZOKERITE:

Electrical insulator[28]:—this is the most important use. A residual product obtained in purifying ozokerite which has a hard waxy nature is combined with India-rubber to give an insulating covering for ocean cables. Ozokerite has a resistance of 450,000,000 megohms per square centimeter as compared with 110,000,000 for paraffin.

Manufacture of candles[29]—Almost all altar candles are made from ozokerite. They will not drip or bend over and they have great illuminating power.

As a substitute for beeswax:—Refined ozokerite has about the same properties as beeswax. It can be bleached perfectly white with chlorine, in which case it can not be distinguished from beeswax except by the taste[29]. In this form it is used as an adulterant of, or a substitute for, beeswax. The manufacturers of ointments, pomades, salves, and plasters[29] use some ozokerite.

As a water proofing material it has considerable use. Paper waxed with it is employed in wrapping soaps, steels, and all kinds of articles requiring moisture-proof wrappings.

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[25] New International Encyclopedia.
[26] New International Encyclopedia.
[27] Mineral Resources of the U. S. 1893.
[28] New International Encyclopedia.
[29] Salt Lake Mining Review, Oct. 15, 1912.

It has the property of permeating the pores of wood, making a perfectly tight fitting material through which no water can pass.

Wax figures and dolls are almost all made of ozokerite as are likewise imitation alabaster statuettes.

In the manufacture of hard rubber for telephone receivers and transmitters, it is compounded with Para-rubber to give it hardness. In this form it is also used for phonograph records, electrotyping, manufacture of buttons, shoe-polish, water-proof crayons, and innumerable other articles which were ozokerite not available, would have to be made of vegetable or animal waxes.

Ozokerite is largely composed of ceresine which is obtained from it by a process of distillation, the residue being known as wax pitch, a material used for cable insulation. Ceresine may be incorporated with oils, fats, resins, etc. In this form it can be applied to innumerable and varied uses. Some of these are floor polishes and wax, artificial wax moulding, water-proofing cartridges and textile fabrics, as a moulding mass for copper and silver plating, in the manufacture of preservatives for sole leather, as pencils for writing on glass and porcelain, as wax for sealing bottles, and as a dressing for black cotton goods.

WURTZELLITE:

Manufacture of varnishes. In a wurzellite varnish the particles are merely held in suspension, and this results in a cheaper and inferior grade when compared with one made from gilsonite. The process by which it is made is a trade secret. Wurtzellite also finds considerable use as roofing compound.

TABBYITE:

This is compounded with Para rubber to manufacture floor mats, rubber paints, and roofings: and as a filler for rubber in automobile tires, etc. As it closely resembles gilsonite, it can no doubt be applied for the same purposes as the latter.

ROCK ASPHALT:

Practically the only use of this material is in the paving industry. According to statements made by the Salt Lake City engineering department's chemist, it would be an ideal paving mixture if it could be obtained of uniform grade.

To date the material brought on the market has been extremely variable in bitumen content, and until some means of supplying a uniform grade is found it can not be entirely acceptable as a surface mixture.

EXPERIMENTAL RESULTS.

The results of the first tests made on the eight samples are given in table one. They are the standard tests recommended by Richardson and required by the New York testing laboratory. The tests are meant primarily to determine the fitness of the material for asphalt paving. None of the samples as they occur comes up to the standards completely, but in the case of Trinidad, Bermudez, Gilsonite, and Rock Asphalt, the bitumen could be mixed with heavy petroleum oil and given the required penetration and other properties. As our work was concerned with the properties of the materials as they occur in nature no compounding was done.

The hardness is given in terms of the commonly accepted mineralogical scale[30]. In all cases—as might be expected—the hardness is low.

The streak is the color of the powder or the color of the mark made by the material on a piece of unglazed porcelain. This was found to be brown in all cases, varying from light to dark.

The specific gravity was determined in two ways. First, with the specific gravity bottle and then by weighing a sample and finding the increase in volume of water in a burette. When the sample is added great care must be taken to have no air bubbles adhere to it. The two methods

[30] Talc.=1, Gypsum=2, Calcite=3, Fluorite=4, Apatite=5, Orthoclase =6, Quartz=7, Topaz=8, Sapphire=9, Diamond=10.

gave very concordant results. The specific gravity is in all cases very close to one.

The softening and flow temperatures were determined by putting a small angular piece of the bitumen on a microscopic slide cover glass placed upon a mercury bath and then heating the mercury.

A funnel was adjusted over the sample and glass. A thermometer passed through the funnel neck registered the temperature of the bath and of the sample. When the first signs of the rounding of the edges and corners was noted that temperature was taken as the softening temperature. The heating was continued until the sample flattened out as a liquid on the glass. This gave the temperature of flow. Where the temperature was above the boiling point of mercury no determination was made.

The fracture was determined by looking at a freshly broken surface. It was found to be conchoidal in all cases; that is, the surface appears to be made up of a series of concentric spheres.

The loss upon heating to 212 degrees F. for one hour gives the moisture and the very low boiling distillates. These values are quite low, as are the values for 325 degrees F. for seven hours, and account in considerable measure for the zero penetration found in all cases except the ozokerite. The oven used to obtain a constant temperature was an ordinary air oven, asbestos covered, with a fan at the bottom to keep the air in circulation, thus preventing one part of the furnace becoming hotter than another. Considerable difficulty was found in the seven hour run at 400 degrees F. to keep the temperature constant, as the gas pressure in the burner varied greatly.

The penetration is the distance a number two sewing machine needle will penetrate the sample when released for five seconds with a 50 gram weight upon it. For the use of the standard machine for making these tests we are indebted to the testing laboratory, City Engineer's Office, Salt Lake City.

The bitumens in the asphalts are divided into two general classes.[31] Those soluble in 62 degrees naphtha are

[31] "Modern Asphalt Pavement", by Richardson, p. 118.

called Malthenes and those insoluble in carbon tetrachloride but soluble in carbon disulphide are called carbenes. Generally carbon disulphide will dissolve all the malthenes and the carbenes. These solubility tests were made by allowing a one gram sample finely ground, to be in contact with an excess of the solvent for 12 to 18 hours. The solution and the remaining solid material were then filtered through a tared gooch crucible made up of a filter of ignited asbestos fiber. The crucible was reweighed after being washed with pure solvent and dried at 100 degrees C. The increase is the amount insoluble in the solvent. From this the amount soluble is found. Great difficulty was found in filtering some of these samples, especially the Trinidad asphaltum. This material contains a large amount of fine sand which clogs the filter. No agitation accompanied these extractions except through a shaking at first and one after about three hours.

The bottles were corked to prevent evaporation of the solvent. In order to facilitate filtering the solid matter was allowed to settle as completely as possible before filtering. The clear solution was poured through the filter, then the solid matter washed into it. The insolubility of wurtzellite is to be noted, as we have occasion to observe this property in connection with later extractions.

The results in Table 1 show physical and chemical properties which may or may not depend upon the ultimate analysis. Table 2 gives the ultimate composition as determined in our work. The carbon and hydrogen were determined by the ordinary combustion method, collecting the water in calcium chloride and the carbon dioxide in potassium hydroxide. Great care must be taken in starting a combustion. The part of the tube containing the copper oxide and lead chromate should be red hot but the part where the boat is placed should be cool when the boat is inserted. If not the gases which are first distilled off will come too fast to be decomposed by the copper oxide and to be absorbed by the potassium hydroxide bulb, and a back pressure will be set up which may puncture the hot tube or force some of the gases containing hydrogen and carbon back into the air purifer.

The nitrogen was determined by the ordinary "Kjeldahl" method, distilling the ammonia into standard sulphuric acid and titrating back the excess.

The sulphur was determined by the Sprague-Ebaugh modification of the Eschka method which consists in baking a weighed sample with zinc oxide and sodium carbonate. The sulphur is oxidized to the sulphate and leached out with water, filtered, acidulated with hydrochloric acid and precipitated and weighed as barium sulphate.

The ash may be determined by reweighing the boat after combustion or by heating a one gram sample in a platinum dish till all carbon is burned off, and then reweighing. In two cases the ash was analyzed. The compositions are given in a separate table below Table 2. This analysis shows the mineral matter of rock asphalt to be of silicious nature.

Table 3 records the results of a series of solubility tests. These results give the amount of hydrocarbon that can be dissolved by 100 grams of the solvent. The method was as follows:—a quantity of hydrocarbon was placed in a bottle in contact with a small amount of solvent. The bottle and contents were agitated for 18 hours by a water motor and shaking apparatus, and then the solution was filtered off. A weighed quantity of the solution was evaporated and the residue weighed and calculated to 100 grams of solvent. All of the solvents tested were first tried qualitatively hot and cold, and where solubility was found a quantitative determination was made. Quantitative determinations with hot solvents were made only where increased solubility was found in the qualitative test. The hot extractions were made in a bottle fitted with a reflux condenser, the solvent being boiling. The hot extractions are starred in Table 3.

Table 4 gives the results of fractional distillations of the hydrocarbons. A ten gram sample was placed in a glass distilling flask and heated until some material came over. Fractions were taken according to the table given.

The thermometer bulb was placed opposite the discharge tube—not in the liquid hydrocarbon. The distillation continued until the sample carbonized.

A number of distillations were made with reduced pressure. A brass retort was used for these as the glass could not stand the external pressure when hot. The results were not satisfactory as we could not condense the distillate completely. Lack of time prevented further investigation along this line and study of the distillates. It was found, however, that gilsonite is soluble in its distillates and in the distillates from wurtzellite and tabbyite. Tabbyite is soluble in the distillates from gilsonite and wurtzellite, but wurtzellite is insoluble in its own distillates or in the distillates of gilsonite or tabbyite. Gilsonite is soluble in stearin and hot paraffin but wurtzellite is insoluble in both.

SUMMARY.

1st. Considerable scattered work has been done, but it needs to be gathered together and reviewed carefully.

2nd. Gilsonite is the Utah asphalt most fully investigated. It is also the most important.

3rd. The uses of these solid hydrocarbons are many and varied and are growing more numerous rapidly.

4th. In the field one asphalt gradually changes into the other. The gilsonite occurring furthest east, then the tabbyite, wurtzellite, rock asphalt, and ozokerite. There may be a genetic relationship among them.

5th. All occur in rocks of the same age—Eocene of the Tertiary.

6th. An interesting series of distillates is obtained at temperatures ranging from 220 degrees to 350 degrees C.

7th. Gilsonite, tabbyite, ozokerite, and the bitumen from rock asphalt are soluble in many solvents to varying degrees but wurtzellite is practically insoluble in all the solvents tried so far.

8th. Though gilsonite, tabbyite, and wurtzellite grade from one into the other in the field, are quite similar in appearance and very similar in chemical composition, still there is a marked difference in their properties, solubilities, etc.

In conclusion it may be said that an immense field is open for investigators in the study of the hydrocarbons. Each individual asphalt needs a thorough working over, not only as to solubility, chemical analysis, etc, but also as to the nature of the compounds of which it is composed. Each product gives interesting distillates. These should be studied and no doubt valuable use could be made of them.

A solvent for wurtzellite is needed. Time and work will develop this. New methods of using these products are needed and will be found by further study.

The field is large and fruitful and invites original workers. To those who desire to carry on an interesting as well as a useful investigation, we recommend the Utah Hydrocarbons.

TABLE I.

ORIGINAL SUBSTANCE	Trin.'	Ber.	Gils.	Tab.	Wurt. 1	Wurt. 2	Ozok.	R. A.
Loss 212°F. 1 hr. %	0.073	0.1765	0.353	0.91	0.53	0.21	0	0.14
Loss 325°F. 7 hrs. %	1.717	6.63	0.217	2.78	2.76	1.66	45.41	1.43
Penetration Residue	0	30	0	0	0	0	15	0
New Sample Loss 400° 7 hrs.	5.25	9.71	0.85	6.40	3.88	1.88	65.20	1.79
Penetration Residue	0	0	0	0	0	0	0	0
Bitumen Sol. in C.S.$_2$	60.36	90.93	99.64	94.63	10.83	8.10	99.46	11.34
Org. Matter Insol. in CS_2	3.94	3.74	0	0.72	87.68	88.54	0.50	0
Inorg. or Mineral Matter	35.70	5.32	0.36	4.65	1.50	3.36	0.046	88.66
Bit. Sol. in 62° Naphtha	41 00	34.40	61.70	58.50	*t*2.76?	*t*2.74?	81.71	9.25
This is % of Total Bit.	68.00	38.85	61.85	61.85	39.10	33.85	82.20	81.50
Carbenes: Bit. insol. in CCl_4	*a*	0	0.18	1.75	1.57	1.65	2.51	1.59
Bit. more sol. in CCl_4	......	1.37	0	0	0	0	0	0
Original Loss on Ignition	64.30	94.68	99.64	95.35	98.50	96.64	99.96	11.34
Fixed Carbon	36.69	39.60	43.13	37.45	35.60	......	10.03	6.85
Sulphur on Original	4.22	4.70	0.52	1.24	4.00	4.34	0.29	0.78
Specific Gravity 78° F.	1.372	1.05	1.018	1.006	1.032	1.004	0.891	2.097
Streak	*b*	*f*	*i*	*i*	*i*	*i*	*i*	*i*
Luster	*c*	*g*	*g*	*k*	*g*	*g*	*o*	*o*
Fracture	*d*	*d*	*d*	*d*	*d*	*d*	*d*	......
Hardness	1	<1	2	<1	1	1	<1	......
Odor	*e*	*e*	*j*	*l*	*e*	*e*	*l*	*q*
Softens °F	203	132	320	264	*m*	*m*	134	......
Flows °F	266	181	377	275	*n*	*n*	140	......
Penetration at 78° F.	0	30	0	0	0	0	30	0

a Could not filter. *b* Dark Brown. *c* Dull. *d* Conchoidal. *e* Tarry. *f* Nearly Black. *g* Glossy. *i* Brown *j* Slight Tarry. *k* Slightly glossy *l* Petroleum. *m* Above BP *n* Mercury. *o* Dull. *q* Slightly oily *t* Wt. increased.

TABLE II.

SUBSTANCE	Trin.	Ber.	Gils.	Tab.	Wur. 1	Wur. 2	Ozok.	R. A.
Carbon	51.06	77.52	85.25	81.32	76.90	79.40	85.35	9.55
Hydrogen	5.84	8.90	10.55	10.40	11.20	10.55	13.86	1.10
Sulphur	4.22	4.70	0.52	1.24	4.00	4.34	0.29	0.78
Nitrogen	0.66	0.89	2.21	2.10	2.18	2.10	0.36	0.31
Ash	35.70	5.32	0.89	4.65	1.50	3.36	0.04	88.05
Ash Analysis	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	......	......	......
Rock Asphalt	78.20	2.20	9.00	5.60	2.10	......	......	......
Tabbyite	35.35	2.50	9.80	29.50	9.45	......	......	......

TABLE III.

SOLVENT	Trin.	Ber.	Gils.	Tab.	Wur. 1	Ozok.	R. A.
Amyl Alcohol	¶	¶	¶	4	¶	¶	¶
Ethyl Ether	109	145	∞	46	¶	13	14
Ethyl Acetate	30	24	*5 3	*7 3	¶	1	*7 4
Amyl Nitrate	84	39	51	¶	*5 ¶	7	16
Amyl Acetate	132	37	86	¶	¶	1	¶
Benzol	48	36	71	35	¶	18	12
Toluol	39	33	72	57	0.09	‡	14
Turpentine	115	116	60	65	45	‡	29
Nitrobenzene	39	24	9	14	*12 ¶	¶	3
Aniline	3	¶	*33 ¶	¶	*2 ¶	¶	¶
Chloroform	10	23	54	33	*1.5 0.96	∞	83
Carbon Disulphide	∞	∞	∞	55	13.45	∞	‡
Carbon Tetrachloride	∞	∞	44.30	36.00	1.8	∞	12
62° Naphtha	‡	63	5	6.80	2.8	7	18
Ethyl Alcohol	¶	¶	¶	*1 ¶	¶	¶	¶
Propy Alcohol	¶	¶	*1 ¶	*11 ¶	¶	¶	¶

Numbers refer to grams soluble in 100 grams cold solvent.
*Grams soluble in 100 grams boiling solvent. ‡ Very sol. ¶ Insol.

TABLE IV.

SUBSTANCE	Trin.	Ber.	Gils.	Tab.	Wur. 1	Ozok.	R. A.	
0–150°C	14.93	9.89	9.34	3.12	16.15	0.21	0.91	......
150–200°C	10.42	7.99	5.34	11.93	21.70	8.91	3.22	......
200–250°C	2.26	16.08	12.84	24.87	22.82	8.38	0.29	......
250–300°C	......	21.12	28.99	13.21	0.91	17.69	......	......
300–350°C	......	......	......	4.77	......	25.89	......	......
350–400°C	......	......	......	......	......	26.85	......	......
Total Volatile	27.61	55.08	56.51	57.90	61.58	87.93	4.42	......
Fixed Carbon	36.69	39.60	43.13	37.45	36.92	10.03	7.53	......
Ash	35.70	5.32	0.36	4.65	1.50	0.04	88.05	......
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	......

THE INTENSITY OF NITRIFICATION IN ARID SOILS.

By

ROBERT STEWART.

(Abstract).

It is a common conception that nitrification takes place rapidly in arid soil. According to this conception, the origin of the nitrogen is the organic matter of the soil or the organic nitrogen formed by means of the non-symbiotic bacteria. The work of the Utah Station shows that this conception is wrong and that much of the nitrate-nitrogen is obtained from the deep soil in much the same way as are the alkali accumulations of the arid West.

NITROGEN FIXATION BY BACTERIA IN UTAH SOILS.

BY E. G. PETERSON AND E. MOHR.

(Summary).

Undoubtedly much of the fertility of western soils is due to the action of soil bacteria, molds and fungi. This statement receives further verification from the following investigation.

Samples of soil from which the organisms here described were isolated were taken weekly from January 9th to November 4th, 1912, thus including representative climatic seasons. The Greenville Experiment Farm was used in this test, Plot 47. One hundred c. c. portions of mannite solution were inoculated with ten grams of soil and incubated at 10 degrees C. After ten days' incubation subcultures were made in mannite solution and were incubated for ten days at 20 degrees C. Plates were made from these sub-cultures, and isolations of pure cultures were made from the plates.

RESULTS.

Several types of bacteria were found but only three appeared that grew readily and for a long period. These three types are briefly described in the paper.

Type No. 1 appeared in the samples on the following dates: Jan. 9, 16, 22, 31, Feb. 7, 14, 21, 28, March 7, 14, 20, April 3, 10, 24, May 1, 8, 15, 22, 29, June 5, 19, July 21, 28, Aug. 4, 11, 18, Sept. 7, 14, 21, 28, Oct. 28, Nov. 4.

Type No. 2 appeared on April 24, May 1, May 29, June 12, June 19, Sept. 7.

Type No. 3 appeared on Jan. 16, March 7, April 10, 17, May 1, 8, 15, 22, 29, June 5, July 12, Aug. 4, 25, Sept. 21, Oct. 14, 21, Nov. 4.

5.335 milligrams of nitrogen, the most valuable element of the soil, were fixed in twenty days by type No. 1.

5.616 milligrams of nitrogen were fixed in twenty days by type No. 2.

5.588 milligrams of nitrogen were fixed in twenty days by type No. 3.

These three organisms which appeared rather constantly in the Utah soil examined are thus shown to be powerful fixers of atmospheric nitrogen. Investigations are proposed to determine the effect upon these and other germs of various cultural methods of various seasons and climatic conditions in Utah.

PHYSICAL RELATIONS OF SUBJECTIVE AND OBJECTIVE COMBINATION TONES.

BY JOSEPH PETERSON.

(Abstract).

If one blows simultaneously two whistles one will hear, besides the two tones thus produced, one or more others more or less prominent. The number that will be heard depends upon the separation distance in pitch of the two primary tones and upon their relative intensities, as well as upon their absolute pitch. In this case these extra tones seem to be located in the listener's ears. They are called combination tones, and are of two kinds—summation and difference tones. Difference tones play an important part in consonance and dissonance, or musical relations of tones.

Helmholtz explained the origin of combination tones in three different ways. The importance of the middle-ear origin view has been greatly minimized by modern research; and I showed in 1907 that the other two explanations are identical in physical principle.

It was early found that of these combination tones, some can be reinforced by physical resonators while others cannot. The former are called objective; the latter, subjective. This, as we shall see, does not mean that the latter do not have a physical basis as well as the former, for they certainly do have.

Many authorities, with Koenig, have denied the existence of difference tones lying between the primaries; e. g. 5, of the interval 4:9. Rucker and Edser not only proved that such tones exist and can be reinforced by physical resonators, but they also proved by the same method, the objective physical existence of summation tones. Since then Krueger and others have established the existence of the corresponding subjective combination tones, tones the existence of which had been questioned by Max Meyer, K. L. Schaefer, *et al.* Subjective and objective combination tones are therefore now brought to a close correspondence, a fact supporting my contention of 1907 that the physical

origin of these two classes of tones is identical in principle. My suggestion of this fact has since been confirmed by articles by certain German physicists in *Annalen der Physik*, particularly Clemens Schaefer.

Several authorities have maintained that the summation tone is a difference tone of upper partials according to the equation a plus b equal na minus nb or a plus b equal na minus mb, where n and m are whole numbers; e. g. 4 plus 3 equal 7 equal 7 times 4 minus 7 times 3. In 1895 Rucker and Edser proved the impossibility of this explanation for objective summation tones. Krueger in 1900 heard subjective summation tones even when the upper partials had been practically eliminated by interference; and I proved in 1907, by the beating of auxiliary forks with audible summation tones, that the latter are not difference tones. My proof rested on the fact that if the pitch of a first partial be lowered one vibration per second that of the fifth partial, e. g., will be lowered five vibrations. The proof was mathematical and has not been questioned.

Subjective combination tones seem, then, to arise in the liquids of the inner ear on the principle of superposition of primary vibrations, and like other combination tones, are therefore really objective to the sensory end organs of hearing.

SOME PROBLEMS FOR UTAH BOTANISTS.

BY M. RICH PORTER.

The object of this paper is not to announce the discovery of some hitherto unknown principle, nor the results of months of diligent research. That must be left to those who do not have so great a variety of subjects to teach and to keep conversant upon. It is my desire, rather, to refer to some of the possibilities of the science of Botany in our state, and to appeal for a more generous encouragement of the subject, thereby increasing its scope of usefulness.

The first great problem of the local botanist is to raise the science from a position of minor importance in the average mind to one equal to Chemistry, Mathematics or English. The trend of education is so intensely toward the directly practical that we are apt not to give science for science's sake the consideration to which it is entitled. If I were to condense public sentiment, as often expressed, to a definition, I would say that Botany is a something, feminine in gender, ornamental in usefulness, subnormal in intellect to be used only by the ladies. That one is a botanist is in many parts a confession that one is either mentally weak or lazy. The conventional Professor Bumpkins of the "Merry Widow" with his squeaky voice, ill-fitting clothes, eccentric ways, dancing through the fields, after every posy or butterfly, gabbling silly nonsense with children, has not been conducive to the serious consideration of Botany as a science. We need more of the scholar, hard at work in his laboratory, patiently determining the divine principles of life, or solving the many practical problems of the community, finding out the proper control of crown galls, tomato blights and the nature of new osmotic relations. We need more generous equipment for the instructors in our high schools—not that I would install college work there, but that the courses might not take the form of elementary nature-study or theoretic text-book recitation; and then, after that, a higher grade of efficiency among the teachers themselves. The ability to pass an examination in "Bergen's Elements" and classify a couple of dozen of spring flowers, does not qualify a person to teach Botany. I am certain that if nothing more has been accomplished at Weber, the students have been convinced that Botany compares with mechanical drawing in accuracy of technique, and is equal to Chemistry or Civics in mental disipline and educational value.

Dare I now, without treading on forbidden ground, or giving offense, make the same suggestion of the lack of proper encouragement, even in our higher institutions of learning? Is there one of them that does not submerge Botany into a "Biological," a "Nature Study," or other department of a different name, or attach it to the end of a Horticulture or Agriculture or some other of the commercial or industrial courses? When as a matter of fact it is the parent and not the offspring of every one of them? Does either of them offer sufficient work to qualify students to do substantial research work or to dignify the science as a profession? One of our leading institutions announces in 1912-13 five courses of Botany, the first of which is "not to be given," two and three alternate with four and five and as the last two are different terms, only *one* year's work can be had. When a department occupies only a fraction of the time of one man, or is handled by student assistants, there is scant incentive for research work into the important problems of nature. May I be permitted to offer another illustration along the same line—a visit to the U. A. C.

The great state of Utah, with almost all of its botanical features yet undiscovered, can furnish, indefinitely, problems, for several experts in every one of the great branches, Physiology, Morphology, Pathology, Systematic Botany, and Ecology. I am happy to note that we have some real pioneers in some of these lines. The Agricultural College has now segregated and equipped a department of Pathology, and placed in charge a very competent man; already the excellent results of Dr. Jensen's work are felt among us. The subject presented at this convention is a new development, not know five or six years ago.

In the taxonomic work Professors Marcus E. Jones, A. O. Garrett and Dr. Paul have done excellent service. And oh! what a field for the future botanist! Each of these has discovered and named many new species and genera of flowers. Thorough as their work has been, I am sure they will agree with me, that their field is little more than opened up. Last year the Forestry Service submitted to the Smithsonian Institution a dozen or more unheard of genera gathered in our western ranges. What Mr. Garrett and Dr. Paul have done for Systematic Botany and Nature Study, viz., made serviceable and reliable text-books for this region, some one ought to do for Physiology and Ecology. No where in the world is there a more interesting, varied and productive study of ecological relations than in the Wasatch Range. In a very few miles we can pass through all grades of fertility, temperature, moisture and altitude, and observe the effect of all these upon the plant growth. From the top of almost inaccessible pine trees, far up in the gorges of the Rockies, Dr. Land took photos of trees growing from crevices in perpendicular cliffs—pictures more highly prized than those from Mexico or Samoa. The same school, U. O. C., sent men to this very valley to gather the *Ephedra trifurca,* the only available source of this interesting gymnosperm in the United States.

Let us come now to a brief consideration of my favorite branch of the subject, Physiology. On one occasion Dr. Barnes came to me and said: "Mr. Porter, the peculiar nature of the arid soils of your state, and the physiological relations of the constitutents of those soils to the plant body, would be a life-long field of research for a Plant Physiologist." To show how easy it is to find practical investigation, permit me to mention two simple demonstrations, arranged for another purpose, and left scientifically incomplete. In order to impress the students of Human Physiology with the evil effects of alcohol drinks on the tissues, the similarity of the animal and the plant cell was pointed out and then seedlings were allowed to grow in solutions of 1-10, 1-5, ½, 1, 3, 5 per cent alcohol and records kept and sketches made. Inside of ten hours the plant in the strength of beer had died. The others followed in their turn with the exception of the 1-10 per cent. This one apparently was stimulated to growth beyond the control. Of course the toxic aplasmolytic effects of the alcohol were of no use to the students and were not determined.

Another experiment was to show the effect of chemicals used for municipal water purification upon the color of green house plants. Bleaching powder in strengths of 5, 10, 20, 50, 100 m per 450 c. c. used. The result was that red geraniums changed to pink, but the color was not uniform and the effect was such as would result in total destruction of the flowers for the market. The strength used also tended to kill the blossom. These things might be determined before cities adopt methods of purification and thus save law suits, injunctions, etc. Copper sulphate and formalin might be used in similar problems.

The greatest of all problems that present themselves at present to me, and demanding solution by some competent plant physiologist, is the relation of the air from the smelters of Salt Lake valley to the growth of the vegetation. It is comparatively easy for a chemist to detect the presence of poison in the stomach of animals that have died, but just what the fumes do to the osmotic relations or photosynthetic processes within the plant body, is quite another question. Do these gases clog up the stomata, or do they plasmolyze the cells? What is the toxic effect of each of them? What strength of these gases would be not injurious, and are all the gases equally fatal? Are there plants more resistant to these than others are, and a hundred similar questions arise immediately which belong to the science of Botany. In conclusion, if the thoughts advanced in this paper will tend to inspire a more vigorous pursuance of that most attractive and beneficial science—Botany, into fields unexplored and unlimited I shall be satisfied.

RECENT ADVANCES IN OUR KNOWLEDGE OF PROTEIN METABOLISM.

By H. A. Mattill.

(Abstract).

The experiments of Osborne and Mendel on Feeding with Isolated Proteins, and those of Abderhalden and his co-workers have emphasized the importance of the individual proteins and their decomposition products as the units of protein nutrition. The specificity of the proteins of animal and plant origin necessitates their complete decomposition into these units, the various amino acids, when they are to be used as food by another animal. The synthesis of the new protein from these decomposition products takes place not in the intestinal mucosa during absorption, as has been held, heretofore, because of absence of positive evidence, but in the tissues of the body generally, under the direct and immediate control of the individual cells. The synthetic power of the animal cell has been greatly underestimated. Evidence for this cellular synthesis has been obtained in the Harvard laboratories with the help of a new and accurate method for determining non-protein nitrogen in blood and tissues. A clinical application of this method promises to be of great value in determining the functional activity of the kidney.

BLOSSOM INFECTION BY SMUTS.

By C. N. Jensen.

In the presentation of this subject, I have deemed it wise to take into consideration somewhat more material than the title of this paper suggests. It has seemed to me wise to discuss the history of the investigations on smut, what forms of smut have been considered in the work of blossom infection, a very general outline of the methods pursued to establish this important point, illustrations of blossom infection of various types of plants, together with infection by smut of plants otherwise than through the blossom or through the young seedling.

The difficulty of the control of smuts has always occupied the attention of the foremost investigators of smut diseases. There have always arisen conditions which seemingly would not work out according to the known theory. The last word as yet has not been said on this important subject, but we are far nearer the solution of it than ever before, as will be shown as I proceed along in the paper.

History.—Smut, in all probability, was known in ancient times, together with rust, under the general term of mildew or blight. Later, in historical times, this subject has received considerable attention again and again. As early as 1733, we find definite remarks by Tull to the effect that "Smuttiness is when the grains of wheat instead of flour are full of black stinking powder." Very little that is definite can be found, however, in print previous to 1807, when Prevost discovered the important fact that the smut spores germinated in water and consequently showed that the smuts were of the nature of fungi.

The next step in advance was by Tulasne, in 1847, when he investigated methodically the germination of spores in water, and proved that on germination it did not give rise directly to mycelium, but to a short germinal tube which produced minute reproductive bodies. He distinguished this tube as a promycelium. A few years later, in 1853, DeBary extended our knowledge somewhat of the mode in which spores germinate and from this date on this type of study, together with infection and cytological study has engaged the attention of many of the foremost mycologists and phytopathologists. In 1858, Kuhn followed directly the penetration of the germ tubes in wheat. The most scholarly epoch-making and accurate work, however, has been done since the eighties of the last century by a German known by the name of Brefeld. Since that date, Brefeld has been publishing on this very important subject and to him we turn for the final word. Up to 1896, all work on the smut question took it for granted that infection always took place through the young seedling, but, in 1896, Maddox, working then in Australia, discovered for the first time that blossom infection occurred in the wheats. This was afterwards rediscovered by Brefeld in 1905, working in Germany. While Maddox first discovered floral infection, still the very important point, whether infection takes place through the young seedling or flower remained unknown until 1905, when our German Brefeld seems to have settled conclusively to the general acceptance of all phytopathologists that both seedling and flower may be infected, but when a smut works through the flower, usually it infects but very slightly through the seedling.

Kinds of Smut Used in Blossom Infection Experiments. In determining blossom infection in the host plants of smut fungi, those forms come first and chiefly under consideration whose spores are powdery and whose spore masses are easily scattered by the wind and thus distributed. These are first of all the different forms of loose smuts which occur in our grains, the loose smuts of barley, of wheat, and of oats; and, by the way, it should be stated that the general impression is that these smuts do not occur in the arid region. In fact, in some fields in Utah, I have found some of these smuts as extensively distributed as in some of the fields of the East. The spores of loose smut, however, are not the only ones which have been considered for blossom infection study. The corn smut spores have been shown to live saprophytically in the soil and bud finally producing what we term air conidia, which, in reality, cause infection of plants as the smut spores themselves; and, by way of parenthesis, I may state that the common stinking smut of wheat so prevalent in the fields of Utah may act as the smut of corn and there is a possibility that these air conidia too can reach the blossom of wheat by means of wind and produce infection. This point needs investigation, and when finally settled, it may clear up some of the inexplainable conditions found in connection with the control of this disease. Brefeld himself to-day is working somewhat on this problem. Still further, we may add that the study of blossom infection has not been limited to the two forms already mentioned, i. e., those forms that produce loose smut, and such as the corn which produce air conidia, but has also been extended to smuts that are carried by air and by water.

METHODS USED IN THE IVESTIGATION OF THIS PROBLEM OF BLOSSOM INFECTION. It may be of interest to mention to you in a very general way some of the methods used to determine blossom infection in smuts. The first difficulty lies in the collecting and presevation of smut spores from the summer in which they are produced until the following spring. The spores are often attacked by insects and destroyed, so that their germinating capacity the following year has been lost. This difficulty has been overcome by the following method. Spore material is gathered in sufficient quantities soon after the breaking open of the spore masses and then kept in a dry place for approximately eight days. The spores are then sifted through a sieve on to white paper. These sieved spores are carefully put away in small sterilized flasks. These flasks are filled in not more than one-fourth to one-fifth. The neck is closed with sterilized paper and spores are put away into a dry cool place for storage through the winter. In spring, shortly before using them, the spores are placed in sterile water for a day and thrown about five or six times on a centrifugal sieve. The first spores thrown out are almost perfectly pure and cultures can be carried out in sterile nutrient solution with scarcely any pollution at all.

Now, as to methods of infection. Seed has been collected the year previous to the collecting of the smut, preserved over winter and planted the following spring, that is, the spring preceding the collection of the smut. The seed is planted and the crop harvested in the fall so that with care and selection we know that the crop produced is practically clean from smut. This seed is preserved over the same winter as is the smut and is used the following spring to start the experiment.

The seed is planted in two plats, one acting for the purpose of control, the other to be used for the purpose of infection. At blossoming time, the smut spores are either blown through an atomizer into the blossoms on all the infection plants, or they are placed by means of a brush into the flowers. The maturing seed of both plats is preserved until the following year, when each is again planted. Also at this planting, two more plats are simultaneously run, the soil of the one plat being previously inoculated with smut spores. The other plat presumably contains no smut spores, but is sown with seed which has been inoculated with the spores. Repeating then the plats as they will stand in the year in which results are obtained from the experiment, we have Plat 1 sown with seed grown from artificially infected blossoms; plat 2 control; plat 3 sown with seed which has been infected; plat 4 sown with seed that is clean, but the soil containing smut spores. In the carrying on of these experiments, it should be mentioned that the greatest precautions have generally been taken to use only seed that has been properly sterilized before using.

I do not want to trouble you with tables to any extent and hence I will repeat the results of but one experiment which was run by Brefeld in 1904-5. The experiment is taken at random amongst the many.

Plat 1. Plants grown from seed produced from artificially infected blossoms, 220 stalks, 67.7 per cent smutted.

Plat 2. Plants produced from seed which, after sterilization, has been inoculated with smut spores, 300 stalks, no smutted plants. , Plat 3. Plants produced from sterilized seed planted in a soil which has been inoculated with spores, 250 stalks, none smutted.

Plat 4. Control. 1000 stalks—one smutted specimen.

Experiments, the results of which were similar to this already quoted, were carried out by Brefeld from 1900 to 1905. These experiments included thousands of plants, the results in general were always the same. In the words of Brefeld, we may say: Here it is proved positively that young ovaries are directly attacked through their stigmas by the germs of infection scattered by the wind; that the smut, however, is not developed in the same year but that rather the germs of infection which penetrated into the young embryonic fruit remain latent in the ripening grain and after the dormant period of the seed grow out of these equally with the germination of the embryo in order to pass over in the inflorescence to the production of the spore masses.

Now, how is the condition of the experiment simulated on a natural scale? It happens as follows. The plants affected with the loose smut mature earlier than the normal healthy ones. In fact, they mature so that the smut is being distributed by the wind at the time of flowering of healthy plants. The distribution of the smut continues for days, a condition which is closely associated with the variation of the time of opening of flowers, which continues also for several days. This condition has been shown to hold true for the loose smuts of wheat, barley, and oats. Definite experiments have been carried out with barley, giving the same general results, as with wheat and the infection of the blossom has become a scientific fact as far as these two crops are concerned. The infection of the blossom of the oats with loose smut has not been attained with as definite results as with barley and wheat. There is no question but that the smut is distributed at blossoming time but in general it appears as if the smut spores do not germinate until the following year. They lie securely protected within the hull next the kernel. In the spring at the time of planting and upon germination of the seed, these smut spores also germinate and infect the seedling. This appears to be the general rule; for the treatment of this smut is similar to that of other smuts where the smut spores adhere to the surface of the fruit. However, with oats, we find that the external treatment is not always as effective as it should theoretically be and in all probability some infection of the ovule the previous year does take place.

Blossom Infection on the Melandryum. The smut forms already described appear in the blossoms of grasses, that is, in plants characterized by wind fertilization. There are, however, a number of smut fungi which occur in plants fertilized by insects. A special characheristic form of this kind of plant is the *Melandryum* of the family *Caryophyllaceae*, which is affected with what is commonly termed anther smut. The infected plants appear healthy except as to the anther, which alone is attacked by the smut fungus. Experiments have completely demonstrated that blossom infection also takes place in this instance, the smut being transported by such insects as butterflies to the stigma where it germinates and grows down into the seed, there to lie dormant until the following season, when the seed is planted.

Smut Infection in Water Plants. As a concomitant supplement to the above described infection by wind and insects, water must further be added as an agent by which smut spores are transported. The forms of Doassansia inhabit mostly the leaves of water plants, for example, Alisma, Sagittaria, and so on, and develop in these localized diseased spots, which can easily be detected by a yellowish appearance. Finally, in these spots are developed the spore masses of the fungi. These spore masses consist of an outer sterile layer of cells surrounding an inner mass of fertile ones. The cells of the outer layer soon lose their contents and become filled with air. The spore mass then floats very readily. The fertile cells of this spore mass germinate in the water like Tilletia. The sporidia, however, continue to bud and form many filiform conidia. These finally are carried by the water and come in contact with the embryonic leaves which they attack and again the characteristic diseased spots with its spore masses are produced. While this is not a case of blossom infection, I mention it in connection with this paper to show how our conception of the attack and distribution of smut is becoming enlarged from the old idea of seedling infection only.

INFECTION OF THE MAIZE PLANT.—Seedlings of maize are never infected. The embryonic tissue of the leaves and flowers, however, are. This happens as follows. The smut spores live saprophytically in the soil. After germination and the formation of sporidia has taken place, these sporidia bud and produce secondary conidia. These, in turn, bud and this continues until some conidia reach the air and are transported by the wind to embryonic tissue, where infection takes place. Any embryonic tissue may be infected, and consequently we often find here flower infection occurring also. The smut spores, it should be stated, in passing, are not capable of growing in pure water at all or only to a very limited extent. They only germinate in nutrient solution. The soil contains such a solution and especially favorable is the solution when the soil is rich in humus or when it contains much manure. This simple fact of spore germination only in nutrient solution being established, it is easily seen how well manured land planted to corn has been claimed by the farmer to yield more smutted plants than the soil not so rich in humus. Another lesson to the investigator, that after all many of the experiences of the farmer are founded upon fact and the investigator may here often find the keynote for the solution of the problem.

A number of plants could be taken up somewhat briefly as those already indicated, and show how they become attacked by smut. It must suffice, however, at present, to say that blossom infection has been shown to take place in Indian millet, in the Panicum species, and in Italian millet. Brefeld at present, as already mentioned previously, is experimenting on the covered smut of wheat and barley to see if the phenomenon of blossom infection does take place to some extent with these smuts.

Summing up, these are some of our conclusions and our present position. First. Besides infection of the seedling, still other forms of infection exist, such as blossom infection of wheat, barley and oats, by the loose smuts, and infection of young leaves, as in the water plants, a point previously overlooked.

Second. In general, only the youngest embryonic tissues of any host plants are the ones attacked by the germs of infection.

Third. Experiments on infection of maize smut have proved clearly that the large host plants in the process of development and formation expose in different places, for example the leaves and the flowers, young embryonic tissue which can be attacked by infection germs.

Fourth. A similar condition to that of the maize happens in water plants where the embryonic tissue of developing leaves is affected.

Fifth. In the loose smuts of wheat and barley and the anther smut of Melandryum, the matter is essentially different from the cases of corn and water plants. Here the disease does not develop in the parts in which infection takes place. The result of infection is shown only after a long period of incubation during the winter time and at the time of unfolding of the inflorescence of the plant the following year. While the idea formerly prevailed that only seedling infection occurred, we have now come to realize that at the flowering time the ovules and stigmas offer assailable tissues for the germs of infection and that this takes place in these embryonic parts.

Sixth. Accordingly, in the occurrence of smut disease in our grains, we must reckon with two places of infection, quite independent of each other, first the young germinating seedling, second the blossoms. We must consider that in separate cases both forms of infection may be effective at the same time, but first one and then the other will have the ascendency. In judging of the natural spread of smut fungi and smut diseases, these recently explained facts are of direct value. Also they are of the utmost value when it comes to a consideration of the control of these diseases.

COMPARATIVE VALUE OF FIRST, SECOND AND THIRD CROP ALFALFA HAY FOR MILK PRODUCTION.

BY W. E. CARROLL.

(Abstract).

During the two years ending March 31, 1913, the Department of Animal Husbandry of the Utah Experiment Station has been testing the comparative value of first, second and third crop alfalfa hay for milk production. Each year fifteen milk cows were used, divided into three lots of five each. Each lot contained two Holsteins, one mature Jersey, a Jersey heifer, and one grade cow borrowed for the experiment. The second year the lots were the same in number and the same size, composed of two Holsteins, two Jerseys and one grade each. During each year, the lots were fed so that each lot at some period of the experiment received each crop of hay, i. e., lot 1, for example, was fed one period on first crop, another period on second crop, and a third period on third crop hay. A preliminary period of about two weeks was run each year in order to get the cows on feed well and the record keeping in good shape. The lots were divided so as to have them as nearly equal in weight, in age, and in period of lactation as was possible with the cows available, and the subsequent records showed that the lots proved to be very uniform.

A minimum allowance of grain was fed each year. The first year, it consisted of one part bran and one part crushed oats. The second year, it consisted of one part bran and one part chopped barley. As small an allowance of grain was given as was thought practical in order to throw the test as completely as possible on the different crops of hay. With this in mind, 0.65 pound of the grain mixture was fed per day for each pound of butter fat produced each week. That is, a cow that was producing 10 pounds of butter fat per week received 6.5 pounds of the grain mixture per day.

The first year, after the preliminary period, the first test period consisted of four weeks, the second test period four weeks, and the third test period three weeks, it being necessary to finish the experiment one week earlier than planned on account of the hay running short.

Both feed and milk were carefully sampled for chemical analysis. The milk was composited for a week and the samples tested for butter fat each week, the calculations for fat being based upon these results.

The results here reported are only for the yields of butter fat and the feed consumed, the chemical data not having been included. The results are stated in number of pounds of butter fat produced for each 100 feed units consumed. A feed unit is an expression to equate the various feeds used to a uniform basis. The factors used are those reported as results of a very great number of Danish feeding experiments and include also data from the results obtained in the United States recently published by the Wisconsin Experiment Station, that is, one pound of grain of certain kinds, such as corn, barley, wheat, and so on, is considered to equal one feed unit. This is taken as a basis. 1.1 pounds of oats are required to equal 1 feed unit, 1.1 pounds of bran equal one feed unit and 2 pounds of alfalfa hay are considered equivalent to 1 feed unit. That is, the grains used stand in the ratio 1 pound of barley equals 1.1 pounds of oats equals 1.1 pounds of bran, equals 2 pounds of alfalfa hay.

The calculations based upon these factors give the first year for each 100 feed units consumed: the first hay crop produced 5.16 pounds of butter fat; the second crop produced 5.40 pounds of butter fat; the third crop produced 4.88 pounds of butter fat.

The results of the second year show that 100 feed units from the various crops produced as follows: First crop, 4.80 pounds of butter fat; second crop, 5.30 pounds of butter fat; third crop, 4.66 pounds of butter fat.

Both years' results, then, seem to favor second crop hay. This is decidedly contrary to the experience of the average farmer and the results cannot be taken upon the figures themselves.

In noticing the way the animals ate the various crops of hay, we found that they took more readily and consumed more actual pounds of first crop hay than any of the others. Third crop hay stood second in this respect and the second crop hay was eaten only reluctantly. It was aimed to feed only what the cows would clean up well each day, but, in spite of this the animals refused considerably more of the second crop hay that was offered them than they did of the other two crops.

The results seem to indicate one of two things, either the hay used differed less between first and second crop than the average hay, consequently produced results closer, or that it is possible for the average cow to consume more alfalfa hay than she will return profit for, suggesting that it may be wise to limit the hay ration of a dairy cow for most economical results. For highest production, of course, if economy is not considered, all the hay that will be cleaned up should be fed and observations made on the experiment would suggest that the hay would stand for this purpose: first crop, third crop, second crop, in the order given.

Any general conclusions or statements are reserved awaiting the results of further experimentation.

Published as Bulletin No. 126 of the Utah Experiment Station, Aug., 1913.

PROGRESS IN CEREAL IMPROVEMENT AT NEPHI SUBSTATION.

BY P. V. CARDON.

(Abstract.)

The work of cereal improvement at Nephi has been in progress since 1908. It has been conducted along two important lines, (1) the introduction of all existing varieties of cereals which gave any promise of being adapted to local conditions, with a view to determining their relative value, and (2) the isolation and increase of superior strains of these varieties.

One hundred and four varieties and strains of cereals have been tested. The tests have shown the superiority of the winter varieties. Of these, winter wheat, especially of the hard group, has given the best results.

The isolation and increase of superior strains has been accomplished by what is known as continuous selection. This work has shown the possibilities of improving the present known varieties of cereals. In some instances an increase of 5 to 10 bushels per acre has been obtained.

MOLECULAR REALITY.

By H. Fletcher.

(Abstract).

A short review of the history of the kinetic theory.

A summary of the equations used in determining molecular magnitudes. Description of Brownian movements in gases. Calculation of the average displacement due to Brownian movements: (1) Along a line; (2) In a plane; (3) In space. Calculation of the actual displacement and time of fall when an outside force is acting. Development of formulae which give the distribution of the displacements about the mean value. Description of recent experiments and presentation of data which completely verify the theoretical formulae. Calculation of all of the molecular magnitudes from the data. Verification of the fact that a gaseous ion and an ion taking part in electrolysis is the same.

SEVENTH ANNUAL CONVENTION OF THE UTAH ACADEMY OF SCIENCES.

Chemistry Lecture Room, University of Utah.
December 26 and 27, 1913.

Friday, December 26, 1913, 8 P. M.

"COMMUNITY LIFE AMONG INSECTS," (Presidential Address), ...By E. G. Titus, U. A. C.

"THE QUESTION OF VALENCY IN GASEOUS IONIZATION," ......By Dr. Harvey Fletcher, B. Y. U.

Saturday, December 27, 1913, 9:30 A. M.

"SOME METABOLIC EFFECTS OF BATHING IN GREAT SALT LAKE,"[1] ...By Dr. Helen I. and Dr. H. A. Mattill, U. U.

"CORN UNDER IRRIGATION," By Dr. Frank S. Harris, U. A. C.

"PRACTICAL EXPERIMENTS WITH ROOT BORERS," By Prof. M. R. Porter, Weber Stake Academy, Ogden

"HOW FAR IS SCIENTIFIC EXTENSION PRACTICABLE," ....By Dr. E. G. Peterson, U. A. C.

Saturday, December 27, 1913, 2 P. M.

"SOME FEATURES OF THE RECENT INTERNATIONAL CONGRESS OF GEOLOGISTS," .....By W. D. Neal, Salt Lake City

"OUTLINE OF MINING AND SMELTING CONDITIONS AT SANTA FE, NEW MEXICO," ...By B. Arthur Berryman
(In the absence of the author, read by the secretary).

"RELATION OF VENTILATION TO THE KEEPING OF FRUITS AND VEGETABLES," ....By Dr. Geo. R. Hill, Jr.

"URADIUM AND VANADIUM DEPOSITS IN UTAH," ....By Prof. M. E. Jones, Salt Lake City

"THE INFLUENCE OF ARSENIC ON BIOLOGICAL TRANSFORMATIONS OF NITROGEN IN THE SOIL"............By Dr. J. E. Greaves, U. A. C.
(In the absence of the author, the paper was summarized by Dr. Titus).

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[1] Published in Amer. Jour. Physiology **36**: 488-500. March, 1915.

CORN UNDER IRRIGATION.

BY F. S. HARRIS.

(Summary).

The proper use of water is the most important question in the agriculture of arid regions; and the consistent use of manure is necessary to the establishment of a permanent agriculture in any country.

Corn is one of the most important of the crops raised by American farmers. Its study, therefore, has economic as well as scientific importance.

This paper reported tests of the effect of soil moisture and manure on the yield and morphology of corn.

The highest yield of corn to the acre of land was produced where from fifteen to thirty acre-inches of water were applied. Twenty inches is probably the best amount to use under Greenville conditions.

Where forty acre-inches of water were applied there was a decrease in yield of corn, a waste of water, a loss of time in applying the unnecessary water, and injury to the soil; hence the wise farmer will avoid the excessive use of water.

Manure gave sufficient increase in yield of corn to make it worth about $2.00 a ton.

Many results are given showing the effect of irrigation water and manure on relative amounts of different parts of the corn plant.

Large amounts of irrigation water cause the corn to have relatively less grain, cobs, and leaves, and more husks and stalks.

Manure decreased the percentage of grain, cobs, and husks in the plant, but increased the percentage of stalks and leaves.

Soil treatments affected the branching of the corn tassels in the same manner that they affected the production of ears.

The time of maturity of corn was delayed by irrigation, but hastened by manure. This is important since the earliness in maturity of corn is very desirable in Utah.

The germination of corn was most rapid and complete in a soil containing a medium amount of soil moisture.

The number of stomata on a given area of leaf surface was increased by a large amount of soil moisture. This probably causes wastefulness in transpiration.

The proportion of roots to tops was increased by lowering the soil moisture. When deep rooting is desired, over irrigation should, therefore, be avoided.

OUTLINE OF MINING AND SMELTING CONDITIONS AT SAN PEDRO, NEW MEXICO.

By B. A. Berryman.

This paper is what might be called a reconnaissance survey of conditions at the San Pedro Copper Mine. The property of the Santa Fe Gold & Copper Mining Co. is located in the San Pedro Mountains, Santa Fe County, N. M. It is about 40 miles from Santa Fe, and 18 miles from Stanley, the nearest railroad point.

This mountain, together with the Ortiz mountain on the north and the South mountain on the south, form a large hog-back in the Estancia valley. These mountains are not very rugged, and practically all rocks are angular, indicating very little water action.

The slopes of the mountains are fairly well covered with vegetation consisting in the main of scrub cedars, pinyon pines, and cacti. The predominant type of cacti is the tree cactus growing to a height of from six to seven feet. The flat Opuntia is also very common, then a few cacti having a bee-hive shape are found. There is practically no shrubbery or small plants, not even sage brush. The cacti seem to take the place here of the sage and rabbit brush as found in Utah.

The San Pedro Mountains are the result of a laccolith intruded into Carboniferous strata. The northern, western, and eastern slopes are composed almost entirely of the laccolithic material, which has a characteristic porphyritic texture. In the central part and on the southern slope considerable of the laccolithic roof is preserved, having a thickness of about 700 feet. To the north of the San Pedro Mountains is a large series of red shales, which are placed in the Cretaceous by the U. S. G. S., they having found considerable ammonites in them.

From the City of San Pedro, which is one and a half miles west of the property, up to the smelter there are about 200 feet of Carboniferous limestones, which occur in heavy flat benches, and are used as a flux by the smelter. It averages from 45 - 55 per cent CaO in excess of silica.

Above the smelter is about 700 feet of highly metamorphosed strata consisting first of beds of limestones in which are crinoid stems, and a few Productus. The horizon is given as the Madera limestones of the Carboniferous, by Waldamare Lingreen. Above the limestones are sandstones and shales, also of the carboniferous period. The whole series dips to the east 10 to 15 degrees.

The greatest part of the igneous rocks is a granodiorite porphyry of a fairly uniform texture. Under a good lens crystals of andesite and hornblende are easily seen, imbedded in quartz and orthoclase. An analysis of this rock gave:

Silica	62.08[1]
CaO	4.76
Na_2O	4.62
K_2O	2.84

Besides the large laccolith there are several dykes intruded into the limestones. One near the top of the mountain is a grayish-yellow porphyritic mass, without any dark crystals. The groundmass is orthoclase and quartz. Another dyke just below the one described has a fine grained white porphyritic texture with a groundmass of a micropoikilitic intergrowth of quartz and orthoclase.

I have not been able up to the present time to find any lamprophyric dykes.

Contact metamorphism is extremely well shown, especially in the roof of the laccolith. The whole sedimentary series that overlies the laccolith and forms the western summit of the mountains is greatly altered. The limestone nearest the igneous rocks is irregularly crystallized and garnetized and contains calcopyrite. The shales above the limestones show less metamorphism, but they have a baked appearance (and have lost to a great degree, their fissility, and where they are calcareous hornfels containing diopsite and lime feldspars are formed).

Considerable faulting has taken place subsequent to the igneous intrusion. All faults so far examined are of the normal type. The dip varies from 70 to 85 degrees and the throw from a few inches to 300 feet.

[1] U. S. G. S. New Mex. No. 28.

The ore deposits of the San Pedro Mountains present a typical example of deposits attending igneous activity. At the contact copper deposits with a garnet gangue are formed. Narrow gold veins are abundant both in the porphyry and the altered sediments. Then in the unaltered limestones farther away from the contact, galena of the replacement deposit type is found. Then as a result of erosion gold bearing gravels have accumulated at the base of the mountains and have been worked since the time of the Spaniards 200 years ago.

The workings of this company are confined entirely to the copper deposits of the garnet zones. There are three well defined ore bearing zones, known locally as Nigger Heaven, Middle, and Lower zone. These garnet zones are separated one from another by a white quartzese porphyry. These quartzese porphyries are facies of the main igneous mass. The distribution of the pay ore in the garnet beds is extremely irregular. At places the ore shoots are 30 - 40 feet high and several hundred feet long. The average height of the stopes are 5 - 6 feet. The ore is mostly calcopyrite with some bernite, cuprite, and a little malacite and azurite in the upper workings where oxidizing conditions have prevailed. The oxidized zone however is very shallow, not more than 150 feet. The calcopyrite is invariably associated with the yellow garnet, andradite, and in a few places with also a little pyrite, specularite, and wollastonite.

Mining is almost entirely by the overhand stoping methods. The shaft is 220 feet deep and is tapped 180 feet from the collar by a tunnel to the surface. Most of the workings are above the tunnel level. Hence all ore is dumped in shoots to this level where it is trammed to the shaft and hoisted to the surface. All waste is trammed out the tunnel, the hoist not being large enough to handle both the ore and waste tonnage. The hanging wall of all the stopes is hard and tough and stands extremely well. Timbering is practically unknown. In a few of the very large stopes pillars of low grade are left for support. If timbering had to be used in the stopes it would increase the cost of mining to such a degree, that from an economic standpoint, mining the ore at a profit would be out of the question.

All the ore is hoisted through the Richman shaft by a two ton self dumping skip, where it passes over the picking belt. The ore first passes over a grizzly and then through a blake crusher set to 4 inches. It is then elevated to the picking belt by a belt conveyor. The picking belt consists of a 24 inch belt conveyor moving about 30 feet per minute. There are from five to ten Mexicans on each side of the belt who pick out the waste which is subsequently trammed to the dump. The sorted ore drops from the picking belt to a cross conveyor belt which delivers it to the bin at the top of the gravity tramway. The gravity tram is about 800 feet long, and by means of two two-ton skips on a three rail system, the ore is delivered to the smelter bins at a cost of from 2 to 3 cents per ton.

The mine ore sample is taken by an automatic sampler installed at the picking belt, the sample being crushed, coned, and quarted as usual.

The smelting is done in a 40 inch by 120 inch copper matting furnace of twenty tuyers, and a drop of 9 feet. The furnace is jacketed with steel water jackets, and operates under a blast of about 11 oz. mercury. The blast is furnished by a Root Blower of 85 cu. ft. air per revolution, and an average speed of 84 r. p. m. The blower being driven by a 125 H. P. Norberg Corliss engine direct connected.

The furnace is tapped on the side under the tuyers, the intermittent tap being used. The matte and slag flows into a small fire brick settler having inside dimensions of 6 feet 8 inches by 3 feet by 2 feet 8 inches. Slag flows from the settler into 5-ton pots which are pulled to the slag dump by a donkey hoist. Matte is tapped into moulds holding about 150 lbs. to the pan depending on the grade of matte. The matte is weighed at the end of each shift, and is then stored in a warehouse until a carload is ready to ship. Each carload averages 43 tons with the probable exception of the last car of each month, when the matte is all cleaned up. An assay for copper, gold and silver, is run on each carload lot. Then a copper average for the month of all lots shipped is run.

The composite slag is run every month, which averages:

SiO_2	40.6%
FeO	20.5
CaO	28.9
Copper	0.55

The copper loss is accounted for by the small amount of settling space in the settler. The matte averages from 45 - 60 per cent copper.

The average analysis of the ore is:

SiO_2	36.0%
Fe	14
CaO	22
Sulphur	3
Copper	2.8%

In order to make a 45-50 per cent matte we have to supply more sulphur. This extra sulphur is furnished by the addition to the charge of a sulphide ore which is shipped in from Leadville, Colorado. The average amount necessary to furnish enough sulphur to give the required 45 to 50 per cent matte is 75 lbs. per 1500 lbs. of mine ore. A typical furnace charge is as follows:

Mine Ore	1500 lbs.
Leadville Sulphide	75
San Pedro Slag	200
Limerock	150
Coke	12.2%

A typical slag from the above charge will average:

SiO_2	40.4%
FeO	21.6
CaO	28.0

The greatest drawback to this company is transportation. As before noted this property is 18 miles from a railroad. Practically all freighting is done by team at a cost to the company of $4.00 per ton. This freighting charge increases the cost of coke to $10.50 per ton. Coal costs $3.50

per ton for haulage from the company mine, 14 miles from the smelter. A Rumley Oil Tractor has been installed, and for 8 months out of the year hauls part of the coke up to the smelter, and matte down to the railroad. The matte is shipped to El Paso for converting. The cost per ton by the tractor is $2.00. No doubt if transportation facilities could be bettered this would be one of the best mines in New Mexico.

THE INFLUENCE OF ARSENIC UPON THE BIOLOGICAL TRANSFORMATION OF NITROGEN IN SOILS.

By J. E. Greaves.

(Published in Biochemical Bulletin, Vol. III, (1913), pp. 2-16.)

(Summary)

The article represents a study of the effects of arsenic upon the bacterial activities of the soil and it shows that one hundred parts per million of sodium arsenate may be applied to a soil rich in calcium and iron without materially decreasing the ammonifying and nitrifying powers of that soil. Smaller quantities may stimulate these activities.

Zinc arsenite, lead arsenate, and arsenic trisulfide stimulate the ammonifying activities of a soil, and their toxicity is not very marked until comparatively large quantities of arsenic are present. The two former reduce the ammonifying and nitrifying activities only one-half when 1,120 parts per million of arsenic are present, while arsenic trisulfide exerts a stimulating influence upon the ammonifying activities of the soil in the lower concentrations and does not become very toxic even in the highest concentrations.

Paris green exerts marked toxicity on the ammonifiers, even when present in small quantities. When present in large quantities it practically stops ammonification in soil.

All these compounds stimulated nitrification, the stimulation being least for Paris green and greatest for lead arsenate.

Arsenic trisulfide and Paris green, when present in large quantities, nearly stopped nitrification.

Arsenic stimulated ammonification and nitrification, when it was present in soils in small quantities, but in very large quantities it was toxic. It is improbable, however, that lead arsenate, zinc arsenite, or arsenic trisulfide, will ever be applied to agricultural soil in quantities sufficient

to become injurious to soil bacteria. Paris green may, but the quantity added would have to be large.

The stimulating activity of the various compounds added to the soil, upon ammonifying organisms and especially upon the nitrifying forms, is partly due to the anion and partly to the cation. Much of their action may be due to their influence upon injurious species.

Water-soluble arsenic may exist as such in soils to the extent of 82 parts per million without entirely stopping ammonification and nitrification. Large quantities of ammonia and nitric nitrogen may be produced in a soil containing 50 parts per million of water-soluble arsenic, which is a greater quantity than any ever found in an agricultural soil.

Measured in terms of their influence upon ammonification and nitrification as it takes place in soil, the toxicity of lead arsenate is the least. Next come zinc arsenite and arsenic trisulfide. The greatest toxicity is exerted by Paris green. From the results reported in the literature on the subject, this seems to be the sequence of toxicity when tests are made on the higher plants.

There is nothing in these results to indicate that arsenic trisulfide, or zinc arsenite, is as safe as lead arsenate for use as an insecticide. Arsenic trisulfide may be safer when first added to the soil, as is shown by its being almost insoluble when first applied and having practically no toxic influence upon ammonification; but, as bacterial action takes place in the soil, the arsenic of the arsenic trisulfide is much more soluble than that of lead arsenate, and becomes toxic to the nitrifying organisms when it is present in large quantities.

EIGHTH ANNUAL CONVENTION OF THE UTAH ACADEMY OF SCIENCES.

Chemistry Lecture Room, University of Utah.
April 2 and 3, 1915.

Friday, April 2, 1915, 8 P. M.

"THE RIGHTS AND DUTIES OF THE SCIENTIST," (Presidential Address) By Prof. Marcus E. Jones, Salt Lake City

"THE TEXTILE FABRICS OF THE CLIFF DWELLERS" ......By Prof. Byron Cummings,, U. U.

Saturday, April 3, 1915.

"CONTROLLING GRASSHOPPERS," ..By Dr. E. D. Ball, U. A. C.

"EFFECT OF SOIL ALKALI ON PLANT GROWTH," ....By Dr. Frank S. Harris, U. A. C.

"SOME UNIQUE RUSTS,"
By A. O. Garrett, High School, Salt Lake City

"EFFECT OF THE AMOUNT OF PROTEIN CONSUMED UPON THE DIGESTION AND PROTEIN METABOLISM OF LAMBS AND UPON THE COMPOSITION OF THEIR FLESH AND BLOOD" .....By Dr. W. E. Carroll, U. A. C.

Saturday, April 3, 1915, 2 P. M.

"A DETERMINATION OF AVOGADRO'S CONSTANT N" ......By Dr. Harvey Fletcher, B. Y. U.

"THE VOICE TONOSCOPE" ..By Dr. Franklin O. Smith, U. U.

"THE ORIGIN OF HIGHER ORDERS OF DIFFERENCE TONES: EXPERIMENTAL" ....By Dr. Joseph Peterson, U. U.

"THE HOT AIR FURNACE—A STUDY OF COMBUSTION" ....By Dr. W. C. Ebaugh, U. U.

"COLOR PHOTOGRAPHY"
By Dr. Chas. T. Vorhies, U. U. and Prof. Marcus E. Jones, Salt Lake City.
(Illustrated with lantern slides and color photographs).

EFFECT OF SOIL ALKALI ON PLANT GROWTH.

BY F. S. HARRIS.

(Summary).

Results of over 18,000 determinations on the effect of alkali in the soil on the germination of seeds and the growth of plants were presented. From these data the following conclusions were drawn:

The effect of the various alkali salts in soils on plant growth and the quantity of alkali that must be present to injure crops are of great practical importance to farmers in arid regions, as well as of considerable interest to the scientist.

Only about half as much alkali is required to prohibit the growth of crops in sand as in loam.

Crops vary greatly in their relative resistance to alkali salts, but for the ordinary mixture of salts the following crops in the seedling stage would probably come in the order given, barley being the most resistant: Barley, oats, wheat, alfalfa, sugar beets, corn, and Canada field peas.

Results obtained in solution cultures for the toxicity of alkali salts do not always hold when these salts are applied to the soil.

The percentage of germination of seeds, the quantity of dry matter produced, the height of plants, and the number of leaves per plant are all affected by alkali salts in about the same ratio.

The period of germination of seeds is considerably lengthened by the presence of soluble salts in the soil.

The anion, or acid radical, and not the cation, or basic radical, determines the toxicity of alkali salts in the soil. Of the acid radicals used, chlorid was decidedly the most toxic, while sodium was the most toxic base.

The injurious action of alkali salts is not in all cases proportional to the osmotic pressure of the salts.

The toxicity of soluble salts in the soil was found to be in the following order: Sodium chlorid, calcium chlorid, potassium chlorid, sodium nitrate, magnesium chloride,

potassium nitrate, magnesium nitrate, sodium carbonate, potassium carbonate, sodium sulphate, potassium sulphate, and magnesium sulphate.

The antagonistic effect of combined salts was not so great in soils as in solution cultures.

The percentage of soil moisture influences the toxicity of alkali salts.

Salts added to the soil in the dry state do not have so great an effect as those added in solution.

Land containing more than about the following percentages of soluble salt are probably not suited without reclamation to produce ordinary crops. In loam, chlorids, 0.3 per cent; nitrates, 0.4 per cent; carbonates, 0.5 per cent; sulphates, above 1.0 per cent. In coarse sand, chlorids, 0.2 per cent; nitrates, 0.3 per cent; carbonates, 0.3 per cent; and sulphates, 0.6 per cent.

SOME UNIQUE RUSTS.

The rust fungi include over two thousand species of parasitic fungi. The usual text-book in elementary botany uses *Puccinia graminis* or wheat rust as the type of these species—a rust probably as atypical as could be selected.

In order that the references in this paper shall be clear, permit me to give a few elementary definitions. Rusts are either autoecious or heteroecious—an autoecious rust being one that has all of its spore forms on the same species of host plant, while a heteroecious rust requires two species of hosts for its life cycle. The complete life cycle of a heteroecious rust is as follows: In the spring spores called aeciospores are produced in chains in a special cup-shaped spore-case (technically a peridium) called an aecium. These spores are blown to the alternate host, and there germinate, producing a mycelium (or rust plant) within the tissues of the host. Within a short time this mycelium fruits by producing clusters of one-celled reddish or brownish spores called uredospores. These blow to other plants of the same species, germinate and form new mycelia, which in due time produce their successive crops of uredospores, and so on all during the summer. The uredospores are the multiplying spores of the plant. In the late summer or in the autumn, the same mycelium which has been producing uredospores now produces clusters of two-celled, thick-walled spores known as teliospores. Although in a few forms these germinate at once, in most forms they remain on the plant during the winter, and in the early spring (about the time the alternate host has begun to leaf out), each teliospore germinates by producing from each of its two cells a tube called a promycelium. This promycelium cuts off four cells at its upper extremity, and from each of these cells develops a minute spore called a sporidium. The sporidium is blown to the host that produced the aeciospores, and there germinates into a mycelium which gives rise to the aecia again.

But we have many variations from the above typical life history. Some rusts never have the aecial stage; some never have the uredo stage; while still other species omit both of these stages, the spores that are produced being only sporidia and teliospores. Again, some do have all the stages when conditions are favorable, but can abbreviate their life-history if one of the alternate hosts is not available for infection. Wheat rust is a splendid example of this.

In the study of the rusts certain general relationships have been recognized as existing in nature. The purpose of this paper is to call attention to some departures from these. For example, it is believed in general that all the rusts on the grasses, rushes and sedges are not only heteroecious, but that they have their aecial stage on some dicotyledonous host. A striking exception to this is *Puccinia graminella* (Speg.) Diet. & Holway, found on *Stipa eminens* Cav., which produces its aecial stage on the same host as the teliospores, i. e., it is autoecious. But *Puccinia graminella* is unusual in another respect. All other grass rusts so far as known produce the complete cycle of spores—aecia, uredo and telial—but this species apparently does not produce the uredospores.

Another unusual grass rust is the race of Puccinia found on Phalaris. These rusts produce their aecia on a monocotyledonous host.

It is expected that the sporidia from the teliospores will inoculate one and only one, or at most two or three very nearly related, species of host-plants. Imagine the surprise of the botanical world when the peculiar case of *Puccinia subnitens* Dietel was recognized. It has been proved by inoculation experiments that its sporidia produce aecia on *Cleome serrulata, Cleome spinosa, Chenopodium album, Radicula sinuata, Sisymbrium incisa, Salsola Tragus, Lepidium apetalum, Lepidium virginicum, Capsella Bursa-pastoris, Erysimum asperum, Atriplex hastata and Sarcobatus vermiculatus*—twelve species representing three very distinct families of plants.

Another rust of much interest, *Aecidium tuberculatum*, E. & K., occurring on *Callirrhoe involucrata*, has been considered of much interest because its mycelium seems to be perennial. Now, an aecium is at most only a temporary structure, and it has no business with a perennial mycelium! On this account, the rust was discussed at some length in 1904 by Mark A. Carleton in Bulletin 63 of the Bureau of Plant Industry. But the apparent discrepancy has just been explained by Dr. J. C. Arthur and F. D. Fromme. In the February, 1915, number of the Bulletin of the Torrey Botanical Club, it is shown that the rust is really an *Endophyllum* in the telial stage (instead of the aecial stage of some rust of the genus *Puccinia* or *Uromyces*). The genus *Endophyllum* is one in which the telial form resembles very closely in appearanc the aecial stage of other rusts. Arthur and Fromme succeeded however in producing the conclusive promycelia and sporidia by means of the Kunkel method of sowing the spores on the surface of a non-nutrient agar.

It is the rule among heteroecious rusts having all spore forms that the teliospores will not germinate until the following spring; i. e., not until they have been exposed to the rigors of winter. But *Uromyces Houstonianus* (Schw.) Shelton is the single known exception to this rule by germinating as soon as produced. It occurs on *Sisyrinchium graminoides* Bicknell.

Some of the most striking departures from rule are found in the genus *Gymnosporangium*. These rusts are heteroecious, having the teliospores on some Gymnosperm, usually of the cedar group, and the aecial stage on some ligneous species of the *Malaceae*. But there are several radical exceptions to this statement. For instance, *Gymnosporangium bermudianum* (Farl.) Seym. & Earle is autoecious, having both spore-forms on species of Juniper. The aecia of *Gymnosporangium exterum* Arthur occur on *Gillenia stipulacea,* an herbaceous annual belonging to the family *Rosaceae,* and those of *Gymnosporangium gracilens* (Peck) Kern & Bethel are found on *Fendlera rupicola* and species of *Philadelphus,* two hosts belonging to the family *Hydrangiaceae.* But still farther removed from the *Rosaceae* is the host of the aecial stage of *Gymnosporangium Ellisii* (Berk.) Farlow, which occurs on *Myrica cerifera* and *M. carolinensis* belonging to the family *Myricaceae!*

Each teliospore of the Gymnosporangia commonly has two germ-pores to each cell; but in the species *G. multiporum* Kern, recently described from Colorado, there are from five to seven (usually the latter number), to each cell.

Still another perculiar Gymnosporangium is *G. Blasdaleanum* (Dietel & Holway) Kern. This species has in the aecial stage, not the usual so-called *Roestelia,* but the genuine aecium. The aecia of *Gymnosporangium Ellisii* (*Aecidium myricatum* Schw.) also has this unusual characteristic.

The number and arrangement of the germ-pores is becoming an important diagnostic character in the rusts, especially in connection with the uredo-spores of the different species. *Uromyces uniporulus* Kern and *Puccinia uniporula* Orton, two rusts found on Carex, are unusual in that their uredospores have each only one germ-pore, while those of all other known species of rust on Carex have at least two. *Puccinia karelica* is an unusual sedge rust in that it is the only known sedge rust with scattered germ-pores, all other known species having equatorial, super-equatorial or subequatorial pores.[1]

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[1]Arthur and Fromme: "The Taxonomic Value of Pore Characters in the Grass and Sedge Rusts." Mycologia 7:28. 1915.

Many more interesting exceptions to the rule of life history and of structure might be mentioned, but the above will be sufficient to call attention to some of the important ones, which have shed new light on the entire subject. In our own State, but little work has been done on this important and most interesting group if plants. Probably many species occur in the State that at present are unknown to science. No attempt has been made by most of the botany teachers of the State to germinate spores, or attempt culture work of any description. And yet no field for original investigation offers more unsolved problems to tempt one than that of the rusts. It is to be hoped that some attention may be given to the subject by the botany teachers of the State, who can be assured in advance that they will find plenty both to interest, to puzzle and to reward them.

EFFECT OF THE AMOUNT OF PROTEIN CONSUMED UPON DIGESTION AND METABOLISM IN LAMBS AND UPON THE COMPOSITION OF THEIR FLESH AND BLOOD.

By W. E. Carroll.

(Conclusions only).

While the data presented seem to warrant the following conclusions, it should be borne in mind that the differences in protein consumption between animals of the three lots were not great, and that even the low protein animals probably received protein somewhat in excess of their truly minimum requirements.

1. The amount and the chemical composition of the feces of lambs is independent of the amount of protein consumed. This is true whether the corrected or the uncorrected data are considered.

2. The feces of lambs contain considerable quantities of purely metabolic products. To determine accurately the extent of digestion of feeds, the only correction usually made—that for metabolic protein—is in itself insufficient. "Metabolic ash," and no doubt other substances as well, influence the accuracy of the coefficients of digestion.

3. The coefficients which are especially affected are those of protein, fat, and ash. On account of the methods used, little confidence can be placed in those of fat and ash as ordinarily reported. The correction for metabolic protein, while the method is far from satisfactory, should always be made.

4. The amount of metabolic protein in the feces is not influenced by the protein intake. It is more nearly related to the total dry matter consumed than to the amount of dry matter digested as reported by some investigators.

5. The amount of protein consumed (the rations being similar in other respects) does not influence the extent to which any of the food nutrients are digested when judged by corrected coefficients of digestion.

6. The uncorrected data indicate the same, except that for protein a positive correlation exists between protein consumption and the coefficients of digestion of this nutrient.

7. High protein consumption results in high urine output and in high excretion of total and urea nitrogen in the urine. Creatinin is excreted in practically constant quantities irrespective of the protein intake. Ammonia and creatin nitrogen are present in smallest amounts and bear no constant relation to protein ingestion.

8. Expressed on a percentage basis, urea nitrogen makes up a higher proportion and creatinin nitrogen a relatively lower percentage of the total nitrogen of the urine of lambs fed a high protein ration than is the case with lambs on a low protein intake.

9. A slight positive correlation exists between protein consumption and nitrogen retention by growing lambs. The same is true for nitrogen absorption (corrected data) and nitrogen retention.

10. The methods used in this investigation failed to show any influence of the amount of protein consumed upon the nitrogenous composition of the flesh and blood of growing lambs. The only chemical effect observed which followed differences in protein intake is the storage of fat in the boneless meat. This seems to be favored by high protein consumption.

THE VOICE TONOSCOPE.

By Franklin O. Smith.

(Abstract).

Many attempts have been made to measure the motor process involved in singing, reading and speaking. Obviously the unaided ear will not serve the purpose. Attempts to measure these processes by means of graphic and photographic apparatus have failed because these instruments are too cumbersome and admit too many sources of error. What is required is a "simple, and at the same time accurate and ready means of measuring the pitch of tones produced by the human voice."[1]

The instrument which has been designed to solve this difficulty is appropriately called the tonoscope by its inventor, Professor C. E. Seashore. Although complicated in structure it is easy of manipulation and is sufficiently accurate for measuring the pitch and timbre of the voice in singing and speaking.

The tonoscope consists essentially of a movable screen in the form of a drum, which turns on an axis at the rate of one revolution per second. By means of a small acetylene gas flame at the end of a speaking tube in front of the moving screen the vibrations of the voice are reflected upon the screen. The tonoscope, therefore, works on the principle of stroboscopic vision, or the principle of moving pictures.

This stroboscopic effect is produced by a unique method. The screen is perforated by 1800 holes each 3.5 mm. in diameter and spaced with the highest possible accuracy. These holes are arranged in 110 parallel rows, each completing the circumference of the drum in uniform spacings for each row. The number of holes increases, by one for each row, beginning with 110 holes, over one octave.

As one sings a given tone, say "c," the row of holes corresponding to the vibration frequency of this tone appears to stand still while all the rows at the right of this one appear to move forward and all those at left appear to

[1] Seashore. The Tonoscope Psychological Monographs. No. 69, pp. 1-12.

move backward. By this means and by other simple devices, the reading of the tonoscope is comparatively easy, thus making it possible to train the voice by means of the eye.

Measurements have been made with this instrument on the ability to strike a pitch, to sustain a tone and to modulate a tone.[2] The vowel sounds have been analyzed and their characteristic qualities revealed. The tonoscope has already demonstrated its utility in discovering musical ability and promises large returns in a specific field of applied psychology.

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[2] W. R. Miles. Accuracy of Voice in Simple Pitch Singing. Psychological Monographs. No. 69, pp. 13-66.

NINTH ANNUAL CONVENTION OF THE UTAH ACADEMY OF SCIENCES.

Chemistry Lecture Room, University of Utah.
April 7 and 8, 1916.

Friday, April 7, 1916, 8.00 P. M.

"INDUSTRIAL RESEARCH IN THE UNITED STATES," (Presidential Address) ...By Dr. Harvey Fletcher, B. Y. U.

"THE ALKALI CONTENT OF CERTAIN UTAH SOILS" ....By Dr. Frank S. Harris, U. A. C.

Saturday, April 8, 1916, 10.00 A. M.

"THE AGRICULTURAL COLLEGE AND SCIENTIFIC RESEARCH" ....By Dr. E. G. Peterson, U. A. C.

"SELECTING BULLS BY PERFORMANCE" ....By Dr. W. E. Carroll, U. A. C.

"PEYOTE, AN INDIAN NARCOTIC" By A. O. Garrett, East High School, Salt Lake City

"THE PRESENCE OF RABIES IN UTAH" ....By Dr. L. L. Daines, U. U.

"AN EPIDEMIC OF COLDS WITH MICROCOCCUS CATARRHALIS.. AS CAUSATIVE AGENT" .....By Dr. L. L. Daines, U. U.

Saturday, April 8, 1916, 2.00 P. M.

"BOTULINUS POISONING" ....By Dr. L. L. Daines, U. U.

"COMPARISON OF METHODS OF TREATMENT FOR GRAIN SMUTS" ....By M. Rich Porter, Salt Lake City

"A NEW COUNT METHOD OF MEASURING THE ELEMENTARY ELECTRIC CHARGE" ..By Dr. Harvey Fletcher, B. Y. U.

"THE VALUE OF GASEOUS IONIZATION IN HYDROGEN" ....By Prof. Carl F. Eyring, B. Y. U.

"OUR NATIONAL AWAKENING TO THE IMPORTANCE OF SCIENCE" ......By Dr. W. C. Ebaugh, Salt Lake City

INDUSTRIAL RESEARCH IN THE UNITED STATES.

By Harvey Fletcher.

Although in some lines, especially chemistry, there has been some industrial research ever since the birth of our nation, it is comparatively recent since it has been recognized as a very important part of the large industrial organizations.

The large corporations are beginning to see that the development work, especially with the big problems, is carried on much more successfully by University men rather than by the so called practical man, who has received his education in the business.

As early as 1795 James Woodhouse, Professor of Chemistry of the University of Pennsylvania, took an active interest in commercial problems. He showed that anthracite coal was better than ordinary bituminous coal for giving "intensity and regularity of heat."

Also about this time John Harrison, the first manufacturer of sulphuric acid, took an active interest in industrial problems. There has always been scientific research men connected with the mining industry, especially in the milling and smelting of the ores. There were a great many chemists who contributed to our industrial development during this time. Work on beet sugar, production of gelatine, illuminating oils, manufacture of bleaching powders, manufacture of Bessemer steel were things which were accomplished by the chemists of this period.

In 1860 Joseph Wharton made it possible to establish firmly a new industry by discovering a new process for the manufacture of zinc.

During the 25 years succeeding this, a great deal was done in the steel industry, the preservation of wood and on products of petroleum, etc. After the construction of power plants at Niagara Falls, making it possible to produce electrical energy very cheaply a number of new processes were invented for the manufacture of metals and chemicals notable among which was the process of producing aluminum by Charles M. Hall, a young Oberlin graduate.

Aluminum was discovered in Germany by Mohler in 1828. In 1855 it cost $90.00 per pound. In 1886 it had fallen to $12.00. The American Castner process brought it to $4.00. Hall discovered that eyolite fused readily at a moderate temperature and when so fused would dissolve alumina very readily. If the solution is electrolized the pure metal is obtained. This process was instituted in 1895 with the result that the market price is now about 20 cents and 50,000 tons are being manufactured yearly.

The Du Pont Co. in Delaware, manufacturers of gun powder, employ 250 trained chemists. Its chemical department comprises three divisions; the field division for the study of problems which must be investigated outside the laboratory and which maintains upon its staff experts for each manufacturing activity together with a force of chemists at each plant for routine laboratory work; second, the experimental station which comprises a group of laboratories for research work on the problems arising in connection with the manufacture of black and smokeless powder, and the investigation of problems or new processes originating outside of the company; the eastern laboratory which confines itself to research concerned with high explosives. Its equipment is housed in 76 buildings, the majority being of considerable size spread over 50 acres. It is estimated that this eastern research laboratory yields a profit of $1,000,000 annually. It is estimated that the recent invention by Gayley of the dry air blast in the manufacture of iron saves the American people about $20,000,000 annually.

In Agriculture, the largest of our industries, we were slow to adopt the methods of scientific research. The first U. S. commissioner report of 1868, he states that in a few colleges some work in agriculture was attempted but, inasmuch as no teachers had been prepared, they necessarily would need to be self taught in the schools in which they were teaching. Shortly after this, a number of Agricultural schools came into existence, so that by 1876, there were 39 colleges with 473 professors and 4,211 students which had taken advantage of the land grant of July 2, 1862, for the establishment of schools of agriculture. However, very little research was done until 1889, when the government experiment stations came into existence.

The first agricultural experiment station in America was established at Middletown, Conn., in the chemical laboratory of Wesleyan University, 1875. By 1887 there were 17 of these in operation in the United States and in 1889 there were 46 stations maintained by the government employing 370 trained men and costing about $720,000 per year.

From this splendid beginning the department of Agriculture has come to be a very important part of the central government. It has divided itself into clearly defined lines regulatory, research, and educational and it is in this branch that the research man gets splendid support from the government. There are now 65 experiment stations and 69 agricultural colleges.

As is evidenced from our program, the scientific men in our Utah experiment station are contributing a very generous share to this great work.

As far as I know, the biologist is doing little for the great industries, except as it has its very important connection with Agricultural research. As physicians and surgeons and as researchmen at our large universities, they are doing a wonderful work for our nation; but they are not hired directly by the large corporations to do research work, although a great number are employed in applying principles which are quite well established in improving sanitation and health conditions.

The farm property in the U. S. A. is now worth about $43,000,000,000 and is increasing daily. Many of the more educated class are looking toward the farm as a desirable place, and since this industry is at the very basis of our existence, it is no wonder that the great volume of the research work done by the government is in the Department of Agriculture. In the year 1913, the printing alone in this department cost $400,000. Its many agents cover practically the whole earth and its annual expenditures are many millions. The Bureau of Soils, the Bureau of Plant

Industry, the Bureau of Animal Industry and the Forest Service have to do with our very national existence. The Bureau of Chemistry, by its relation to the pure food laws touches our daily lives and protects the manufacturer from unfair competition. The work of this bureau also stimulates manufacturers of foods to produce better products, and therefore these companies are beginning to see the real need of establishing research departments in connection with their business. The work of this bureau is supplemented by the work of the state and city boards of health.

So we may say that through the combined efforts of the Department of Agriculture, the experiment stations, agricultural colleges, manufacturers of farm implements, is devoted a greater amount of scientific research than any other business in the world.

Then there is the bureau of fisheries, which spend $40,000 on a highly specialized field of biology, the bureau of geological survey spending about half a million, a great deal being spent for original research, the bureau of mines spending over $300,000 for technical research on problems pertaining to our mining industry. The bureau has done a great deal for mining in the way of finding new and better explosives. All coal used by the government costing $8,000,000 is purchased only upon the recommendations of this bureau. Then we have the Bureau of Standards. So we see at the present time, the government is doing a great deal in industrial research, but I think it is only a fair beginning and in the future we will see a rapid growth in the line of work, especially in some departments.

Just as Germany has become a great industrial nation, so will the United States when she realizes the necessity of a close co-operation between the University laboratory and the industrial plant.

It is comparatively recent since any of the large corporations have maintained a research department with the exception of a few individual chemists, and there are a great number who still do not see the necessity of maintaining such a department. I mention particularly some of the achievements of some of the corporations whose research departments are, we might say, just in the making.

The American shoe industry was one of the first to maintain a well directed research laboratory. It is marvelous when we contemplate what they have accomplished, both in the preparation of the leather and the precision apparatus which constructs the shoe. These achievements are due to no single individual, but to a group.

The development of the automobile, especially the low priced car, or putting it plainly, the Ford, is a marvel.

The gasoline consummed in our country equals the water supply of a town of 40,000 inhabitants and its costs, only on holidays and Sundays, are $1,000,000. Many of the automobile companies now maintain research departments comprising designers, chemists, machinists, physicists, mathematicians, etc. One tire manufacturer alone spends $100,000 upon his research department.

In 10 years time the Ford Automobile Company increased its output from less than 2,000 cars to one half million. Each acre of floor space, and there are 47.5 in the plant, produces annually $3,000,000. The number employed number 21,000 and it is claimed that they receive the highest average salaries of any similar group in the world.

It is estimated that a complete Ford car leaves the factory every 25 seconds. The organization of both the men and the placing of machinery is almost perfect. Such a phenomenal growth and astonishing organization is only possible with a well equipped research department of experts, in physical science, in biological science, in social science as well as in commerce and business. Nearly all of our optical companies are starting or already maintain good research laboratories, employing both physicists and chemists.

The Eastman Kodak Company has a splendidly equipped laboratory which has just recently been built in Rochester, N. Y., for specialized work in research. It spends lavishly funds for the investigation of problems which are based upon the fundamental principles upon which the industry rests.

In the paper industry general research is confined mainly to the Forest Products Laboratory at Madison and in the industry it seems we need more technically trained men, men of university training. Most of the manufacturers of paper are content with men who have been trained in the business.

In the steel industry a great amount is expended annually on research work. Especially gratifying has been the results of the work upon the strength of steel rails. In twenty years the locomotive increased its weight over four times so that by about 1905 22 per cent of the rails were moved the first year, due to depressed heads. The problem was given to the research men in the South Chicago Steel Works, and, by changing process of manufacture and the composition of the steel rail they seem successfully to have solved it. The steel rails sent out from this furnace have been in operation 4 or 5 years and no bad reports have been received. When such things are accomplished, the promoters readily see the cash value of the research department.

Probably the largest industrial research laboratory at the present time is that conducted by the General Electric Company in Schenectady, N. Y., and yet it has only been organized fifteen years. In 1901 Dr. N. R. Whitney, Professor of Chemistry in Mass. Inst. of Technology, was engaged to organize a laboratory of physical and chemical research. At first he only gave half his time and his laboratory was 50 x 100 feet in one of the older buildings of the Company. Inside of a year the laboratory force grew to twelve men. In three years (1904) Dr. Whitney gave up his teaching and devoted all his time to research and had thirty-five assistants. During this year the laboratory was moved to new quarters, occupying about forty good research rooms, all equipped with lathes and laboratory equipment. The wiring was such that voltages from 0 to 6,600 volts and currents from 0 to 200 and power up to 150 KW could be supplied to any room. There was also a well equipped store room of chemicals, a machine shop, and a library maintained. All scientific journals are kept on file. During the period when the laboratory was in one room from 1901 to 1904 research work on electric furnaces and their products, organic and inorganic insulating materials, metallurgical operations luminous, was done.

During the succeeding period the metallized carbon filament, the mercury arc rectifier, and the magnetito arc lamp were produced.

Then came the development of the tungsten filament which has revolutionized electric lighting and made possible the X ray target and the tungsten make and break contact.

The wonderful development of the electric furnace is a result of this laboratory. The perfection of this furnace has made possible the study of the magnetic properties of iron alloys, with the result that hysterices and eddy current losses have been greatly reduced. At present the research staff is over 150 and the laboratory is located in a modern seven story building and occupies a floor space of 66,500 square feet. Power is supplied at 250 volts d. c. Three wire systems and at 40 cycles 3 phase 120 volts. In the laboratory power plant are sixteen machines which deliver power at different voltages and at frequencies ranging from 25 up to 2000 cycles. Currents up to 12,000 amperes and voltages up to 2,000,000 may be obtained. An elaborate switch board enables an operator to send any kind of current and voltage anywhere in the building. In the power house there are also a liquid air machine, an air compressor, two large vacuum pumps.

The building is piped throughout with city water, river water, illuminating gas, compressed air vacuum, high pressure hydrogen, low pressure hydrogen, oxygen, high pressure steam. Distilled water may be delivered by gravity to any room, and 250 motors, 80 transformers and 60 vacuum pumps are distributed through the building.

On the first floor are offices, the library of 1400 volumes and the machine shops. The second floor is occupied by research work on insulation; by production work on Coolidge X Ray tube, and by the carpenter shop. Because of the importance of insulation, the company devotes much time to its improvement. On the third floor is the analytical laboratory and electrolytic work. Also work on transformer steel and other alloys are on this floor. One can readily see the importance of a slight decrease in the transformer core loss because of the great saving of power throughout the United States.

The lamp work is located on the fourth floor. A small factory for the manufacture of all kinds of lights is maintained. Photometers of every description for testing efficiency and the most modern apparatus for making life test are on this floor.

Also laboratories of a purely scientific nature with no definite end in view are maintained simply to contribute to scientific thought. Often they suggest definite problems which are of commercial value to the Company.

Besides the one laboratory described, the General Electric Company maintains research laboratories at the Lynn and Pittsfield plants which specialize on the production problems. There are lamp development laboratories at Harrison and Cleveland which develop and standardize new processes, materials, and lamp designs for the factory. There is the physical laboratory at Cleveland, which conducts experiments in physical and physiological aspects of light and illumination. There is the illuminating laboratory at Schenectady devoted wholly to illuminating engineering. There is also the consulting engineering department laboratory, the testing laboratory, and the standardizing laboratory which are all separate from the main research laboratory.

One of the coming research laboratories is that of the Western Electric Company who are the manufacturers of all the telephone and telegraph instruments used in U. S. A. This company is affiliated with the American Bell Telephone and Telegraph Company and manufacture all apparatus used by this company. Two months ago I had the pleasure of visiting this laboratory.

There are in the United States at least fifty splendidly equipped research laboratories, some of them spending over one-half million dollars per year.

So a few of the industries have broken down the tradition that their business and the academic trained scientists have no connection.

It has been mainly due to the work of the University that industrial progress in the past has been possible, although the poorly paid professor received very little financial reward. Today the university man is beginning to receive recognition for his place in industrial development. The banker is beginning to realize that a man who devotes himself to the development of science for science sake alone often yields large financial returns.

For example: A few years ago the electron theory, ionization effects, and especially the photo electric effects were considered of pure academic interest.

This photo electric effect has made possible the wireless telephone, and the new amplifier may soon replace the Pupin loading coil for long distance transmission.

Also the phenomenon of pure electron emission has been used in the Coolidge X ray tube which is so valuable to the physician, and also on the high voltage rectifier. It was not long ago when Lord Rayleigh found nitrogen, taken from the air, had always a slightly different density than that generated in the laboratory. He felt himself obligated to science to try and clear up the discrepancy. In cooperation with Sir Wm. Ramsay, he discovered argon. This gas is very inert and good for nothing, so what was the use of all the trouble? The only answer Ramsay would have given is that it was a contribution to our knowledge of science and is therefore worth while. But a friend might have said to him (as a number of my friends have said to me about my worthless work of chasing electrons down in the laboratory at Provo), "Why don't you invent something which will benefit mankind or which will bring you financial reward" and he still would have answered, "Science is worth while for science sake alone."

But very recently (within two years) the most efficient electric light now on the market is made with this gas. It will save millions of people "dollars and cents" and give them a very much better light.

A good example of showing the relation of the progress of manufacturing industry and research is the history of our talking at a distance. First we called loudly and the strongest voice was the best telephone. Then the idea of a speaking tube which was not connected with the voice was introduced by a research man. The tinsmiths and plumbers did the rest as far as perfection was concerned. Then came the development of electro-magnetic induction and no one dreamed of its having any connection with speaking at a distance. Joseph Henry, in his cellar at Albany, who had to steal a little time from his full daily program of study to experiment in a field he loved, discovered electromagnetic induction. By means of the transmitter and receiver these principles finally changed the speaking tube into a long wire. To one not familiar with the principles underlying the telephone, it may appear as simply long drawn out speaking tubes, but the principles underlying the action of the two are entirely different. Then followed the mathematical researches of Maxwell and the noted experiments of Hertz, which made the wireless telegraph possible. I have already spoken of the photo electric cell which made the wireless telephone possible. Again to one who was simply observing the change in methods of long distance talking might say the tubes are now drawn so fine that you can't see them, but as shown by this illustration, the progress is not through fine wire drawing by newly discovered fundamental laws of nature which were all found out by the pure research man.

Fortunately the financiers are beginning to realize the importance of spending a good sum for research work connected with their business, but still this advanced sort of research does not get the encouragement it deserves. There are a few institutions which are devoted to this cause, but I am sure that in the near future a great more encouragement will be given from the government and from big business.

When put in the industrial research laboratory, the University trained man has, as has been indicated, shown his superior ability and the board of directors has been forced to take notice. As a further illustration and a very apt one, let me quote from Dr. Whitney, head of the General Electric Research Laboratory. "I have seen whole factories entirely overhauled a number of times in the past few years in order to make the newest lamps. Not only have entire floors of complicated and expensive machines for making carbon lamps been thrown out and new machinery for making metal filament lamps installed, but before packing cases containing new machines could be opened and unpacked in the factory they have been thrown out as useless, as the advance from squirted metal filaments to drawn wire filaments proved the better way. Before the limit of factory efficiency on vacuum lamps could be reached, the introduction of nitrogen into the lamps brought the factories an entirely new factor and now before the consumers have more than commenced to feel the effects of nitrogen-tungsten lamps, the manufacture of argon and its introduction into the lamp becomes a reality. If the research laboratories which discovered the means of bringing about these changes with their corresponding economies, could tax the consuming public a cent for every dollar thus saved to the public, the laboratories would receive over $1,000,000 a year to spend on further research."

After all, as we see, the people are the ones most interested in research work and usually they don't know it.

On account of the great impetus given industrial research due to the supreme success of some of its laboratories, the large coporations are scouring the country for the best men in the Universities. The salaries are much higher than those usually given the University and College professors, and the equipment is fast becoming superior to that of the University laboratory. Therefore, unless there is a reaction on the part of the University, it will lose most of its best men, especially of the younger class.

However, I believe this will force the University Professor's salary up to its desired place, alongside of other professions requiring equal training and ability. On the whole, the outlook is very optimistic. There is an awakening in science. And just as sure as the government and big businesses continue to increase in their efforts to foster it, this nation will enter an era of industrial prosperity that it has never known before.

THE ALKALI CONTENT OF CERTAIN UTAH SOILS.

BY F. S. HARRIS.

(Summary).

Alkali determinations were made in soil from seven counties in Utah. Samples were taken from typical alkali spots, from parts of the same field producing good crops, and from places surrounding the bare spots where only about a half crop was produced.

Determinations were made of total soluble salts, chlorides, carbonates, and sulphates in these soils to a depth of four feet.

Curves were given showing the distribution of the different salts at various depths in each soil.

The highest concentration and the location of salts was found to vary considerably; in some soils it was found in the surface foot, while in others it was two, three, or four feet below the surface.

Taking an average of all seven counties, good crops grew where there were 5,089 parts per million total soluble salts, but no crops grew where there were 14,397 parts per million of salts. There was about half a crop where the total salts were 9,263 p. p. m.

As an average of the three counties where sulphates were low, no crops were produced with a concentration of 10,709 p. p. m. of salts, while there was only half a crop with 6,455 p. p. m.

A study of the individual curves shows just about the toxic limit of alkali salts under field conditions where the salts indicated are present.

SELECTING DAIRY BULLS BY PERFORMANCE.

By W. E. Carroll.

(Abstract).

The method reported evaluates the bulls on the basis of the records of *all* their Advanced Register daughters. The records were reduced to a percentage basis in order to eliminate the age factor.

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OUR NATIONAL AWAKENING TO THE IMPORTANCE OF SCIENCE.

BY W. C. EBAUGH.

Mankind is prone to use shibboleths or catch words. A person conversant with our language at various periods of time would have no difficulty in telling when such phrases as the following were used most frequently: "Liberty, Fraternity, Equality", "Masses against Classes", "Abolition", "Labor against Capital", "See America First", "Conservation of National Resources", "Safety First", "Efficiency and Scientific Management", "Preparedness".

With the shock of war in August, 1914, entirely new conditions arose in the industrial as well as in the political world. The war itself, based on race—old hatreds and suspicions in Europe, brought out much that was worst and much that was best in mankind. Over night was effected a world transformation. Men were removed from peaceful occupations to those of war; schools and universities were deserted for camp, barracks and trenches; industries were turned into new channels and science itself was directed with new aims.

On the one hand was the call for destructive agencies, and the scientist and technologist provided munitions not only of the older types of explosives, but also deadly gas and liquid fire to add horrors to the already horrible. In ordnance the skill of metallurgists produced alloys of qualities unknown in earlier wars. Submarine and aerial warfare called for new methods and new means.

On the other hand science was forced to supply agencies for constructive work, to find new uses for old materials and new materials for new needs. Hygiene and medicine called for new industries, by which elements were forced into new combinations to meet these unusual needs.

No matter how our sympthies may lie with respect to the participants to the present struggle, all must admire the wonderful "preparedness" and team work shown by Germany. Overnight the land whose battle cry for centuries has been "Feinde rings herum" (enemies around about) called into place all available resources, and since that time has been very largely dependent upon self-help. Girt about with a proverbial wall of steel, and unable to secure raw materials from overseas, or even from adjoining parts of Europe, a nation of seventy million souls, living within an area about five-sixths as large as Texas, has given a wonderful exhibition of the way in which science and technology can be forced to do superhuman things when superhuman demands are made.

First and foremost came a demand for explosives, and that meant nitrogen in various forms of combination. With ordinary sources of nitrates shut off, it was necessary to convert inert nitrogen of the atmosphere into compounds rich in energy, and it was done. With cotton excluded from imports, substitutes had to be found; wood pulp had to be used—and it was done successfully. Ammonia had to be produced from atmospheric nitrogen, and the cyanamid process solved the difficulty. Copper and zinc became scarcer and scarcer, therefore other alloys and even paper were substituted for them. Petroleum having been excluded from imports was replaced, in part at least, by substances obtained from the distillation of coal—a distillation carried out, not with the ordinary beehive oven but with byproduct ovens and others of improved constructions. It is claimed that some coals have been subjected to treatments whereby hydrocarbons become the principal products. "Petrol" is as important to the modern army as food or ammunition.

As the result of a carefully thought-out plan the first blows struck by Germany were directed at the portion of France and Belgium able to supply coal, iron and other raw materials not found extensively in Germany, and a second great offensive was directed at Mesopotomia in order to open up a district from which foodstuffs might be obtained.

In England naval efficiency was found adequate to meet the emergency as soon as it arose. The work of constructing armies for oversea campaigns was no greater than that required to produce supplies for both army and navy. In a nation of individualists, more or less unused to team work and the subservience of the individual to the organization, results obtained at first proved to be very unsatisfactory; and it was only the persistent faith in their ability to "muddle through somehow" that enabled the British to withstand the severe shocks of repeated defeats inflicted by a well organized, well supplied emeny. When the effort was made to determine wherein the difference between England and its enemies was to be found, it was not long until the conclusion was reached that they would have to do *after* the conflict began what Germany has completed *before* the war started. The nationalization of industries under the direction of Lloyd George and the facility with which supplies and men were brought from the colonies to England proved to be the salvation of the country. Even with this, however, it was soon recognized by the British themselves that something more than political acumen is necessary to meet the new condition, as is shown by the following quotation from a writer in the London Fiancial News.

"No unofficial war document thus far published can compare in importance with the manifesto issued yesterday on the subject of our national neglect of science. The signatories include many of the foremost scientific names of the day. The arguments are crushing in their conclusiveness. Best of all, if it is permissible so to speak, the manifesto is issued at a time when we are face to face with the most lurid of object lessons. The bulk of our failures in the war have been a consequence of our neglect of that scientific energy, strenuousness and organization of which the Germans make so much. We believe their achievements in this field are exaggerated. At the same time, they are far too obvious for us to remain undisturbed by them unless we mean to resign our ancient place in the world."

The signatories of the scientific manifesto point out that our highest ministers of state are mostly ignorant of the obvious facts and principles of "mechanics, chemistry, physics, biology, geography, and geology". It will be noted that economics is not included, possibly because it is regarded as a department of biology. The same ignorance, as the scientists say, runs through the public departments of the civil service, and is nearly universal in the House of Commons. Its existence has been demonstrated by the announcement, on the part of a member of the government, that the possibility of making glycerine from lard was a recent discovery. Doubtless some other minister will shortly allude to the law of gravitation or to spectrum analysis as phenomena which have recently come within the cognizance of the government. The remedy for this state of affairs, in the opinion of the distinguished scientists, "is a great change in the education which is administered to the class from which public officials are drawn". Science should play a larger part in the civil servants' examinaions, to the exclusion of Latin and Greek. "Eventually, the Board of Trade would be replaced by a Ministry of Science, Commerce and Industry, in full touch with the scientific knowledge of the moment". In those circumstances, the manifesto goes on to say, with an optimism which is almost pathetic, "public opinion would compel the inclusion of great scientific discoverers and inventors as a matter of course in the Privy Council and their occupation in the service of the state." But if the Privy Council is to be filled up with scientific discoveries, how are party hacks and political schemers to be rewarded for their sycophantic services where they can not afford to pay the price for a knighthood or a peerage?

About the peremptory necessity of better scientific organization on national lines there can be no two opinions. It is not only a question of our prosperity, but of our existence. The law of the survival of the fittest works just as inexorably among nations as it does among individuals. We can be the fittest if we like. Unless we do like we shall not survive. But if we are to tackle seriously this problem of scientific reorganization, we shall have to scrap the whole of our rotten and antiquated political machinery. The scientific mind and temper can not possibly flourish in an atmosphere of political trickery, nepotism and plunder such as that which has surrounded us for the last few centuries. For instance, what is the first characteristic of the true scientific spirit? Surely, the desire to ascertain the whole of the facts, and then to pass an unbiased judgment upon them. The true scientist, secure of his data, will follow his intellect whithersoever it leads him. But these principles are reversed under the House of Commons. In what should be the assemblage of the best national intellect there is no place for intellect at all. No private member of the House of Commons is allowed to pass an independent judgment on facts, scientific or otherwise. Before the data are submitted to him he is told what his opinion must be. If he can not quite make up his mind, he taps humbly at the door of the whip's office and is there told what he thinks. The greatest of all scientific achievements is possibly the Newtonian principle that every portion of matter attracts every other portion of matter in the universe with a force proportionate to the respective masses, and inversely as the square of the distance. If, in normal times, the House of Commons were ordered by the whips of the predominant party to pass a resolution that Newton was wrong, and that "every atom of matter in the universe repels every other atom, conversely as the circle of the distance" (whatever that may mean), the members would file into the division lobby with their customary subservience. In normal political circumstances the House of Commons will pass anything, no matter how mischievous or ludicrous if it is ordered so to do. When the national sovereignty is in the hands of such an assemblage of unintellectual automatons as that, he who anticipates legislative sympathy with scientific achievement might with equal prospect of satisfaction hope to taste green cheese from the moon.

Very much the same may be said of the civil servants. All the highest posts are filled by private "influence". They go to the exprivate secretaries of ministers and to the sons, sons-in-law, brothers-in-law, nephews, cousins and other relatives of the men who are already "bosses" in the various departments. Talent and distinction are boycotted. Suppose the greatest of scientific discoverers—a Darwin or a Wallace—to be in rivalry as candidate for a high position in the civil service with some son-in-law of a minister or "commissioner". The scientist might as well retire from the contest. The young ass would get the position and a few thousands a year with it. If he were hopelessly unable to discharge the duties, a competent deputy would be engaged at the expense of the taxpayers. That system fills the civil service with the offscourings of incapacity. Years ago Sir Charles Trevelyan said:

"There is a general tendency to look to the public establishments as a means of securing a maintenance for young men who have no chance of success in the open competition of the legal, medical and mercantile professions—the dregs of all other professions are attracted towards the public service as to a secure asylum."

Thanks to this wicked system, it was recently announced that no less than five masterships of the High Court had been bestowed by "influence" on the sons of judges, to the exclusion of hundreds of better-qualified men, who, unfortunately, had not been fathered from the bench. When the administration of justice is itself tainted with nepotism, and when the dregs of every profession are appointed to the highest positions in the public service as a result of private "influence", we have a long way to go before scientific achievement, no matter how distinguished and beneficial, will count for much in this country.

There are, however, some encouraging signs. The political truce is opening the eyes of the public to the stupidity of allowing the British Empire to be run in the interests of political schemers and lazy bureaucrats. Three or four years ago it was a common belief that our insane party system was an essential of effective government. That delusion is gone forever. We are now beginning to understand that an Empire is run on precisely the same lines as a great business. The partners of a great commercial undertaking would not tolerate the presence among them of a man who, like a politician, announced his opposition to proposals before he knew what they were or who, like a bureaucrat, was incessantly plotting for his own hand and pocket against the interests of the partnership. True science and politics are incompatible. They can not exist together any more than the eagle and the squid can share the same apartment. Science has at this moment the most magnificient opportunity that has ever enjoyed of seizing the steersmanship of human destiny. Every man who wants to see his country great, progressive and prosperous, marching as a standard-bearer at the head of the advancing legions of mankind, should back the scientist with every ounce of energy that he possesses. If otherwise, he wishes to see her mean, petty, retrogressive, squalid and contemptible, let him support a return to our debasing party strifes, with their concomitant triumph of the political schemer and all the host of parasites whom he enriches out of public money."

And as indicating the increased respect with which science ought to be treated a short quotation from NATURE is also apropos:

"I wonder whether other readers of Nature besides myself caught the interference fringes from three facets of this glittering subject in the issue of December? The first was the Royal Society's advertisement for applications for grants for scientific investigations from the government fund; the second, the editorial contrast between the rates of pay for legal and for scientific services; and the third, the anniversary address of the president of the Royal Society, containing the suggestion that science does not take its place in the national organization because the general public looks upon scientific investigations as a hobby.

What else can the general public do while men of science, in dealing with one another, generally act upon the principle that scientific investigation is is a hobby for which facilities are required, not payment? The demonstration afforded by the Government Grant Committee and the Committee of Recommendations of the British Association is conclusive. The normal practise is for these committees to be asked to supply a portion—rarely the whole—of the expenses of some scientific investigation. The applicants in reply to the advertisement will think it meritorious to offer their brains and the time required to use them without asking for any payment. That is the true criterion of a hobby.

So great is the power of science to transform serious occupations into hobbies that even lawyers sometimes find themselves astride and ambling with the rest.

In justification of the scientific societies, it may fairly be said that they were intended for the riding of hobbies, and everything in their constitution and practise conforms with the eminently useful ideal. Scientific societies rely very largely upon unpaid work and long may they continue to do so. One of their chief attractions is that within their precincts there is a respite from the wearing obligations of debit and credit. One can not find the like about a law court or a house of business, where as a rule those who are paid most are treated with the highest respect.

It is the difference between hobby and business that brings us to the parting of the ways. If the national scientific effort is organized through the agency of societies where all the best work, even by the officers, is done without any regard to payment, we can not expect the public to look upon science as a business into which pecuniary considerations enter. It is, and must remain, a hobby. If, on the other hand, there should be created a Privy Council for Science, as Sir William Crookes suggests, there would be at least a permanent staff to whom the idea of paying for brains and time would not be fundamentally repugnant as it must be to the officers of a society.

The idea of scientific investigation as a hobby does not necessarily originate with the general public; it is indigenous in the older universities, where there are a large number of college officials intellectually competent to undertake researches, some of whom do and some do not. At Cambridge in my time scientific investigation was the occupation of the leisure men whose maintenance was provided by the fees and emoluments of teaching. It was as much a hobby as chess or photography. There was no sense of collective responsibility for providing the nation with answers to its scientific questions. Scientific researches had become an element of competition for rewards of various kinds, and some "research students" were paid; but the idea of "making a living" by scientific investigation never reached the surface, though the merit acquired by research might weigh in the appointment to a post of teaching or administration. On the contrary, the early agitation for the endowment of research was regarded as finally disposed of by calling it the research of endowment, as though the wish to be paid were conclusive evidence of insincerity.

The suggested council will have some difficulty in organizing adequately paid research. The endowed researcher in the national interest must expect an occasional audit of an imperious character, and his employers must see their way to act upon it. With teaching the difficulty is less. If the students of one year do not respond, the next year may be more successful. It takes just about a lifetime to satisfy ourselves about our own weaknesses. The responsibility is nicely divided; it is just as much the duty of the students to learn as of the lecturer to teach, and neither student nor teacher has the material for a considered judgment upon the matter. That is why the "hobby" system with occasional rewards for exceptional success, is so popular. It can be worked best by letting things go their own way.

The present state of things, which all agree in deploring, can be altered by drawing a clear distinction between a society's hobbies and the nation's purposes, and entrusting them to separate administrative management. Mr. Carnegie has made it clear that the financial detachment of a voluntary society is not essential to the successful organization of scientific research".

But what of America? First came the call for relief work on account of deplorable conditions in Belgium and other parts of Europe. The response was immediate and the organization for collection and distribution of supplies worked out well, in spite of almost innumerable obstacles. Our inherent unwillingness to take up arms except when all other means have failed, prevented our actually entering the conflict. With the passage of time, however, there came the feeling that our nation must undertake to put its house in order so that were the stern realities of war to present themselves, we would be prepared, in a measure at least, to meet them. With respect to military and naval matters, both machinery and personnel, our public prints have had much to say. Concerning financial and industrial preparedness they have had less to say, perhaps because the latter topics do not afford opportunities for spectacular head lines to the same extent as do the former. But taught by the example of warring Europe, President Wilson and his co-workers called into existence the Naval Advisory Board, made up of men who had already won their spurs by scientific and technical achievements; this Board soon recommended that there be established a national research laboratory on such a scale that experiments, tests, and researches might be carried out in all branches that had to do with questions of national defense. As expressed by them, they wanted to make their mistakes and rectify them before hostilities began. Another far-reaching recommendation was that their Board be enlarged by the addition of representatives in each State from our greater engineering and scientific societies. It is probable that in the near future announcement will be made through the public press as to the persons who have been selected as members of this enlarged Board, and an outline of their duties will be published. It will be seen, therefore, that scientist and technologist have already begun to receive recognition from the military and naval branches of our government.

Object to it as we may, it is nevertheless true that necessity is the mother of invention, and that the rigors of war and of peace have forced quick solutions of problems that otherwise might not have been solved. One hundred years ago France, isolated by her enemies, offered a reward for the best process for manufacturing soda, and LeBlanc evolved his well known method. A score of years ago one of the largest German chemical factories needed fuming sulphuric acid so badly, in order that it might produce a synthetic dye stuff to take the place of one formerly obtained from a certain plant, that it devoted, it is said, more than a million dollars to experimentation before it was rewarded with Knietsch's contact method for producing sulphur trioxide and sulphuric acid of any desired strength. Similarly the inevitable exhaustion of Chili nitrate deposits within a generation stimulated efforts to convert atmospheric nitrogen into nitrates and ammonium compounds, with the result that the problem was solved shortly before the present conflict in Europe began.

Our early American researches had to do chiefly with utilitarian aims. Even astronomy was cultivated because of its connection with navigation. Agricultural experimentation, medical research and other branches of scientific activity might be mentioned in illustration. In later years the same trend is observable. Moissan's epoch-making discoveries in France with an electric furnace of small dimensions were followed by the production of electrochemical substances of great importance here in America. More recently the formation of alloy steels, the utilization of rarer metals, the preparation of plastics, etc. exemplify the same thing.

Under present market conditions business men have turned to the American chemist and manufacturer with demands for certain products in quantities unheard of heretofore. The most notable instances, perhaps, are the calls for potash and nitrogen fertilizers, and the amount of activity among research men to produce these materials at reasonable cost can be appreciated only by those who are in touch with the situation. And very striking, too, are the demands for coal tar products. Unfortunately those who are clamoring loudest seem to think it possible for the American scientist and engineer to create overnight and in the face of all the difficulties involved in patent rulings a complicated industry that has been developed in Germany only through the concentrated work of scientists and manufacturers during the past two generations. Not only is it necessary for us to change the method of distilling coal, but there must be brought about such interdependence of companies handling special products that co-operation will take the place of competition; and this, too, in the face of our laws concerning combinations in restraint of trade. Heretofore we have gone largely upon the principle that America was a place where raw materials could be produced cheaply and where we would make what we could not buy. *Now* we see where such a policy would lead us, and want to rectify our mistake by fostering all means leading to economic independence. Our extreme individualism and excessive competition must give way to a closer knit industrial organization where legitimate interdependence in production and distribution is recognized and fostered.

The unreasonableness of many demands have been hinted at above. "Make dyes and drugs at once!" There has been overlooked entirely the fact that the chemical industry in Germany represents an investment of millions of dollars, has taken years to grow, has hundreds of scientists engaged in research work, and thousands more employed in applying the discoveries of research men. With us it means a change from the beehive to the byproduct and other modern ovens, and from the manufacturing of coarse or intermediate chemicals to what are known technically as "fine" chemicals.

And with respect to patent difficulties—warring nations may and do treat all codes and regulations as scraps of paper, or subject to interpretation, according to the needs of the moment, by an executive "order in council", but peaceful nations with high ideals cannot morally resort to such expedients. Unquestionably changes in patent laws are necessary, especially to break down the "dog in the manger policy", and to make actual operation of a patent in this country a condition for holding the patent.

It will thus be seen that the present crisis has shown our needs along certain lines, and as a result a call goes up for help with none to help but scientists and technologists. It is time for nationalization of industry and co-operation in America. Trained economists with scientific and technical skill are needed to anticipate wants and then provide for them. On a large scale this is or will be done by the naval

Advisory Board—which will really be a governmental Advisory Board—and on a small scale by the services of trained observers, organizers and engineers, experts in various lines. Our cousins across the waters have found the futility of entrusting big enterprises solely to men of the lawyer—capatalist—governmental class, and have come to rely largely upon the advice of trained specialists. The call comes to *us* as scientists. Are we ready to meet it? That this is no dream of a professional scientist, but is shared by men who direct practical affairs is shown by our concluding paragraph, taken from an address delivered by Secretary F. K. Lane, Department of the Interior, before one of the sections of the Pan-American Scientific Congress recently:

"I fancy that if Christopher Columbus is able at this time to survey this world and see what is happening that he is well pleased at his venturesome voyage. While the nations of the world that he left have their knives at each other's throats the peoples of this new world have sent their most learned men, their philosophers, their scientists, inventors and engineers to talk with one another as to how this new land may become wiser, richer and be made more useful. This is surely a contrast. It is a condition for which my knowledge of history offers no parallel.

There are times I know when nations who believe in themselves must fight. But let us not delude ourselves with the notion that civilization is the product of arms. The only excuse for war is to secure peace, that men of thought, resourcefulness and skill may have opportunity to make themselves masters of the secrets of nature.

For the real battle of the centuries is not between men or between nations or between races. The one fight, the enduring contest, is between man and physical nature.

There is no denying the fact that we live in a world that is hostile and secretive. It is organized to destroy us if it can. Our enemies have cunning and ferocity. We have but to fold our arms and the beasts, the flies, the rats, the mosquitoes and the vermin would make us their easy prey. And if they could not win by force, they would bring death by starvation. This world was made for a fighting man and for none other. Softness is not to be our portion, because nature knows no holiday. So man must battle with nature that he may secure that physical peace necessary to give his spirit a chance to show itself in things of beauty and deeds of goodness.

And this is what we call civilization—this triumph over the downpull of nature. We make her yield. We master her secrets. With wooden club and stone axe, with bow and arrow and with fire man mastered his wild enemies, and then with seed and water man mastered the surface of the earth. The sea challenged him; and he discovered the floating log, the paddle and then the sail, until he made himself master also of the surface of the sea. These things it took ages to do. Nature revealed nothing. Man had to observe and reflect that he might discover or invent. Was there ever such a discovery as that a planted seed would sprout and yield? Or that the wind wonld drive a hollowed log?

But these things happened long ago. And now we have made not only the surface of the land and sea our own, but their depths as well. The wind not only fills our sails, but we master the air itself. We make our own lightning and harness it to work for us, to push and to pull, to lift and to turn. We have found the great secret that nature can be made to fight nature. But we must fight with her for our weapons. They are not handed to us; they are hidden from us. If man is to have dominion over this earth, he is committed to an unending search. He must bore and burrow, dig and blast, crush and refine, distill and mix, burn and compress until he forces nature to yield her locked and buried treasures.

Nature would have man isolated, but he triumphs over her with billets of steel and threads of copper. He swings a hammer and an engine is made that makes him neighbor to the world. He whispers to a wire which shouts the spoken word into space.

Nature would have a limit to the soil's supporting strength, but man robs the air of its nitrogen and the rocks of their phosphorus and potash to revivify the unwilling earth.

Nature would have man the victim of insidious enemies that stop or clog the human machine, but man distills from the buried carbons agents that stay destruction for a time, and now man has found a mineral which gives promise of opening the way into a new world of mysterious restoration.

This is a glorious battle in which you are fighting—the geologist who reads the hieroglyphs that nature has written, the miner who is the Columbus of the world underground, the engineer, the chemist, and the inventor who out of curiosity plus courage, plus imagination, fashion the swords of a triumphing civilization. Indeed it is hardly too much to say that the extent of man's domain and his tenure of the earth rest with you."

TENTH ANNUAL CONVENTION OF THE UTAH ACADEMY OF SCIENCES.

Salt Lake City, Utah, April 6 and 7, 1917.
Room 21, Young Memorial Building, L. D. S. U.

Friday, April 6, 1917, 2 p. m.

"THE PRESSURE-WATT CHARACTERISTICS OF DRAWN WIRE TUNGSTEN LAMPS"
By C. Arthur Smith, East High School, Salt Lake City

"THE VARIATION OF THE ELECTRIC CONDUCTIVITY OF THIN METAL FILMS"......By Dr. Orin Tugman, U. U.

"THE ANASTOMOSING OF ARTERIES AND VEINS IN A CAT". By Dr. Newton Miller and James S. Godfrey, U.U.
(Paper read by the junior author).

"MODERN BIOLOGY AND PREFORMATION"..........By Dr. Newton Miller, U. U.

Friday, April 6, 1917, 8 p. m.

"THE WORLD WITHOUT SCIENCE" (Presidential Address)....................By Dr. Frank S. Harris

"THE VALUE OF SCIENTIFIC RESEARCH IN FORESTRY"...By C. F. Korstian, Forest Service, Ogden

"AN ESSAY COMPARING MAMMALS AND BIRDS OF NORTH CENTRAL EUROPE WITH RELATED SPECIES IN NORTHERN UNITED STATES,"
By S. Moth Iversen, Salt Lake City

Saturday, April 7, 1917, 10 a. m.

"FREEZING TEMPERATURES IN FRUIT BUDS"...............By Dr. Frank L. West, U. A. C.

"BEET MOLASSES AS A FEED FOR WEANLING PIGS"..................By Dr. W. E. Carroll, U. A. C.

"WEATHER, SOIL, DISEASE AND QUALITY IN POTATOES"..........By Dr. Geo. R. Hill, Jr., U. A. C.

"FACTORS AFFECTING THE DEPTH OF PLANTING VARIOUS CROPS"............By Howard J. Maughan, U. A. C.

Saturday, April 7, 1917, 2 p. m.

"THE EFFECTIVENESS OF THE CORROSIVE SUBLIMATE TREATMENT OF POTATOES" By Bert L. Richards, U. A. C.
(Presented by Dr. Geo. R. Hill, Jr., in the absence of the author).

"THE PRESENT SITUATION OF RABIES IN UTAH"....................By Dr. L. L. Daines, U. U.

"THE TIME ELEMENT IN VOLUNTARY CONTROL"..............By Dr. Geo. S. Snoddy, U. U.

"THE LIQUID SULPHUR DIOXIDE METHOD OF DETERMINING AROMATIC HYDROCARBON OILS"
By Thomas Joseph, U. U.

"THE DESTRUCTIVE DISTILLATION OF GILSONITE"............By Theodore Erickson, U. U.

THE PRESSURE-WATT CHARACTERISTICS OF DRAWN WIRE TUNGSTEN LAMPS.

BY C. ARTHUR SMITH.

Perhaps no industry in the country ever had so phenominal a growth as that of the incandescent lamp. Although its history covers only the brief period of thirty-five years, it has in that time been developed to such a high state of perfection that it has practically crowded out every competitor from the field of electric lighting. In less than three years after the first incandescent lamp made its appearance, the arc lamp industry began to show signs of uneasiness, and scarcely five years had gone by when the manufacturers of the arc lamp were forced to improve their designs in order to hold their place in indoor lighting.

The first incandescent lamp was of the carbon filament type, very fragile, of low efficiency as expressed in watts per candle power, and of uncertain duration. For nearly twenty years it was the only incandescent lamp on the market. In 1899 the tantalum lamp was invented by a German scientist and immediately entered the field as a strong competitor because of its excellent illuminating qualities and high efficiency. For a time it looked as though it would displace the carbon lamp entirely, but within a year from its introduction a new process of preparing the carbon filament was discovered. The result of this discovery brought forth what is known as the metallized carbon filament, and the carbon lamp henceforth became the Gem lamp. Its durability was greatly increased, its efficiency was raised to nearly that of the tantalum lamp, and the first cost was considerably less as it was a cheaper lamp. It thus continued to hold first place for indoor lighting until the year 1908 which was one of supreme importance in electric lighting industry. It marks the advent of the tungsten lamp. This lamp immediately took first rank on account of its excellent illuminating properties and high efficiency, and this in spite of the fact that it was extremely fragile which rendered the renewal cost rather high. This defect, however, was remedied by a discovery made in 1912 by the General Electric Company in which tungsten, one of the most brittle metals, was rendered so ductile that it was possible to draw it out into very fine wire, down even to .001 of an inch in diameter. Thus, the second period in the development of the tungsten lamp began under the new name of the Drawn Wire Tungsten lamp.

The tantalum lamp ceased to exist almost immediately after the appearance of the tungsten lamp in 1908, and the drawn wire tungsten of 1912 practically eliminated the carbon lamp. The arc lamp was driven from the field of indoor service by the Gem lamp so that since 1912 the tungsten lamp has continued to enjoy a complete monopoly of indoor electric lighting. The arc lamp held its place in outdoor service until 1914, when the incandescent lamp engineer, not content to rest from his labors until his lamp was made serviceable for outdoor as well as indoor lighting, discovered that a light bulb filled with an inert gas gave as brilliant a light as the arc, and that without materially affecting the efficiency or the life of the lamp. This is known as the Mazda C or gas filled tungsten lamp, and owing to the presence of the gas can be raised to a very much higher temperature with scarcely an appreciable disintegration of the filament, thus giving a high degree of illumination throughout as long or even longer life. This fact enables the manufacturer to put out lamps up to any desired candle power. The highest power lamp on the market at the present time is the 1000 watt lamp, but there is no reason why an even higher power lamp could not be made if such were desired. Within the last year efforts were made to produce this same type with a wattage sufficiently low to be made practicable for ordinary service with the result that a 75 and 100 watt lamp were placed on the market and are beginning to attract attention already. The arc lamp therefore having apparently reached the limit of its possibilities is fast disappearing; and the time is undoubtedly near at hand when it will have become an historic relic to be studied merely for the purpose of comparison. But the place occupied by the arc lamp in the past is not to be minimized. As is always the case in pioneering, things are usually done in a wasteful, more or less haphazard, and, judged from more highly developed standards, in a primitive style. So it was with the arc lamp, the pioneer in electric lighting. For the first twenty-five years, time, energy, and material were wasted so far as practical results were concerned. But it is a significant fact that almost immediately after the invention of the incandescent lamp the failures were put to good account and a really serviceable arc lamp arose out of the ruins of these failures. From this time on it was a race between the two types with the arc continuing to fall farther and farther behind, notwithstanding the fact that its efficiency always was and is even yet considerably higher than anything yet attained by the incandescent lamp. Its failure is due among other things to the necessarily complicated mechanism of its regulating device, to the necessity of frequent attention in changing electrodes, cleaning, etc., and the lowering of illumination by deposits from the electrodes on the surface of the globes.

This brief survey of electric lighting is given in order to emphasize the lines along which development up to the present time has progressed, which are efficiency, illumination, and durability. Tests are made by the manufacturers with these factors constantly in mind, but since the lamps are seldom used except for ordinary service they are not usually carried much above the normal load.

It occurred to me that it might be interesting to carry the test from voltages considerably below normal up to the burnout point of the lamps in order to examine the illuminating characteristics through as wide a range as possible. Therefore a large number of lamps both of the carbon and tungsten types were tested from 80 volts up to the burnout point (which was for carbon lamps from 200 to 220 volts and for tungsten from 270 to 290 volts). In nearly all cases the lamps tested were new. The primary object was to determine the candle power and efficiency characteristics through the entire range. The curves thus obtained suggested certain non-uniform variations in these characteristics in the region of high voltages. It was thought that these variations might be traced back to more fundamental relations, viz. pressure-watt characteristics. In order to determine this, three lamps of the tungsten type were selected and this characteristic studied. The lamps selected were 25, 40 and 60 watt.

The curves in figure 1 show the volt ampere characteristic of each lamp. It will be observed that the rate of increase of the current diminishes slightly as the voltage increases. The cause of this is revealed in fig. 2 showing the relation between volts and resistance. The similarity of the two sets of curves is evident with the exception of the 25 watt lamp. Here the rate of increase of resistance increases slightly causing the curve to bend downward instead of upward as in the curves of the other lamps. But the greater slope of the resistance curves as compared with that of the current curves indicates that the rate at which the increasing resistance diminishes is less than that at which the increasing current diminishes, and since by Ohm's law current is inversely proportional to resistance it undergoes less variation than it otherwise would. This has a direct bearing upon the power consumed since watts equals volts times amperes, and explains at once why tungsten lamps consume less power at the same voltage than carbon lamps whose resistance diminishes with increased voltage.

The curves represented in fig. 3 are the pressure-watt characteristics. They show a constantly increasing value of power throughout the entire range. There are no apparent anomalous characteristics either in these or in the previous curves, therefore they should submit themselves readily to rather simple mathematical treatment. By their shape we recognizze them as belonging to the parabolic family and hence may be represented by the equation

$$w = ae^n \qquad \text{(1)}$$

where w is the watts, e the volts, and a and n physical constants. By eliminating a we may solve for n which is found to give an average value of 1.6 for all the lamps.

Substituting this value for n and solving for a, we find that its value depends upon the size of the lamps. This was to have been expected since no two curves pass through the same origin. For the 25 watt lamp it is .0102, the 40 watt, .0173, and the 60 watt .0231. These values are found to be roughly proportional to the rated watts of the lamps. A comparison between the observed and calculated values of the watts shows a close agreement throughout the entire range. This seems to confirm the uniform variation indicated by the curves.

It would seem, therefore, that whatever the cause of the anomalous characteristics in the candle power curves for high voltages, it must be looked for elsewhere than in the direct relation between volts and watts. If the pressure-power relationship is uniform throughout the entire range of voltage, as it seems to be, and the candle power relationship is non-uniform, as it undoubtedly is, the true cause must appear in some intermediate step resulting probably from a change in the properties, either physical or chemical, of tungsten. Since drawn wire tungsten undergoes certain mechanical and heat treatment in its preparation it may be that such changes take place in the region of high temperatures even though no such changes have been observed in the native metal.

TABLE I.

	Amperes			Ohms			WATTS.					
							a = .0102		a = .0173		a = .0231	
e	25	40	60	25	40	60	25	25 cal.	40	40 cal.	60	60 cal.
80	.135	.242	.322	592	331	248	10.5	11.3	19.4	19.1	25.8	25.9
100	.158	.274	.365	633	364	274	15.8	16.2	27.4	27.4	36.5	36.8
120	.180	.309	.410	668	388	293	20.6	20.5	36.1	36.6	48.2	48.9
140	.200	.339	.450	700	413	311	28.0	28.1	47.5	46.9	62.9	62.9
160	.220	.364	.487	728	440	328	35.2	34.4	58.2	58.1	77.9	77.6
180	.235	.391	.525	765	460	343	42.3	41.4	70.4	70.3	94.5	94.0
200	.255	.415	.555	785	483	361	50.1	49.5	83.0	83.0	111.0	111.1
220	.267	.439	.585	824	502	376	58.6	57.0	95.5	96.5	128.8	128.9
240	.280	.461	.617	850	520	389	68.1	65.5	111.9	111.2	148.0	148.1
260	.292	.480	.645	890	540	412	76.0	74.6	124.9	126.5	167.5	169.0
280	.298	.495	.651*	946	566	415*	83.0	83.9	138.5	142.3	176.0*	179.0*

* e = 270 volts. $w = ae^n$. w = watts, e = volts.
a and n = constants.

THE VARIATION OF THE ELECTRIC CONDUCTIVITY OF THIN METALLIC FILMS.

BY ORIN TUGMAN.

(Abstract).

It is known that the electrical conductivity of a very thin sheet of metal may change rapidly with time. Films of metal, made by chemical deposition and by a cathode discharge, show this change. Usually the conductivity increases with age so that in a few hours after the film is made its resistance has decreased to one half of its former value.

This phenomenon has been explained by the emission of occluded gases which when escaping allow the particles of deposited metal to coalesce.

The experiment described in this abstract was done to find the effect, if any, of violet light on the conductivity of thin metal films. Silver films were made by chemical deposition on glass. The Brashear formula using Rochelle Salts to precipitate the metallic silver, was used.

In ordinary daylight the resistance of such films decreased, from the beginning the thin film showing a more marked change than thick films. Under the light from a quartz mercury lamp the resistance increased with the first incidence of the illumination. If the film was taken out of this light the resistance again began to decrease. A film left in the light from the quartz lamp for several days showed an increase of resistance to infinity. An examination of the film revealed a dark brown deposit on the glass which was soluble in ammonium hydroxide. It is evident that the silver becomes oxidized under the ultra violet light and that the increase of resistance is due to this chemical change.

These thin films are more readily oxidized under ultra violet light than the surfaces of thick plates. A polished plate was under this illumination for thirty-six hours and showed no oxidation.

More extended experiments of this nature are in progress.

THE WORLD WITHOUT SCIENCE.

By F. S. Harris.

As people move about in the world performing their several tasks with the aid of numerous mechanical devices and surrounded by many conveniences and luxuries, they are prone to look upon these conditions as having always existed, when in reality the last century has seen more progress in scientific discovery than have all the previous centuries of human history. It is only necessary to compare conditions in the days of our great grandfathers with those today to realize how very rapid has been the change. The debt that mankind owes to science is made clear on comparing the possibilities of a civilization in the absence of science with one assisted by the powerful agencies of modern research.

It has been the practice of a certain class of persons to undermine the teachings of science, thinking that they were thereby staying the ravages of some hideous monster and rendering a service to mankind. Thanks to the gradual spread of learning, persons of that class are rapidly being replaced by those who see in science nothing to be feared but something to be fostered and developed. People are finding that the sole aim of science is the discovery of truth, and that no amount of suppression will prevent truth from eventually being discovered. That scientific workers often draw erroneous conclusions from available facts no one can deny; but that they should be hindered in the pursuit of their investigations because of a few mistakes would be to deny them the charity that is extended in every other endeavor of mankind.

Science, unlike religion, has had to develop very slowly. In religion, the revealed word has always been a guide and has pointed the way; in science, every step has required long and tedious work. It required ages for man to learn how to draw on nature for her hidden secrets. Old habits of thinking had to be discarded and new methods of work devised before noteworthy results could be obtained;

but with these difficulties overcome, advancement was rapid.

Going back to the very dawn of history we find the Egyptians possessed of considerable knowledge of the stars and the seasons. They also understood the properties of the triangle and used this knowledge in resurveying the land that was flooded each year by the Nile.

There was no real development in science, however, until the Greeks began their rather systematic observations of nature. Aristotle (384-322 B. C.) and his student Theophrastus recorded many accurate observations from their studies of animals, plants and rocks; but all the science of the Greeks was so intermixed with speculation and philosophizing that a great deal of error crept in. At that time the methods of modern science were entirely unknown, but the scope of the work was so broad that practically all the sciences now trace their origin to the time of Aristotle.

Later, Alexandria became the center of the Greek world; here all the learning of the time was centered. Euclid, Hipparchus, and others collected data on astronomy, geometry, trigonometry, optics, heat, and even anatomy. The greatest work during this time was done at Syracuse by Archimedes (287 B. C.) who created the science of statics.

The Romans did little for science. Pliny (23-79 A. D.) collected all the writings of those who had gone before, but he contributed nothing new. His compilation, however, did much to preserve the information that had been discovered by earlier scholars.

During the middle ages practically nothing was done in science. The people were so completely bound to authority that original studies were almost unknown. Aristotle was the universal authority on all branches of science. The story is told of a heated discussion arising over the number of teeth in the horse's mouth. All the authorities were searched and ponderous writings submitted on this question that could have been so easily settled by simple observation. The whole attitude of mind led to study of authorities who had written on nature rather than to a study of nature itself.

Science in the middle ages was fostered chiefly by the Arabs who believed in the pseudo-sciences of astrology and alchemy, but they did much to advance algebra and some of the sciences. By the end of the 14th century astrology reached the summit of its popularity. At this time everything that happened on the earth was attributed to the condition and position of the stars. Disease, weather, crop growth, and even personal fortune or misfortune were thought to be profoundly, if not completely, dependent on heavenly bodies. Man was in no sense thought to be master; he was considered to be merely a victim of the stars.

Tradition, belief in authority, and superstitions of the false sciences of astrology and alchemy long and successfully resisted the advance of knowledge. Time-honored ideas, nevertheless, received a rude shock at the hands of Copernicus (1473) and by 1600, when Giordano Bruno was burned at the stake, the germ of original investigation had been planted. In the next century perhaps the greatest revolution in thought that has occurred in all history swept the western world. To this many factors contributed: the genius of a few great men like Newton, Galileo, Harvey, Kepler, Descartes, Bacon, and Leibnitz; the invention of the telescope and the compound microscope; and the general awakening of thought by the Renaissance.

Before Galileo, only two modern men of science are conspicuous: Copernicus, who studied the movements of heavenly bodies, and Vesalius (1514-1564) who overthrew the authority of Galen and studied at first hand the organization of the human body. Not until the seventeenth century did modern science gain a secure footing. In 1628 William Harvey, by adding experiment to observation, demonstrated the circulation of the blood and created a new physiology, and in 1687 Newton published his "Principia" which established the science of mechanics. These two contributions were so revolutionary that the earlier ideas of physical and biological science were almost completely upset; and through them a foundation was laid on which the structure of modern science could be reared.

In the eighteenth century the development of chemistry by Lavoisier aided by Scheele, Priestly, and others gave to scientists a new and powerful instrument for solving many of the mysteries of nature. In the early part of the nineteenth century there was almost a complete change in science. The old idea of the spontaneous origin of life was given up; the methods by which plants and animals feed and grow were discovered. Science was subdivided with specialists working on each of its branches.

Then followed a popular interest in science which resulted in the contribution of very much larger sums for research than could previously be obtained. Before this time the scientist was considered to be out of harmony with the rest of mankind; he was forced to carry on most of his investigations secretly. As the century advanced, science gradually won a hearing. At first it was grudgingly tolerated; later its more conservative teachings were made a part of ordinary schooling, and toward the close of the century it was given a place of equal rank with classical subjects in the college curriculum. Since the middle of the century the practical service of science to mankind has gradually become so well known that today scientific research is considered to be as much a part of governmental duty as any branch of the public service.

The wisdom of diverting public funds and private endowments to scientific research and instruction will be more fully appreciated by a review of some of the contributions of science to transportation, communication, medicine, manufacturing, agriculture, household economy, and other branches of human activity.

Probably in no practical phase of man's life have the discoveries of science yielded more far-reaching results than in transportation. It is only necessary to compare the old sailing vessel, the horse car, and the stage coach with the modern steam ship, the electric trolley, the steam-drawn train, the automobile, and the flying machine to realize what the discoveries that made these improvements possible have meant to civilization. It will be readily seen that the activities of the modern world would be utterly impossible with the old methods of transportation. When months were required to haul a wagon load of freight across the continent, it is obvious that nothing but the most precious commodities could be thus conveyed.

The casual observer looking at an automobile does not realize that it is made up of many complex parts, each one of which probably required a number of stages of development on the part of scientific workers before it was finally completed. The electric current used in the spark, the workings of the internal combustion engine, the mechanism used in transmission, and the vulcanizing of rubber which made pneumatic tires possible all demanded years of patient work on the part of scientists.

Closely associated with transportation are the improved methods of communication. Fast mails, the telegraph, the telephone, and the wireless telegraph and telephone indicate the service that science has rendered to the communication of intelligence. At present only a few hours are required to learn the happenings in all parts of the world, while in the days before science discovered the uses of steam and electricity, months were necessary to convey news to the various parts of a country as large as the United States. In the old days business had to be confined largely to local transactions; today there is no geographical limit to exchange. Formerly the people knew practically nothing beyond local happenings; at present all feel themselves to be parts of an immense world community.

Human health and well being have been so materially aided by science that a return to the old conditions would arouse a feeling of horror in all who realize the situation. It has not been many centuries since practically all bodily ailments were attributed to unfavorable stellar conditions or to evil spirits. The disease was diagnosed by a study of the stars rather than by an examination of the body.

The germ theory of disease had its origin as late as 1860 and was not thoroughly established until almost 1880. Before this time medicine was simply groping in the dark.

A few specific treatments were known, but many of these were founded on false principles. The work of Pasteur on the micro-organisms causing disease and the application by Lister of the knowledge of these organisms in antiseptic surgery have probably done more to overcome human suffering than all previous discoveries.

The utter helplessness of man in blindly coping with disease is realized when it is known that in Naples 300,000 people died in five months due to contagion, and in Constantinople 10,000 people died in a single day. As late as 1867, 3.4 per cent of the women confined in hospitals died, while today the mortality is only .08 of one per cent. Before the days of Pasteur and Lister about 41 per cent of those having a limb amputated died, while today the percentage has been reduced to about 5. These are only a few of the many illustrations that could be cited to show how scientific discoveries have helped in the control of disease and in the reduction of the death rate.

In manufacturing of every kind the discoveries of chemistry and physics have wrought such changes that scarcely any of the processes used by our grandparents are in use today. The new is being replaced by the newer. Electricity, taken from the waterfall and transmitted to where it can be best utilized, now turns the wheels of machinery once operated by hand. In the digging and smelting of ore, in the making of iron and steel, and in the converting of these into articles of commerce, all the processes have been improved by discoveries of science. Similar improvements have been made in the textile industries; in fact, every branch of manufacturing is now using science as a basis in production. Through science many luxuries that could formerly be enjoyed only by the rich are now placed at the disposal of everyone.

Such household conveniences as electric lights, steam heat, modern plumbing, and labor-saving machines have added much to the comforts of home and have given the housewife a greater opportunity to prepare herself for intelligent motherhood.

In agriculture, the oldest of the arts, the transformations due to science are scarcely less marked. From the time of the ancient Greek, when farm practice was often based on dogmatic traditions, to the present time when the principles underlying agriculture are well understood, the methods employed have changed radically. Practically all of this change has come during the last century since science has been used in solving the problems of the land.

Before 1840, when Liebig finally demonstrated the methods by which plants obtain their food, soil management was based on erroneous and wasteful ideas. Since that time the advances in agriculture have been so rapid that volumes would be required to record the discoveries. Every phase of farming has been improved until today one man is able to produce as much as was formerly produced by many. This means that the products of the farm can be furnished at a more reasonable rate, and also that many of those formerly required to produce the world's supply of farm products are now at liberty to engage in other productive enterprises.

Probably sufficient has been said to show how all the arts and industries of mankind have been profoundly influenced by the work of science. In brief, without the results of science we would find ourselves in isolated communities, dependent on local production, with no adequate means of transportation or communication, and subject to the ravages of disease. We would be forced to content ourselves with very few personal conveniences; and, worst of all, our minds would be dominated largely by superstitious ignorance regarding our surroundings. With the aid of science man is able to become master of his environment; he may harness the forces of nature and use them to advance his own welfare as well as to make the earth an abiding place worthy of his God-given intelligence. Best of all, he is enabled to obey that part of the first command wherein he was given dominion over the earth and was required to subdue it.

ANASTOMOSING OF ARTERIES AND VEINS IN A CAT.

BY NEWTON MILLER AND JAMES S. GODFREY.

In the spring of 1916 a number of cats were brought into the Zoological laboratory for dissection. Among this number was one which showed a very unusual degree of anastomosing of arteries and veins.

A carmine starch mass was injected into one of the carotids with the result that it passed over into the veins, especially those of the hind legs and the posterior region of the abdomen. Since starch grains do not pass through the capillaries, it was evident that direct unions between arteries and vein were present.

Examination showed one large connection between the caudal artery and the common iliac vein, which caused the filling of the post caval. In addition four others were found in the branches of the internal iliacs; seven in the branches of the femorals; three in the branches of the iliolumbars; two in the adrenolumbars, and one in the intercostals which filled the azygos vein. Also five others were found in the branches of the right subclavian artery and vein. This is a total of twenty three, besides there were evidences of others which we were unable to locate.

VALUE OF SCIENTIFIC RESEARCH IN FORESTRY.[1]

By C. F. Korstian.

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Scientific research may be defined as the experimental observational method of diligently searching after natural facts and principles instead of relying on the answers secured by imagination or through deductive reasoning from assumed premises. In other words research implies the application of the senses and reasoning powers with which nature has endowed man, in finding out all he can concerning the vast world and universe about him. Man never can be perfectly sure that he has found out all about them until he is able to control them, which, you will say, is physically impossible. The principle of research, as the only foundation of all knowledge, has hardly yet thoroughly penetrated the thick walls of academic dogmatism and a false conceit of knowledge. Research means progress which denotes the replacing of the old by the new.

It seems superfluous to speak of the value of research in general before so academic an audience. Consequently your attention will be directed primarily to the value of research in forestry and incidentally to some of our problems in forest research. Forestry is defined as the science and art of managing forests in continuity for forest purposes, i. e., for wood products and forest influences.

The economic and industrial development of the United States is of comparatively recent date. The abundance of many of the natural resources of the country have heretofore made the consideration of their exhaustion a subject of little public interest. The increasing rapidity with which the natural resources of the nation have approached a state of depletion in the more populous and better industrially developed parts of the United States has recently emphasized the need of the utmost foresight in their conservation. In recognition of this need the Federal Govern-

[1]Read before the Utah Academy of Sciences, April 6, 1917. Published by permission of the Secretary of Agriculture.

ment of the United States in 1891 made radical changes in the public land policy through providing for the establishment of national forests from the timbered portions of the then unappropriated public domain. The total area of the national forests now approximates 155 million acres, while state and communal forests aggregate approximately four million acres. The standing timber on the national forests alone is valued at nearly 600 million dollars. The merchantable standing timber in the United States, exclusive of Alaska, amounts to around 2,800 billion board feet.

One of the most interesting and far-reaching movements in conservation in the United States has been the nation-wide movement toward the public ownership of forest property, especially potential forest land. The direct value of the forest which accrues to the public at large makes the practice of forestry economically possible by the public before it becomes practicable for the private individual. Since forestry in the United States originated in a general educational propaganda any great constructive movement in forest conservation cannot be a success in this republic without its being solidly supported by public opinion. [2]Toumey believes that public opinion will continue to grow in this country until ultimately at least 50 per cent of the strictly non-agricultural lands capable of producing forest crops are publicly owned.

At this time when the United States is all but in the throes of actual warfare, the speaker cannot refrain from digressing from the main theme for a moment in order to utter a word regarding the proper place of the scientist and the forester in the national preparedness campagin which is now being conducted. Preparedness signifies, not only the optimum military and naval forces necessary for repelling the enemy, but also the ability of a nation quickly to adapt itself to the rapidly changing conditions wrought by war and to render available the latent resources of the Nation in the shortest period of time. Major Ahern, a soldier and a forester, in a discussion of the preparedness

[2]Toumey, J. W., The Interdependence of Forest Conservation and Forestry Education. Science, N. S. 44; 327-337, 1916.

question recently informed the speaker that, in his opinion, foresters could render more efficient service to their country through the moblization of the forest resources of the Nation than if they took their places with their regiments in the front line of battle. It is the firm conviction of the speaker that the organization and development of the latent national resources should likewise demand the attention of scientists as much or even more than the actual preparation of war equipment and participation in battle.

Forestry education fosters the forest policies of the Nation, determines the methods of forestry practice and therefore should advance simultaneously with forest research. Without one the other would be impossible. The remarkable increase in agricultural research and consequently agricultural education in the United States during the past fifty years has profoundly influenced the production of agricultural products. The enormous sums spent annually by the Federal Government and the States in the promotion of agricultural research are returned a hundredfold through increased and diversified production. Needless to say, all are familiar with the excellent work which is being done by the large number of agricultural colleges and experiment stations and will agree that they are living testimony to the public belief that the success of agricultural pursuits depends primarily upon the results of research which actually control agricultural development and advancement. The forest schools and forest experiment stations are fully as essential in the application of rational forest conservation as the agricultural colleges and experiment stations are essential in agricultural conservation. They are necessary if the practice of forestry is to remain an integral part of the national development of our natural resources and the future growth and exploitation of forest crops are to remain commensurate with the demands of the Nation for all time to come.

[3]Graves has shown that, while it is true that forestry as an art and an applied science utilizes the results of research in the natural and engineering sciences and while it

[3]Graves, Henry S. The Place of Forestry among Natural Sciences Report of Smithsonian Institution for 1915, pp. 257-269.

is also true that the forester's activities, especially during the pioneer period of establishing forestry practice, may be largely administrative in character, there is nevertheless a fundamental forestry science which has a distinctive place among the other natural sciences. The science of forestry gains its distinction partially through its correlation of parts of many of the other sciences, such as botany, physics, chemistry, mathematics, engineering, entomology, zoology, and geology, but more specially through the resultant science—forestry—which depends upon an intimate knowledge of the life of the forest as such and the discovery of the natural laws governing its growth and development.

In forestry, as a natural science, we deal with the forest as a community in which the individual trees influence each other and also influence the community as an organic entity. The life history of the forest varies with the individual species entering into its composition, the density of the stand, the manner in which the trees of different ages are grouped, the climatic and soil factors which influence the vigor, growth and development of the individual trees. By abuse the forest may be greatly injured and as a living biological community, it may even be completely destroyed. The forest responds promptly to care, protection, and improved methods of treatment and by skillful management it may be made to produce a very high quality of products in greater amounts and in a shorter time than if nature were left to take her own course.

In forestry, as in other pursuits, the practice depends upon the science and logically should follow rather than precede. Scientific work in forestry can only develop gradually since the life of a single individual tree may extend over an average of six or seven generations of man.

Forest research in its development in every country must pass through a series of evolutionary stages, which, although not always sharply defined, may be grouped as follows:

1. The observational stage; when very little is known of the forest. The observations are generally made in con-

nection with other preliminary organization work such as a reconnaissance of the forest resources.

2. The investigational stage; when there is information available as to the species most in need of being studied and an actual need is felt for the results of special studies, although they are still intensely practical and designed so that the results will be available at once and of immediate application.

3. The scientific research and experiment station stage; when the character and extent of the forest resources are known and many of the real forest problems have become apparent. Efforts are made through the use of delicate instruments to secure fundamental scientific knowledge by which the biological laws governing the forests may be better understood.

Forest research in the United States has just recently reached the third stage of its development. It will become more and more stablized through the recently created Branch of Research of the U. S. Forest Service, which is co-ordinate with the administrative branches of the Service, and the Committee of the Society of American Foresters appointed to co-ordinate and correlate all forest investigations conducted in the United States and Canada.

With this rather brief discussion of research as a necessary adjunct to the actual practice of forestry your attention will now be directed to some of the present problems of forestry practice which will be solved through forest research. The fundamental problems which underlie a large number of the smaller practical problems of national forest management may be grouped as follows:

1. Studies of the life histories of forest trees, which are similar to studies of the life histories of animals, insects, and fungi, and form the basis for the silvicultural management of the forests. These studies also embrace the study of the biological characteristics of tree seed, i. e., the source of seed and its viability, the relation of seed to climatic and physical factors, and its physiological characteristics such as its capacity for delayed germination, which are fundamental to the regeneration of our forests, whether by arti-

ficial reforestation or through natural reproduction. If the life histories of our forest trees were thoroughly known, many of the methods of handling our forests would have been determined.

2. Studies of the relation of tree life to the physical and climatic factors of the habitat which go into the basic causes of the biological characteristics of forest trees. Studies of the relation of light, climate and soil to tree growth are now under way.

3. Volume, growth and yield studies of individual trees and stands, which embrace the laws of the growth of individual trees and stands. This field of investigation has been barely entered. There is a great opportunity for developing basic principles which will simplify the methods of the regulation and management of our forests.

4. The ecology of virgin forests, which includes a study of the relation between forest types or associations and their physical conditions of growth. This group is really an extension of the studies of life histories of individual trees to entire stands. When further progress has been made these studies should furnish a solid basis for the silvicultural management of our different forest types.

5. Studies of ecological succession on cut-over, burned-over, and culled forest areas. Studies of what actually takes place after a virgin forest is cut-over, or burned under the prevailing climatic and physical conditions of the region afford the best opportunities for establishing definite relations between a method of cutting and natural reproduction. Such studies also provide a basis for the rational determination of the suitability of the site for artificial reforestation and the species to be used.

6. Studies of the organic and climatic enemies of forest trees. The study of the organisms which injure forest trees is really a field for the forest pathologist, forest entomologist, and forest zoologist, while the study of the effects of snow, hail, wind, sun-scald, lightning and other climatic factors upon trees properly belongs to the forester.

7. Studies of forest influences, including the relation of forests and other vegetative cover to run-off, erosion and streamflow, the relation of forests to the climate of the region in which they are located and the regions lying to the leeward of the forests, and the effect of the forest cover upon the physical condition of the soil. These studies are basic to studies of the economic value of the forest.

8. Studies in forest economics. Data are now being compiled which show the monetary value of watershed protection to irrigation and agricultural lands dependent upon irrigation waters, to water power and to navigation. It is estimated that the service which the national forests perform in the conservation of water for irrigation alone amounts to $2,500,000 annually. Another important study is that of the effects of destructive cutting, which is typical of the private ownership of timber lands in important lumber producing regions, upon the economic and sociological welfare of the region. A study of the disposition of State timberlands and other natural resources by the State governments is in progress, the objects of which are to show (1) the prevailing policy of the States with reference to the disposition of such resources and the purpose of their use, (2) the efficiency of the State administration of the conservation policy with reference to forest resources; and (3) the general results of the State ownership of forest resources from the standpoint of the Nation as an entity.

9. Studies in forest fire protection, which have as their objects the development of a more scientific basis for rating forest fire hazard and liability, the determination of the relation of meteorological conditions to fire hazard and fire protection, the working out of the principles underlying fire protection, the determination of the basic principles of assessing forest fire damage and the relative damage in different types of forest under varying conditions. Fire protection studies are of fundamental importance to the adequate protection of the national forests from fire and in the efficient administration of them.

10. Forest products investigations, which include studies of the mechanical, physical and chemical properties of wood, wood preservation, pulp and paper-making, kiln-drying, seasoning, wood distillation, industrial statistics of the production, consumption and prices of forest products, mill-scale and depreciation studies. A comprehensive study of the lumber industry is being conducted by the Forest Service in co-operation with the Bureau of Foreign and Domestic Commerce and the Federal Trade Commission which aims to analyze in a constructive way the conditions in the leading forest-using industry of the United States, and to show their influence on the stability and advancement of the industry and on the conservation of the forest resources of the Nation. Other studies deal with the technical phases of utilization and marketing and the replacement of wood by other materials.

11. Range investigations, which include studies of the carrying capacity of the national forest ranges, the natural and artificial reseeding of the range, improved methods of handling stock, methods of developing stock-watering places, eradication of poisonous and unpalatable plants from the range, the effect of grazing upon forest reproduction, the relation of grazing to erosion, streamflow and forest fires. This group of studies is especially important in the Intermountain Region where national forest range management is perhaps more important than in almost any other region.

The Federal Government naturally assumes the leadership in forest research in the United States through the Forest Service. Out of a total annual appropriation of approximately $5,700,000, close to $375,000 are expended for research work in the groups just mentioned. This expenditure is admittedly necessary in order to lay the foundations for the practice of forestry, both on the national forests and elsewhere, for an increase in the productiveness of the forest resources, and for the economical use of forest products. A well-equipped Forest Products Laboratory is maintained by the Forest Service in co-operation with the University of Wisconsin at Madison, Wisconsin, where the majority of the research in forest products is conducted. The main purpose of the Laboratory is to promote economy and efficiency in the utilization of wood and in the processes by which forest materials are converted into commercial products. The Forest Service now maintains eight forest experiment stations each in a different forest region, one of which is located on the Manti National Forest in central Utah. At these stations, the Forest Service studies the biology of the forest trees, the relation of tree life to the environment, the ecology of virgin forests, ecological succession, forest protection, forest influences and the more highly scientific range investigations. Such really scientific problems as the effect of the forest upon the climatic factors, i. e., the temperature of the air, wind, soil moisture and humidity of the air, are being studied by means of frequent and thorough instrumental observations. The long-time studies of the effect of the source of seed upon the resulting trees and the physiological characteristics of forest tree seeds are also centered at or near the forest experiment station.

Time has not permitted the entering into any amount of detail in connection with the discussion of any of the above-mentioned lines of investigation, all of which are being pursued by the Federal Forest Service as aggressively as funds will permit. No attempt has been made at this time to present the actual results of the researches of the Forest Service, which may be secured in the detail desired by consulting the numerous publications of the Forest Service and the annual reports of the Forester. With this general survey of forest conservation, forestry as a natural science, and the more important problems of forest research confronting the Forest Service, it can be seen that the monetary value of scientific research in forestry is enormous indeed, that forest research in the United States is still in its infancy, and that, as one of the youngest branches of scientific research, it has a Herculean task before it.

MODERN BIOLOGY AND PREFORMATION.

By Newton Miller.

The Greeks as early as the 6th century B. C. were meditating on the origin of animals and their methods of propagation. Thus in the literature of this people we are told that fishes are produced spontaneously; that eels take their origin in the slime of the sea shore where air, light, water and earth meet in a creative matrix; even Aristotle taught that caterpillars were generated from green leaves.

Near the end of the Greek period the Christian religion became widely accepted and people looked more and more to the Scriptures for trustworthy information. And the book of Genesis told them of special creation. So the matter rested securely for sixteen centuries upon the de novo origin according to the Greeks and upon the teaching of Genesis.

But this should not always be. An innocent little experiment by Redi disproving the spontaneous origin of flies started a long series of experiments involving the work of Helmholz, Tyndall, Schleider and Schwann, Schroeder and Dursch, Postem and Kent, which have demonstrated conclusively that spontaneous origin of life does not exist. In the words of Harvey "Only life from an egg." Thus the Greek conception was eventually overthrown.

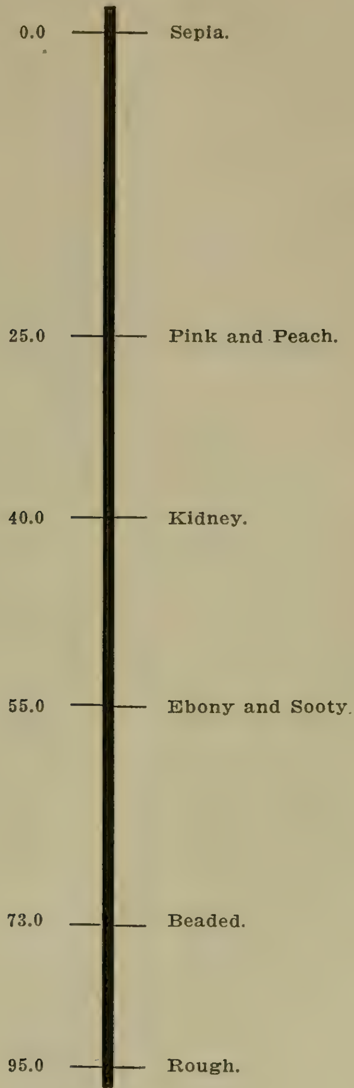
Harvey, whom I just mentioned, was asserting that life takes its origin in an egg. What is an egg? Some believed the egg to contain all that is essential to life and it only needed the male element to cause it to unfold. Others considered the egg only suitable medium in which the contribution from the male can develop. Among the Ovoists sprang up a school of preformationists headed by such men as Spallanzini, Haller and Buffon. They taught that the egg contained a chick, this chick an egg with a miniature chick in it, and this another egg and chick, etc. A Chinese box affair. This is a special creation to a nicety, and why not?

Casper Wolff was not so easily convinced, and by 1759 he was able to demonstrate that the chick was not preformed in the egg; that its parts were added in the course of development. This work was verified by other embryologists and the theory of preformation seemed forever knocked into a cocked hat.

But not so. Yet it required more than a century to revive. In this time the cell had been discovered and its importance realized in part. A closer study of the cell revealed a nucleus and the nucleus chromosomes. Direct observation and experiments have shown these chromosomes to play an important role in heredity.

Weismann made these the basis for his theory and on paper he formulated a most intricate super structure which he insisted must exist in a mature form in the chromosomes. His biophores and determinants, ids and idants were all there in the egg ready to direct the development of the individual from the fertilized egg to maturity. But these ids, idants, chromosomes, etc. are contributions from similar structures in the parents; those chromosomes of the parents from those of the grandparents, and so on ad infinitum. It is true Weismann never advocated that a chick lay preformed in the egg, yet his theory certainly smacks strongly of preformation.

And now the most recent experimental evidence is in a measure supporting Weismann's theory. T. H. Morgan and his students are at work mapping out the characters in the chromosomes, or more accurately the factors for characters. A glimpse at the chart will make this clear.



The bar is the Chromosome. To the right are indicated the factors for color and structural characters. The figures to the left show the relative distances the factors are apart.

The figure here shown is one of the four chromosomes of a ripe ovum of the fruit fly, *Drosophila ampelophila.*

If the figure is a faithful chart of a chromosome then much can be read into it in the light of a large amount of data which has accumulated in the last ten or twelve years. First, the chromosome is a product (an offspring) of the chromosomes of the parent. Second, the factors for character are contributed by the father and mother, and lastly, the factors are definitely spaced in definite chromosomes. Thus the offspring is a composite of the parental characteristics and therein is the modernized conception of preformation.

AN ESSAY COMPARING SOME MAMMALS AND BIRDS OF NORTH CENTRAL EUROPE WITH RELATED SPECIES NATIVE IN NORTHERN UNITED STATES.

By L. Moth Iversen.

In drawing a comparison between animals of one continent with related species of another, it may not be out of the way to include our neighbors (or, if you please, servants) of zoologic standing, usually termed our domestic animals. Briefly, I would state that dog, horse, ox, sheep, hog and cat appear unchanged in character and otherwise, even if their treatment and mode of living have undergone changes (more particularly in our Western States). This might be said of fowls, ducks, geese, also. In horses, for example, you may find just the same individual differences of behavior, etc., as in Europe and that although many of them in early life had the freedom of the range in the wild and woolly West.

Passing on to game mammals, the European wolf is perhaps a counterpart of our timber-wolf; while coyote holds more of a peculiarly fox nature, barring the howling voice and gregarious habit. Thus the writer has noticed the latter, single, on one occasion, moving for miles in a manner distinctly reminding him of a fox on its nightly hunt, stopping frequently and sniffing the air with nose high. Here it may be added that among wolves, as well as bears, cases are described where individuals have behaved in a quite exceptional manner, as witness: "Le loup de Gevaudan" in the time of Louis XIII. of France—a terror of that mountain country—once driven off and defeated by a few young children, without firearms, even after having seized their baby brother who was saved. (As a rule, both wolf and badger possibly may be regarded a little more independent in their ways there than here.)

Of foxes, I am inclined to think less is seen here. Lynxes are usually more retiring in Europe than here. Otter, mink and beaver show little difference; ermine none;

skunk—you know—is strictly American. Our numerous species of squirrel, ground-dog, marmot, gopher and spermophile naturally cut a much greater figure in the landscape than the few corresponding Northwestern Europeans. Wild rabbits seem to show less fear in Western United States: on occasion one met on a narrow spit of land on the eastern coast of the Baltic sea jumped into the water to escape an unarmed man.

The migratory rat which swam the Volga river as an invading army in 1728 (?), and which reached Salt Lake City about 1906 (?), shows according to my observation considerable change. While all the specimens I have seen here have been undersized (and poorly fed), very large ones were often seen in Denmark showing little fear either of man, dog or fox, let alone cat—unless the latter be of unusual size and strength. Our pack-rat I cannot speak of from personal experience. One of our small bats is remarkably courageous when cornered, biting savagely.

Whale and seal in many species belong to both sides of the Atlantic ocean.

Ruminants of certain families, forty to sixty years ago, were still lording it in hundred thousands west of the Missouri-Mississippi; and now bison and elk have, practically speaking, been sent to the "happy hunting grounds" (those in Jackson Hole and Yellowstone excepted), with antelope following suit. In 1880 there still were herds of the latter counting thousands in Wyoming. The same fate has befallen the European bison outside of the very large Bialowicz forest in Lithuania where some sixteen hundred were still protected by the Czar about twenty-five years ago. The World War in 1915 deprived him of this forest (and in 1917 of his throne), so the number of the imperial game is not likely to be much greater to-day than that of our national game in Yellowstone National Park.

Of rapacious birds, eagle, falcon, hawk, buzzard and kite exhibit much the same features of character, but American species of hawks are numerous and some show more courage and self-confidence than Europeans do towards man, for which they are often very poorly rewarded.

For instance, a beautiful squirrel-hawk, more than two feet long, took his last earthly rest in a tall popular on M street in this city, about twenty or twenty-five years ago, because before it could be prevented an ardent huntsman brought the stately bird down with his gun. Owls are frequently objects of unqualified hatred, entirely unwarranted.

Four species of owls were observed by me in Denmark and as many in Utah. Of these half at least can be recommended for admission by St. Peter as useful, unrightfully persecuted, birds. The wonderful *Speopyto* (the "burrowing" owl), I can truthfully say holds a record, for in any country and at any time I found no creature of more prepossessing manner, or sympathetic demeanor, than this useful and innocent, childlike soul—the sweetest of all Americans. I have in mind one brought home from the foot-hills by my little son in about 1895. (It was killed next day by a half-witted boy with a flipper). Six or more may often be seen on top of their burrow, apparently enjoying the view of hill or valley. The Danish species, which this mostly reminds of, is Minerva's owl which nests in village churches, and whose antics on a straw-thatched cottage-roof in bright sunshine I watched thru a field-glass in 1875 from a house about fifteen rods distant. This was in northern Jutland; and the entertainment afforded by these three or four owlets, flapping their wings and gleefully playing, will always remain with me.

Both species are consequently diurnal and contrast with such as the common night or wood owl and many others. The night owl is in my opinion the bird of most peculiar language, as the female will be heard flying with her howling mate to utter her distinct "gy e'ep" following his "oo-hoo".

Another interesting comparison can be drawn between the great uhu of the Germans, now scarcely found in Denmark, and the large horned owl of United States. The first is sixty-three to seventy-seven centimeters in length while the latter is perhaps sixty centimeters. Both are redoubtable birds, and the former is both larger, stronger and possessed of a more distinguished (almost awe-inspiring) bearing. In May, 1870, driving through a big forest in southern Zealand, our company stopped the team to admire a splendid mountain-owl on one of the lowest limbs of a big beech tree. A young count left the conveyance and threw a small rock at the bird which, however, did not even change his position—never stirred. I told him to leave it alone when he manifested a desire to obtain some expression from it. Impressed by its dignity, we all kept our eyes riveted on the majestic creature facing us as if commanding or granting a favor.

The turkey-buzzard stands without comparison as there are no vultures in northern Europe and I had no opportunity of observation in other parts of the continent.

Choosing some waders and web-footed birds, we may examine such related species as the two coots, the European and American, which are quite different in markings; storks, no species of which is native of North America; herons, cranes, pelicans and swans and hell-divers. The last named are quite different species in the two continents but present corresponding features. The crane is found in some parts of northern Europe but, like the pelican, not breeding in Denmark. One must go to southeastern Europe to find the pelican which is of different species from those of America, but like the one we are familiar with in Utah, migratory and, as all species, a powerful flier. Its mode of life, that is in flying, swimming, feeding, etc., is much the same as those of America. Sometimes the north African heron is seen in southern Europe. Coots have large families, making quite a feature; sometimes as many as twelve young may be seen swimming with their mother. They are not molested here nor there.

Touching upon such as I have known individually, the white stork stands out conspicuously with the mute swan as a character bird. The nests of both birds abound in the northern part of my native island, Zealand; therefore, I can truthfully say that the same pair of birds, either stork or swan, will return year after year or rather always to the same nest. In fact, because of their size and strength and familiarity, or acquaintance, with the human population, a census could be taken of them without great difficulty in many localities. Their residence is established. Because of the storks' color, they are easily noted in or near their nests either on thatched roofs of houses or barns or in large stunted trees near houses. Apropos of the thatched roof so commonly connected with the stork nest, I will say that I have seen the home of the bird built on tiled roofs in a number of cases in one city (Horsens, Denmark) of my acquaintance. A pair of young swans returning to the home nest and finding it occupied will occasionally take up abode on a very undeserving pond in order to maintain and secure sole occupancy of the locality.

The white stork is and has been for centuries the ever welcome associate of Danes, Dutch, Germans, Poles and a few other nations, who consider it sacred in the sense of protecting and loving it and according it the respect due a decent neighbor. A similar friendship is extended to the mute swan which is given the right-of-way on any pond or lake it may choose for a summer home, whether tame or wild. In my native country it is a thing unknown to lift a gun at a white stork, and I have never heard of a mute swan's being killed; but a different attitude is taken towards the singing swan, it being hunted like any game in proper season. Once in the month of August I saw thirty-nine white storks standing together, the largest number personally seen at one time. The largest number of mute swan seen together at one time flying was eight (in the month of May) when the writer was driving past a lake upon which the birds undoubtedly had no home as it was devoid of islets.

Different is the story of the black stork. It never voluntarily comes near man. Its home is in tall, old forests, far from human abodes. This bird is a fisherman, and I have seen it applying its art in Jutland, alone, but not far from our boat. I have never heard of its being hunted, maybe because it is not particularly palatable as a food. Fish eaters are seldom tasty.

As previously stated, the singing swan does not enjoy the peace and love accorded his brother, the mute swan.

A winter guest on the sea coast, he is an easy prey in fog, blizzard or wind to the vandal hunter. Here it might be stated to bear out the evil tale which the bird would tell of experience because of his unprotected exsistence, I have seen a person known to be a poacher walk through the open streets of a town (Holbek) proudly carrying a beautiful specimen which he had shot, flung over his shoulder.

On inland lakes, also, the beautiful and attractive greater diver, *podiceps* is seen, behaving like a coot and an excellent mother. The corresponding species, hell-diver, I have seen both on Lake Michigan and Utah Lake, but not with families.

The whooping crane, whose European cousin is the grey crane (*Grus cinerea*) and celebrated for its dancing performances, ought to be protected by us, in my opinion, for its great beauty in the landscape. To a smaller extent I feel the same for the American white pelican.

There are numerous items of interest which time will not allow me to bring out to-night, such as nest-building, parasitic birds—the cuckoo (*C. canorus*) and cowbird, as well as others, and immigrants or imported as the "English" sparrow, which, by-the-way, seems more intelligent here than in Europe, although I have heard that in England it truly sings.

In conclusion, therefore, I dare say that even a centenarian who had taken an active interest in animals (furry or feathered) would, if privileged to live in health an additional century, be convinced that new phases of animal life could be found and observed and old questions more fully answered; and that without consideration to the vast interest that might be awakened through the so little explored field of their many languages.

BEET MOLASSES AS A FEED FOR WEANLING PIGS.

By W. E. Carroll.

(Summary).

Thirty grade Tamworth pigs between 9 and 12 weeks old were divided into three as nearly uniform lots as possible. A basal ration composed of 2 parts ground barley and 3 parts wheat shorts was fed to all lots. Lot 1 received only the basal ration; Lot 2, the basal ration and 1 pound of beet molasses for each 100 pounds live weight; Lot 3, the basal ration and 2 pounds of the molasses for each 100 pounds live weight.

Feeding was done by lots. Weights were taken weekly of each lot and individual weighings were made each month.

Feeding began July 23 and as early as August 28 two pigs in Lot 3 died. Up to this time the pigs in neither Lots 2 nor 3 appeared as thrifty as in Lot 1.

The symptoms preceding death were loss of appetite, lack of thrift, and partial loss of muscular control, resulting in a wobbling, uncertain gait. This muscular weakness sometimes lasted a day or two and then disappeared for a time. There was no scouring in any of the cases, as would be expected had the animals been overfed in the ordinary meaning of that term.

Post mortem examination of two of the typical cases showed no decided pathological condition. The livers and kidneys were, however, considerably congested.

The first death in Lot 2 occurred September 18. At the close of the test Lots 2 and 3 each contained only 3 live pigs, while not one pig had been lost from Lot 1. The average live weight of the surviving pigs was 57 pounds for those in Lot 2 and 47 pounds for the ones in Lot 3, as against 88 pounds for the average of the 10 pigs in Lot 1.

Such disastrous results were not expected at the beginning and no provision was made for an adequate examination of the affected and dead animals.

No explanation is offered for the cause of death, as other experiments are recorded where more of the molasses was fed than in this test. The age of the pig, however, may be a factor.

FACTORS AFFECTING THE DEATH OF PLANTING VARIOUS CROPS.

BY HOWARD J. MAUGHAN.

(Summary.)

Experiments showing the effect of the depth of planting on the germination and growth of various seeds have been recently completed at the Utah Agricultural Experiment Station. Wheat, oats, corn, barley, alfalfa, peas, beans, sugar beets, and sorghum were planted in a fertile clay loam soil at depths from 1 to 8 inches under three conditions of soil moisture to find the best depth for growth under different soil conditions. The growth of the young plants was observed at 5-day intervals from planting, making a total of 17,280 determinations.

The tests showed that although the 3 to 6 inch plants usually gave a higher percentage of germination, the depth of planting seeds does not influence germination or sprouting very much. The 3 to 6 inch depths were especially favorable for the germination of alfalfa, sugar beets, and sorghum seed.

The depth of planting giving optimum germination was not materially affected by the percentages of soil moisture used, although the soil with high moisture was about two-thirds saturated and the soil with low contained less than half as much. With beans, however, the optimum germination depth was 2 inches and 4 inches for high and low soil moisture respectively.

The plants nearly always grew faster when planted from 1 to 2 inches deep in the soil regardless of soil moisture. This was noticed particularly with small seeds, with seeds having poor germinating power, and with the roots more than the tops. Deep planting seriously retarded the growth of both the roots and tops of the young plants.

The height of the plants above the soil generally decreased as the depth of planting increased. The largest growth of plants above ground never occurred from seeds

planted deeper than 3 inches. Small seeds planted deeper than 3 inches failed to reach the surface in 20 days.

Thus, while the best germination usually occurred with the 3 to 6 inch plantings, the growth of the plants was faster with shallow sowings. Well-developed root systems and a good growth of tops were produced by the shallow-planted seeds, while the young plants from the deeper-planted seeds were using their stored food endeavoring to reach the surface of the soil.

THE TEMPORAL CONDITIONS OF VOLUNTARY CONTROL.

BY GEORGE S. SNODDY.

The investigations which form the basis of the report I shall give today have been in progress for the last five years and have been performed largely in the laboratory of experimental psychology at Clark University. Some experiments in continuation of the original investigation have been performed in the laboratory of the University of Utah. This paper will attempt to abstract certain portions of the results which I believe will be interesting and intelligible to a group rather more interested in general science than in the subtle points of psychological theory and experimentation.

Before we attempt to present the point of view developed in these experiments, a few statements about the field of voluntary control in general, would seem to be of value in clearing up the meaning and purpose of the investigation. In the first place voluntary control has not been submitted to very careful experimentation; which state of affairs is largely due to two conditions. On the one hand, psychologists have not, until very recently, found it necessary to learn very much about the conditions of control, and, on the other hand, when they did resort to experiment, they were often misled into unprofitable theories and speculations. When modern industry turned to the psychological laboratories for aid in the securing ways and means by which they could get more efficient service out of workmen and at the same time make the life of the employee longer and more enjoyable, experimental psychologists were stimulated to attempt some fairly well directed experiments in this field. Prior to this time, however, experimental efforts were in part suppressed and in part misdirected by the prevailing conception of will which is the heritage of psychology as well as of common life.

The gist of the popular or common sense conception of will is most clearly seen by redirecting our attention to the title of this paper, the conditions of voluntary control. We seem to be assuming, as the popular mind would say, that the will is not free, that it is subservient to something, viz., these very conditions we are about to study. This same popular mind would say that the will is a dynamic, causal agent which is not at all the result of conditions. To use a dynamic figure, he would probably say that the will is the charge of explosive which blows these socalled conditions to the four winds. From this conception, which was at one time the view of psychologists and still the view of the popular writers such as Channing, Larsen and others, psychologists had to be freed before profitable experimentation could proceed. The writer has no desire to seek fame for himself, rather charity, when he says that this study is one of the first attempts to put the will problem on what I want to call a profitable experimental basis. In fact the experimental part of the thesis herein contained, so far as it is a study of control, is in every way original with the writer.

The only studies which have thrown any light at all on the physiological conditions underlying voluntary control are those from the abnormal field. These studies have been made upon abnormal patients in hospitals and asylums. In many of these abnormal cases, the control, which has been built up by long practice, as in the case of handwriting, has been lost piecemeal through progressive breakdown of the nervous system in disease. The remnants of the nervous system left intact and the resulting loss in control has thrown a flood of light on the physiological mechanism of control. These studies have not, however, left us with any means of aiding or determining the conditions of control in the normal subject, and it is just these which the industrial psychologist wants to be able to do.

With just these ideas in mind, the writer was stimulated to attempt some actual experiments with normal subjects on the conditions of control. I cannot introduce you to my point of view better than by narrating some of the stages of development through which I went in building up the experiment. William James years ago made a general statement, altogether without analysis or explanation, with reference to the acquisition of skill and the influence of time periods upon that acquisition, "that we learn to skate in summer and swim in winter." In other words, James had observed that the recess period following a practice period was of enormous value in building up a skill of execution in a practiced act. As already indicated James did not attempt to offer a satisfactory explanation of the phenomenon. The verification of James' observation is so difficult to obtain that it has never been received very seriously. Some observers have contended that they have seen ample proof of this law and as a result have accepted it, but these observations had to meet the far more general law that we seem to forget a little of everything during the recess periods which follow the practice. The typist who returns from a vacation expects to practice considerably before he reaches the efficiency maintained before the recess. In the face of such results, it was difficult for many psychologists to believe there was any truth in James' contention. Forgetting was held to be so well nigh universal that it would always seem to militate against, if not completely offset, any improvement which might take place across a recess interval. On the other hand we have had observations from such unscientific sources as golf players who observe that the first day of practice seems to net them nothing, but upon returning to the game after a recess of a few days they are surprised to find that the first stroke seems to be just the right one. Many of these observers have contended that the degree of skill secured over the recess intervals far exceeds any acquisition in later practice. Psychologists, however, have generally contended that these observations are simply the result of illusion and that if accurate measurement be taken we are sure to find that the golf player has lost much of his efficiency over the recess interval.

To make our story shorter the writer admits that he had become a firm believer in the doctrine of the recess interval as propounded by James long before he knew that James had ever advanced such a view. To demonstrate this law in an experimental situation has always seemed to me a practical and valuable experiment. But to do so one would need to employ an activity which involved little or no forgetting, otherwise, the loss during the recess from forgetting would far more than compensate any gain that would come from the recess. Little progress was made in the matter of finding a learning exercise which involved no forgetting until the writer came across a study made by Judd, while still a teacher at Yale, which dealt with practice on some of the optical illusions until the illusion would be overcome. Judd found that after the illusion had been overcome by constant practice that the learning, and such it actually is, would persist without modification for a period of a year.

Judd had given us a clue. But, what were we to do? Judd's apparatus could not be duplicated because of the enormous expense. We hit upon the device known as mirror tracing. This seemed to involve the illusion and was open to accurate and easy use in the laboratory. Our first experiment with the mirror tracing was a complete success. We found that after a certain degree of efficiency had been secured, that this was not only retained but oftentimes improved upon after a lapse of nine months. James was verified and we found ourselves in possession of data far richer than James had ever suspected, for it was not only shown that improvement would occur over the recess interval, but that some recess was absolutely necessary for improvement to take place at all. It was also shown that the amount of recess or time out between practices which was necessary for the highest efficiency varied enormously with individuals. This led us to feel that we had found a device by which we could measure the time element of voluntary control. The results from futher experimentation more than justified our hopes. Below, are indicated some of the conclusions from our studies which bear directly upon the problem of control.

To summarize our findings here: In the early stages of the learning the recess period is absolutely necessary for any improvement in accuracy; the least improvement cannot be made until a recess period is allowed. As the learning continues, however, the length of the time interval required for control becomes less and less. A stage is ultimately reached where further improvement will be a gain in speed, not accuracy, and this improvement is dependent upon series, not recess, practice. A complete learning curve is dependent upon recess period practice at first and mixed series and recess practice later.

The length of the recess interval necessary for the attainment of the highest efficiency in accuracy varies enormously from subject to subject. Some subjects require a period five times as long as do others. For most subjects maximal efficiency in accuracy is secured during the early stages of the learning by one practice per day.

An average group of subjects may readily be divided into those requiring long recess periods for the attainment of accuracy and those who can secure a high degree of accuracy with a short recess. If twenty-four hour recess intervals precede all practices, an average group of college students will differ slightly in the attainment of accuracy. Now if the interval preceding practice is reduced to ten minutes, there will be wide variations as to accuracy attained, the highest often being three to four times as high as the lowest. From this it is seen that individuals differ not so much in their ability to attain accuracy as in the temporal conditions underlying its attainment.

Those subjects who show the poorest control are (1) those who speed up most during series practice; (2) those in whom this speed is little retarded by the insertion of short recess intervals; (3) those who are popularly called quick, snappy, and more accurately, nervous; (4) those most affected by drug stimulants such as strychnine or caffein; (5) those most affected by the social stimulus or the presence of others in the laboratory; (6) those in whom the efficiency from time to time is extremely variable.

Those subjects who show the best control are (1) those whom the world would call somewhat slow, the phlegmatic type in general; (2) those who do not lose their accuracy in a marked way by light doses of strychnine or caffein;

(3) those who are not affected by the social stimulus; (4) those whose work is not variable from time to time.

In conclusion I would point out that one of the essential elements in voluntary control as revealed by these studies is the time period which must precede a performance. Since this period is long for some and short for others, and since the time period necessary for an accurate performance is lengthened by drug stimulants such as strychnine and caffein, it seems clear that the phase of control which we have measured is fundamentally a process of neural integration or upbuilding which in turn conditions the accuracy output of the subject, especially the temporal conditions of that output. The integration proceeds at different rates in various individuals and is probably going on all the time but, with respect to any one performance, if the anabolism would exceed the katabolism the subject must have a cessation of activity in that performance. The anabolism is preserved by the elimination of all drugs and the katabolism hastened by the administration of them. This anabolism is greatly aided by the practice of all those economies and abstinences generally found to favor health and bodily vigor.

THE LIQUID SULPHUR DIOXIDE METHOD OF DETERMINING AROMATIC HYDROCARBON OILS.

By Thomas Joseph.

(Abstract).

Oils and tars are for the most part complex mixtures of solids and liquids, not all of the same type, but belonging to widely different chemical groups. Since the commercial value of the oil or tar depends upon the relative amounts of these various components, a method of making quantitative determinations is of considerable importance, and a number have been proposed. These methods all remove the constituents of basic nature by washing a dilute acid, and those of acid nature by washing with a dilute alkali. There remain then to be determined (a) unsaturated hydrocarbons, either cyclic or open chain compounds, (b) benzene derivatives and (c) saturated hydrocarbons, either cyclic or open chain compounds. The method most commonly pursued from this point on is to remove the unsaturated hydrocarbons by shaking with ordinary concentrated sulphuric acid, the unsaturated compounds dissolving in the strong acid, and are then easily separated from the lighter layer of immiscible oil. The benzene derivatives are then dissolved in dimethyl sulphate, leaving the saturated hydrocarbons unattacked.

Several objections attach to this method, the most serious being that none of the separations are complete and exact. The sulphuric acid will dissolve some of the benzene derivatives, and the dimethyl sulphate will dissolve some of the saturated hydrocarbons, especially if these are of low boiling point. Another serious objection is that while dimethyl sulphate is almost odorless, and so gives no warning, it is at the same time a very active poison.

In October of 1915 Dr. W. F. Rittman, of the U. S. Bureau of Mines, published the details of a different method, in which unsaturated compounds and benzene derivatives are removed together by dissolving in liquid sulphur

dioxide, the saturated hydrocarbons remaining unattacked and forming an upper layer of immiscible oil. Dr. Rittman very carefully and specifically pointed out that the separation must be made at a temperature not higher than 20 degrees centigrade, and that if the oil contained in excess of 25 per cent of benzene derivatives and unsaturated compounds the addition of liquid sulphur dioxide would not cause a separation into two layers. In that case it is necessary to add enough of an inert paraffin oil to reduce the content of unsaturated and benzene hydrocarbons to less than 25 per cent.

In attempting to make use of Dr. Rittman's method in our own work on oils and tars we quickly found that we were able to get satisfactory separation into two layers, even when 60 per cent or 80 per cent of the oil dissolved in the sulphur dioxide. We also found that in some cases repeated washing with the sulphur dioxide would completely dissolve the sample of oil. This suggested the possibility that the saturated hydrocarbons are not so insoluble in the liquid sulphur dioxide as Dr. Rittman had assumed. In following up this point we found that every sample of petroleum oil we could get hold of was soluble in the sulphur dioxide, the solubility running sometimes as high as 10 per cent of the weight of oil taken, and using an equal volume of the solvent. The oils tested included gasolines, kerosenes, hexane and heptane, and specially prepared distillates of definite boiling point range. We also found that as the percent of benzene derivatives increased the amount of the added diluent recovered diminished. The maximum recovery of added diluent (gasoline or kerosene) is had when the amount of benzene derivatives does not exceed 30 per cent, but a quantitative recovery cannot be had in any case, due to the solubility of the added diluent (gasoline or kerosene) in the sulphur dioxide. This introduces an error into the method which it would seem almost impossible to overcome.

THE DESTRUCTIVE DISTILLATION OF GILSONITE.

By Theodore Erickson.

(Abstract).

Utah possesses very extensive deposits of solid and semisolid hydrocarbons, of which gilsonite, elaterite and asphaltum are perhaps the best known. These hydrocarbons are at present but little utilized, and hence the Department of Chemistry of the University of Utah has undertaken a systematic study of them to determine if possible, (a) their real chemical nature and (b) their commercial possibilities. At present gilsonite is receiving our attention, and our work thus far has been confined to destructive distillation at atmospheric pressure.

When subjected to destructive distillation at atmospheric pressure, gilsonite yields about 50 per cent of its weight in a thin black oil, about 30 per cent of its weight appears as gas, and about 20 per cent remains in the retort as coke. The gas yields about 0.25 per cent of ammonia, but as yet no further examination has been made of it and the coke has not been examined.

The oil, 8 liters of which we prepared, was washed with dilute sulphuric acid, then with dilute sodium hydroxide, then with water, and finally dried over sodium. It was next fractionally distilled, using an efficient distilling column filled with short pieces of aluminum wire. Cuts were made each 5 degrees, and the distillation repeated eleven times. The temperature range of the distillation was from about 40 degrees to above 300 degrees, and all the distillations above 150 degrees were carried out under a pressure of 15 mm of mercury. After this distillation was finished the whole series was again distilled making 2 degree cuts instead of 5, and this was repeated 10 or 11 times. By this time there were well defined accumulations of oil at various points in the series, and these accumulations were next redistilled, taking one degree cuts. The object of these repeated distillations was to secure as perfect as possible a separation of the oil into its various components. We are now engaged in the chemical and physical examination of these oils.

INDEX

Page

A General Survey of the Jurassic in Southeastern Utah—J. B. Forrester 33

Alfalfa Hay for Milk Production, Comparative Value of First, Second and Third Crop (Abstract)—Dr. W. E. Carroll 114

Alkali Content of Certain Utah Soils, The (Summary)—Dr. F. S. Harris 153

Anastomosing of Arteries and Veins in a Cat, The—Dr. Newton Miller and James S. Godfrey 185

Ants, The Honey (Abstract)—A. O. Garrett 22

Aromatic Hydrocarbon Oils, The Liquid Sulphur Dioxide Method of Determining (Abstract)—Thomas Joseph 214

A Short Comment on Bulletin 371 of the U. S. Geological Survey—J. B. Forrester 24

Ball, Dr. E. D., mentioned 5

Bardwell, Carlos and others—Chemical Properties of Utah Hydrocarbons 78

Beet Molasses as a Feed for Weanling Pigs (Summary)—Dr. W. E. Carroll 205

Berryman, B. Arthur, mentioned 6

Berryman, B. Arthur and others: Chemical Properties of Utah Hydrocarbons 78

Berryman, B. Arthur: Outline of Mining and Smelting Conditions at Santa Fe, New Mexico 122

Biological Investigations upon the Other Sciences, The Influence Of—A. O. Garrett 68

Blossom Infection by Smuts—Dr. C. N. Jensen 106

Bombus and Osmia, Nesting Habits of—Dr. Philena Fletcher Homer 16

Brighton, Thos. B. and Others: Chemical Properties of Utah Hydrocarbons 78

Cardiff, Dr. Ira D., mentioned 5

Cardon, P. V.: Progress in Cereal Improvement at the Nephi Substation 117

Carroll, Dr. W. E.: Beet Molasses as a Feed for Weanling Pigs (Summary) 205

Carroll, Dr. W. E.: Comparative Value of First, Second and Third Crop Alfalfa Hay for Milk Production (Abstract) 114

Carroll, Dr. W. E.; Effect of the Amount of Protein Consumed Upon the Digestion and Protein Metabolism of Lambs and upon the Composition of their Flesh and Blood (Conclusions only) 137

Carroll, Dr. W. E.: Selecting Dairy Bulls by Performance 141

Carroll, Dr. W. E., mentioned 6

Cellulose Ferments, The (Abstract)—Dr. J. E. Greaves 64

Chemical Properties of Utah Hydrocarbons—Carlos Bardwell, Benjamin Arthur Berryman, Thomas Bow Brighton, Kenneth Brown Kuhre 78

Page
Comparative Value of First, Second and Third Crop Alfalfa Hay for Milk Production (Abstract)—Dr. W. E. Carroll........... 114
Constitution and By-Laws.. 9
Corn Under Irrigation (Summary)—Dr. F. S. Harris............. 120
Destructive Distillation of Gilsonite, The (Abstract)—Theodore Erickson 216
Daines, Dr. Lyman L.: mentioned................................ 6
Drawn Wire Tungsten Lamps, The Pressure-Watt Characteristics of—C. Arthur Smith.................................. 172
Ebaugh, Dr. W. C.: Our National Awakening to the Importance of Science 155
Ebaugh, Dr. W. C., mentioned.................................. 5
Effect of the Amount of Protein Consumed upon the Digestion and Protein Metabolism of Lambs and upon the Composition of Their Flesh and Blood (Conclusions only)—Dr. W. E. Carroll.. 137
Effect of Soil Alkali on Plant Growth (Abstract)—Dr. F. S. Harris.. 131
Effect of Soil Moisture on the Morphology of Certain Plants, The (Summary)—Dr. F. S. Harris................................ 65
Electric Conductivity of Thin Metallic Films, The Variation of the (Abstract)—Dr. Orin Tugman......................... 177
Erickson, Theodore: The Liquid Sulphur Dioxide Method of Determining Aromatic Hydrocarbons........................ 216
Eyring, Prof. Carl F.: mentioned................................ 6
Factors Affecting the Depth of Planting Various Crops (Summary)—Howard J. Maughan............................ 206
Ferments, The Cellulose (Summary)—Dr. J. E. Greaves.......... 64
Fletcher, Dr. Harvey: Industrial Research in the United States (Presidential Address) 142
Fletcher, Dr. Harvey: Molecular Reality (Abstract)............. 118
Fletcher, Dr. Harvey: mentioned................................ 6
Forestry, Some Present Day Problems in—E. R. Hodson........ 45
Forestry, Value of Scientific Research in—C. F. Korstian........ 186
Forrester, J. B.: A General Survey of the Jurassic in Southeastern Utah 33
Forrester, J. B.: A Short Comment on Bulletin 371 of the U. S. Geological Survey 24
Forrester, J. B.: mentioned..................................... 5
Garrett, A. O.: Honey Ants (Abstract)........................... 22
Garrett, A. O.: mentioned...................................... 5, 6
Garrett, A. O.: The Influence of Biological Investigations Upon the Other Sciences (Presidential Address).................. 68
Garrett, A. O.: Some Unique Rusts.............................. 132
Gibson, Professor J. L.: mentioned.............................. 5, 6
Gilsonite, The Destructive Distillation of (Abstract)—Theodore Erickson 216
Godfrey, James S. and Dr. Newton Miller—The Anastomosing of Arteries and Veins in a Cat.................................. 185
Goodwin, Dr. S. H.: mentioned................................. 5
Greaves, Dr. J. E.: The Cellulose Ferments...................... 64

Page

Greaves, Dr. J. E.:The Influence of Arsenic Upon the Biological Transformations of Nitrogen of Soils (Summary)............ 128
Greaves-Walker, A. E.: mentioned.............................. 5
Hall, E. M.: mentioned.. 5
Harris, Dr. Frank S.: mentioned................................ 6
Harris, Dr. Frank S.: The Alkali Content of Certain Utah Soils... 153
Harris, Dr. Frank S.: Corn Under Irrigation (Summary).......... 120
Harris, Dr. Frank S.: The Effect of Soil Alkali on Plant Growth (Abstract) 131
Harris, Dr. Frank S.: The Effect of Soil Moisture on the Morphology of Certain Plants (Summary)...................... 63
Harris, Dr. Frank S.: The World Without Science (Presidential Address) 178
Henderson, Professor W. W.: mentioned......................... 5
Historical 22
Hodson, E. E.: Some of the Present Day Problems in Forestry... 45
Homer, Dr. Philena Fletcher: Nesting Habits of Bombus and Osmia 16
Homer, Dr. Philena Fletcher: mentioned......................... 5
Honey Ants, The (Abstract)—A. O. Garrett...................... 22
Industrial Research in the United States—Dr. Harvey Fletcher... 142
Influence of Arsenic upon the Biological Transformation of Nitrogen in Soils (Summary)—Dr. J. E. Greaves............ 128
Influence of Biological Investigations Upon the Other Sciences, The—A. O. Garrett.. 68
Intensity of Nitrification in Arid Soils, The (Abstract)—Dr. Robert Stewart 96
Iron, The Rusting of (Abstract)—Dr. C. W. Porter.............. 63
Iversen, L. Moth: An Essay Comparing Mammals and Birds of North Central Europe with Related Species in Northern United States 199
Jensen, Dr. C. N.: Blossom Infection by Smuts.................. 106
Jensen, Dr. C. N.: mentioned.................................... 6
Jones, Prof. Marcus E.: mentioned.............................. 5, 6
Joseph, Thomas: The Liquid Sulphur Dioxid Method of Determining Aromatic Hydrocarbon Oils (Abstract).............. 214
Jurassic in Southeastern Utah, A General Survey of the—J. B. Forrester.. 33
Knowlton, Dr. A. A.: mentioned................................. 5, 6
Korstian, C. F.: Value of Scientific Research in Forestry........ 186
Kuhre, Kenneth D. and others: Chemical Properties of Utah Hydrocarbons 78
Mammals and Birds of Northern Central Europe with Related Species in Northern United States, An Essay Comparing—L. Moth Iversen 199
Mattill, Dr. H. A.: Recent Advances in our Knowledge of Protein Metabolism (Abstract)................................ 105
Maughan, Howard J.: Factors Affecting the Depth of Planting Various Crops (Summary)................................. 206
Miller, Dr. Newton: mentioned.................................. 6

Page
Miller, Dr. Newton: Modern Biology and Preformation.......... 195
Miller, Dr. Newton and James S. Godfrey: The Anastomosing of Arteries and Veins in a Cat.................................. 185
Modern Biology and Preformation—Dr. Newton Miller.......... 195
Mohr, E. and Dr. E. G. Peterson: Nitrogen Fixation by Bacteria in Utah Soils (Summary).................................. 97
Molecular Reality (Abstract)—Dr. Harvey Fletcher.............. 118
Neal, W. D.: mentioned.. 5, 6
Nephi Substation, Progress in Cereal Improvement at the (Abstract)—P. V. Cardon 117
Nesting Habits of Bombus and Osmia— Dr. Philena Fletcher Homer.................................. 16
Nitrification in Arid Soils, The Intensity of (Abstract)— Dr. Robert Stewart 96
Nitrogen Fixation by Bacteria in Utah Soils (Summary)— Dr. E. G. Peterson and E. Mohr.................................. 97
Norton, Miss Gertrude: mentioned.................................. 5
Notes on Vertical Distribution of Temperature— Dr. A. H. Thiessen.................................. 55
Officers of the Academy from 1908 to 1918.......................... 5
Our National Awakening to the Importance of Science— Dr. W. C. Ebaugh.................................. 155
Outline of Mining and Smelting Conditions at Santa Fe, New Mexico—B. Arthur Berryman.................................. 122
Peterson, Dr. E. G. and E. Mohr: Nitrogen Fixation by Bacteria in Utah Soils (Summary).................................. 97
Peterson, Dr. Joseph, mentioned.................................. 6
Peterson, Dr. Joseph: Physical Relations of Subjective and Objective Combination Tones (Abstract).................... 99
Peterson, Prof. Wm.: mentioned.................................. 5
Physical Relations of Subjective and Objective Combination Tones (Abstract)—Dr. Joseph Peterson.................... 99
Porter, Dr. C. W.: The Rusting of Iron (Abstract).............. 63
Porter, M. Rich: Some Problems for Utah Botanists.............. 101
Program of the First Annual Convention.......................... 15
Program of the Second Annual Convention.......................... 21
Program of the Third Annual Convention.......................... 32
Program of the Fourth Annual Convention.......................... 44
Program of the Fifth Annual Convention.......................... 61
Program of the Sixth Annual Convention.......................... 78
Program of the Seventh Annual Convention.......................... 119
Program of the Eighth Annual Convention.......................... 130
Program of the Ninth Annual Convention.......................... 141
Program of the Tenth Annual Convention.......................... 170
Progress of Cereal Improvement at Nephi Substation (Abstract)—P. V. Cardon.................................. 117
Protein Metabolism, Recent Advances in our Knowledge of (Abstract)—Dr. H. A. Mattill.................................. 105
Recent Advances in our Knowledge of Protein Metabolism (Abstract)—Dr. H. A. Mattill.................................. 105

Page
Roster of Members 7
Rusting of Iron, The (Abstract)—Dr. C. W. Porter 63
Rusts, Some Unique—A. O. Garrett 132
Selecting Dairy Bulls by Performance (Abstract)—
Dr. W. E. Carroll 141
Science, Our National Awakening to the Importance of—
Dr. W. C. Ebaugh 155
Science, The World Without—Dr. F. S. Harris 178
Smith, C. Arthur: mentioned 6
Smith, C. Arthur: The Pressure-watt Characteristics of Drawn
Wire Tungsten Lamps 172
Smith, Dr. Franklin O.: The Voice Tonoscope (Abstract) 139
Smuts, Blossom Infection of—Dr. C. N. Jensen 106
Snoddy, Dr. George S.: The Temporal Conditions of Voluntary
Control 208
Soil Moisture on the Morphology of Certain Plants, The Effect
of (Summary)—Dr. F. S. Harris 65
Some Present Day Problems in Forestry—E. R. Hodson 45
Some Problems for Utah Botanists—M. Rich Porter 101
Some Unique Rusts—A. O. Garrett 132
Spooner, C. C.: mentioned 5
Stewart, Dr. Robert: The Intensity of Nitrification in Arid
Soils (Abstract) 96
Stewart, Dr. Robert, mentioned 5
Sundwall, Dr. John: mentioned 5
Temperature, Notes on Vertical Distribution of—
Dr. A. H. Thiessen 55
The Pressure-watt Characteristics of Drawn Wire Tungsten
Lamps—C. Arthur Smith 172
Thiessen, Dr. A. H.: Notes on Vertical Distribution of
Temperature 155
Titus, Dr. E. G.: mentioned 5, 6
Tugman, Dr. Orin: The Variation of the Electric Conductivity
of Thin Metallic Films (Abstract) 177
United States, Industrial Research in the—Dr. Harvey Fletcher 142
Utah Botanists, Some Problems for—M. Rich Porter 101
Utah Hydrocarbons, Chemical Properties of—
Carlos Bardwell and Others 78
Utah Soils, Nitrogen Fixation by Bacteria in (Summary)—
Dr. E. G. Peterson and E. Mohr 97
Value of Scientific Research in Forestry—C. F. Korstian 186
Voice Tonoscope, The (Abstract)—Dr. Franklin O. Smith 139
Voluntary Control, The Temporal Conditions of—
Dr. Geo. S. Snoddy 208
Vorhies, Dr. C. T.: mentioned 5
West, Dr. Frank L.: mentioned 6
Widtsoe, Dr. John A.: mentioned 5
World Without Science, The—Dr. F. S. Harris 178

TRANSACTIONS

of the

UTAH ACADEMY OF SCIENCES

VOLUME II (1918-1921)

1921

TRANSACTIONS

of the

UTAH ACADEMY OF SCIENCES

VOLUME II (1918-1921)

1921

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MAMMOTH
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CONTENTS.

Eleventh Annual Convention (1918) 15-45

Twelfth Annual Convention (1919) 46-117

Thirteenth Annual Convention (1920) 118-174

Fourteenth Annual Convention (1921) 175-267

Index 269-276

List of Officers

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LYMAN, DR. RICHARD R. (1912)
Professor Civil Engineering, U. of U., 47 E. S. Temple, Salt Lake City
MAESER, DR. SHERWIN(1917)......................Asst. Professor Chemistry, U. A. C., Logan
MALMSTEN, HARRY E. (1921)............Grazing Examiner U. S. Forest Service, Ogden
MARTIN, DR. THOMAS L. (1921)..................................Professor Agr. B. P. U., Provo
MATTHEWS, BRUCE R. (1921)
Teacher Chemistry, West High School, 954 S. W. Temple, Salt Lake City
MORSE, MISS HAZEL L. (1916)....Teacher Physiography East High School, Salt Lake
NICHOLS, JOSEPH K. (1921)..........................President Dixie Normal College, St. George
OGILVIE, ORIN A. (1920)...352 Milton Ave., Salt Lake City
OTTE, JOSEPH E. (1918)..Salt Lake City
PAUL, DR. J. H. (Charter, 1908)....Prof. Nature Study & Geog., U. U., Salt Lake City
PEHRSON, E. W. (1909).....................Asst. Professor Mathematics, U. U., Salt Lake City
PITTMAN, D. W. (1910)..........................Asst. Agronomist Exp. Station, U. A. C., Logan
PLUMMER, DR. CHAS. G. (1918)...................................465 E. S. Temple, Salt Lake City
QUINN, ELTON E. (1920)....Asst. Prof. Chemistry, U. U., 1360 Browning, Ave., Salt Lake
RICHARDS, DR. B. L. 1921)...Plant Pathologist, U. A. C., Logan
ROCKEY, D. W. (1921).........................General Chemist, Amalgamated Sugar Co., Ogden
SEARS, DR. HEBER J. (1921)....Prof. Hygiene & Preventive Med., U. U., Salt Lake City
SHACKELL, DR. LEON F. (1921)
Prof. Physiology and Physiological Chemistry, U. U., Salt Lake City
SHOEMAKER, DAVID A. (1921)............Grazing Examiner, U. S. Forest Service, Ogden

SMITH, ORSON (1918)..........Teacher Sandy High School, Murray
SPALDING, TOM (1917)..........R. F. D. 1, Box 108 Provo
STEINER, CHRISTIAN D. (December, 1913)
Professor Agr. Education, U. U., Salt Lake City
STEVENSON, CLARENCE C. (1921)....Asst. Metal., U. S. Bureau Mines, Salt Lake City
SUGDEN, JOHN W. (1917)..........915 Deseret Bank Bldg., Salt Lake City
THOMAS, ELBERT D. (1917)......Prof. Oriental Life and Culture, U. U., Salt Lake City
THOMPSON, HARRY L. (1921)..........Professor Pharmacy, U. U., Salt Lake City
THORNE, GERALD G. (1918)
Sugar Beet Investigator, U. S. D. A., 962 So. 8th West, Salt Lake City
UNSELD, GEO. P. (1920)..........Tchr. Physics, West High School, Salt Lake City
VARLEY, THOMAS (1921)..........U. S. Bureau Mines, Salt Lake City
WILSON, C. OREN (1916)
Teacher Economics, East High School, 940 McClelland, Salt Lake City
WINGATE, JAMES F. (1921)..........Teacher High School, Springville

MEMBERS-ELECT.*

ALBRO, FRANCIS W. ....Chemist Sperry Flour Co., Ogden
BECRAFT, R. J..........Asst. Prof. Range Management, U. A. C., Logan
EDLEFSEN, N. E..........Instructor in Physics, U. A. C., Logan
PACK, HERBERT J..........Instructor in Zoology, U. A. C., Logan
STEWART, GEO..........Professor Agronomy, U. A. C., Logan
THOMAS, M. D..........Assoc. Agronomist, U. A. C., Logan

*Nominated by Council to be presented for election at the next meeting of the Academy.

Constitution

ARTICLE I.

Section 1. The name of this organization shall be "The Utah Academy of Sciences."

ARTICLE II.

Sec. 1. The objects of this Academy shall be to promote investigation and to diffuse knowledge in the various departments of science.

ARTICLE III.

Sec. 1. *Members*.—Any person interested in the promotion of science may be a member of this Academy upon nomination by the Council and assent of three-fourths of the members present at any regular meeting.

Sec. 2. Each applicant for life, resident or associate membership must be proposed in writing at a stated meeting of the Academy by two or more resident or life members. Except at the last session, names ratified by the Council shall be placed in the hands of the members at least one session before election. A three-fourths vote of members present shall be required for election.

Every person applying for membership in the Academy shall accompany his application with the initiation fee and the first annual dues, and shall sign the Constitution.

Sec. 3. *Fellows*.—Fellows may be elected by the Council from the members upon presenting satisfactory evidence of having done original investigation.

Sec. 4. Fellows who have removed from the State may be transferred to associate membership.

Members or Fellows who have removed from the

State and who have been dropped from the rolls for the non-payment of dues, may upon their return to the State have their names restored to the rolls as provided for new members in Art. III, Sec. 2 of this Constitution.

Sec. 5. Honorary members shall be non-residents of the State. They may be elected on account of special prominence in science on the written recommendation of two members of the Academy. The elections shall be in the manner prescribed for resident members.

Sec. 6. *Patrons*.—Any person paying to the Academy the sum of one hundred dollars ($100.00) at one time shall be classed as a patron and shall be entitled to all the privileges of a member and to all publications of the Academy.

Sec. 7. *Fees*.—Resident members shall pay an initiation fee of one dollar and annual dues of two dollars; but the Secretaries shall be exempt from the payment of regular dues during the years of their service.

Sec. 8. *Life Members*.—Any person who at one time shall contribute twenty-five dollars ($25.00) to the funds of the Academy may be elected a life member of this Academy and shall be exempt from all assessments therein.

ARTICLE IV.

Sec.1. *Officers*.—The elective officers of this Academy shall be chosen by ballot at the annual meeting, and shall consist of a President and two Vice Presidents, who shall perform the duties usually pertaining to their respective offices. All of the officers shall be elected or appointed from the Fellows.

Sec. 2. *Secretaries*.—There shall be a Permanent Secretary and a Corresponding Secretary appointed by the Council to hold office during the pleasure of that body. The duties of the Permanent Secretary shall be those ordinarily pertaining to that office and in addition he shall have charge of all books, collections and other property of the Academy. The Permanent Secretary shall also perform the duties usually assigned to a Treasurer.

The Corresponding Secretary shall perform the duties usually pertaining to that office under the direction of the Permanent Secretary.

The Permanent Secretary and the Corresponding Secretary shall be exempt from the payment of regular dues during the period of service in their respective offices.

Sec. 3. *Council.*—The Council shall consist of the Past Presidents, the President, the Vice Presidents, the Secretary and three Councilors-at-large to be elected from the Fellows of the Academy at the time of the election of the officers.

Sec. 4. *Vacancies.*—In the event of a vacancy in the office of President, the First Vice President shall serve the unexpired term, and the Second Vice President shall succeed the First Vice President. The Council shall have power to fill any other vacancy in the offices.

ARTICLE V.

Sec. 1. *Place of Meeting.*—Unless otherwise directed by the Academy, the annual meeting shall be held in April of each year at such place as the Council shall designate. Other meetings may be called at the discretion of the Council.

ARTICLE VI.

Sec. 1. *Amendments.*—This constitution may be amended at any annual meeting of the Academy by a vote of three-fourths of attending members of at least one year's standing. No question of amendment shall be decided except at a regular session of the annual meeting, nor shall it be decided at the same session when presented. All proposed amendments shall be presented in writing.

By-Laws

1. The first hour, or such part thereof as shall be necessary, in each session shall be set aside for the transaction of the business of the Academy. The following order of business shall be observed as far as practicable:

1. Opening.
2. Minutes of last meeting.
3. Reports of Officers.
4. Reports of Standing Committees.
5. Appointing of Special Committees.
6. Unfinished Business.
7. New Business.
8. Reports of Special Committees.
9. Election of Officers.
10. Election of Members.
11. Program.
12. Adjournment.

2. The President shall deliver a public address on the evening of one of the days of the meeting, at the expiration of his term of office.

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

4. Members who allow their dues to remain unpaid for two years, having been annually notified of their arrearage by the Secretary, shall have their names stricken from the roll.

5. The Permanent Secretary shall collect initiation fees, dues and other moneys for the Academy and shall have charge of the distribution, sale and exchange of the published transactions of the Academy, under such restrictions as may be imposed by the Council.

6. Eight members shall constitute a quorum for the transaction of business.

7. No paper shall be entitled to a place on the pro-

gram unless the manuscript, or an abstract of the same, will have been previously delivered to the Secretary.

8. Five members of the Council shall constitute a quorum.

8. In all points of parliamentary procedure not covered by this Constitution and By-Laws, Roberts' Rules of Order shall prevail.

10. These By-Laws may be amended by a two-thirds majority vote of the members present at any regular meeting, provided that the proposed by-law be submitted in writing to the Secretary.

ELEVENTH ANNUAL CONVENTION OF THE UTAH ACADEMY OF SCIENCES.

Physics Lecture Room, University of Utah, Salt Lake City, Utah
April 5 and 6, 1918

"Exceptional Growth of Some Mammals and of a few Lower Species of the Northern Hemisphere"......
S. Moth Iverson

"The Quest of the Student of Nature".........................
Dr. Chas. G. Plummer

"Our Country—A Retrospect"......................Wm. D. Neal

"Reversals in Photographic Plates"........C. Arthur Smith

"An Equation of the Density—Exposure Curve of a Photographic Plate"........................Dr. Orin Tugman

"Intensity and Distribution of Illumination From Automobile Headlights"...........................Orson Smith

"Possibilities of Oil and Gas in Salt Lake and Cache Valleys"..................................Prof. Hyrum Schneider

"The Second Reclamation of the Desert"..Richard A. Hart

"Major J. W. Powell and His Work"..Francis M. Bishop

"Some Uncommon Insect Pests in Utah"......................
....Prof. A. L. Matthews

"Food and Feeding of Nestlings"......Dr. Newton Miller

PERSONAL REMINISCENCES OF JOHN W. POWELL.

BY FRANCIS MARION BISHOP.

Gentlemen:—

It affords me genuine pleasure to be of your number at this time, and for a brief space to have the honor of speaking to you of one who has left lasting evidence of his fitness to do the work he chose, because he loved it, and who with Longfellow could say that he believed "The talent of success is nothing more than doing what you can do WELL, and doing WELL whatever you do without a thought of fame," but only of the work itself, and with Dickens could truthfully add—"Whatever I have tried to do in life, I have tried with all my heart to do well, whatever I have devoted myself to, I have devoted myself to completely." John Wesley Powell's life was a living exponent of these two thoughts.

His early youth was characteristic of many of our American boys—who so full of ambition and purpose can hardly brook nature's apparently slow process in the growth of body and mind to make them fit for the work they have to do. His parents, Joseph Powell and Mary Dean Powell, of old English stock but intensely American, gave to the boy that strength of body and those sterling qualities of mind that later developed and expanded until he became a leader of unusual abilities. His parents landed in New York in 1830, after a time removing to Palmyra and thence to Mount Morris in Livingston Co., where on the 24th of March, 1831, John W. Powell was born and as his name would indicate his parents were Methodists, but they were conscientiously opposed to slavery, which was in a way countenanced by the Methodist Episcopal Church. Joseph Powell, the Major's father, left that church and on the organization of the Wesleyan Methodists, he became a regularly ordained preacher of the latter church. Mrs. Powell was a highly educated and very intellectual woman, and in this atmosphere of social, educational, political and religious fervor the future scientist and explorer grew and flourished.

From New York State his family moved to Jackson, Ohio, when he was about 5 years old, and in 1846 moved still westward to South Grove in Walworth Co., Wisconsin, where a farm was purchased. As he grew in years, certain traits of character developed, among them, that one that marked the future explorer, that trait of doing all his work well, became a notable quality in the boy's life. His ploughing, sowing and work of all kinds on the farm was of the best and his business ability in buying and selling for the farm was admitted by all his neighbors. In addition to his farm work, he now began most zealously to strive for an education, which was the dearest wish of his parents, who continually impressed upon him the importance of the highest education possible. In the accomplishing of this object he continued his studies at Janesville, Wis., working night and morning to pay his way. In 1851 his family moved to Bonus Prairie, Boone County, Illinois. Two years later, at Wheaton, Illinois, he entered the Wesleyan College, where he remained until 1855, when he entered the preparatory department of the Illinois College at Jacksonville. In 1857 he began a course of study in Oberlin College, Ohio, where in the study of botany he discovered his true vocation, the investigation of natural science. He became an enthusiastic botanist, and searched the woods and swamps around Oberlin with his characteristic thoroughness, making an almost complete herbarium of the flora of that section.

In 1858 as a member of the Illinois State Natural History Society, he engaged with the society in a natural history survey of the state. Powell having the department of Conchology, with his usual thoroughness made the most complete collection of the mollusca of Illinois ever brought together by one man. Incidentally botany, zoology and mineralogy came under his attention, and he secured collections for the Society in each of these departments of research. With broad mental grasp, now a pronounced trait, he perceived that all these sciences were but part of the greater science of geology, to which wonderful study he determined to devote his life. Thus while studying, teaching and lecturing, usually on some topic connected with geology, in 1860 he visited the southern states and closely observing the sentiment of the people on the subject of slavery, he became convinced that nothing short of war could settle the matter. In the winter of 1860-61 as principal of the public schools of Hennipin, becoming convinced that war was inevitable, he began studying military tactics and engineering, and in the spring of 1861, when the call came for volunteers he was the first man to enroll in Co. H., 20th Regt., Illinois Infantry. When the regiment was organized at Joliet, Illinois, he was appointed Sergeant-Major and as such went to the front. With his mind thus stored with military science he could not be kept down and became at once invaluable to the military authorities. He was placed in charge of planning, laying out and constructing the defensive fortifications of Cape Girardeau, Mo., doing the work so thoroughly that he received the unqualified commendation and approval of Gen. Fremont, commanding the department.

He was now commissioned as First Lieutenant of Co. H, and after a few weeks' service with his Company, was put in charge of the fortifications he had constructed. During the winter of 1861-62, he recruited a battery of artillery composed of loyal Missourians, which was mustered into the U. S. Army as Battery F, 2nd Regt. Illinois Artillery with John Wesley Powell as Captain. His battery was ordered soon after to Pittsburg Landing, Tenn., and he took part with it in the battle of Shiloh, April 6, 1862, where in directing his battery in firing he lost an arm. On account of imperfect surgery, a second operation was necessary, leaving only a stump below the elbow, which caused him pain most of the time in future years. Returning to his command as soon as the wound had healed, as Division Chief of Artillery, he took part in the siege of Vicksburg and the Meridian Raid. Then he served on detached operations at Vicksburg, Natchez and New Orleans, until the summer of 1864 when he was returned to his former command in the Army of the Tennessee, and bore an active part in all the operations after the fall of Atlanta. When Sherman started on his march to the sea, Major Powell was sent to General Thomas at Nashville and was placed in command of a brigade of twenty batteries of artillery and served on Gen. Thomas' staff at the battle of Nashville, and to the end of the war in 1865. His career as a soldier was marked by that same thoroughness in the study and mastery, not only of details of military life, but also of military science. Especially was he apt in the use of material at hand for the accomplishing of his ends, building bridges out of cotton gins, and protection for his guns from gunny sacks and old rope and shields for his sharpshooters from the mouldboards of old ploughs found upon abandoned plantations. During the time he was in the service he never overlooked an opportunity to continue his studies in natural science, making collections of fossils in the trenches of Vicksburg, and land and river shells from the Mississippi swamps adjacent.

Upon his return to civil life, Major Powell accepted the offer of the chair of geology in the Illinois Wesleyan University, although offered a very lucrative political appointment. After my regiment was mustered out, I met the Major here in January, 1866, and became one of his pupils in the domain of the natural sciences, under his care. In 1867 he was elected to the chair of geology in the State Normal University at Normal, Illinois. At about the same time, he was elected curator of the Illinois State Natural History Society, whose collections of specimens were in the museum of the Normal University. He thus became attracted to the great West then just opening up for general research, as a new field for profitable scientific research, and his determination to be first in the field led him to organize a party, composed largely of his students in the Wesleyan University and friends in the western part of the state, including his brother-in-law, Prof. A. H. Thompson, afterwards intimately associated with Major Powell in his various surveys.

At this time I was working in the Museum and was fortunate enough to be selected as one of this party and starting from Council Bluffs, via Plattsmouth, we crossed the plains going up the Platte River to Denver and south along the Front Range, scaling Pikes Peak, July 27, 1867, westerly through South Park and northerly to a point almost due west from Denver, thence out of the mountains and back to Julesburg on the Union Pacific Railroad, and home and school work again. This trip through the mountains opened up a wonderland for the Major, so again in 1868 he was in this field, devoting his salary and appropriations from the Illinois Industrial University, at Champaign, and other financial assistance to the expenses of this venture. When this party broke up in the autumn of 1868, Major Powell, Mrs. Powell and the Major's brother, Walter B. and a party of hunters, including the Howland brothers, Wm. Dunn and Wm. R. Hawkins, afterwards members of his first party to explore the canyon, crossed the range to White River and wintered near the camp of Chief Douglas and his bands of Utes. With the return of spring the Major went to Granger on the U. P. Ry., disposed of his outfit and hastened on to Washington and induced Congress to pass a joint resolution approved by Gen. Grant, allowing the Major to draw from any western army post rations for a party of twelve men, while engaged in making explorations and collections for public institutions, and a most worthy concession it was. He again obtained permission to divert his salary and appropriations from the various institutions in Illinois, these and an appropriation of $500.00 from the Chicago Academy of Sciences, and contributions from friends, all of which were spent for the advancement of his great purpose, the solving of the last great geographical problem of the U. S., that of the Canyons of the Green and Colorado Rivers, as well as making collections in other branches of scientific investigation.

Major Powell organized his first expedition and started from Green River, Wyo., in the spring of 1869, taking the river at its flood, for otherwise many of the broad shallow rapids would have been so full of rocks as to be impassable, but with plenty of water in the channel they were run in safety. At Green River, Wyo., the altitude is about 6000 feet, while the mouth of the Rio Virgin at Black Canyon, the last canyon of the great gorge, the altitude is about 700 feet above sea level, and to determine how this 5300 feet drop was made by the river, as well as to unravel many of the wierd legends that threw a halo of mystery around this thousand mile gorge, were some of the things Major Powell had in mind.

With characteristic foresight, he provided for all observations as to directions of the river and topography to be taken in duplicate so that in case of loss of one, the other set might be preserved. The wisdom of this precaution was demonstrated shortly after entering Lodore Canyon at the foot of Brown's Park, when one of the boats was wrecked in a rapid, called Disaster Falls, and the men and everything in the boat were spilled in the river. Two of the crew reached shore and the third landed on a low rocky island in the river, from which he was rescued after numerous trials and brought in safety to the mainland. All of the instruments and provisions in this boat were given as a peace offering to the merciless river, but no life was sacrificed.

Day after day the wonders of the great river and canyon unfolded until the mysteries of the canyon became common, every day occurrences. With no further mishap, the party reached the head of Marble Canyon, beginning just below the mouth of the Pariah River in Arizona. In this gorge a legend claimed that the river ran into the side of a great mountain and disappeared for miles and finally appeared on the other side of the range. The wonders of the 600 or 700 miles of canyon passed were marvelous, almost beyond conception, with canyons so deep and narrow that the stars could be seen in day time, with stretches of continuous rapids for scores of miles followed by miles of placid water. With the most stupendous exhibition of natural sculpture work, from great pot holes containing pine trees, two feet in diameter, not reaching the levels of the walls, to the largest natural bridges in the world, this panorama had passed by, but what lay beyond in this gorge with a rapid to begin it—what was to follow? The Major and his men were inured to danger, and whatever their misgivings in their talks about their camp fire, when the order to go was given, after a few days' rest, not a man hesitated, but men and boats took the river again. This canyon, 45 miles long, formed part of the first great bend of the river where it cuts through the southern end of Kaibab Plateau or Buckskin Mountain and extends to the mouth of the Little Colorado River, where the nature of the rocks change from limestone to granite and the canyon reaches a depth of over 6000 feet and from the moment of starting was one titanic fight against the power of the river. This battle continued until on the second great southern bend of the canyon, about 150 miles down, rounding the Shevwitz Mountain or tableland, a point was reached where the whole volume of the river appeared to roll up against the mountain side and to disappear. Here was the great siphon; here was the place where he who entered left all hope behind. The men who composed this first party were all hunters, trappers or miners, with many superstitious fears, but could not be driven. For three days the Major and his party tried to scale the canyon wall to get out on top and try to find out what was beyond but failed to find any break in the solid canyon wall, and discussed the next step, until the stars warned them to rest if possible. All but three of the party finally agreed to go ahead and risk the river, as the Major argued and believed if they could get out they would find that the water made a quick turn to the right and went along all right. He tried every way to persuade these men, the Howland Brothers and Bell, to risk the river and go ahead. These three were called cowards and other hard words and finally they declared they would go no farther, risking the canyon wall and getting back to civilization, rather than be swallowed up by the thirsty river. When the Major became satisfied that these men would not go on, he called the party all together, decided to leave them one boat, one third of all provisions and instruments, one set of records, and then go on, hoping they might succeed in getting out and reaching some of the southern settlements of Utah. He further agreed if they got through, to wait for them and to fire their three guns as a signal that all was well and to come on. In carrying out this plan, one boat was pulled out for them but in such a position that it could easily be launched again and bidding a silent good-by the two boats pulled off and one after the other, as was their custom, plunged into the seething, roaring waters. When the first boat struck the maelstrom as the Major had declared his belief, the canyon broke squarely to the right and in less than 30 minutes both boats were in comparatively smooth water.

The Rubicon had been passed. A landing was at once made and for two days every signal that could be made was made in hope that the third boat would come on. But they waited in vain. The feeling engendered had become so bitter that although the Howland boys and Bell could see that the other boats had gone safely through, yet they were too sore to go on, and sorrowfully the Major and his party proceeded. Nothing of any moment occurred until at the end of Black Canyon below the Rio Virgin, the hazardous trip ended and the party broke up. The Major with his valuable records returned by way of St. George, Utah, in the hope of hearing of his other men, but no word of any kind had been heard. After waiting several days at St. George, no message of any kind coming of or from them, with a heavy heart he came on to Salt Lake and from here to Washington to report.

In 1870, the Major learned that the Schevwitz Indians living on the plateau, near where the men separated had one or two watches and guns, that from all accounts belonged to the missing men. Ever anxious to learn of their fate he decided to come to Utah at once, and selecting Walter H. Graves and myself from Bloomington, Ill., came to Salt Lake by rail and from here in wagons and on horseback we went to Pipe Springs, Arizona, and from there with Jacob Hamlin and Ashton Nebeker as guides and interpreters, we went to the southern slope of the West Side Mountain of Lieut. Ive's survey, now called Mt. Trumbull, and from there sent a runner to the Schevwitz village about 30 miles away, inviting the chiefs to come in and have a council and smoke the pipe of peace. Two days later the chief men of the village, eleven of them, came and after an all-night parley, this was what Powell learned—That his men had succeeded in finding a way out of the canyon and in a famished condition, without water, they reached the Indian Village. Unfortunately for them, a day or two before a renegade Indian called "Pete", from Colorado, had reached this same village. As he could talk a little English, the men told their story and their desire to reach St. George, the Mormon settlement, about 75 miles distance. However, improbable as their story of coming down the river in

"Water Ponies" might have seemed, all would have gone well had not "Pete" in his talk convinced the Indians that the white men were telling lies and that they were bad men and had come from Colorado to steal their squaws. After giving the men food and water and bidding them sleep, under the direction of "Pete" an ambush was planned and shortly after starting for St. George the next morning, they were cruelly ambushed and killed, their poor bodies being literally filled with arrows. A watch and some other keepsakes of the men were recovered and sent back to their parents in New England and so closed that chapter of mistakes and sorrow. While waiting for the Shevwitz Indians to come from their village, our party made a trip down the Lateral Canyon to the Colorado River, looking out a point in the canyon where supplies might be brought in for a second expedition, the plans for which were being formulated in Powell's mind. Our work having been accomplished, we returned to Bloomington and during the fall and winter, I was engaged in making a map of the Green and Colorado River Canyons, from the field notes taken. This map when finished was the first map ever made of this great gorge from topographical notes, and was taken to Washington and placed on file in the War Department, as the official map of this survey of the river; and in subsequent work was found to be remarkably correct. Powell's thirst for knowledge of this hitherto unknown country was not quenched by the first trip, and realizing the many natural imperfections and defects, he immediately began organizing his second expedition to make a more perfect exploration and scientific survey of this wonderland, whose mythological barriers had been burned away or broken, by his first canyon trip.

In May, 1871, the second party fully equipped with instruments and supplies made its start from Green River, Wyo., with three boats and eleven men. At Brown's Park, 75 miles down the river, one of the party, Mr. Richardson, was sent back, and the other ten going on and making a successful exploration of the Green and Colorado Rivers and the lateral canyons as far as the head of Grand Canyon, at the mouth of the Pariah River, where, owing to the lateness of the season and the cold water, we were compelled to leave the river and continued the field work on land during the fall and winter, along the west side of the Canyon.

Now that the work was successfully launched, Congress generously came to his assistance, making appropriations for continuing the survey, topographical and geological, of the country adjacent to the river, the expenditure of the appropriations being under the supervision of the Smithsonian Institution, yearly, thereafter, until 1879, when the work of this survey was consolidated with those of Hayden and Wheeler and afterwards known as the "U. S. Geological Survey". Prof Clarence King was made the director, as the Major felt that he had been too closely interested in its creation to allow his name to be presented. The new consolidation was placed under the Department of the Interior, and in 1881, Clarence King resigned and Major Powell was immediately appointed in his stead. The result of Powell's original field work was topographical maps of a large part of Utah and considerable portions of Wyoming, Arizona and Nevada, as shown by many volumes of reports and monographs. Among them may be cited—The Exploration of the Colorado River of the West, 1869 to 1872; The Geology of the Uinta Mountains and Lands of the Arid Region, by Powell; Geology of the High Plateaus of Utah, by C. E. Dutton, U. S. A.; Geology of the Henry Mountains, by G. K. Gilbert; and four volumes of Contributions to North American Ethnology, one of which contained Lewis H. Morgan's famous monograph on "Houses and House Life of the American Aborigines." Early in his western work Major Powell became interested in the native tribes, studying the language, tribal organization, customs and mythology of the Utes, Pai Utes and the Moki or "Shenimos", Wisemen, as they called themselves, and on one occasion was formally adopted into one of the Moki Clans. Through his influence at the consolidation of the three surveys, a Bureau of Ethnology was established and attached to the Smithsonian Institution with Powell as its director, an office he held until 1894 without salary. His labors as a pioneer in the science of ethnology have been recognized by leading societies and institutions of learning throughout the world. As a lecturer he was independent, interesting and forceful and never lacked the ability to turn things to accomplish his purposes. About this time, on one of his lecturing tours, the Major was engaged to speak at the University of Michigan where it was a custom for the students to guy the speakers, even Charles Sumner being a victim. Powell had been warned of this practice, and as he advanced to the platform in evening dress he was greeted with a call of "How are you, Coat-tails?", which was repeated from all parts of the house. During a momentary lull, he exclaimed with a peculiar squinting of his eyes, and the half laugh his friends so well remember, "Your greeting reminds me of Dave Larkin's reply, when criticised for wearing a wamus in July. Dave said, with his slow drawl, 'If you don't like my wamus, I can take it off.' " The answer with the suggestion took instantly and after the laughter had ceased, cries came from everywhere, "You'll do. Go on".

This incident aroused Powell and he has often said he never talked better nor had a more attentive audience. With his closing sentence he said, "I have given you the finest account of the exploration of the Colorado River my command of language permits. I have been dramatic and as eloquent as I thought this occasion demanded. If anyone wishes a plain statement, regarding the exploration, I will be happy to give it to him at my hotel". After a moment's hush, as the students grasped the implication there came cries of "Sold." However, a large number called upon him and found he had stated only facts, as of course he had. In his later years when he should have rested, he took up the study of psychology and philosophy, which aggravated his malady, sclerosis of the arteries, and produced his last illness. As a result of his later studies he published two treatises—"Truth and Error" and "Good and Evil," the first relating to matter, motion and conciousness as related to the external universe or the field of fact, and the other as related to humanity or to welfare.

The life of Powell is an example of intelligent, persistent endeavor. His power to look ahead and to forecast events, standing on the imperfections of the present, was extraordinary. As a soldier, he was a patriot; as an explorer, he was a hero. As a far-seeing scientific man, as a loving friend and a delightful comrade whether by the camp fire or in the study, and as a true sympathizer with the aspirations and ambitions of subordinates or equals, there has seldom been his superior.

The United States, especially the western states, will long remember Powell and his survey of the Colorado Canyon; and I can only add: *Requiescat in pace.*

CASES OF EXCEPTIONAL GROWTH OF CERTAIN SPECIES OF MAMMALS, REPTILES AND INSECTS.

BY L. MOTH IVERSEN.

(Abstract).

1. Giants and dwarfs in the human races, comprising both entire peoples and exceptional size of individuals belonging to universally known nations (freaks).

2. Unusual developement of bodily strength, height or weight in domestic animals.

3. Similar facts concerning terrestrial or marine mammals (birds) or reptiles asserted and accepted by prominent or famous students of nature.

4. Similar facts concerning terrestrial or marine mammals (birds) or reptiles observed by the writer in Europe and U. S.

5. Exceptional size of insects (isolated cases).

6. A few fish "stories" and some figures concerning the piscatorial realm.

7. An attempt to show an effect on phenomenal stature—claimed or scientifically proved.

THE QUEST OF THE STUDENT OF NATURE.

BY CHARLES GRIFFIN PLUMMER. M. D.

(Abstract).

He seeks TRUTH!

His field of search and adventure is the Universe.

His subjective mind and his objective mind participate in every activity. His interpretation of the realm he contacts is restricted only when he is dominated by his objective mind. It is when he is ruled unreservedly by his subjective mind that he interprets to the fullness of his capacity.

As he fares forth he promises himself that he will use his eyes and his ears ungrudgingly. He disregards the man-made orthodoxy that creation is made up of the animate and the inanimate classes.

Those creatures that walk and run and crawl upon the earth, that fly in the air and swim in the sea, have a strange fascination for him, because they exhibit characteristics about which he knows little.

It is probable that in his early life he was more directly concerned with such creatures because the teachings of many years led him to believe they alone manifested what is termed life. Yet when he grew to be more keenly observant and was wholly in harmony with his surroundings his attention became rivited upon that other division, the inanimate or lifeless (so-called) part of creation.

Time comes when he acknowledges the potent personality of the lowly weed and vegetable; the undying charm and beauty of the wayside flower; the imposing majesty of a giant tree; the strangely persistent cohesion of the rock and mineral molecules as they form the crust of the planet, as their mass is uplifted into great and rugged mountain chains or is reduced to dust by elemental activities that make the soil which affords lodgment for the seeds of all plant life.

Then there is forced upon his consciousness the

thought that these manifest life but they do not exhibit their activities to his objective mind.

He becomes an animated question-mark. The "When?" and the "Where?" and the "Why?" press him for explanation. These interrogatories are answerable.

The unvarying harmony that reigns in undisturbed Nature impresses him mightily. He is set at ease by its wondrous music ONLY when the natural balance is maintained upon the earth. Obviously such a balance exists by design and rules always when wild-life is left to the administration of its own affairs.

Long continued investigation compels the student to believe that the white man is the arch disturber and destroyer of this balance. Why? Because he breaks his own laws and disregards all Divine Laws, of which he is wholly ignorant or quite inconsiderate, in his every day association with his fellows.

Sometime, somewhere, there comes to him the knowledge that mankind suffers much unnecessarily. If man's assumption of dominion over all creation were not so clearly an attitude of ownership, did he not protest and speculate and contend with such eagerness and heat, his course beside other created things would be more harmoniously pursued.

Protest and speculation have no place in nature.

However much mankind may seek complete domination over all the earth, his dominion ceases upon the sudden appearance of incomputable insect hordes. These creatures multiply so rapidly, eat so voraciously, and destroy so extensively that even man and his vaunted power is of no avail in their presence.

All animal life depends upon the products of the earth for its sustenance. There is nothing but wild bird-life that stands between ultimate starvation by mankind with his herds and the insect hosts that prey upon his crops.

This thought teaches the student that the real munition plant is the earth and that food is the only munition with which mankind may fight all battles to successful issue.

He recognizes the obvious value of everything in creation. That each product is not only for his use but for the use of his neighbor as well. He says that all occupy important places in a Divine Cosmogony that strives ever toward perfection.

Of course he grieves for those who suffer material injury by such shortsightedness as indiscriminate killing of earth's creatures may bring about, as well as for those dissatisfied ones who drive their ships of Science into unknown harbors and ride unrestfully in shallow waters. He offers them the same field of quest and venture he travels in which they may delve understandingly if they choose to do so.

The thought of wholeness (perfection) in Nature possesses him. He has found out that a study of Nature without including man in its scope is incomplete and hence unsatisfactory. Why? Because man is just as much a product of Nature (Divine Law) as is any other thing in creation. So the student of Nature refuses to consider attributes alone in his study. He is intent upon characteristics. How a thing lives and reacts toward his fellows is of prime worth to him.

He endures experiences which teach him that life is made up of unnumbered individualities—that each one has a right to live and does so in peace with all others according to its guidance by Nature. When mankind assumes the right to remove from the earth in the name of Science, for sport, in the pursuit of opulence or in vainglorious exhibitions before his kind, immense numbers of the myriad forms of life on every side, he does so at his peril. A day of reckoning comes that is pitiless and that is fatal to such daring ones.

The stonewall of CAUSE which Science has erected is a man-made reduction of knowledge to rules and to symbols. It looms large and impenetrable before the scientist in his supreme effort to understand and to explain. The farther the scientist goes into the subject of Nature upon his present-day fundamentals the more deeply he is submerged in a sea of doubt. He starts out upon a long, long, most interesting journey to him and arrives—where?—at the point from which he set forth!

The scientific followers of Aristotle and his teachings tried in vain to account for this bugbear. In sharing with Democritus his atomic theory of the earth's formation, Epicurus married Chance to Chaos—but we know that this union was a sterile one!

There are those scientists who still cling to the belief that some day the fruit of this union will be forthcoming and thus prove the stability of their reasoning.

The student who uses his entire equipment as it is obvious Divine Mind intended it should be used under all conditions, pins his faith to the oldest of all thoughts concerning CAUSE—the spiritual—because it makes the strongest appeal to his reason and offers the most satisfaction.

His conclusion is that an omnipresent, immutable spiritual law rules the Universe (NATURE) and IT demands obedience from the multitudes numbered in ITS creation.

When this student accepts the administration of Nature's laws as the wisest handling of great complexities he is in perfect harmony with his surroundings. He has faith in the light that guides him and never becomes a discordant factor in God's great out-of-doors.

Man falls out of his place in evolution when he disregards this spiritual guidance. Nature unaided by Divine Law likewise fails.

The student has learned also that only the fit shall survive.

He would return to the lost art of teaching, that of discipleship.

By this manner of direction he is compelled to believe that the study of nature is not confined to the commitment of first principles to memory; to scientific differentiation of a few trees and flowers and animals and insects. Rather is it a gradual realization of the meaning of and appreciation for one's everyday environment.

Nature-study does not teach a love of man-made law; but it does teach the Divine Law of Love!

OUR COUNTRY: A RETROSPECT.

Being a study in Progress, Achievement and Influence.

BY W. D. NEAL.

(Abstract).

The paper discusses certain phases of progress and achievement made by the citizens of our country, or of men who have lived here and whose experiments, inventions and discoveries were developed largely by our people or in our own country.

A broad general view of advancement along lines of growth in population, development of resources, science, invention, education, founding of cities and states, industries, material prosperity and self government: their influence both directly and indirectly upon our own people and those of other nations.

The paper maintains that, while at the beginning of our history, people of the old world little dreamed that anything good could come out of America, since then our progress and achievements along the above lines have been such as to influence for the better, both in peace and in war, the manners, customs, laws, industries—yes, even the food they eat, the clothes they wear, the sights they see, the sounds they hear, the thoughts they think, the liberty and freedom they enjoy, of many people on all the continents of our earth.

Today America leads; her achievements are epoch making; her success has led the other nations as well as our own, to better conditions and her greatly beneficial influence on the human race is practically undisputed.

REVERSALS IN PHOTOGRAPHIC PLATES.

BY C. ARTHUR SMITH.

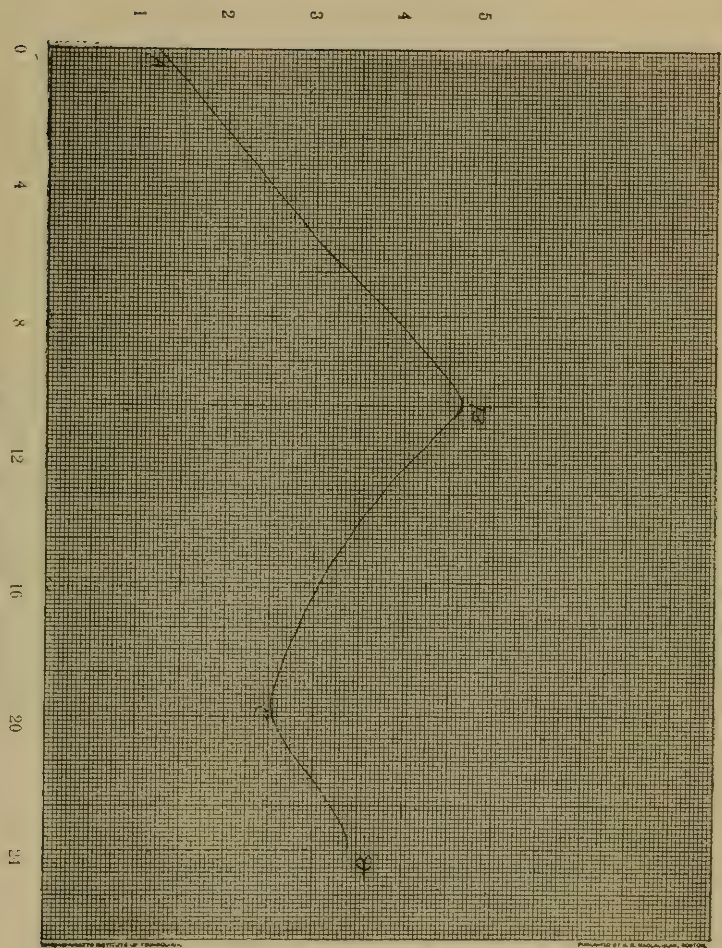
(Abstract).

The density of a photographic plate increases as the logarithm of exposure, up to a certain maximum. On further exposure the density is found to diminish to a minimum. On still further exposure it begins to increase again. These points of maxima and minima are called critical points and vary with the kind of plate exposed.

The relation of density to exposure is best shown by the curve fig. 1. B and C are the critical points. The rever-
the curve, fig. 1. B and C are the critical points. The rever-
sal of the plates begins at B. It is seen that the curve between C and D has approximately the same slope as that between A and B. The same is true of the slope between B and C and A and B. The curve has the appearance of having reached a second maximum at D, but time did not permit taking data beyond that point. It is possible that had we continued our exposures we would have found a succession of maxima and minima points, but the character of the curve beyond that shown is problematical. It might settle down to a regular sine curve, or it might obey the decay law and finally disappear entirely, or it might become wholly irregular.

Just what is the cause of reversals in a photographic plate does not seem to be well understood. There are two theories regarding it. It is thought by some to be due to a chemical change produced by the action of light on the silver salt. By others it is believed to be due to a photoelectric effect upon the silver grains. This theory is based on the now established fact that light incident on a metallic surface will produce an electric discharge from the surface of the metal.

DENSITY.



LOG. OF EXPOSURE IN SECONDS.

AN EQUATION OF THE DENSITY EXPOSURE CURVE OF A PHOTOGRAPHIC PLATE TAKING REVERSAL INTO ACCOUNT.

BY ORIN TUGMAN.

(Abstract).

The equation derived by Hurter and Driffield accounts only for a curve which never reverses. This equation was derived on the laws of absorption and that a silver bromide grain in a photographic plate remained exposed.

This equation assumes that after a silver halide grain absorbed a sufficient energy to be exposed, further absorption will render the grain unexposed. After that more energy will be required to expose the grain again and so forth.

The equation is an infinite series of exponential terms.

INTENSITY AND DISTRIBUTION OF ILLUMINATION FROM AUTOMOBILE HEADLIGHTS.

BY ORSON SMITH.

(Abstract).

Automobile headlights fitted with various types of lenses have been tested to determine the relative distribution of light about each type. In each case a curve has been plotted showing the results of the test.

Measurements were taken by means of a portable photometer constructed by placing a Bunsen screen in one end of a light-proof box, four inches square and four feet long, and a portable lamp carriage in the opposite end The instrument was calibrated to read directly in foot candles by comparing it to a standard lamp, certified by the Electrical Testing Laboratories.

POSSIBILITIES OF OIL AND GAS IN SALT LAKE AND CACHE VALLEYS.

BY HYRUM SCHNEIDER.

(Abstract).

In both of these regions gas occurs in artesian wells and companies have been organized to drill for oil. Petroleum occupies a position of great importance in the successful prosecution of modern warfare. Its production is fast falling behind an increasing demand; therefore if these fields offer reasonable possibilities their exploration should be encouraged but if, on the other hand, Science indicates their barrenness, useless expenditures of money should be discouraged.

Wherever oil and gas have been found in commercial quantities certain geologic conditions prevail. (1) There is a source, either in the form of organic matter from which oil or gas is derived or as disseminated oil, from which the oil or gas has accumulated into so-called pools. (2) The structure of the rocks, their porosity and ground water conditions are favorable for the accumulation of the oil or gas, or both, into pools.

Do these conditions prevail in Salt Lake and Cache Valleys? Salt Lake Valley is a down thrown block, along the great Wasatch Fault. On this block there has accumulated, since the faulting, over 2,000 feet of detrital material or valley fill. A discussion of oil and gas possibilities in this region must take into account the valley fill and the rocks of the down thrown block on which the detrital material was deposited. In so far as the geologic story of the valley fill can be read, it seems that climatic and other conditions were unfavorable for the deposition in it of sufficient organic matter to produce oil or gas in commercial quantities. Even if the source of the oil were there, structural and ground water conditions are unfavorable for its accumulation into pools. The rocks of the down thrown block beneath the detrital material are the same as were the rocks at the surface of

the up throw block to the east, at the time of faulting. A study of the Wasatch Front Range shows no oil bearing rocks in it now and indicates that there probably were none at the time of faulting. So even though there seems to be at least one favorable structure in the rocks buried beneath the detrital material which partly fills Salt Lake Valley, there can be no oil pools in these rocks without a feeding source.

Cache Valley, as Salt Lake Valley, is partly filled with detrital material, which is no more promising ground for oil and gas in commercial quantities than is the valley fill of Salt Lake Valley. Nor does a study of the Bear River Range to the east of Cache Valley or the Wasatch Front Range to the west, offer inducements to drill through the detrital material into the rocks beneath.

THE SECOND RECLAMATION OF THE DESERT.

BY R. A. HART.*

(Abstract).

The importance of agriculture and the necessity of making every acre of land produce its highest economic return have been brought forcibly to our attention by the great war.

We, of the West, are concerned particularly with agriculture based on irrigation.

We have come to think of irrigation as being a guaranty of crop production and generally are acquainted with its benevolent aspects. Most of us are unaware of the fact that the unrestrained use of irrigation water is a potent factor in the reduction of crop returns and in the actual deterioration of lands. As a matter of fact, an alarming proportion of the lands that have been brought under irrigation are now unproductive to a greater or lesser extent.

Irrigation results in the water-logging and mineralization of the soil of the arid region. The accumulation of alkaline salts is the result of a high water-table and the only effective remedy is underdrainage followed by proper cultivation and irrigation. Drainage lowers the water table and prevents its fluctuation within the root zone, while the subsequent treatment provides for the leaching out of the soluble salts.

The reclamation of lands injured by irrigation is both feasible and economical and makes possible an important contribution to war needs.

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SOME UNCOMMON PLANT PESTS.

BY A. L. MATTHEWS.

The work in the Salt Lake City War Gardens for the year of 1917 brought to light two pests, uncommon to the state of Utah, namely the Blackleg, (*Bacillus phytophthorus*) and the corn-root web worm, (Genus *Crambus*). A new pest which as far as can be determined was discovered—the Tomato Aphis, possibly belonging to the *Macrosiphum solanifolii*. The discussion of these pests will be treated in the order of importance relative to their destructive characteristics.

BLACKLEG. (*Bacillus phytophthorus*).

As nearly as can be determined Blackleg made its first appearance in America in an Idaho potato field, in 1915. The disease has spread rapidly since that date and was discovered for the first time in Utah in 1917, in connection with the Salt Lake City war gardens.

Blackleg originated in Europe, reached its greatest development in Germany, and later it found its way into England. (Carruthers, W., Journ. Roy. Agr. Soc. Eng., 68, p. 226-1907). The development of the disease in Germany was in connection with potato and the beet sugar farms. As far as is known at the present time, the Germans have not found a remedy for the disease. The practice in England, where the disease is known, is to hold it in check by crop rotation. How the disease got into America is very much a matter of conjecture.

Blackleg is a disease due to a bacterium called *Bacillus phytophthorus*. The disease affects different plants differently but all plants attacked show similar characteristics. A description of the disease on the potato will suffice to explain how the disease can be detected. When the potato is attacked with Blackleg the lower leaves wilt, turn slightly yellow, then brown and finally dry up and drop off the plant. The last leaves to wilt and drop from the plant are those at the top. When the stem is cut it reveals either a dry decayed or a moist decayed condition. Sometimes the young tubers carry black spots on their surface and when cut near the stem end, the medullary rays often show dark rings. The disease spreads rapidly in hot weather with the land in a wet or continued wet condition. All farm and garden plants are susceptible to the disease except the cereals. Corn is immune and should be planted in gardens where this disease is present.

The root crop when attacked does not show the disease until well developed. The lower portion of the root decays and the decayed portion gradually works up toward the top; the leaves at last wilting and drying up in a similar manner.

In this city where fields were attacked by Blackleg as much as 75 percent to 90 percent of the crop was destroyed.

Remedy: No absolute remedy is known. The disease can be held in check by careful irrigation and rotation of crops. Fields where the disease is known to be present should be planted to a cereal crop for two years; corn is probably the best. Lime and strong nitrogenous manures, especially nitrate of soda and sulphate of ammonia should not be used on infected land. Bordeaux mixture does not seem to do much good. Dr. Otto Appel says, "Potatoes, beans, carrots, parsnips, cucumbers, turnips, vegetable marrow, beets and mangolds are susceptible to this disease and should not be cultivated for two years on land where the disease occurred.

CORN-ROOT WEBWORM (Genus *Crambus*).

The corn-root webworm should not be presented to the Utah Academy of Science, since a number of descriptions have been written relative to it. The only reason for presenting the subject at all is to show that the pest has become established in Utah and agriculturalists should always be on the outlook for it. The history and description of the insect can be found in any good text on the subject, but in order more forcibly to bring the pest to the attention of the people of Utah this paper will describe it in brief. The description which follows is merely a compilation of descriptions taken from texts on the subject, following O'Kane. (O'Kane; Injurious Insects).

The corn-root webworms are from ¾ to 1 inch long when full grown, and their bodies have numerous low tubercles. They hatch from eggs laid by small, active moths which have the habit of resting on grass stems with their wings folded around their bodies. There are two generations annually, the moths of the second brood appearing in the latter part of summer. The worms feed in a silk tube more or less covered with particles of dirt.

The outward evidence of attack is the stunted growth of the corn or the death of young plants. When the corn is pulled up the roots are matted in a web.

Remedy: Fall plowing and cultivation will help to hold the pest in check, but to avoid injury corn should not be planted on land which has just been broken up from sod or weeds. Infected land should be fallowed during the latter part of the summer and should not be planted to corn the following year.

TOMATO-BUD APHIS.

History: As far as is known this insect was first determined during the summer. No literature has been found describing the insect to date. It made its appearance in Salt Lake City during the summer of 1917.

Description: Tomato fruit is set from the flowers directly. Last summer the blossoms continued to drop from the plants and in many instances it was impossible for the fruit to set. After intensive study, a microscopic insect, which had the appearance of an aphis, was discovered on the plant. The insect seemed to work in groups of five or six sucking the juice from the lower stalk about ¾ of an inch from the bud. This seemed to weaken the stalk sufficiently so that the bud dried up and dropped off. The winged aphis was discovered associated with the infected portion of the plant.

Remedy: Strongly fertilize the soil and give the plant an abundance of water. Nitrate of soda in the proportions of one pound to three gallons of water and the application of one pint of the solution to each plant seemed to help the condition, probably by making the plant hardy. A solution from manure is equally as effective. Spray the plant with a tobacco solution or a weak kerosene emulsion which will kill the insect.

THE FOOD AND FEEDING OF FLEDGLINGS.

BY NEWTON MILLER.

(Abstract).

Several species of young birds were observed throughout a complete bird's day. The data thus collected show rhythms of feeding and give a good idea of a day's work of the various birds. The data also gave an index to the amount and kind of food consumed. The amount and kind of food used is one of the determining factors in computing the economic importance of a species.

Young birds do not get all the food they desire. There is a struggle for the offerings of the parents and usually one gets more than his share. This in part accounts for the frequent occurrence of one large or one small fledgling in each nest. The young cowbird is the notorious example.

The complete article will be illustrated with charts.

TWELFTH ANNUAL CONVENTION OF THE UTAH ACADEMY OF SCIENCES.

Physics Lecture Room, University of Utah, Salt Lake City, Utah
April 4 and 5, 1919

"A History of Entomology to 1800"..By Harold R. Hagan, U. A. C.

"Detection of Overgrazing by Means of Indicator Plants"...By Mark Anderson, U. S. Forest Service, Ogden

"The Problem of Handedness".......By A. L. Beeley, U. U.

"Investigations in Dehydration"..By Tracy H. Abell, U. A. C.

"Distilled Water as a Medium for Growing Plants"..By Dr. M. C. Merrill, U. A. C.

"Determination of Probable Temperature at a Particular Place for a Definite Hour on a Definite Day"..............................By Dr. Frank L. West, U. A. C.

"Alkali Water for Irrigation"..By Dr. F. S. Harris and N. I. Butt, U. A. C.

"The Relation of the Method of Analyzing Alkali Soils to the Limits of Toxicity"..By D. W. Pittman, U. A. C.

"A Theory of Capillary Flow"...By Dr. Willard Gardner, U. A. C.

"Is Electric Air Heating Feasible?"...By Dr. Joseph F. Merrill, U. U.

"Atoms and the Atomic Theory"...By Dr. W. D. Bonner, U. U.

"Evaporation and Soil Moisture in Relation to Forest Planting"...By C. F. Korstian U. S. Forest Service, Ogden

HISTORICAL OUTLINE OF THE DEVELOPMENT OF ENTOMOLOGY TO 1800.

BY HAROLD R. HAGAN.

Entomology is a modern science. It is still a very young science with many rough, projecting points of achievement marking the contributions of the rare genius in the field. To glance back at those earlier workers and recall their labors and successes in entomology is indeed a pleasure.

Aristotle is our first historical figure. In the philosophical branches of science he was more often in error than in truth. I think perhaps this can be traced to his efforts to equal or surpass his great teacher, Plato. It is certain that "Platonic" philosophy exerted a tremendous influence upon his life and work.

His temperament was better suited to observing and recording natural phenomena, however, than to philosophical deduction and the interpretation of physical forces. His contributions in biology represent an amount of work rarely surpassed in more modern times. I doubt that he had a complete first-hand knowledge of all the animals treated by him. He fails to mention many common animals in his country, yet he undoubtedly had considerable data concerning them. In his writings he considers over five hundred species, which is a far greater number than the average educated person today can even mention by common name. In his writings, I believe it safer, in general, to accept the accurate statements as the results of his own labors, while much of the descriptive material at variance to truth is more likely the "filler" of his encyclopaedic efforts gathered from others. He gave considerable attention to insects and some of his eight order names are still in use, but of course with much more limited fauna in each as the result of modern intensive study and development of the science.

In his studies of the life-history of the honeybee and the silkworm he became fully aware of the metamorphosis of insects. Knowing the egg and larval stages as he did, it is difficult to realize why he should express his belief in the spontaneous generation of insects. In his dissections he acquired a splendid general idea of gross external and internal anatomy, yet he classifies insects as "animals without blood."

The great historical figure, Aristotle, is given so much space in my brief resume, for he alone in all antiquity stands before us as a careful investigator and a philosopher of the life of the biological world. Modern thinkers of the eighteenth and nineteenth centuries broke entirely away from his interpretations of nature and developed a new philosophy culminating in the "Origin of Species." The twentieth century shows a distinct and growing tendency to parallel his line of thought, and while rejecting his philosophical treatment of the subject, to endeavor to grasp his subtle understanding and sympathy with life.

With the decline of Greece as the center of culture and learning, we lose track of original workers in biology and the historian usually sets up the single Roman compiler of natural history, Pliny, as a connecting link between ancient and modern biology. His writings simply record others' work and the fictitious tales of travelers. They are to be read with discrimination, as they are entirely encyclopaedic in scope, recounting the fables as well as the knowledge of his time. They contain little truth. They were widely read by the Arabians after the Roman period, and were a source of the teachings of the Moors. They were later re-translated into the languages of the Christian races. He interestingly describes the origin of the silkworm industry and shows that when he wrote the art of beekeeping was already centuries old.

During the long interval between the time of Aristotle and the beginning of the Renaissance, there were no important students of insects. The awakening of the whole of mankind and all subsequent mental growth, economic development and religious freedom of thought, trace their beginnings in this period known as the "Renaissance." The crusades fostered the spirit of exploration, the collection of trophies, the accumulation of spoils of war. The knowledge of Greek language and literature developed naturally. Among other things were found and eagerly read the voluminous works of Aristotle. The cause of such wide interest in natural history which we see exhibited at this time probably had its origin in several activities among which should be mentioned the truer estimation of the position, size, and movements of the earth in our solar system, the invention of the printing press, and the marvelous tales of a new world and its fauna, following the voyages of Columbus. A rapidly increasing population supported a leisure class who encouraged the capture abroad and exhibition at home of all sorts of strange animals. A literature was imperative in the face of these new ideas, facts, and specimens. What was more natural than to turn to the writings of the ancients? On the zoological side Aristotle was the authority, and his pupil, Theophrastus, had almost as much weight in botany.

For some time it was supposed that the works of Aristotle covered all nature; and as there was nothing to add men busied themselves translating and attempting to reconcile new discoveries with the old text; or somehow they entirely overlooked the new fact if it contradicted their written records.

Among the first of the writers of the Middle Ages we find very little or no originality of thought, their work consisting largely of selections from the Peripatetic School. Aldrovandus, however, ignored the classification of the animal kingdom by Aristotle and erected one of his own. Although it was in several respects very inferior to that of the Greek, we should observe him as the first independent thinker to publish his ideas. As was the universal custom until very recent times, entomology shared the leisure moments of the naturalist. With so wide a field for investigation why, they thought, should any one part of the living world receive isolated, concentrated study at the expense of all? To this idea, Aldrovandus and those succeeding him firmly adhered; hence, we sometimes find their names more closely united to botany or to other branches of zoology, and the entomologist must confess that their work in the field of insects was largely incidental.

By the middle of the seventeenth century we find a growing activity among a new school of biologists who clearly recognized the inadequacy of their predecessors' philosophy and methods in the present growth of the biological sciences. This period was marked by a further extension of the general knowledge of insects through descriptions and particularly through a new art, delineation. As examples, we should mention the plates drawn by Madam Merian and the paintings of Geodart, both being superior to any previous attempts. The systems of Swammerdam and of Ray were serious efforts to erect a more modern classification for the identification of insects. The introduction of the microscope into the science by Leeuwenhoeck, Lister, and Hooke opened a vast new field of research in minute anatomy. Malpighi, in fact, produced a justly famous work with the aid of this instrument—his anatomy of the silkworm. Another Italian, Francis Redi, at this time attacked and overthrew in the scientific mind, at least, the doctrine of equivocal generation for practically all organisms. The later researches of Pasteur on the microorganisms disposed of a group beyond the technique of Redi. The study of the life histories and the metamorphoses of insects had as a patron that most careful, accurate, and critical observer—Reaumur, who, with the grace and excellent diction characteristic of the Frenchman, recorded his observations in attractive form for the popular mind. He might justly be criticised for paying no attention to systematic arrangement or classificatory values in his writings. We find the same lack of appreciation of taxonomy in a later period in the elegant writings of his countryman, Buffon.

One of the most important developments of his time, however, was the classification of Ray which was in a measure an expansion of Swammerdam's system. Its feature was the employment of a definite character in the separation of the orders. It was founded on the completeness of the metamorphosis. Although in many respects unsatisfactory and even inferior to that of Aristotle, it pointed out the path to a more satisfactory system which was later widely accepted. His classification has attained fullest expression in the system established by Handlirsch through Latreille early in the twentieth century.

The following period, the era of Linne and his pupils, exhibited unparalleled enthusiasm among biologists, the further improvement in dissections and study of the life cycles of insects and the discovery of many new fields of investigation from the entomological side.

Up to this time insects had been given popular names, or for scientific purposes the name consisted of a short descriptive phrase or two, something after this fashion: "The little, round, black ladybird with two red spots on the elytra." Now with the number of described species of insects constantly and rapidly growing, this method led natural history swiftly to the rock of confusion for its speedy wrecking and possible destruction. Linne, the botanist, with his great intuitive faculties, however, seems to have been born and trained especially to supply this want of a proper terminology. "Linne's general philosophical propositions in botany can be traced to Cesalpino, his terminology to Jung, and his doctrine of sexuality to Camerarius." Thus, we can see that the theory of Linne's classification is essentially Aristotelian and was carefully employed in the recognition and sifting of the facts in natural affinity and in his interpretation of the organs of fructification. Supplementary to classification he recognized the prime importance of a short, accurate and exact system of terminology. As a result, he took up Jung's system and applied it consistently. Consistency of application is what Jung did not follow and the method was never shown to full advantage until presented by Linne.

Linne recognized the desirability of a natural system of classification and admitted that his was to a great extent artificial. The former method was necessary to trace lines of descent and real affinities in nature, while the latter he drew up carefully, basing it primarily upon certain arbitrarily selected distinctive structures, and offered it to the world simply as a convenient system of separating and determining species without too serious thought as to their fundamental relationships. Entomologists must further remember that his classification was fashioned in the first place to satisfy a long felt need in his particular field, botany. Later it was extended also to the zoological field and finally it was taken up and perfected by specialists in their various branches of the animal kingdom.

This rigid and artificial classification failed in some very notable cases to find the cordial support in France one would naturally expect. Buffon was his first serious opponent on this question, and he put forth the most weighty and incontrovertible arguments against the Swedish naturalist. To paraphrase one, as an example, he said in effect: "Why adopt so unnatural a system where one puts the tabby, our household pet, in the same group with the ferocious lion and tiger? No, no, it were far more natural and generally understandable if we make up a system of classification wherein both the dog and the cat were put in the same group with the horse, the rabbit, and the pigeon, our domestic friends."

Buffon's official position, a political plum, was really very efficiently filled by him. As director of the Jardin du Roi he spent his salary and considerable additional sums in improvements. His correspondence bore fruit in constant contributions of specimens from foreign lands. His fluent, elegant writing was perhaps the greatest single aid in the popularization of biological science in his time. His entomological work, in conclusion, was done by those in his employ. He had scarcely any first-hand information concerning insects.

Another, who with greater reason, sought a natural system of classification was Cuvier. He was of a different type to Buffon and one whose work, while not directly in the field of entomology, still influenced the systematists in the latter field. The ideas embodied in the study of comparative morphology were, in entomology at least, finding expression in the changes in methods of taxonomy.

The system of entomological classification given by Linne was founded upon the organs of flight. De Geer now added the organs of manducation to those of flight, but the resulting classification was perhaps less satisfactory than the former. A little later Fabricius, a pupil and great admirer of Linne, attempted a system of classification based simply on cephalic distinctions, chiefly the maxilæ. His system also was no improvement over that of Linne, yet his work on the lower orders was a distinct aid to their better understanding. Leach in England adopted part of the Fabrician system and fitted it to an extended portion of Linne's classification. He introduced the idea of having all names in the same rank end with the same termination. This feature is used today except for generic and specific terms. Latreille, the first bona fide entomologist (and it is said by authorities of the present time no greater figure has since appeared in the entire field) combined the best features of preceding systems most intelligently and succeeded in erecting the system upon which we depend for our present taxonomic work.

While a satisfactory classification was in process of evolution to its culmination in Latreille, other developments of the science were rapidly taking place. Insect delineation and hand color work in the offerings of Herbst, Huber, Esper, Panzer and others have never been excelled. Their work was marvelous for its preciseness and faithful reproduction of anatomical and chromatic details.

Considerable advance in the knowledge of insect transformations at this time was probably due to the inspirational work of Bonnett in his study of the life history of the aphid and the phenomenon of agamic regeneration. The publication of his results created great excitement not only in entomological science, but among zoologists in general, and even held the attention of the popular mind for a considerable time. About fifteen years later Lyonet's work on the internal anatomy of the goat-moth appeared. The major part is concerned with the larval stages. It is conceded that no more skillful, accurate work of like nature has since appeared. As an example of minute dissection, it still stands a model in entomological science. Another movement to be noted was the establishment of entomological societies to provide common meeting places for followers of the science and as a medium through which publications and ideas could be disseminated. Other scientific organizations founded for the advancement of pure and applied science were now opening branches devoted to the encouragement of the biological sciences in all of which entomology, sooner or later, was represented. Finally, at the close of the eighteenth century a new development of entomological science, economic entomology, arose to fill the needs of the young American nation. It now seems quite certain that economic entomology had sporadic encouragement in Germany in reducing forest pests before this time, and in another sense had a history dating from ancient accounts of the silk-worm and the honeybee industries. Still for its widest scope and fullest growth it is typically an American science.

This brings us in historical sequence down to the beginning of the nineteenth century. In this period so many remarkable changes occurred in every branch of the science that it must rest for the present. Intensive specialization within the science; subordination of many of the problems, once held as fundamental, to new concepts; and, lastly, the rapid strides in agricultural and medical entomology are in brief, perhaps, the principal ideas to be traced through the century still to be treated.

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DETECTION OF OVERGRAZING BY MEANS OF INDICATOR PLANTS.

BY MARK ANDERSON.[1]

The primary purpose of our federal forest administration is to protect the forests and watersheds against injury, to develop the highest possible use of the forest resources consistent with this policy of protection and improvement.

One of the principal forest resources in this region is the native forage. For this reason, we have been concerned mainly with the work of bringing about a proper utilization of the forage crop produced each year. If grazing is to be permitted at all within the National Forests, it must be properly regulated. That grazing properly regulated is in harmony with a proper practice of forest conservation has been demonstrated beyond any doubt.

Our first responsibility is to determine how the range will be grazed. Our second responsibility is to determine who shall share in the use of the forest forage. The first duty then consists in preventing misuse of the range, either in the form of overgrazing or under-utilization. The second duty, which consists mainly in maintaining a relationship between local agriculture and the forest range, or rather in preventing monopoly in the use of forest ranges, has very little, or nothing, to do with the science of range management, and will therefore be neglected in this discussion.

HOW SHALL THE RANGE BE GRAZED?

To tell you in detail how ranges should be divided between the different classes of stock based upon the character of the forage, topography, etc., would consume more than twenty minutes in itself. To tell you how the grazing periods should be fixed and how detrimental premature grazing is to the range would consume at least

[1]Grazing Examiner of the U. S. Forest Service, Ogden.

another twenty minutes. There are numerous other phases of range management, such as herding sheep, salting cattle and reducing losses from poisonous plants, each of which could hardly be covered in one lecture. For this reason, I will aim only to tell you what the presence of certain plant species on the range mean to the range inspector.

Recent trampling or close cropping are by no means the most reliable indicators of the intensity of grazing, neither is an eroded condition the most common result of overgrazing, even though it is probably the most serious result where it occurs.

A few of the best indicator species are Sneeze Weed[1], Nigger Head[2], Tar Weed[3], Yellow Mustard[4], Knot Weed[5], Senecio[6].

The mere presence of these plants alone is not conclusive proof of an overgrazed condition but where any of these plants predominate over considerable areas to the evident replacement of more palatable species the evidence of overgrazing can be taken as conclusive. Then, too, if the area under observation is overgrazed palatable shrubs such as Service Berry[7] and Snow Berry[8] will be found in a stubby condition and in many instances only the dead stumps of such shrubs will remain. In aspen types where the range is overgrazed there will nearly always be a noticeable lack of aspen reproduction. The term overgrazing is used here to mean grazing to a degree of intensity that will result in reducing the grazing capacity of the range. This is usually the result of very slow process of too intensive use or too early grazing extending over several years.

(Will then show about 10 lantern slides of inferior or poisonous plant species growing on overgrazed areas, two or three of eroded areas, two or three of browse and

[1]*Helenium Hoopesii.*
[2]*Rudbeckia occidentalis.*
[3]*Madia glomerata.*
[4]*Sophia incisa.*
[5]*Polygonum sps.*
[6]*Senecio sps.*
[7]*Amelanchier sps.*
[8]*Symphoricarpos sps.*

tree species injured through overgrazing, two or three illustrating how grasses will crowd out weeds on exclusive sheep ranges and vice versa on cattle ranges, two of cattle and sheep grazing together, and five of properly-grazed range types).

The principal causes of overgrazing are premature grazing or too early use of the range in the spring, poor distribution of stock or an excessive number of stock. Premature grazing is the chief cause of over grazing or injury to the range, particularly on cattle areas near the older established communities. Our sheep ranges are, on the whole, in much better condition than are our cattle ranges, mainly for the reason that sheep are better controlled and kept off the range until it is ready, while cattle are generally poorly controlled and in most cases, get onto the high range before it is ready. As a rule cattle are not so well distributed on the range as sheep and consequently there is more localized overgrazing on cattle ranges than on sheep ranges.

One of our biggest problems in forest protection in Utah is to develop some practical means of preventing premature grazing by cattle and to secure a more uniform distribution of cattle on the range. The construction of fences would be the most effective means in checking the too rapid drifts of stock to higher ranges in the spring and also to keep the stock from congregating on certain range units. If properly constructed, these fences would make it possible to practice deferred and rotation grazing. By a system of alternate protection the forage plants on certain range units would be permitted to regain vitality and revegetate the range.

Another big step toward solving the problem would be to educate more forest officers and more stockmen to recognize overgrazing when they see it, by a study of the range, particularly with reference to the presence of particular plant species that are in reality the best indicators of the condition of the range.

THE PROBLEM OF HANDEDNESS.

BY ARTHUR L. BEELEY.

The writer's sole aim in the presentation of this paper is to analyse and clearly define a problem,—the problem of left-handedness.

By way of showing that there is a problem here and not an imaginary one let me call your attention to the extremely right-handed nature of our mechanical environment. Both the letter and the newspaper which you read this morning began in the upper left-hand corner and the written and printed symbols had meaning only as you read them from left to right.

The handle to the door through which you entered this room turns only to the right.

If you enjoyed the distinction of coming to this meeting in a Ford you will recall the right-handed nature of the "self-starter." Your dinner this evening was prepared in pans and kettles with spouts convenient for the right-handed cook. The gas jet or electric plate upon which the food was heated is controlled by a switch turning only to the right. If you dined in town you will recall something of the orchestra which entertained you; the pianist played the most difficult parts of the score with his right hand. The cash-girl secured your change from a register operated from the right hand side. And so on ad infinitum. In a word, our mechanical environment, just as our system of handwriting, has developed in relation to the kinds of movement most easily made with the right hand. Imagine then, if you will, the problems of the four and a half million left-handed persons in our country alone who must adjust themselves to their right-handed surroundings.

It is already known quite definitely that left-handedness exists in about four or five per cent of the normal population. Between one and two million of the left-handed Americans are at present under the tutelage of our school system, part of whose business it is to develop manual skill and facilitation. The lamentable inefficiency of our methods of instructing this large group was vividly brought to the writer's attention in a recent survey of the handwriting problems and achievements of some 300 left-handed children in the public schools of the city of Chicago. The hand writing was, quite naturally, very much inferior to that of the right-handed pupils, but more significant was the fact that these unfortunate left-handed ones invariable received less help from their teachers than their right-handed neighbors, not to mention such additional disadvantages as cramped, unhygienic postures arising out of an attempt to adjust to light and desk arrangements adapted to the needs of the right-handed. In the absence of anything authoritative from physiology and psychology the teacher is naturally left to her own rule of thumb procedure in such cases, and this procedure, strangely enough is to "break" the pupil of his left-handedness by forcing the use of his right hand. When this fails the pupil is regarded as mentally incorrigible and is left to his own resources.

There is another aberration known in this field as "mirror writing." It is left-handwriting executed by an exact reduplication of the movements of the right hand, in a symmetrical way from the central point in front of the body out toward the left. This writing becomes legible and is like right-hand writing when seen in a mirror. In the writer's investigation of this aspect which canvasses a total school population of 106,000 children, he found only 42 bona fide cases of "mirror-writing." In the course of an intensive study of several typical cases, it was brought out that teachers and parents alike regarded the phenomenon as somewhat of a sub normal, criminal tendency. Invariable the method of correction was by the use of force.

Some evidence exists, also, which although small is by no means negligible, that the forced changing of children from their native left-handedness to right-handedness after speech and writing have become more or less habitual, results in certain speech defects, such as stammering, stuttering, and even some of the more complex aphasias. The explanation of this is based upon the already established fact that in right-handed persons for example, the left-cerebral hemisphere dominates the right half of the body and also controls the speech movements. Since handwriting is a form of speech and directly involves the speech centers in the cerebrum, to change one's handedness after the cerebral centers have become physiologically established, is to produce aberrations referred to. These facts and even the limited data accumulated make it morally incumbent upon the teacher as well as the parent to proceed cautiously in training the child who exhibits any left-handed tendencies whatsoever.

With increasingly complex and specialized mechanical environment calling more and more for manual skill and dexterity upon the part of vocational workers and others, the problem seems entitled to more than passing notice. The industrial worker or the soldier who loses his dextrous hand or arm must be fitted by society for economic independence and usefulness. Such rehabilitation, it is obvious, can proceed only intelligently with some recognition and study of the complex neuro-muscular processes involved. It is hoped that the United States Surgeon's General's Office will sieze the opportunity to contribute to the solution of this problem by a thoroughgoing analysis of its results and observations in the matter of manual re-education.

Such then are a few of the more important aspects of the problem of left-handedness. Let us turn our attention now to a brief discussion of the available facts, theories, and opinions which together constitute our present stock-in-trade for an attack of the problem.

While the median of the results of all investigations dealing with the prevalence of left-handedness, gives the distribution as 4% of the normal population, it is noteworthy that Ballard, Smith, Weber and Lombroso hold that the characteristic is more frequently found among males than females. Five other workers find left-handedness more frequent among delinquents, and Lattes finds it more prevalent among negroes. The wide disparity between the results of the various studies would seem to be due largely to two things. First, a too narrow survey, and second, a questionable technique which in most instances is unverifiable and unknown to all but the investigator himself.

There have been but two systematic studies made which deal with the hereditary aspects of left-handedness;—Jordan and Ramaley. In both instances, however, the results point to the conclusion that left-handedness is a Mendelian recessive. In the light of this and other facts, it would seem that there are all degrees of handedness ranging from extreme left-handedness to extreme right-handedness with a moderate right-handedness as the mode, or the most frequent type. But our difficulty here, as elsewhere in this problem, is that the studies have been too few and all not sufficiently comprehensive.

The origin or cause of right- and left-handedness has been a favorite theme of the educational theorist. I shall mention a few typical explanations.

It is argued by some that a child's handedness is a result of imitating its parents, or that it arises from the mother's constant method of carrying it.

Again it is said that the great majority of right-handedness is largely the result of education.

It is argued by Gould (8) and others that since the heart is the most vital organ of the body and is located nearer the left side, in primative warfare the shield was held in the left hand thus protecting the heart, while the right hand became the spear hand and has consequently acquired a dexterity which has been perpetuated through the ages.

Some argue that since the viscera on the right side of the body are heavier than on the left side (the liver and lungs), this condition places the center of gravity to the right of the anatomical center, thus rendering the use of the right limbs more likely. That owing to the position of the arteries the blood is forced through the right subclavian artery under a greater pressure than through the left, and as a result the muscles of the right side are better nourished and stronger. Left-handedness is explained by the earlier branching off of the left subclavian artery.

The last two theories imply that left-handedness is the result of a transposition of the viscera or what is known as *situs inversus*. Cases of transposition are on record which were not correlated with left-handedness. Furthermore, all left-handed people are not characterized by visceral transposition.

Judd and others say that since the two sides of the brain receive their blood supply through arteries which are asymmetrical, that where the blood supply is larger to the left side of the brain, the right hand is naturally developed to a higher degree of dexterity; where the right side of the brain receives the greatest blood supply the person is naturally left-handed.

This theory is invalidated by the presence of the anterior communicating artery, which connects the two cerebral arteries of the brain and forms part of the Circle of Willys. As a result the cerebral blood supply is pooled, so to speak, thus making it impossible for one hemisphere to receive a greater blood supply than the other.

Again it is held that "in about 96 percent of all infants the right eye is the better-seeing eye and thus compels the right hand to work with it." Stevens & Ducasse determined experimentally that in a majority of their subjects objects appearing in the right half of the field of vision of both eyes, are uniformly enlarged over objects appearing in the left half of the field of vision. From this they conclude that "by reason of the fact of a marked difference in the space sense of the two halves of the retina, objects in the right half of the field of vision by appearing larger attract the visual attention which in turn leads to grasping movements with the right hand. The hand thus favored by earliest experience acquires a special skill which causes it to be used in all manual acts requiring the greatest precision." A fatal objection to this theory is the fact that among the congenitally blind one finds about the same proportion of right- and left-handedness as among the sighted.

In the matter of mirror-writing, by far the most nearly complete study of its kind was made by Fuller, of the University of California, who holds that "the knack of mirror-writing can be acquired by any one, although most of us are unaware of this latent ability." The simple explanation of mirror-writing being "that certain impulses which do not ordinarily function, are, by the conditions under which mirror-writing takes place, allowed to be so." Many subjects were induced to write mirror-wise under the following various conditions: Hypnosis, Drugs, Abstraction, Insane, Hemiplegia, Feeble-minded, Deaf and Dumb, Skilled persons, University students, etc. According to his results, the more complete the dissociation, whether temporarily induced by hypnosis or by drugs, or as a permanent characteristic of the insane, the more the subject wrote "mirror-wise." From this he concludes that in every case of true mirror-writing "there must be a mental disturbance, a dissociation of attention, a deflection of the mental content; a low grade of intelligence or else a serious disturbance of the higher faculties."

Fuller's physiological explanation of reversed writing is based upon the fact that any movement of one side of the body is accompanied by a potential symmetrical impulse of the corresponding part of the opposite side. Mirror-writing, he says, is but a specialized instance of such associated movements. He goes on: "In every instance of stimulation of a nerve on one side of the body (primary stimulus), there is, by the arrangement of the central paths, opportunity afforded for the stimulation of the corresponding nerve on the opposite side of the body (secondary stimulus). It will thus occur that the graphic representation of the secondary stimulus will be an exact mirror replica of the graphic appearance of the primary stimulus. Accordingly, all symmetrical movements may be traced ultimately to a single brain area. From this area, the motor complex of the side primarily intended to be active receives its stimulus. The opposite side is stimulated to a lesser degree either by its direct connection with the primary area; or indirectly by its connection with the opposite motor complex; probably both means are available. For the purpose of mirror-writing it is most convenient to assume the truth of the second alternative, viz., that the connection is with the opposite motor cortices through the corpus collosum."

Fuller concludes then that "upon the use of the right hand for ordinary writing depends our ability to write mirror-wise with the left hand. It is a necessary condition that the child must have had some practice with his right hand at the ordinary writing." Otherwise there will be no mirror-writing by the left hand, "for those who have been allowed to use their left hand freely from the first, find rightward writing as easy as do the right-handed."

These explanations of the physiology of mirror-writing are the most plausible extant, and merit acceptance but for the fact that a very important type of mirror-writing which Fuller failed to investigate, is still an enigma. The writer found, after an intensive study of ten typical cases of mirror-writing which had appeared in the normal school population, that the very first handwriting attempts of these children were left-hand reversals. Now according to Fuller's own words: "The child must have had some practice with his right hand at ordinary writing before 'mirror-writing' can occur."

Furthermore, according to this theory, the left-handed child who writes conventionally with his left-hand, and is made to use his right hand will spontaneously write mirror-wise with the right hand. The facts, however, do not support this hypothesis.

Again, the implication from these conditions is unmistakable that mirror-writing is positively correlated with dissociation or insanity. Here again a discrepancy arises, since it is a matter of record that while many mirror-writers are retarded, some are also known to be precocious.

Fuller, however, by his physiological analysis of mirror-writing has incidently thrown some light upon another phase of the problem,—the causal relationship between speech aberrations and the changing of handedness.

A just criticism of Fuller's method would seem to be that he induced reversed, left-hand writing in subjects who are not normally "mirror-writers," rather than studying the characteristics and the spontaneous behavior of those who execute mirror-writing normally. The method might be likened to a study of insanity made by inducing a temporary insanity in otherwise sane subjects.

The writer's own results, even with their admitted limitations, call for another explanation. In such an attempt, it would be futile to neglect or to ignore the salient characteristics of the mirror-writers themselves. For instance, it was found that the ten who were chosen for intensive study, were found by the writer's own objective tests to be extremely left-handed; the other thirty-two were reported by their teachers as being also markedly left-handed. This fact would imply a strange "motor imagery."

What really happens, it would seem, in case of such a child is that his first and early concepts of the writing act are awry; that is to say, that as he perceives others writing in the conventional style with the right hand the imagery thus stimulated does not possess the optimum balance or association between the "visual" and the "motor" elements. While such a person does not reproduce with one hand the movements learned by the other, nevertheless the sight of those who do write normally is conceived of in "motor" terms, i.e., the most natural movements involved in a reproduction of the same. Furthermore, it is not difficult to see that such a child's "scribble-period" may serve as a process of trial and error, by means of which he readily learns that the easiest form of movement is with the left hand and from right to left. In such cases as these, in which we also have extreme left-handedness, the period of "happening on to" the easier type of movement will naturally be very short, since it will take but a very few trials to reveal which is the easier form of movement.

These, then, are the principal data available, with some of their limitations pointed out. Such practical school-room problems as the following still remain unsolved, however. If left-handedness is hereditary, up to what point is it safe to force left-handed children to become right-handed? What are the probabilities of inducing speech defects by changing handedness? Can a person who is naturally left-handed ever become as dexterous with his right hand? Growing out of these questions, however, there arises a more fundamental problem of greater importance, viz: How may the native handedness of young children be detected or diagnosed? It was to this basic aspect of the problem in an attempt to derive a test, that the writer applied himself.

In carrying out his investigation the writer proceeded on the assumption that a test involving acts of dexterity would be superior to a test of skill or endurance, since such a test would ultimately be given in most cases to children between the ages of four and eight years.

The desired test, in order to be valid for the purpose in mind, must be relatively accurate when applied to individual cases.

The test must be simple, not alone of comprehension by the subject, but in construction and application; it must be designed to meet the needs of school administrators, teachers, and other educational officers.

It must choose as a means of diagnosis some type of skill which, when tested in young children will reveal and express the relative potential dexterity of the two hands.

The ability or dexterity tested must closely resemble the principal dexterities called forth in school work and in practical life; at the same time the two must not be identical. That is, one could not adequately detect native handedness by asking a first-grade child to write his name, first with the right hand and then with the left, and thus determine the superior hand by the superior product. A valid test must obviate the practice element as much as possible.

With these basic considerations in mind the writer decided on the general plan of trying out certain of the existing and most suggestive tests in order, first, to eliminate the least promising, and, secondly, either to perfect the remaining ones or to glean suggestions for the construction of a new test. The essence of the general method was to apply certain tests to a large number of children of different school ages, whose handedness was already known quite accurately, and to determine the validity of the tests by the degree or extent to which its results corresponded or correlated with the known facts of the children's handedness.

In all, eight mechanical tests were evaluated experimentally on a group of 465 school children. Six of these tests had already been suggested and used in attempts at diagnosis; two of these tests embodied the writer's own ideas and conclusions. The test which I have here is the one which has yielded the most accurate results yet obtained in diagnosing handedness. The test however is still relatively valueless until norms of ability have been developed through wide application to large groups. When this is accomplished one could compare an individual's score with the norm, and say with reasonable definiteness, for example, that subject "A" whose score is x could safely be changed to right-handedness without any appreciable loss in dexterity, while subject "B" whose score is y, ought by all means to remain left-handed.

All that is claimed for the investigation is that it has discovered and made possible a more scientific means of diagnosing handedness, and has thereby facilitated the elaboration of these and other findings in the field.

In conclusion, it would seem that the opportunities and the obligations of science in regard to the problem of left-handedness has two well-defined aspects. First, to facilitate the adaptation of those persons who are strongly left-handed to their right-handed environment, and second, to effect an early change to right-handedness in those who are known to possess only a slight left-handed tendency, or are nearly ambidexterous.

It is hoped that this discussion will indicate the need of a thoroughgoing scientific attack of the entire problem of handedness, not alone by psychologist, but by physiologist as well. In the first place, a survey of the entire problem should be made which will include all of the normal as well as the abnormal aspects, involving intensive experimental research of individual cases as well as extensive statistical study of types. Second, the technique of the investigation should be carefully evolved and made altogether objective and verifiable. Third, the results, to be of value, should be critically interpreted. Such an attack of the problem of handedness would also materially assist in dispelling the intellectual fog which hovers around so much of our present discussion of the brain and its functions.

INVESTIGATIONS IN DEHYDRATION.

BY T. H. ABELL.*

United States Government reports show that 15 per cent of all the food stuffs produced in this country spoils before it reaches the markets, and 25 per cent of all that reaches the markets, spoils before it reaches the consumer. With multitudes of poorly fed people in many regions of the world, there is certainly a pressing need to save this wasted food. Food experts tell us that the solution of this problem is to be found in dehydration. The canning industry preserves large quantities of perishable products for use in large centers of population; the dehydration industry will furnish easily transportable forms of food for the frontiers of the world. Newly perfected or soon to be perfected methods of dehydration will furnish a product, light of weight, small in bulk, non-perishable, which, when properly treated, can be made to resume the bulk, appearance and flavor that it had in the original fresh state.

Dehydration has been practiced for at least six thousand years, it is as old as civilization. The earliest records from Egypt and Asia refer to dehydration. Dried foods were found in vessels in the ancient temples of China. The Egyptians perfected the art of drying to such an extent that they successfully preserved their chief citizens that we might excavate and exhibit them in our museums.

The methods of dehydration used today in different foreign countries differ only slightly from the older methods, and differ from each other mainly in the treatment previous to drying. In Egypt and China the vegetables are dipped for two minutes in boiling water. In Germany they are subjected to the action of steaming for two minutes and then dried in rotating drums in which the temperature goes as high as 500 degrees to 700 degrees F. In tropical regions where the products are dried in the sun, they are first treated with warm solutions of

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salt, bicarbonate of soda, potassium nitrate, or the fumes of sulfur. In Mexico, the materials are placed in bags, pounded and squeezed, and then hung in the sun to dry. When meat is dried, it is first rubbed with some material which will act as a repellent to flies and insects. With the exception of China and Germany, there has been little progress made in foreign countries in methods of drying. And even in those two countries the object was not to produce a vegetable or fruit for table use in the "near fresh" state, but to make a food that could be ground up and used as a flour substitute, soup stock, or material to be fermented as a source of alcohol.

In this country, perhaps the first improvements made in the methods of dehydration were about 1867 when Mr. D. Lippy of Ohio invented a small evaporator which was later improved by Topping. From then on for the next ten years, many evaporators were invented, mostly of the kiln, stack and tunnel types in which the principle involved was that of drying by convected heat. Other types of driers developed at this time in western New York were the steam-tray driers, and air-blast driers. Since then there have been improvements and enlargements of these types of machines with the addition of such labor saving devices as power corers, peelers, slicers and bleachers.

Beginning about 1914, there were many evaporating and dehydrating machines invented. These are all of a more or less complicated construction and operation. I will briefly describe six of the more recently invented machines together with the principle of their construction and the theories upon which their operations are based.

No. 1, patented in 1916. The object of this machine is to eliminate as far as possible the handling of the product. This is accomplished by automatically feeding the prepared material onto horizontally rotating discs across which are passed currents of air of predetermined temperature and humidity. When the material is dry, a scraper is lowered onto the disk and the material moves off diagonally into a receiver.

No. 2, patented in 1917. The theory involved is that artificial drying should resemble natural drying in the sun. That is; there should be the application of radiant heat, of convected heat, and all the variations of temperature and humidity found in a solar day. The material is allowed to "sleep" between periods of dehydration. The machine designed to accomplish this is one in which air is dehydrated to the proper humidity by being passed through a spray of brine, then heated to the proper temperature, then passed into separated cells containing stacks of trays of the material to be dried. There are dampers in these cells so arranged as to direct the currents of air intermittently through the different parts of the stack.

No. 3, patented in 1917. The operation of this machine is based on the theory that, first, if a cellular body is heated, the cell fluid expands, forcing the cell wall to expand; the cell wall in expanding becomes thinner thus allowing more rapid exmosis of the cell fluid; second, when this exuded water is removed by heated air currents the process of evaporation lowers the temperature of the cell to the point where exmosis ceases; third, light, in the form of electric light, aids in the exmosis of water from plant cells. This idea was worked out in a machine composed of a revolving drum made of compartments in which the material to be dehydrated is placed. Through the center of the drum run steam or electric coils which heat the material to 110 degrees F.; after the material reaches this temperature the air currents are forced through the compartments. Electric lights are so placed as to illuminate the drying material. The steam coils in the center of the drum keeps the material heated up to proper temperature.

No. 4, patented in 1917. This machine was designed to dry hops and is operated on the theory that materials dry more uniformly and that there is less physical or chemical change in the cells when the temperature of convected heat starts at 120 degrees F. and is raised at intervals until it reaches 170 degrees F. In this way the material is dried to such a low moisture content that there is not enough moisture to allow the enzymes to become active, but there is still enough left to protect the oils from rapid oxidation, as would happen if the material were to be dessicated.

No. 5, patented in 1918. The object of this machine is to utilize the heated air until it is thoroughly saturated with moisture. This is done by using air of determined temperature and humidity, passing over a portion of the article to be dried, raising the temperature, mixing it with fresh air to maintain its original moisture-absorbing capacity, and passing this mixed body of air over a second group of material, and so on many times until the air is saturated with moisture.

No. 6, patented in 1918. The theory upon which the operation of this machine is based is that vegetable matter more readily exudes moisture under the action of radiant heat than of convected heat, the rapidity also depending upon the degree of temperature and the amount of air pressure. The material is dehydrated by so arranging the apparatus that there are intermittent applications of radiant heat, electric light, and moving air currents, at definite air pressure.

Many other devices have been invented and many attempts have been made to dehydrate all kinds of foodstuffs. They have mostly been failures as will be seen by the fact that Mr. Sweet, the government expert, says that "fully 90 percent of the dehydrated materials purchased by the government within the last two years were very poor and would never have been accepted except for the stress of war."

Great success has been claimed for some of the inventions I have described, but it seems to me that there are two principal drawbacks to the widespread adoption of these machines. In the first place they are so complicated in construction that they are liable to be quite costly to install, and what we need today is an inexpensive machine that may be easily installed by a small group of producers. In the second place, although in actual operation these machines may produce a high grade product, some of them are based on theories that either need proof, or are not applicable to the conditions.

There are many problems still to be solved before we can produce the right kind of dehydrated goods. Even the inventor of several of these machines admits that the problem is not so much one of the extraction of water from the tissues as it is a problem of the proper treatment before and after dehydration. The problem of treatment before dehydration has occupied the attention of many investigators. Attempts have been made to prepare the material by dipping in solutions of salt, sodium bicarbonate, by boiling, steaming, and sulfering. Perhaps with vegetables some of these treatments may be successful, but with fruits no success has been attained.

It is true that for many years apples have been treated with sulfur fumes before evaporation, but one can hardly say that the process is sucessful. The color and flavor of sulfured apples are anything but inviting. Unless apples are treated some way before drying, they lose their aromatic flavor and become discolored due to the process of oxidation. If the process of oxidation can be retarded or prevented, a lighter colored and more highly flavored product could be obtained.

Proceeding upon this theory, investigators have recently been able to work out a method for producing a delicious dehydrated apple. This work was carried on by Mr. James at the Illinois Experiment Station and by myself at the Utah Experiment Station. The apples were prepared by slicing into very thin strips by passing the whole apple through an ordinary apple peeler. These thin slices dry more uniformly than thick slices or "quarters." In order to prevent or retard the process of oxidation the tissues were then treated with a solution of sucrose and glucose. It was found that the sucrose solution method could be replaced by using dry granular sucrose which was quickly dissolved by the moisture on the cut surfaces of the apple tissue. Varying concentrations of solutions and amounts of dry sugar were used and it was found that in general (especially with the glucose) that the browning of the tissues decreased as the concentration of the solution was increased. However, disregarding the color of the product, these treatments produced a sweet, pleasantly flavored product far superior to the ordinary sulfured apple (refer to specimens).

It is evident that the sugar from the solutions penetrated into the intercellular spaces of the tissues and formed a protective covering which at least retarded the process of oxidation. It was also found that the sugar treated apples after dehydration and subsequent treatment with water regained their original shape and consistency more quickly and more completely than did those dried without treatment. By using large quantities of sugar a sweet candy-like product is obtained, which, when thoroughly dried, may be ground to powder and used as a flavoring matter.

The outlook for dehydration holds wonderful possibilities; it is a coming industry. The problem in connection with the actual process of the extraction of water have probably, to a large extent, been solved; but the problems that will hold our attention for some time to come will be those of the proper treatment of the material before and after dehydration.

DISTILLED WATER AS A MEDIUM FOR GROWING PLANTS.

BY M. C. MERRILL.

Because of the extensive use of distilled water as a medium in which to grow plants for comparative purposes in solution-culture work, it was felt that there was justification for experimental work in order to determine more definitely the relation of plants to this medium. This paper will deal with the methods of work and the results obtained from the standpoint of growth relations and also by means of the effect produced upon the medium as determined by means of electrical conductivity measurements.

1. HISTORICAL.

The relation of plants to distilled water is a matter that has been under more or less serious consideration at different periods for a long time. As early as 1691-1692 Woodward, who first employed the method of water culture in his interesting experiments, found that plants grew better in river water than in either rain water, spring water, or distilled water. The difference was of course due to the quantity of plant food contained in the medium, and this idea, coupled also with the character of the nutrients, has been the basis for a vast amount of physiological work since that time.

A review of the literature on the subject shows that three main views have been entertained as the reason why plants and animals thrive better in natural water or aqueous media than in distilled water. These views are:

1. Because distilled water lacks essential nutrients;
2. Because it contains deleterious substances;
3. Because of the extraction or exosmosis of salts, or

nutrient materials, from organisms immersed in distilled water.

Holding each of these views there has been a formidable array of scientists at different periods, each group contending strongly to establish the correctness of its view-point. Among those holding the first view may be mentioned Boehm and Deherain.

The second view was associated with the theory of "oligodynamik" action of copper and other toxic substances which were found to be present in distilled water in minute traces and which produced effects simulating toxicity on the organisms placed in the medium. Kolliker, Nasse, Nageli, Aschoff, Loew, Locke, Ringer, Copeland and Kahlenberg, Deherain and Demoussy, Lyon, Bokorny and Hoyt were among those who gave attention to this phase of the problem at different times.

Because of finding by electrical conductivity measurements and otherwise that salts are extracted from organisms placed in distilled water, Plateau, Ringer and his school, Loeb, Koeppe, Oldham, Peters, True and others were led to believe that injury to organisms in distilled water found its best explanation on the basis of the extraction of necessary nutrient salts.

The results which the writer obtained in this phase of work led him to a somewhat different conception in regard to this subject. This conception is that pure distilled water is not harmful *per se*, but that because of the static condition forced upon them as a consequence of the absence of plant food, the growing cells become easy prey to bacterial and fungous action. Excretion of electrolytes does occur but this should be regarded merely as a concomitant condition and should not be considered as a cause of degeneration unless the electrolytes themselves be toxic.

2. METHODS.

Canada field peas (*Pisum sativum*) and horse beans (*Vicia faba*), the small variety, were selected for this work because of their splendid adaptability for growth in solution cultures. After thoroly sterilizing the seeds they were germinated on galvanized iron "hardware cloth" which was placed over a pan full of tap water into which the roots descended upon germination, thus giving an excellent lot of vigorous, uniform seedlings with serviceably straight radicals about two inches long.

Ordinary glass tumblers, the sides of which were covered with black paper and the top by perforated paraffined paper, were used as containers. Ten plants were grown in each tumbler in most cases. Pfeffer's nutrient solution and doubly distilled water with a specific conductivity of 2.064×10^{-6} were used as the media. For the conductivity work a Wheatstone bridge—telephone apparatus was used. The temperature was controlled to 1/10 degrees C. by use of a specially constructed water tank holding fifty gallons with a pilot flame underneath.

3. RESULTS.

If distilled water injures plants by reason of extracting nutrient materials, then it would be expected that greater injury would result if the distilled water were renewed or changed frequently during the time the organism were in it by virtue of the increase in its extracting ability. To test this out, both peas and horse beans were grown in doubly distilled water forty-seven and forty-five days respectively. For half of the cultures the water was replaced by fresh water every four days. The water for the other half of the cultures was not renewed, tho the small loss by transpiration and evaporation was made up in order to maintain a constant level in the tumbler. The results obtained at the end of the period are shown in Table I.

TABLE I.

Effect of Renewed vs. Unrenewed Distilled Water on the Growth of Peas and Horse Beans.

Medium	Green Wt. of tops in grams.	Dry Wt. of roots in grams
PEAS:		
Distilled water renewed	28.55	1.131
Distilled water unrenewed	28.08	1.259
HORSE BEAN:		
Distilled water renewed	110.30	3.315
Distilled water unrenewed	99.56	2.772

These results therefore indicate that the so-called injury to plants in distilled water cannot be entirely or even satisfactorily explained on the basis of extraction of solutes from the plant tissues. If that were the case we should have the greatest injury and least recovery in those cultures in which the distilled water was renewed, the periodically renewed water effecting *in toto* a greater exosmosis of the salts than the water that is not renewed, as will be shown later.

Growing these plants in distilled water for varying periods from one to twenty days, in half of the cultures the water being renewed every four days and not renewed in the others, and then transferring them to full nutrient solution, showed that in general better recovery resulted in the full nutrient solution in the case of those plants whose distilled water medium had been renewed. The period of five to ten days was found to be the limit of time peas and horse beans could remain in distilled water and then recover normally and continue their growth in the usual way. They could of course be kept in distilled water for much longer periods than that and later continue growth when placed in full nutrient solution, but their growth would not then be entirely normal.

An interesting effect in this connection is the delayed maturity and prolonged growing season of plants first grown in distilled water and later grown in full nutrient solution as compared with those in the nutrient medium the entire time.

If distilled water is in itself toxic then it should be interesting to get quantitative data on its effects as measured by the power of plants so treated to recover. This power should furnish a good index regarding the extent of any injury suffered. By comparing the ultimate time limits for various media of slight toxicity after which recovery in full nutrient solution is possible, we are able to get a basis on which to determine the relative toxicity of each medium. Table II shows the results of experiments along this line, and gives the longest period in the toxic solution after which recovery is possible:

TABLE II.

Redistilled water	30—40 days.
N/100 $MgCl_2$	4— 8 days.
N/1000 $MgCl_2$	about 20 days.
N/1000 $CaCl_2$ & N/20 $MgCl_2$	about 16 days.
N/12800 H_2SO_4	about 20 days.
N/400 KOH	about 20 days.

The solutions used have been considered as approximately the critical concentrations that would have practically no deleterious effects on plants. That being the case, the results show that pure distilled water can not be regarded as toxic. What is here illustrated for distilled water then is not toxicity but merely the length of time those plants can survive in a medium without nutrient materials.

Suspecting that bacteria and fungi play an important role in the deterioration of plants kept for some time in distilled water, an experiment was performed to determine the effect on the growth of the plants of sterilizing the medium by boiling it in a return condenser every four days. The results are shown in Table III.

TABLE III.

Effect Produced on Growth of Plants by Sterilizing the Water in Which They are Grown.

Culture No.	Medium	Condition of medium	Green Wt. of tops in gms.	Dry Wt. of roots in gms
1	Dist. H_2O	Unrenewed	1.55	.141
2	Dist. H_2O	Renewed	1.65	.150
3	Dist. H_2O	Sterilized	2.40	.225
4	Dist. H_2O	Sterilized	3.05	.233

Whether the beneficial effect of the sterilization was due to the destruction of the bacterial and fungous floras of the medium, to a decomposition of any contained toxic substances, or to incidental effects such as aeration of the water by the boiling process, was not definitely determined. All things carefully considered, however, the stronger line of evidence seems to favor the first-mentioned hypothesis.

The results of the conductivity experiments were both interesting and enlightening. The first point that was definitely determined was that there was much greater total and permanent excretion of electrolytes from the plants in the renewed than in the unrenewed distilled water. Table IV shows this result. The reading on the Wheatstone bridge for distilled water only was approximately 6.0. That figure is then considered the starting point for the conductivity readings for exosmosis, and the values given represent the readings on the bridge.

(See Table IV.)

Another point of interest was the reabsorption of electrolytes—as seen by the decrease in conductivity of the medium—in those cultures in which the distilled water was not renewed. This phenomenon was also frequently observed to be characteristic of normal, healthy peas when transferred from full nutrient solution to distilled water. There would be considerable exosmosis but after one or two days reabsorption would occur.

Conductivity readings of the distilled water medium every five days for a period of fifty days show a gradual rise in the conductivity, which becomes more rapid after the tenth day. This is no doubt due to the results of bacterial and fungous action on the decomposition of the tissues and the setting free of electrolytes. The curve for the green weight of the tops rises for the first ten days and then declines. After ten days in distilled water the complete normality of the plants no longer existed, a growth condition previously referred to.

Believing that the question of injury to plants in distilled water was intimately bound up with that of lack of reserve food materials, an experiment was carried out bearing upon this point. Plants were grown for varying periods in full nutrient solution and then transferred to distilled water whose conductivity was then taken at two-day intervals for twenty days. For comparison, readings were also taken of distilled water the plants in which had not been in the full nutrient solution at all. It was found that these latter deteriorated most rapidly and gave the highest conductivity readings, whereas those in the full nutrient solution longest before being placed in the distilled water gave the lowest readings at the end of the twenty days.

The results obtained seem plainly to indicate that injury which plants sustain in distilled water is very closely related either to the lack of available nutrients in the medium or of reserve food material in the tissues. A seedling is in an exceedingly plastic state of growth. If no food materials become available the embryonic tissues which are in such an active condition of growth soon become disorganized, possibly suffering partial autolysis and becoming the prey to bacterial and fungous action. We would expect, therefore that the larger the seeds (and hence also the supply of stored materials), the longer the seedlings could remain in distilled water before deterioration. Comparison of True's results on *Lupinus* with those here presented on *Pisum sativum* and *Vicia faba* seems to fulfill that expectation. We should also expect that the more nutrient materials the plant absorbed, the better it would be able later to withstand any deteriorating influences in the distilled water, and the experiment above noted seems to bear out that idea also.

4. DISCUSSION AND CONCLUSION.

It is believed that the evidence furnished is sufficient to support the conclusion that pure distilled water *per se* is not toxic or injurious to plants, and that various other factors enter in to cause the deterioration noted when plants are placed in that medium.

Of course by qualifying the assertion to include pure distilled water only, we have thus eliminated the effect that may be produced by toxic substances in the distilled water, no matter from whence derived. The abundance of work that has been done on the toxicity of various substances to plant tissues would of course lead us to expect injurious effects if such substances were present in any quantity in the distilled water. With that phase of the question we are therefore not much concerned at present. With a distilled water prepared as indicated, and with a specific conductivity which is approximately $2x10^{-6}$, we have a water sufficiently pure for use in the consideration of other aspects of the question, and attention is directed to these.

The evidence presented has inclined us strongly to the view that the fundamental basis of the deterioration of plants in distilled water rests upon the food relation of such plants, but that, on the other hand, an exosmosis of food materials or nutrient salts is in no way responsible for the difficulty. It is considered that the question of the food relation plays an important role in the incipiency of the disorder, but that this is quickly followed by factors which have been initiated as a result of the inimical food or nutrient relation.

A plant must assuredly have food in order to thrive. The more food it has stored up in its tissues, the longer it can survive in a medium devoid of it. But because of the absence of available food it is believed that the tissues of the plant begin to become disorganized and in that condition fall a ready prey to bacterial and fungous action, which may then set in and play a very important part in the subsequent decomposition of the tissues.

TABLE IV.

Comparative Exosmosis in Renewed and Unrenewed Distilled Water.

Culture No.	Water renewal	Conductivity readings.								Duration of treatment days	Total increase in conductivity
		Frequency	1st	2nd	3rd	4th	5th	6th	7th		
1	Every day	Every day	32.9	10.4	10.0	8.9	9.7	9.4	10.2	7	49.5
2	None	Every day	36.3	22.8	21.4	17.8	15.2	12.5	11.4	7	5.4
3	Every 2 days	Every 2 days	10.8	9.3	9.6	10.7				8	16.4
4	None	Every 2 days	25.0	14.3	13.6	11.0				8	5.0
5	Every 4 days	Every 4 days	12.9	15.0	16.1	16.1				16	36.1
6	None	Every 4 days	10.7	12.4	15.9	19.5				16	13.5

DETERMINATION OF THE NORMAL TEMPERATURE BY MEANS OF THE EQUATION OF THE SEASONAL TEMPERATURE VARIATION AND OF A MODIFIED THERMOGRAPH RECORD.

BY DR. FRANK L. WEST, N. E. EDLEFSEN, AND S. P. EWING.

The normal air temperature is a periodic function of the time, there being two prominent periods, a twenty-four hour and an annual period.

The mean daily temperature for the different days of the year for Utah was plotted and the following empirical equation for the curve obtained by the method of the Fourier Series.

(1)

$$T = 48.5 - 22.2 \cos(\Theta - 19°54') - 2.7 \cos 2(\Theta - 149°5') - 1.0 \cos 3(\Theta - 17°3')$$

T, representing the temperature, and Θ the time, expressed in degrees, e. g. April 1st would be 90°, July 1st 180° etc. The same curves for widely separated places in the interior of the United States are nearly identical in shape and when superimposed on the curve for Utah—in the most extreme case—projected at the crest but 2 above and at the winter minimum 2 below the curve for Utah. The first term in the above equation is the mean annual temperature for the place considered (a function of latitude and elevation) and simply moves the curve up or down the page while the shape or amplitude is determined by the differences in temperature between summer and winter and varies at different places in the interior of the United States from the Utah value from 1 to 4 degrees. The equation given above therefore is of rather general application. Simply insert for the first term, the mean annual temperature for the place in question, leave the rest of the equation as it is and the normal mean daily temperature for the day desired at the place chosen may be calculated.

The curve representing the twenty-four hour temperature change (thermograph record), modifies its shape gradually each day, flattening out as winter appoaches. During the summer, when heat is being received fast one would expect the rise in temperature to be greater, for the same time interval, than in winter and thus we find that the daily variation in temperature is about twice as much in summer as in winter. However, the ratio of the hourly temperatures to the mean daily temperature Fahrenheit is nearly constant whatever day of the year is selected, e. g. the ratio of the maximum to the mean is very approximately a constant for all days of the year. Irregularities will be caused by storms and enough ratios must be taken to eliminate these in obtaining this constant. These per cents of the mean daily temperature, range from seventy for the minimum just before sunrise to 130 for late afternoon, (somewhat smaller range for humid regions,) and when plotted gave a curve very similar to the thermograph record of a clear day. The equation of this curve is

$$P=97.3-25.2\cos(\Theta-67°10')+3.7\cos 2(\Theta-38°)-1.5\cos 3(\Theta-23°16') \tag{2}$$

P, representing the per cent of the mean daily temperature and Θ the time of day expressed in degrees, e. g. 6 A. M. would be 90°, noon 180°. etc. This equation is also of rather general application, at least approximately.

To determine the normal temperature at any place, say e. g. Denver at any day and hour, say May 1st at 4 A. M.—insert the mean annual temperature of Denver for the first term of equation (1) and substitute for Θ the May 1st equivalent which is 1/3 of 360=120° and solve for the mean daily temperature for that day. In equation (2) insert for Θ 4/24 or 1/6 of 360°=60° and solve for the per cent corresponding to 4 A. M., multiply this per cent by the temperature obtained from solving equation (1) and the 4 A. M. May 1st Denver normal temperature is obtained.

The errors include the fact that one more year's record might change the normals used and the graph of the equation might not coincide with the plot of this new data. These errors are very slight. In applying the method in the eastern part of the United States where cyclones cause large departures from the normals, longer records are required, the curve of annual temperature change has a slightly different shape or amplitude and the ratio of maximum to mean for the day is smaller but approximately constant.

One fourth of the earth's surface is as dry as the Great Basin of Western U. S., where the precipitation is 12 inches, the humidity 50%, and 80% of the days are without rain. These wide departures from normals are comparatively rare and the above method is useful in long time temperature prediction.

Using the above method it was found that in the arid west, the chances are one in six that the actual temperature will differ from the computed value by less than 2°F., two in five that it will be 5°F., one in four that it will be around 10°F., and 1 in 7 that it will be as much as .15°F. Cyclones and anti-cyclones are the main causes of these departures. By consultation with the Weather Bureau concerning the location of these "highs" and "lows," these differences may be very considerably reduced.

ALKALI WATER FOR IRRIGATION.

BY F. S. HARRIS AND N. I. BUTT.

With the increasing demand for agricultural products, there is need for the reclamation of more of the present unproductive lands. Although Utah now irrigates more than a million acres, perhaps double this area could be irrigated if all of the present supply of water could be utilized. On account of alkali troubles which developed soon after water was applied, several irrigation projects have failed even though they had an abundance of water. Some soils contain quantities of alkali which might be expected to give trouble as soon as irrigation is commenced and time is allowed for the salts to be dissolved and accumulated at the surface of the soil by evaporation. There are some ruined soils, however, which originally did not contain sufficient alkali to be troublesome, but have been contaminated from other sources.

Seepage water often percolates from higher lands bringing disastrous quantities of alkali. Irrigation water, which in many cases contains considerable seepage, sometimes holds sufficient alkali to make the land sterile in a very few years. Often irrigation streams carrying far too little alkali salts to be noticed by tasting, hold so much that without adequate precaution in their use, the toil in reclaiming the land could easily be wasted before profitable cultivation began.. Millions of acres of land in India, the Euphrates Valley, and Africa have been made unproductive by alkali accumulation. It is, therefore, important that we avoid the use of water likely to throw out of use land which, though unused at present, may be needed in the future.

Since the waters causing injury to lands in other parts of the country have been somewhat carefully studied, we know in a general way the approximate quantities of alkali that may be present without fear of damage to the soil. The limits which have been set by the various investigators, however, vary through a wide range. Differences in drainage of the soil, the kind of alkali, the quantity of water used, and several other factors make definite limits impossible. The water in streams may hold only a small quantity of salts in the spring when it comes direct from the melting snows, but later in the summer when it is most needed for irrigation the alkali content may have reached a dangerously high point because of seepage and return waters. This fluctuating salt content of the streams may further complicate the problem for streams which vary considerably in volume; they may fall within the limits of safe water during part of the year and be dangerous at other times.

A soil with good drainage is seldom troubled with alkali. Such a soil, without being materially injured, could be irrigated with alkali water too strong to be successfully used on more impervious ones. If we can find a means to make use of the stronger alkali irrigation waters on the sandy or well drained soils and reserve the purer waters for the more impervious but richer loam and clay soils, great good will be accomplished.

An arbitrary limit for the quantity of salts which may be present in an irrigation water without causing a rapid deterioration of the land due to alkali, may greatly assist in classifying waters as safe or unsafe for general irrigation purposes provided the modifying factors are taken into consideration. In California where there is more trouble from sodium carbonate, or black alkali, than is found in Utah, the limit for safe irrigation water is placed between 600 and 700 parts of alkali salts to each million parts of water or between 0.06 and 0.07 per cent. Where the main salt is sodium carbonate, as small a proportion as 300 to 500 parts might prove injurious.

Utah waters, however, are troubled mainly with the less harmful sodium chloride and sodium sulphate. Under Arizona conditions where the salts are mostly sodium sulphate and sodium chloride in much the same proportion as in Utah waters and where the drainage is fairly good, as much as 1,000 parts per million is not considered entirely unsafe to be used for irrigation.

In New Mexico the water of the Pecos River which contains proportionately more sodium sulphate than the majority of Utah irrigation waters, is said to be fit for irrigation until it reaches a strength of about 1,250 to 1,500 parts per million of alkali salts or where the total salts are about double this quantity.

Where water known to contain alkali in such large quantities as to be harmful is flowing past farms threatened with drouth, it is a great temptation to use the water for a single irrigation with the intention of washing the salts from the soil when purer water can be had. In the Bear River Valley on a clay loam soil, a farmer used the water from the Malad River which contains over 4,000 parts per million of salts, mostly sodium chloride, to irrigate a grain field. The grain almost immediately wilted and the crop was lost. Such water might have been endured for the season on a lighter and better drained soil.

Most of the irrigation waters of Utah contain such small quantities of alkali salts that they may be classified as good under ordinary conditions. Perhaps a dozen of the streams and rivers fall in the class which are of dubious quality, and a few of these are unquestionably harmful under the local conditions. Springs and wells vary so much in alkali content in different places that individual analyses must be made before their quality for irrigation can be determined. (For analyses of some of the more important streams of the state, and a number of wells and reservoirs used for irrigation, Bulletins 147 and 163 of the Utah Experiment Station are instructive.)

Under field conditions, the injury done by alkali in irrigation water is difficult to determine definitely because of alkali already in the soil, accumulation of the salts in the upper strata of the soil, and the interfering action of various non-alkali salts. To study the factors separately, a number of experiments were begun at the Utah Experiment Station in 1915 and continued until 1918.

The first experiment consisted of two series of earthen jars, one containing loam soil and another sand, to which the alkali salts were added in pure solutions somewhat as under ordinary irrigation. To avoid evaporation from the jars with its consequent accumulation of the salts at the surface, the tops of the jars were covered with paraffine paper as soon as the plants were up. Field studies are often complicated because of varying moisture conditions in the soil. In these experiments the moisture was maintained at 20 per cent of the dry weight of the soil in both the loam and the sand by adding the alkali solutions to the plants as fast as they used the water. The crop in all cases was wheat; wheat being more easily handled and studied than most other crops and its action under alkali conditions having been more carefully studied. Low concentrations of the various solutions were not used as this would have prolonged too greatly the experiment. The same conditions result from running the experiment with stronger solutions. It is the quantity of injurious salts in the soil less the quantity held in an insoluble form which determines the toxicity to the plant. The conditions reached in the four years of the experiment with a given strength of solution could have been obtained in double this length of time with half the strength. The results are applicable to field conditions only where the soil is impervious or nearly so. Also where the moisture conditions of the soil are different from those of the experiment an allowance should be made accordingly.

To learn which parts of the plant are affected by the alkali, studies were made of the dry weight of the plant, the number of leaves produced per plant and their length, the number of culms and their length, the number of heads, and the number of spikelets per head. The following conclusions have been drawn from the experiments:

As a general rule, the dry weight of the plants indicated the action of the alkali better than the other determinations. However, as the number of leaves per plant, the length of culms, and the number of heads produced were affected much the same as the dry weight, these factors might be used roughly to estimate the toxicity of alkali soil. When the conditions were unfavorable to high production of dry matter so that variation in production was not large between the different treatments, certain of the factors other than dry matter indicated the quantity of salts in the soil better than did the weight of the plants.

On a loam soil without good drainage the various factors show that wheat should never be irrigated with water containing as much as 1,000 parts per million of sodium carbonate and that even 500 parts per million will materially reduce the growth of the plants within three or four years. The plants receiving sodium carbonate in all strengths from 500 to 4,000 parts per million wilted in the loam soil and produced a poor growth during the first year. Water containing an appreciable quantity of sodium carbonate should not be used on heavy or impervious soils.

A mixture of the three salts sodium chloride, sodium carbonate, and sodium sulphate in equal quantities was not so harmful as the most toxic salt on loam soil but ranked high in this respect. Such a mixture was apparently stimulating when applied to the loam soil in a strength of 1,000 parts per million during the third and fourth years, but for the first two years it was rather toxic. As much as 4,000 parts per million of mixed salt solution was too toxic for good growth.

Water containing 1,000 parts per million or more of sodium chloride proved harmful to wheat on undrained loam soil in two years.

Applied to this soil water containing 4,000 parts per million or more sodium sulphate proved to be dangerous to wheat in two or three years. When added in concentration of 1,000 parts per million this salt did not appear essentially harmful in four years.

In the use of water, plants growing in soil containing sodium carbonate were very wasteful while those in sodium chloride were more economical.

The size of the leaves in the loam soil decreased as the strength of the solution increased. The leaves were apparently affected both in number and length by small quantities of alkali in the soil. Mixed salts appeared more toxic than the single salts to length of leaves and number of heads per plant.

The length of culture do not appear to be so closely related to alkali as to other factors, either in loam or sand soil. In general the number of spikelets per head decreased with increasing strengths of alkali. The weaker alkali, especially sodium chloride and mixed salts, apparently stimulated the production of spikelets.

For the sand soil the salts did not seem quite so toxic to the plants at a given concentration and time as did the loam. This was perhaps due to a larger proportion of free water in the sand; both soils containing 20 per cent of water but loam holding it more strongly. Sand soil withstood up to 1,000 parts per million of sodium carbonate water for two to three years without a great reduction in the production of wheat. This strength of solution reduced the crop to less than one-half for the fourth year. Water containing 1,000 parts per million or more of any of the alkali salts when applied as needed by the plants to an undrained sandy soil made it too toxic for grain production in three to four years. Production was not greatly decreased by sodium sulphate until a solution with a strength of 4,000 parts per million was used.

Alkali irrigation water appears to influence plant production only so far as it increases the strength of the soil solution above a point tolerated by plants. More salts than are ordinarily considered harmful were withstood in this experiment before fatal strengths were reached. This was perhaps because the soil was kept high in moisture by weekly irrigation.

In another experiment water containing sodium carbonate proved more injurious to wheat plants after they had reached the five-leaf stage than the other alkali salts. Both sodium chloride and sodium sulphate stimulated dry matter production up to a certain concentration even when the soil contained many times the quantity ordinarily harmful. When watered with an alkali solution after reaching the five-leaf stage of growth sodium chloride caused the plants to produce dry matter with less water than did other treatments. Wheat growing on alkali free soil was retarded in growth in a single season by water containing as much as 10,000 parts per million of sodium carbonate but 25,000 parts per million of sodium chloride and much more than this of sodium sulphate was endured by plants which were past the five-leaf stage. Wheat appears to be many times more sensitive when in the younger stage of growth than it does after it reaches the five-leaf stage.

An experiment with seedling plants shows the average order of toxicity for the different treatments to be sodium carbonate, sodium chloride, magnesium chloride, calcium chloride and sodium sulphate; sodium carbonate being most harmful and sodium sulphate least. Solutions containing less than 60,000 parts per million of sodium chloride apparently stimulated dry matter production in seedling plants.

Sodium chloride was slightly more toxic to growth in height of seedlings than other salts and sodium sulphate distinctly favored this development. Highly concentrated solutions of these salts tended to reduce the height of the plant. With the weaker strengths of alkali, plants withstood sodium chloride better than sodium carbonate, but when the stronger solution was applied the plants were killed at an earlier stage with sodium chloride than with sodium carbonate. Plants were apparently little injured at the end of the three weeks when growing in a soil watered with a 200,000 parts per million solution of sodium sulphate, the highest strength tried. The action of alkali on plants does not seem to become manifest immediately after the salts are added to the soil in the form of alkali solutions.

For seedling plants toxicity of a single irrigation with a solution of alkali salts, when based on an average of the erectness of the plants, wilting of the leaves, browning and corroding of the base of the stems, and the general healthfulness of the plants, was first apparent at a strength of 0.3125 molecules or where the soils contained about 1,800 parts per million of sodium chloride 3,300 parts per million of sodium carbonate or 4,400 of sodium sulphate. Sodium carbonate was most harmful in these strengths followed by sodium chloride and sodium sulphate. The unmixed salts or those diluted only slightly by the other two salts appeared more toxic than where all three salts were somewhat more equally mixed. Mixtures of sodium carbonate and sodium chloride were as toxic as either salt alone and in some cases more so, especially where there was a marked toxic effect of the salts. The condition of the plants was reduced to less than half normal when the sodium chloride soil had received about 2,923 parts per millon, the sodium carbonate soil 5,300 parts per million, and the sodium sulphate soil 14,207 parts per million of salts in the unmixed treatments.

It appears that the stage of growth reached by the plant before the alkali is brought in contact with it, has considerable influence on the injury that will be done to it.

THE RELATION OF THE METHOD OF ANALYZING ALKALI SOILS TO THE LIMITS OF TOXICITY.

BY D. W. PITTMAN.

The importance of the alkali problem need not be emphasized here. So large a percentage of our non-productive land is non-productive because of alkali as to make the study of alkali of major importance in this region. One of the first problems to be met with by the investigator is to be able to tell by examining a piece of land whether or not it contains enough alkali to prohibit or lessen crop production. The two phases of this problem are: to determine by analysis how much alkali the soil contains, and to determine by experiment how much alkali the crops will endure. Both these phases have been studied by many investigators but with methods so varied that the results obtained by different men are hardly comparable. There are almost as many methods of testing for alkali and of expressing the results of the tests as there are men studying the problem, each man using a method most adapted to his line of work. On the other hand, the men studying the toxic limits of the alkali salts may use salt solutions, may add the salts to the soil, or may test natural alkali soils by one of the various methods. All these methods yield entirely different results and a study of the literature in this line gives such widely different limits of tolerance of crops for the various salts as to leave one in a state of confusion.

In this work it was the intention to show that different methods of analyzing soils gave different results and to give a little data on the toxic limits of a few salts as shown by some of the more common tests. Preliminary studies too lengthy to be included here showed that the different standard methods of testing soils for alkali salts and of expressing the results gave differences occasionally amounting to over 1000 per cent in the results. A study of the literature on the toxic limits gives still greater differences. Therefore, only a few of the analytical methods were tried out in this experiment.

The tests were arranged in series so that each was repeated many times and the relative deviation of the methods was determined. The methods used for determining the salts were as follows: First, the salt was added in solution in various concentrations to the soil in tumblers. The soil ranged in this case from sand to clay including many mixtures with loam and varying organic materials. Second, at the conclusion of the experiment the soils in these tumblers were tested by water extraction for the salts added the method being described later. Third, these same soils were tested for total alkali with the electric bridge as described in U. S. Bureau of Soils Bulletin No. 61. Fourth, the soils were tested for total alkali by determining the freezing point of the soil at its normal moisture content, a method that has recently been perfected by Bouyoucos and McCool of the Michigan Station for determining the osmotic pressure and thus indirectly the concentration of the soil solution at the normal moisture content of the soil.

The method of water extraction used was as follows: The soil was dried in an oven and a 50-gram sample weighed out. This was stirred in 500 cc. of distilled water with a broad paddle for five minutes, allowed to settle for an hour and filtered through a Chamberlain-Pasteur filter. The filtrate was tested for sodium chloride by titrating an aliquot part with N/50 silver nitrate using potassium dichromate as an indicator; it was tested for sodium carbonate by titrating an aliquot part with N/50 sulfuric acid using methyl orange indicator and expressing the total basicity as sodium carbonate; it was tested for sodium sulfate by the ordinary gravimetric method. A rather extensive series of experiments showed that varying the time of agitation and the proportion of soil to water had considerable influence on the sodium carbonate results but had little influence on the other salts. The method described above was adopted because it was convenient and seemed to give as consistent results as any.

The crop producing power of these soils was determined by planting ten kernels of New Zealand wheat in each of the tumblers, maintaining the soil at a uniform, favorable moisture content and allowing the seed to germinate and grow for three weeks. The growth was then cut off at the surface of the soil, dried, and weighed.

With each row of tumblers was one which contained the same soil as the others but no salt added. The dry weight of plants produced in this was taken as 100 per cent and the yield of the other tumblers computed on this basis. To express the relative deviation of the results the probable error in per cent of the mean was used. This figure is the percent of the average result which marks the limits above and below the mean within which half of the individual results will fall. It is worked out by the formula

$$\text{P. E. (\% of mean)} = \pm \frac{67.45\sqrt{\frac{\Sigma d^2}{n}}}{M}$$

where "Σd^2" is the sum of the squares of the differences between each individual result and the mean, "n" is the number of samples, and "M" is the mean or arithmetic average. "n" is at least 150 determinations for each figure.

The results are summarized in Tables I, II, and III.

TABLE I.

Crop production for soils containing different amounts of sodium chloride compared with different tests for the salt.

Crop Production	Salt Added p. p. m.	P. E. % of Mean	Salt by Extraction p. p. m.	P. E. % of Mean	Salt by Bridge p. p. m.	P. E. % of Mean	Freezing Pt. Depression ° Centi.	P. E. % of Mean
100	0	51	196	91	918	72	.41	55
114	200	49	387	66	716	61	.49	52
104	400	39	492	41	963	50	.55	42
113	600	42	656	44	1155	53	.61	44
104	800	52	858	53	1434	62	.70	53
98	1000	45	1082	47	1760	51	.83	48
81	1500	59	1544	60	2403	63	.98	60
65	2000	54	2054	55	3062	57	1.23	55
50	2500	63	2608	64	3645	68	1.44	65
39	3000	70	2994	70	4227	72	1.66	71
23	3500	92	3399	92	4704	93	1.85	93
16	4000	115	3812	116	5016	117	1.93	116

TABLE II.

Crop production for soils containing different amounts of sodium carbonate compared with different tests for the salt.

Crop Production	Salt Added p. p. m.	P. E. % of Mean	Salt by Extraction p. p. m.	P. E. % of Mean	Salt by Bridge p. p. m.	P. E. % of Mean	Freezing Pt. Depression ° Centi.	P. E. % of Mean
100	0	51	728	62	705	67	.76	55
126	500	64	849	70	747	74	.75	66
111	1000	48	959	54	710	59	.77	50
83	2000	21	1170	28	886	37	.83	24
65	3000	29	1710	33	1104	35	.89	30
37	4000	75	2068	76	1392	78	1.05	76
21	5000	92	2555	93	1925	95	1.18	94
14	6000	102	3024	108	2298	104	1.30	104
8	7000	152	3395	153	2695	153	1.46	153
5	8000	238	3944	241	3208	239	1.69	239
4	9000	130	4527	131	3555	132	1.78	132
3	10000	280	4910	280	3900	281	1.91	281

TABLE III.

Crop production for soils containing different amounts of sodium sulfate compared with different tests for the salt.

Crop Production	Salt Added p. p. m.	P. E. % of Mean	Salt by Extraction p. p. m.	P. E. % of Mean	Salt by Bridge p. p. m.	P. E. % of Mean	Freezing Pt. Depression ° Centi.	P. E. % of Mean
100	0	51	455	63	637	59	.31	51
111	500	46	864	50	978	50	.41	70
94	1000	42	1418	48	1350	44	.45	51
91	2000	42	2474	45	2098	47	.57	46
79	3000	46	3579	48	2616	48	.72	49
68	4000	50	4600	52	3236	54	.87	55
55	5000	59	5570	61	3950	61	1.04	62
42	6000	72	6798	73	4662	75	1.14	75
36	7000	95	8099	96	4998	96	1.19	97
28	8000	99	9560	100	5496	100	1.28	100
23	9000	115	9990	116	6345	116	1.30	115
16	10000	125	10810	125	6850	127	1.46	126

These tables show little difference in the tests for sodium chloride and sodium sulfate but sufficient difference in the sodium carbonate to make this salt show more or less toxic than sodium chloride according to how it is determined. None of the regular tests consistently show over half of the sodium carbonate added to the soil. The exact explanation of this is still a matter for research. The deviations are not noticeably different for any of the methods showing that most of the deviation is in the crop growth and not in the analysis. This would indicate that in field work it makes little difference what method is used to determine the salts in the soil so long as the data on the relative crop growth or toxicity have been worked out by a similar method.

Summarizing briefly, these experiments show that:

1. Different methods of determining the alkali content of soils give widely different results, especially with sodium carbonate or "black alkali."

2. There are great differences in the toxic limits of alkali as found by different investigators.

3. The methods tried out in detail are about equally satisfactory in themselves.

4. In field studies it is necessary to use figures for the toxic limits which were determined by the same method of testing as employed in the work.

5. Tables have been prepared showing the toxicity of three alkali salts as determined by four different methods.

A THEORY OF CAPILLARY FLOW.

BY DR. WILLARD GARDNER.

Slichter, in the Nineteenth Annual Report of the U. S. Geological Survey, has given us a theoretical solution for the flow of water through homogeneous sand under pressure, and various investigators have measured the distribution of capillary water at "equilibrium." Buckingham, in Bureau of Soils Bulletin No. 38, has proposed an equation for the flow assuming a capillary potential gradient and a resistance function, both of which depend upon the amount of moisture present. His solution is, however, incomplete and involves an empirical evaluation of the potential as a function of the moisture content.

Slichter's solution for free water is a rather successful application of Poiseuille's law for capillary tubes to the irregular pore tubes in the sand. The case of the movement of moisture in unsaturated soil is only formally analogous to free water movement, the cause of motion being a moisture gradient. Stokes' law is developed for the case of an isolated particle moving in a fluid at a distance remote from the boundary surface, and these conditions are of course not rigorously fulfilled in the case of adjacent particles moving relatively through thin irregular columns of water. With the hope, however, of approximating a correct solution we have made the assumption that Stokes' law is applicable to horizontal one-dimensional capillary flow, substituting in place of the gravitational constant a variable kinematical factor which depends upon the moisture content and the moisture gradient.

While the physical state and properties of the so-called hygroscopic moisture is an unsettled question, it is believed that the capillary moisture is located primarily at points of contact of adjacent particles and the pressure gradient giving rise to capillary movement is due to varying surface curvature. For spherical grains of uniform size the pressure (which is the product of the surface tension and the curvature) is a determinate function of the volume of the ringshaped water wedge and the pressure gradient is therefore a determinate function of the moisture gradient. Since the soil particles are not spherical, a rigorous solution of the problem would perhaps be only approximately correct as applied to the soil. We have therefore attempted only an approximate (1) determination of the function, yielding the tentative relation:—

$$\frac{dp}{dx} = \frac{k}{\rho^{\frac{4}{3}}} \frac{d\rho}{dx}$$

where p is the pressure, ρ the density of moisture at a point whose linear coordinate is x, and k is a constant involving the radius of the particle and the surface tension of the liquid.

Substituting this value in Stokes' equation we obtain for the velocity,

$$v = \frac{c}{\rho^{\frac{4}{3}}} \frac{d\rho}{dx}$$

where c involves the surface tension, coefficient of viscosity and the radius of the particle.

A simple standard rigorous mathematical development yields the differential equation:—

$$\frac{d\rho}{dt} = - \frac{d}{dx}(\rho \bar{v})$$

where $\bar{v}$ is the mean relative velocity between soil particle and moisture at a point whose coordinate is x and

(1) NOTE.—The curvature of the soil particle was neglected in the region of the water wedge, and the relation between the two radii of curvature of the surface was assumed to be of the form,

$$r_1 \pm \frac{ar_2}{r_2 + b}$$

moisture content per unit volume is ρ and t is the time. Substituting for v the value given, we obtain finally:—

$$\frac{d\rho}{dt} = -\frac{cd}{dx}\left(\frac{d\rho}{dx} \cdot \frac{1}{\rho^{\frac{1}{3}}}\right)$$

Assuming equilibrium, we may equate the right hand member to zero and the finite equation thus obtained is given as follows:—

$$\rho = (ax + b)^{\frac{3}{2}}$$

where a and b are integration constants. It will be observed that the surface tension, viscosity, and radius of particle disappear from the "equilibrium" equation. This equation is parabolic in character and a negative value of the coefficient a will give values consistent with experimental data at present available (including in particular that presented by Dr. Widtsoe in Utah Station Bulletin 115).

We are conducting some laboratory work and hope to furnish an empirical solution which will be reported later.

IS ELECTRIC AIR HEATING FEASIBLE?

BY JOSEPH F. MERRILL.

(Abstract).

During the winter season the atmosphere of Salt Lake City has become uncomfortably smoky. A demand has arisen for the elimination of this smoke. The question arises, is there any feasible way of doing this?

Among the suggestions made for the elimination of the smoke nuisance in Salt Lake City is the installation of steam electric generating plants at the coal mines and the transmission of the electric energy to the city to be used for heating purposes. The question arises as to the feasibility of this method.

Heat, of course, is a form of energy and is convertible into other forms—electric, for example—and other forms of energy are convertible into heat energy. Further, energy is a measurable entity. The usually employed units of mechanical, heat and electric energy and power and the relations between them are the following: mechanical, foot-pound and horse-power; electrical, watt and kilowatt; heat, calorie and British thermal unit.

1 ft. pound=the energy expended in overcoming a force of 1 ℔. through a distance of 1 ft.

1 hp.=33000 ft. ℔. per minute.

1 hp.=746 watts=0.746 kw.

1 B. t. u.=778 ft. ℔.

$$1 \text{ hp. hr.} = \frac{33000 \times 60}{778} = 2545 \text{ B. t. u.}$$

$$1 \text{ kw. hr.} = \frac{2545}{0.746} = 3412 \text{ B. t. u.}$$

These numerical relations enable us to express electrical energy in terms of heat units or heat in terms of electrical units, etc.

Now, suppose the most modern and efficient steam-electric plants yet designed were built at the Carbon County Coal Mines one hundred miles away and the power

transmitted to Salt Lake City and used for heating purposes. The losses and efficiencies of the members of this system under the best operating conditions, that is, when the system would be fully loaded would be about as follows:

	LOSSES		
	Individual	Overall	Ind. Efficiency
Boiler, ash-pit and chimney	25%	25%	75%
Turbines	70%	53%	30%
Generators	5%	1%	95%
Station uses and minor losses	10%	2.5%	
Transformers, three sets	5%	1%	95%
Transmission and distribution line losses	20%	4%	80%
Total loss from coal pile to heating unit			86.5%
Overall efficiency of system			13.5%

These are the best results that could be obtained from the most up-to-date generating and transmission system. They show that only 13.5% of the energy latent in the coal would be delivered to the house electric heater in Salt Lake City. This conclusion might be stated in a somewhat different way.

Experience shows that it takes about two pounds of soft coal consumed in the most efficient modern steam turbo-electric plant to deliver 1 kw. hr. of electric energy to a near-by consumer. But two pounds of this coal delivers 24,000 B. t. u's giving 1 kw. hr. or 3412 B. t. u's in electric heat, or 14.2%.

Now a good house furnace heating system, properly managed, has a thermal efficiency varying from 50% to 65%, which is at least four times the efficiency of the steam-electric heating system, and this notwithstanding the fact that the electric heater itself has an individual efficiency of 100%.

Hence, if it were possibe to install the most modern steam turbo-generating plants at the coal mines it would require the combustion there of at least four times more coal to heat Salt Lake City than is now burned. From the stand-point of conservation this waste is not permissible.

Now let us look at the problem from the economic stand-point. The question arises as to how much electric heat energy would cost as compared with furnace heat obtainable by means now in vogue. Coal burned in large quantities at the mines would certainly be much cheaper per ton than when burned by the small consumer in his furnace.

Based on the cost of the Conner's Creek plant of the Detroit Edison Company, one of the most efficient, economical steam-electric plants in the country, modified to Utah conditions, the electric plant construction-cost at, or near, our coal mines, assuming plenty of water for condensing purposes, (an assumption contrary to fact) would be at least $75.00 per kw. of plant capacity. A transmission and distribution system would cost an additional $50.00, thus making an investment cost of at least $125.00 per kw. of installed capacity.

Interest, depreciation, taxes and insurance, conservatively estimated at 12%, would necessitate an annual charge of $15.00 for every kw. of installed capacity. And to heat comfortably in our winter weather would require 1 kw. installation for each 1000 cu. ft. of house space, or 15 kw. for the average sized bungalow. This would mean a charge of $150.00 for electric heat to pay the fixed charges alone. When to this amount is added the operating and maintenance costs the amount would be doubled, or $300.00.

Now this cottage that could theoretically be electically heated for $300.00, could be equally well heated with a good furnace burning 8 to 10 tons of coal, costing from $55 to $75—less than a fourth of the cost of electric heat.

Let us look at the problem from another view point, and find at what price electric energy would have to be sold to make electric heating as economical as furnace heating.

Let us assume a house heating plant to have an efficiency of 60%, that a ton of coal costs $8.00, and that one pound of coal has 12,000 B. t. u's. Then there would be delivered from one ton of coal 12,000 x 2000 x 0.6=14, 000,000 B. t. u's, which divided by 3412=4220 kw. hr. equivalent to one ton of coal. This would have to be sold at the electric heater for $8.00 or 0.19c per kw. hr. which is impossible, commercially considered.

From considerations of conservation of coal and economical use of money electric air heating by power furnished from turbo-electric plants is not possible.

But how about hydro-electric power, it may be asked.

It would require an installed generating capacity of at least 500,000 kw., conservatively estimated, to heat Salt Lake City. Now, in the first place there is not this much hydro-electric power available or developable in the State of Utah. In the second place it would cost $200.00, or more, per kw. to build the plants, lines, etc., to get the developable hydro-electric power to the city. Hence, when the fixed, operating and maintenance charges were paid it would be found that hydro-electric power would cost practically as much as steam-electric power.

Electric heating is, from an economic standpoint, a sort of alchemist's dream. We all know that electricity does produce heat, and we all realize and appreciate what a wonderful thing it would be to dispose of our coal piles and ash pits, and smoke, dust and cinders, and would therefore fain think it practicable. But a most cursory study of the subject, either from the stand-point of thermal dynamics, or social or economic science, show that it is utterly impossible of general application.

THE ATOMIC THEORY AND THE ATOM.

BY W. D. BONNER.

The atomic theory had its inception, apparently, among the early Greek philosophers. Thus Thales, Anaximines and Heraclitus, all of whom lived during the sixth century B. C., argued that all material things are built up from one fundamental substance. Each one, of course, chose a different thing to serve as his primitive element, water, air, and fire, respectively, and each chose poorly. In the 5th century B. C., Democritus clearly stated that all things are made up from a primitive element, and that this element is made up of the smallest particles possible, the atoms; that these atoms differ from each other in form and size, but are all of identical composition and that they all are in a state of continuous motion. Slight variations on this theme, such as changing the number of primitive materials, and makng new selections for them, was the only progress made in developing a theory of the composition of matter, until the 19th century A. D. In 1803, John Dalton attempted to formulate a quantitative hypothesis regarding the composition of substances, as opposed to the purely qualitative speculation which had been indulged in up to that time. He had, for a foundation, the knowledge of a considerable number of the chemical elements, as we now call them; he knew that the great number of individual substances are made up of these numerically few elements, and also, the Law of Definite Proportion was, by this time, fairly well established. The first question, then, which he asked himself was, are the atoms of the elements all exactly alike, or are they only similar? If they are the latter, then it is reasonable to believe that one should be able to prepare samples of the same pure substance differing slightly from each other, just as one can separate fine sugar crystals from coarse ones. At first sight this seemed quite probable, for was not river water different from spring water? Closer examination, however, showed that neither is pure and that both contain other things than water. When these other things are removed, river water and spring water give samples of water which cannot be distinguished each from the other. Dalton concluded, then, that the atoms of any pure substance are all exactly alike. He assumed, further, that compound substances are made up of atoms of their component elements in fixed numbers, and arranged in a perfectly definite manner.

In 1808, Gay-Lussac published his researches on the combining volumes of gases, and stated what we now know as the law of Combining Volumes, or the Law of Definite Proportion by Volume. He did not, however, state the very obvious corollary, viz:—that the number of particles in equal volumes of different gases, under like conditions, must be the same, or at least proportional. This was done three years later, by Avogadro, who also pointed out the necessity of a new conception, viz:—that the ultimate particle of a compound gas must be different from that of a gas not compound. He used the terms "integrated molecule" for the former, and "elementary molecule" for the later, they being the equivalents of the molecule and atom of the present nomenclature.

The atomic theory, then, as stated by Dalton and modified by subsequent workers, is that all substances are composed of discrete particles called molecules, and that these molecules are in turn made up of one or more particles called atoms. These atoms are of a limited number of kinds, but atoms of any given kind are all exactly alike, and these atoms represent the limit of divisibility of matter.

About 80 different kinds of atoms are known, and their relative weights have been worked out most carefully, over a long period of years. In fact, our table of atomic weights is probably the memorial of the greatest amount of the most exacting scientific work of one kind ever attempted. A large amount of this work had been accomplished by the middle of the 19th century, though a great deal of correction, revision and refining has gone on since.

The atomic theory still remains much as Dalton and his contemporaries left it, and nothing to cause any noteworthy revision of it came to light for many years after their day. It is true that certain chemists in Europe and in America turned against the atomic theory, and Ostwald even went so far as to write a textbook of chemistry in which the atomic theory was practically ignored. This movement, however, did not gain a very large following, more perhaps because of the inertia of the chemists than for any other reason.

It was not until 1895 that a discovery was made which had an ultimate effect upon the ideas previously held regarding the composition of matter, and which finally occasioned a restating, or perhaps more properly an enlarging of the atomic theory. This was Roentgen's discovery of the X-rays.

It is not within the scope of this paper to take up in detail this discovery, and its consequences, but for the sake of completeness I will outline briefly the subsequent developments. The remarkable properties of the X rays led, of course, to a thorough investigation of their nature and of their source. This led to a closer examination of the cathode rays produced in a vacuum tube, since the two were apparently connected, and in 1897 J. J. Thompson showed that the cathode rays consisted of a stream of particles, of apparent mass about 0.001 that of the hydrogen atom moving with great velocity. and carrying negative charges of electricity. One of the peculiar properties of the cathode rays is to set up phosphorescence on the walls of the vacuum tube, and it was at one time considered possible that this phosphorescence was in some way connected with the production of X rays. This we now know not to be the case, but the suggestion had most peculiar results. It occured to several investigators that, if the induced phosphorescence in the vacuum tube could set up X rays, then perhaps substances which are naturally phosphorescent give off something similar to X rays. One of these investigators was Becquerel, and among the substances which he investigated was potassium uranium sulphate. This he put in a package with a photographic plate, but separated from the plate by several layers of black paper, and the whole was left for some time in a dark place. On developing the plate, it was found to be darkened, showing that the potassium uranium sulphate was giving off rays more penetrating than light. He soon discovered, however, that the actinic effect was not due to phosphorescence, but was a property of any uranium compound, or of metallic uranium itself, irrespective of the phosphorescence of the substance. Becquerel also found that the rays given off by uranium or its compounds had the property of discharging an electrified body. This property was examined by Rutherford, who showed that the uranium rays were of two sorts, one much more penetrating than the other.

Shortly after Becquerel's discovery, Mme. Curie made a systematic examination of substances for radioactivity, as the phenomena shown by uranium compounds were now called, and found that thorium possessed the similar property, and in about the same degree as uranium. She also found that the radioactivity was a property of the uranium or of the thorium, and was not influenced by the other substances present. Soon after this she began an examination of uranium and thorium minerals, and found some which were several times more active than uranium itself. This could only be explained by assuming the presence of an unknown substance much more radioactive than uranium. She set to work then to separate chemically, if possible, this substance, and actually separated not one but two very active substances. The one which separated with bismuth she named polonium, and the one which separated with barium she named radium.

So much, then, for the historical development leading up to the discovery of radioactivity, and of radioactive substances. The subsequent development would be too time consuming to discuss historically and in detail, and I shall therefore briefly summarize our present knowledge of the radio chemistry. When the emanations from radioactive substances had been carefully examined it was found that they are of three types, called for convenience the alpha, the beta and the gamma radiations. Any radioactive element may give off one or all of these. They are distinguished by the following properties:—the alpha rays are positively charged, the beta rays negatively charged, the gamma rays carry no charge. The alpha rays consist of particles about four times the size of an atom of hydrogen, the beta rays consist of particles about 1/1800 the size of a hydrogen atom, while the gamma rays are probably of the nature of X rays, but of shorter length. The alpha rays have been shown to produce atoms of helium, the beta rays are, perhaps, atoms of negative electricity, electrons, and may be the ultimate particles of which all matter is composed. In addition to the above, the alpha rays are quickly absorbed by the atmosphere, the beta rays are able to penetrate thin metallic foils, while the gamma rays penetrate considerable thickness of metals.

About 30 radio active substances have been recognized, and some of them have found their places in the Periodic Table of the Elements. Briefly stated, a radioactive element is one whose atom may become unstable, and spontaneously break up. This may happen to many atoms in a short time, i. e., the decomposition is rapid, or it may happen to only a few in the same time. When such an atom decomposes, it may give off alpha particles, i. e., helium atoms, and it is changed into something else. This new substance may change again quickly into a third, and so on through many transformations, or, the new substance may be quite stable. On the other hand, if the atom, on decomposing, gives off beta particles and not alpha, its mass remains almost unaltered, and its chemical and physical properties are perhaps unchanged.

We have, then two very important additions to the atomic theory made by the radioactive elements. In the first place the chemical atom is not the limit of divisibility. This place has now been taken by the electrical atom, the electron. In the second place the atoms of the chemical elements are not all alike. The second point may best be understood by following the course of a radioactive disintegration, as shown graphically by the chart. It will be seen that, beginning with uranium, successive radioactive disintegrations occur until finally the atomic weight has changed from 238 to 206, and the substance has changed from uranium into lead. During this transformation several new forms of matter have appeared, some of them being very short lived, others relatively stable, and some of them undoubtedly fit into the periodic table of the elements. During this same period of disintegration, eight atoms of helium have appeared, so that the gross difference between an atom of uranium and an atom of lead is 8 atoms of helium. The most important point to be noticed here is that by this decomposition of uranium to form lead, with the simultaneous production of 8 atoms of helium, the atomic weight of the lead is put at 206.2, i. e., uranium of atomic weight 238.2 loses 8 atoms of helium, of atomic weight 4, leaving a material of atomic weight 206.2. Now the atomic weight of lead has long been known to be 207.2, and hence one of two conclusions is inevitable. Either the material resembling lead, and which is always found in radioactive minerals, is not lead, or, it is possible to have a substance of different atomic weight from lead, but yet showing all the chemical and physical properties of lead. In other words, the atoms of lead are not all exactly alike. Lead of undoubted radioactive origin has been very carefully examined, both in the metallic form and in the form of salts. The spectrographs of radio lead and of ordinary lead are exactly alike, and the molar solubilities of the salts are also identical. When, however, these solubilities are expressed in grams of salt per liter, the solubility of the radio lead is less, and by an amount agreeing with its lower atomic weight. Actual atomic weight determinations on the purest radio lead to be obtained give an atomic weight of 206.08, markedly less than that called for by the calculation made above. If, however, the radio lead has originated from radium, of atomic weight 225.96, by loss of 5 helium atoms, the atomic weight of lead should be 205.96, a still lower value. Assuming that radio lead has arisen equally from uranium and from radium, the average atomic weight becomes 206.07, a result in surprising agreement with the experimental data. The interesting question arises here, why has radium an atomic weight of 225.96? If radium is a decomposition product of uranium, by loss of 3 helium atoms, its atomic weight should be 226.2. Has it then, during this disintegration, given off enough beta particles to change its atomic weight by 0.1%? This is hardly probable, since the number of electrons in a given atom seems to be of the order of its atomic weight. Is there, then another radium, not originating from uranium, and whose atomic weight is less than 225.96? This explanation is in accord with the behavior of lead, which is already well authenticated. Another very interesting question arising here, is why does ordinary lead have an atomic weight of 207.2? Is it a mixture of radio lead with a lead atomic weight 208 or greater? If so, where did this heavy lead originate—from thorium, of atomic weight 232.4, by loss of 6 helium atoms, or is it a synthetic element, instead of the decomposition product? The question of course cannot be answered by speculation, but some information would be secured by actually separating from ordinary lead its constituent heavy and light leads. Work along this line is actually under way.

It follows from this discovery of leads of different atomic weight, that the atomic weight of the chemical elements is not the characteristic function it has always been held to be. Rather, it is the position of the element in the atomic series which governs its physical and chemical properties, and any given position in this series may be occupied by a group of elements, chemically identical, and inseparable, but of different atomic weights. It may even be that all of our chemical elements are such groups of "isotopes", the atomic weight of the element being the average for the group.

The decomposition of the chemical atom is, then, a matter of unquestioned fact. Does the reverse process occur, and are atoms being synthesized as well as decomposed? The answer to this question cannot, at present, be made with assurance. There are many things, however, which indicate such a possibility. Nitrogen and hydrogen, and phosphorus and hydrogen unite to form compounds which react with acids to give salts very much like certain well known metallic salts. The negative group in ammonium salts, for example, gives practically all the analytical reactions of the potassium ion. This group certainly is not an element, and this may represent the limit in which we may proceed in this direction. Atomic disintegration has proven, so far, to lie outside the influence of any force at our command, and atomic synthesis may likewise demand the use of forces at present unknown, or uncontrolled. It is not at all improbable, however, that atoms are being continually synthesized, perhaps under our very eyes but at such slow rates, and so quietly that it has escaped observation.

Since radioactive disintegration, so far as observed, always proceeds by the elimination of electrons or of helium atoms, it would seem to be suggested that these two are constituents of all matter. Such is perhaps the case for the electron, as any substance, apparently can be made to give off electrons, and the electrons from all substances are apparently identical. The helium atom, however, cannot be the only primitive element, and for two reasons. In the first place we know one element of atomic weight less than that of helium, and in the second place the atomic weights of all the elements are not multiples of 4. A discussion of the hypothetical constitution of the atom is perhaps not in the province of a chemist, and would be beyond the limit of this paper. It has been suggested, however, and with a large degree of reasonableness, that the atoms of all chemical elements are made up of combinations of atoms of two, or perhaps three elements.

W. D. Harkins has brought forward such a system in which he uses hydrogen and helium as the two primitive elements, while Nicholson uses hydrogen and two hypothetical elements, nebulium, of atomic weight 1.6281, and proto-fluorine, of atomic weight 2.3615. It is to be noted that the sum of the atomic weights of these two hypothetical elements is almost exactly the atomic weight of helium.

CONCLUSION AND RESUME'.

The older conception of the chemical atom was characterized by its simplicity. The atoms of any given elements were all alike, were homogeneous and indivisable. The physical and chemical properties of the atom were a function of the mass of the atom, its atomic weight.

The present conception of the atom, which needless to say is still changing in its details, regards the atom as a complex system, composed of various units. These units are, (1), atoms of hydrogen, or helium, or of both, or perhaps atoms of substances as yet unknown, and (2), electrons. The mass of the atom is principally represented by the first.

The units constituting the atomic system are so arranged that the system possesses great stability. It may happen, however, that this system reaches a state of instability, in which case it may lose electrons, the atomic weight remaining unaltered, or it may lose atoms of its constituent elements in which case a sensible change in atomic weight occurs.

Only helium atoms have so far been observed to be given off during such changes.

EVAPORATION AND SOIL MOISTURE IN RELATION TO FOREST PLANTING.

BY CLARENCE F. KORSTIAN.*

With the great diversity of sites which are available throughout the Intermountain Region for forest planting, it has been difficult to select those upon which success is assured, especially toward the lower limits of tree growth in the chaparral or oak-brush zone, without a knowledge of the relation of climate to plant growth. Heat and moisture have long been recognized by plant geographers as fundamentally important in determining the character and distribution of plant associations. Only within the last decade, however, have plant ecologists made material advancement in the quantitative measurement of the water relations of plants. The importance of serious quantitative research to determine the relation of climate to the growth and development of vegetation can scarcely be over-emphasized. When the adverse climatic factors are known failures may be largely averted by the judicious selection of sites and of those species especially adapted to withstand the limiting factors. With uniformity of the soil the amount of moisture in the soil available for plant growth, the evaporating power of the air or the combined effect of the two factors is very frequently the determining criterion of a plant association. It has been repeatedly shown that the evaporating power of the air affords a rather concise and satisfactory summation of the combined effects of temperature, humidity and air movement insofar as these factors influence transpiration A detailed study, therefore, of the evaporating power of the air and of the available soil moisture for a given site not only affords an expression of the water relations of the plants of that site but also considers the other factors mentioned.

This problem is being studied intensively on the Ephraim Canyon watershed of the Manti National Forest in Sanpete County, Utah. During the last two growing

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seasons the evaporating power of the air has been measured by means of the Livingston porous cup atmometer and soil samples were taken at ten-day intervals to show the march of soil moisture on the five important sites under study:

1 Manzanita (*Arctostaphyllos platyphylla*) association.
2 Wild apple (*Peraphyllum ramosissimum*) association.
3 Sagebrush (*Artemisia tridentata*) flat.
4 Sagebrush flat, denuded of all vegetation.
5 Oakbrush (*Quercus gambelli*) association.

Empirical plantations of 2-1 western yellow pine (*Pinus ponderosa*) transplants were also established on each site.

The march of the evaporating power of the air and of the soil moisture were illustrated graphically. The success of the western yellow pine plantations does not correspond very closely with the evaporation intensity because the latter does not take into account the question of the available soil moisture. The results secured to date would indicate that a satisfactory expression of these factors could be indicated by the ratio of evaporation to soil moisture. The evaporating power of the air and the available soil moisture appear to be the chief physical factors in limiting the growth and development of plants in the chaparral zone.

In order to obviate the necessity of securing detailed instrumental records on every site considered for forest planting the native plants indicative of a favorable site should be determined in the course of the correlation of the important physical factors with plant growth. From present indications those plants having deep roots, good crowns, affording some shade but not dense enough to cause suppression and which have relatively high transpiration rates should indicate the most favorable sites. Forest extension in the chaparral belt should be limited to those lands having an assured supply of available soil moisture and which are protected from excessive evaporation either because of their topographic position or by the presence of a vegetative cover composed of a goodly representation of favorable site indicators.

THIRTEENTH ANNUAL CONVENTION OF THE UTAH ACADEMY OF SCIENCES

Physics Lecture Room, University of Utah, Salt Lake City
April 2 and 3, 1920

FRIDAY, APRIL 2, 8 P. M.

SYMPOSIUM ON THE "CONSTITUTION OF MATTER"

"The Theory of the Constitution of Matter," Presidential Address ....By Orin Tugman, U. U.
"The Oil-drop Method of Measuring the Electric Charge." ....By Carl F. Eyring, B. Y. U.
"The Electron Theory of the Conduction of Electricity." ....By Frank L. West, U. A. C.
"The Theory of Valencies." ......By W. D. Bonner, U. U.
"The Relativity Theory." ....By E. W. Pehrson, U. U.
"The Einstein Theory." ....
By Geo. P. Unseld, West High School, Salt Lake City.
"Matter from the Point of View of a Personalistic Philosophy." ....By W. H. Chamberlain, U. U.

SATURDAY, APRIL 3, 9:15 A. M.

"Capacities of Soils for Irrigation Water." ....
................By O. W. Israelson and F. L. West. U. A. C.
"Proper Proportions of Grain and Alfalfa for Fattening Steers." ....By W. E. Carroll, U. A. C.
"The Breeding of Canning Tomatoes." ....
............By M. C. Merrill and Tracy Abell, U. A. C.
"The Value of Farm Manure for Utah Soils." ....
....By F. S. Harris, U. A. C.
(Published in Bulletin 172, U. A. C. Exp. Station.)
"Research Work of the Experiment Stations of the U. S. Bureau of Mines." ....
........By Thomas Varley, U. S. Bureau of Mines, U. U.

"Hydrometallurgy as Applied to the Mineral Industry." ....
By Clarence A. Wright, U. S. Bureau of Mines, U. U.

"Oil Shales and Their Economic Importance." ....
....By Martin J. Gavin, U. S. Bureau of Mines, U. U.

"Pyrometallurgy and Its Future Possibilities." ....
......By John C. Morgan, U. S. Bureau of Mines, U. U.

"Chemistry and Its Relation to Metallurgy." ....
By Edward P. Barrett, U. S. Bureau of Mines, U. U.

SATURDAY, APRIL 3, 12:00 M.

Complimentary luncheon to members of the Academy by the University of Utah at University Dining Hall.

Address at Luncheon by President John A. Widtsoe, University of Utah.

SATURDAY, APRIL 3, 1:00 P. M.

"A Capillary Transmission Constant and Methods of Measuring It." ....By Willard Gardner, B. Y. C.

"Mid-Tertiary Deformation of Western North America." ....By Hyrum Schneider, U. U.

"Electrical Conductivity of Thin Metal Films." ......
....By Orin Tugman, U. U.

"Is Disinfection a Reaction of the First Order?" ......
....By L. F. Shackell, U. U.

"Some Problems in Daylight Illumination." ....
By C. Arthur Smith, East High School, Salt Lake City

"Equilibrium Conditions in the System Calcium Sulphate-Manganous Sulphate-Water." ....
.................By A. G. Kline, and T. B. Brighton, U. U.

"Standardization from Constant Boiling Hydrochloric Acid." By J. T. Bonner and T. B. Brighton, U. U.

"Comparison of the Action of Potassium Cyanide and Sodium Cyanide on Alkyl Halides." ....
..................By W. D. Kline and W. D. Bonner, U. U.

"The Determination of Arsenic as Lead Arsenate." ..
............By A. E. Anderson and T. B. Brighton, U. U.

THE THEORY OF THE CONSTITUTION OF MATTER.

BY ORIN TUGMAN.

For a long period of time scientists have believed that all matter is composed of discrete particles called molecules. The evidence for the existence of molecules is so well established it is considered unnecessary to repeat all the experimental data bearing on that question. It is enough to know that molecules have been counted not one by one, but experiments have been devised by which it is possible to calculate the number of molecules in a cubic centimeter of gas with greater precision, says Professor Milikan, than it is possible to count the number of people living in New York City. The number of molecules in a cubic centimeter of any gas at a temperature of zero degrees centigrade and normal atmosphere pressure is calculated to be

$$N=26.5 \times 10^{18}$$

with a probable error of only one-tenth of one per cent.

That molecules are composed of atoms is also a well established theory. The great amount of chemical data is sufficient for this theory.

After we have proved the existence of molecules and atoms the next logical question is what are the constituents of atoms. We want to know what is the structure of a carbon atom which gives it chemical and physical properties different from a nitrogen atom or an atom of lead or any other atom.

This question has not yet been fully answered but the research scientists have made a start toward its solution. The problem is being attacked from many sides and many phenomena which have hitherto been studied without thought of atomic structure are now known to be intimately related to the structure of the atom.

As in the study of matter attempts were made to find the smallest particle which defied further division, so efforts were made to find the smallest charge of electricity which could exist as a separate and distinct entity. One value for this electrical charge was found in the conduction of an electrical current thru a solution of sulphuric acid. In this experiment hydrogen and oxygen are set free and the mass of hydrogen and oxygen is always directly proportional to the quantity of electricity passed thru the solution. Knowing the mass of hydrogen liberated and the quantity of electricity used, it was possible to calculate the electrical charge carried by one hydrogen ion. The value obtained was 3×10^{10} electrostatic units. This value was in error because the number of atoms in a cubic centimeter of gas was not so accurately known. The name electron was given to this charge by Dr. Johnston Stoney in 1891.

In the conduction of electricity thru gases, bodies were found which caused this same charge, some were charged positively as the hydrogen ion and others were charged negatively. While the negative charge had the same value as the charge on a hydrogen ion in solution the negative electron was found to have a mass much less than the mass of the hydrogen ion.

Other sources of negative electrons were soon found. We now know that all hot bodies emit negative electrons. The incandescent filament in our electric lamps is shooting out a veritable hailstorm of negative electrons. Radium and other radioactive substances are also sending out a shower of negative electrons. We get an emission of these bodies by illuminating metals with light. When violet light is allowed to shine on a piece of zinc it becomes charged with positive electricity showing that negative electricity has been removed. The negative electricity is removed thru the expulsion of negative electrons. In all these cases the charge on the negative electrons is the same and the mass of them is found to be $\frac{1}{1874}$ of a hydrogen atom. When this important fact was fixed it became necessary for us to revise our notions about the atom being the smallest indivisible particle of matter.

Now having found a particle of mass much smaller than the mass of the hydrogen atom and whose electric charge, according to the most recent measurements, always equals 4.7 x 10^{10} electrostatic units we want to know how this negative electron enters into the structure of the atom. The answer to this question is not complete. We are now in a tangle of theory and experimental data which will require the keenest minds to unravel. It is my purpose to present the problem as seen by the world of science today. Naturally the solution is sought by investigating the phenomena which exhibits a source of negative electrons.

The photo-electron effect is the emission of negative electrons by matter when illuminated. Practically all substances exhibit this effect in varying degrees. Sodium and potassium are very marked in this respect. When a surface of sodium is illuminated with violet light negative electrons are shot out with velocities increasing as the frequency of the light increases. In other words the shorter the wave length of light the greater the velocity with which the electrons leave the metal surface. The intensity of the light in no way affects this velocity but affects only the number of negative electrons shot out. The relation between the velocity of emission and the frequency of electron emission is stated by the equation

$$\frac{1}{2} m V^2 = h + P$$

where P is a constant depending on the energy required to pull the electron out of the surface, m is the mass of the electron and h a constant. It appears, therefore, that for light of any given frequency f an amount of energy hf must be absorbed before an electron can be expelled That is, the energy must be absorbed in units not smaller than hf. The constant h has a value 6.547 x 10^{27}.

We find this constant h appearing from an entirely different direction. When Max Plauck attempted to derive an equation which would express a relation between the temperature of a body and the emitted wave length which had the maximum energy he assumed that radiation energy was affected only in units depending on the frequency of the wave. The equation which he derived fits the experimental facts better than any other. It is a most remarkable fact that the constant by which Plauck multiplied the frequency to find the units in energy radiated has the same value as the constant found in the photoelectric effect.

It appears, therefore, that radiant energy is also in units which are indivisible, an idea which does not conform to our usual conception of energy of wave motion. But the experiments indicate we have energy radiated and absorbed in quanta of hf. This forms the basis of the quantum theory.

It is impossible to study matter without studying energy and vice versa. We are led to ask what is the structure of the atom which can absorb or radiate energy only in quanta of hf. This is another baffling question which has not been answered. We have been able only to skirmish a little around the edge of this field of investigation.

When a metal surface is illuminated negative electrons are immediately shot out. The energy of emission in some cases is over 4,000 times as much as the atom could possibly have absorbed from the beam of light. Obviously this energy could not have come from the light. The electron had the energy before it left the atom. But we want to know how the light wave releases this energy. The atomic model which we construct in our minds must have the property of radiating energy in quanta and have at least one negative electron which has the energy of a quantum and so arranged that this energy may be released by a light wave.

Let us approach the atom from another experiment. Radioactive substances give out negative electrons as well as bodies carrying positive charges. Each positively charged body called an alpha particle causes a charge equal to twice the charge of a negative electron and its mass is four times the mass of a hydrogen atom. These alpha particles are shot off from radium with sufficient velocity to pass thru thin sheets of metal. When a number of alpha particles are shot thru a piece of gold foil the particles are scattered in a way which indicates these positive charged bodies were being repelled by other positively charged bodies in the gold foil. By using foil of other metals a scattering effect is obtained which gives a measure of the positive charges within the metal. When the positively charged alpha particle comes near a positive charge in the atom we may expect a repulsion. In the case of a head-on collision the alpha particle is thrown straight back on its path. The conclusions of these experiments state that the center of an atom is a nucleus of positive electrons each positive electron carrying a charge equal to the charge on a negative electron. Moreover the number of positive electrons in this nucleus is equal to one-half the atomic weight thus:

What is there around the positive nucleus? We have a speculation on the hydrogen atom which appears to satisfy in many respects. N. Bohr, a mathematical physicist, has conceived a hydrogen atom as made of one negative electron revolving around a single positive electron. The attraction between the two charges is balanced by the centrifugal force on the revolving electron. Bohr assumes the negative electron can move in a number of different orbits and that it can jump from one orbit to another. Under stable conditions when the atom is not radiating any energy the negative electron is revolving in its innermost orbit. If perchance this electron is pulled out of its inner orbit radiation is produced by the electron settling back by jumping from one orbit to another; revolving, of course, in each orbit before jumping to the next. It is obvious the energy of the electron is different in its different orbits. Bohr assumes radiation of energy occurs when the electron jumps from any orbit to the next inner one. Such a model leaves much to be desired. It does not explain the mechanism of radiation. We know radiant energy is a wave phenomenon and a wave is generated by a vibrating body. The Bohr atom does not give us any vibrating body.

In face of these objections the Bohr atom is remarkably successful. A mathematical analysis of its mechanism shows the relations between the wave lengths which such an atom could radiate. It is a significant fact this relation theoretically derived does not agree with the relation between the wave length of the hydrogen spectrum. When an electric discharge is sent thru hydrogen gas we get the characteristic spectrum of that element. Also we know there is a state of ionization in the gas at this time. That is, we have negative electron knocked off the hydrogen atoms. A hydrogen atom which loses a negative electron becomes charged positively. Consequently there is a tendency for these ions to recombine. Experiment has fairly well demonstrated that light is emitted when recombinations are being effected or when the negative electrons are settling beck to their innermost orbits.

While a mathematical analysis of a more complex atom has not been made we should feel elated over the progress up to date. The existence of a positive nucleus for all atoms appears proved beyond a reasonable doubt. It follows that the number of negative electrons revolving about the nucleus must equal the number of positive electrons in the nucleus if we are to have a neutrally charged atom.

THE ELECTRON THEORY OF CONDUCTION OF ELECTRICITY.

BY DR. FRANK L. WEST.

When a salt, such as sodium chloride, is dissolved in water, the chlorine atom receives an electron from the sodium atom and separates from it becoming an ion (the anion) and the sodium atom, having lost a negative charge, is left positively charged. (the cation) Ordinary normal solutions of the common salts dissociate to the extent of about 65%; i. e. two out of three molecules have broken up into ions. The more dilute the solution the greater the degree of dissociation. The strong mineral acids and bases and the strong organic bases dissociate to the extent of 90 to 95%, the weaker ones to a correspondingly less degree. The degrees of dissociation are determined by the amounts of abnormality of osmotic pressure, elevation of boiling point, depression of the freezing point, by the electrical conductivity at the given concentration and at infinite dilution, and by chemical means such as the rates of saponification of esters by bases and the hydrolysis of sugars by acids. These methods give results differing from each other by as much as ten per cent. The discrepancy is usually explained by assuming that the above mentioned ions have a few water molecules attached to them making a cluster. The molecules break apart into ions before the electrical force is applied. When the two electrodes are inserted into the solution, the positive cation migrates toward the negative pole and the negative anion toward the positive pole, in other words there is a lateral shift toward the electrodes and this motion is superimposed on their otherwise random motions. The degree of conductivity depends on the number of ions present, their charge or valence, and their mobility under unit potential gradient. It increases with temperature even though there are fewer ions there because of the large increase in mobility due to diminished viscosity.

The metallic conduction is usually explained by assuming that there are approximately as many electrons as atoms more or less free to move about in the metal—the electrons acting as if they were a gas and were in solution in the metal. Rising temperature drives some of them off. Those metals that are good conductors of electricity are also good conductors of heat, the ratios of the heat conductivities to the electrical conductivities for the metals varying from 7 to $9\frac{1}{2} \times 10^{10}$. By assuming that heat is conducted through the metal entirely by these electrons, and that the electrical current consists of a lateral shift of these negative electrons towards the positive end of the metal superimposed upon their random motion, two equations for these conductivities have been obtained, and when the one is divided by the other and values substituted in them, the ratio comes out approximately 6×10^{10}, which agrees fairly well with the above mentioned values and suggests that the above assumptions and explanations of conduction are probably correct.

Gases are normally almost perfect insulators, it requiring approximately 30,000 volts to get a spark across a one centimeter air gap. The conductivity increases with diminished pressure until very low pressures are obtained. At pressures less than 1/100 of 1 mm. of mercury the so-called cathode stream is obtained, which is a stream of negative particles, called electrons moving toward the positive electrode with a velocity ranging from 1/10 to 1/2 the velocity of light.

Gases from around flames, hot metals, arcs, phosphorus, X Rays, radium, metals on which ultra-violet light has fallen, gases from electrolysis, gases that have bubbled through water, etc., are all temporary conductors of electricity. The gaseous ions may be electrons, atoms or molecules that have lost an electron, or either of these with some neutral molecules attached to them. When an electrical field is applied, these ions migrate toward the electrodes thus constituting the electrical current.

MATTER FROM THE POINT OF VIEW OF A PERSONALISTIC PHILOSOPHY.

BY W. H. CHAMBERLAIN.*

I do not see how anyone acquainted with the facts can longer doubt the existence of insensible realties called electrons, atoms, and molecules. Electrons are points of electrical power, and the atoms and molecules which they constitute are definite complexes of points of electrical power, and so, with the physicist Whetham, we may refer to the sensible masses of matter which these molecules constitute and into which material nature differentiates itself as complexes of energy.

Philosophy for its purpose of understanding material nature most concretely can accept an energy complex as the unit in terms of which it would explain the nature of matter if such an energy complex can be supplemented and made to include the correlative perceptual powers of persons stimulated and sustained by such energy complexes in any actual experience of matter. Philosophy would also call emphatic attention to the invariable presence, as a dependent aspect of any such interaction of energy complexes and personal powers, of sensations in spatial and temporal forms of arrangements. The simplest and yet the best understood case of such interaction of which we know is perhaps that of the interaction of persons in mutual knowing or conversation in which the powers of each person in confluence with certain of the energy complexes in material nature stimulate the perceptual powers of others together with their dependent sensory aspects.

In inorganic matter, whether this matter is in the solid, liquid or gaseous state, the motions or changes dictated by any energy complex are commonly regarded as determined, mechanical, and as capable of accurate definition or description. In the higher or complexer

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energy complexes known as organic mechanisms, the changes going on are also commonly regarded as determined, or mechanical. In the development of an organism from a germ cell or even from a somatic cell the developing organism changes as a whole, the changes in each part taking place in relation to determinate changes going on either simultaneously or successively in other parts so that these changes are also determined or mechanical and go on in a predictable order. A still greater complexity is observable in the conduct of these organic mechanisms in interaction with the rest of material nature and with other organic mechanisms. Most of the changes going on even in the behavior of organic beings are also commonly and properly regarded as determined, mechanical, capable of accurate description, and as going on in orderly or predictable sequence.

But in these higher energy complexes, especially in the conduct of the human organism, we become aware of the presence of free, undirected, or non-mechanical causes, as also directing material changes. For very commonly men are striving through faith, hopeful of the achievement in some new outcome of their strivings of more life, more satisfying ways of using their powers, higher values. These strivings then are tentative, spontaneous, non-mechanical, and, from the standpoint of the individual striver at least, not determined. Free causes are here seen to dictate unpredictable, non-mechanical changes going on in material nature.

In the study of the conduct of the human organism we may also become aware of the genesis of mechanical or determined causes. For the almost invariable outcome of our blind strivings is a satisfactory way of acting, a way that needs no conscious modification and which by repetition becomes a habit which henceforth will go on mechanically when stimulated. A complexer outcome of this free cause or blind striving is an organised system of habits which goes on mechanically when stimulated. This may be easily seen in cases where conduct can be abstracted from a confusing mass of correlated material changes, as it can be in the case of learning to speak a language. In striving to pronounce a new word, say bourgeoisie, after a chance but satisfactory combination of elementary habits has been secured, and then fixed in by a repetition of the success, each constituent habit is mechanically, or without conscious direction or interference, followed by its definite successor. A describable causal series of material changes is here seen to have its genesis in a free cause. Also such mechanical complexes of habits are the matter or stuff of still higher strivings and achievements, strivings that stimulate them to action and keep them in operation. Thus these higher strivings are seen to be the indispensable stimuli and support, the free and imminent causes, of the mechanical or transeunt type of causes.

A completer view of these strivings or free causes reveals the fact that they go on in immediate interaction with the strivings of others, with other free causes. In fact such free causes are most commonly stimulated, controlled, and sustained in their growth by other and similar free causes. The strivings and achievements of others, vaguely apprehended by us, if they are properly related to our own interests, create in us a feeling of need. Then they stimulate, correct, and support our own strivings. The striving to learn to pronounce a word or to learn to do almost anything else is due to our interest in others whose imitation by us would fulfil our own interests, or whose imitation of us would further our unselfish interest in their own achievements. Free causes may be stimulated, nourished, and sustained by other free causes, and in the process of their fulfilment mechanical causes are both an outcome, and a set of powers or energy complexes that form the basis or material for still higher degrees of striving and achievemnt.

In the study of this socialized human conduct we seem to gain a view of but a small section of material nature. But many philosophers believe that in this section we have a specimen of matter which reveals to us its essential and universal nature, that in socialized human conduct there is revealed the general structure of the vast system of energy complexes which constitute material nature. But they also believe that we must supplement the strivings of human and sub-human free causes by the cooperative strivings of a super-human free-cause confluent with the human and the sub-human in order fully to account for the systems of energy complexes which constitute material nature. They think that the strivings of such a great free cause in cooperation with the strivings of lesser free causes are revealed in the evolution of organic forms, and in the achievement and fixing in by repetition of the mechanical causes discoverable in every new species. They also think that the inorganic elements and compounds, while viewed in isolation they seem to be mechanical energy complexes, when more fully viewed are but abstract aspects of strivings whose outcome has been matter for the construction and nourishment of organic mechanisms, and the conduct issuing from them.

These philosophers think, then, that material nature is a system of free causes or persons. Such causes being free are of course undetermined, and so they are ultimate, uncreated, or eternal realities. Through their immediate relationship to one another they give rise to all habits or energy complexes, and so to all changes, whether free or mechanical, going on in material nature. And this outcome includes all those energy complexes arising from an imitative reproducing or a knowing of the lives of others, or in the slowly developing perceptual adjustments to the sensory, spatial, and temporal aspects of the energy complexes which underlie and dictate these perceptual adjustments.

As each of these free causes or persons is a centre of freedom and life to all the others, and in striving and achieving guides and sustains both the blind and the thoughtful strivings and choices of any or all of the others, perpetual progress or life would seem to be a character of all free causes or persons. From the nature of the material world as a natural system of such free causes or persons this progress or living must be universally shared or rational, that is, the fullest living must be moral and religious. The end, then, of material nature, without our recognition of which the growing processes that constitute material nature cannot of course be fully understood, no more than can a plant without its flower and fruit, is the establishment of a moral and religious society of persons each of whom will find his satisfaction in efficient and loving service.

Physics no longer deals as of old with mechanics, sound, heat, light, magnetism, and electricity, as with distinct and unrelated sets of facts. Even chemical and astronomical facts are now dealt with in physics. This restoration of a broken unity by physics has, no doubt, been largely due to the discovery of the electron, a unit upon which all physical facts are seen to depend. But biological, psychological, and sociological facts are never found dissociated from matter. They also are physical facts.

As the psychical nature of all energy complexes becomes more fully understood, and as these psychical realities become properly correlated with the strivings and achieved habits of men, there will be furnished a unit in terms of which all the heretofore sundered facts of human experience can be understood; and the unity of material nature, broken for us because of the piece-meal way in which the study of it has been approached historically, will be full appreciated.

THE BREEDING OF CANNING TOMATOES.

BY M. C. MERRILL AND T. H. ABELL.

The tomato (*Lycopersicum esculentum* Mill.) is of American origin. According to De Candolle it is probably native of Peru. Having no name in the ancient languages of Asia and being introduced in cultivation in some of the Asiatic countries only within the past century or so, it is strikingly different from many of our food plants, which had their origin in southwestern Asia and have been generally cultivated for thousands of years.

Tho not known in Europe prior to the discovery of America, the tomato has nevertheless been grown in the South and Central American countries for a long time. It was taken to Europe by the early Spanish explorers and soon spread thruout that continent. In 1596 the tomato was introduced into England where it was known for a long time as the "love-apple", and was grown only for ornamental and medicinal purposes until well into the eighteenth century before being used as a vegetable.

Under cultivation to-day there are many types of the tomato so different from each other that were it not known that they arose by variation under cultivation, botanists would undoubtedly place them under different species, as did Dunal, the great early authority on the genus *Lycopersicum*, who recognized ten species of this genus. At the present time for instance, there are certain sub-species or botanical varieties under *esculentum* which botanists will not accept as species but which undoubtedly show more striking differences between themselves and the mother species than are to be found among some other groups of *Lycopersicum* which are recognized as good species by botanists. Some of these sub-species or botanical varieties are:

vulgare, the common garden tomato;
cerasiforme, the cherry tomato;
pyriforme, the pear and plum tomato;
validum, the upright tomato which looks like a potato plant;
grandifolium, the large-leaf tomato.

One interesting type which is accepted by botanists as a good species is *Lycopersicum pimpinellifolium*, the currant tomato. This has been grown principally for curiosity and as an ornamental plant, but has recently been introduced into garden cultivation under the name of German raisin tomato. But horticulturists are inclined to regard it as much more like the species *esculentum* than are some of the botanical varieties indicated above, which botanists will not accept as distinct species.

And so De Varigny's dream of an experimental garden where new species can be originated at will under the eye and hand of the skilled experimenter has come true and has been true for a long time. But he, in common with other biologists, has not recognized that fact. No matter how utterly different a plant may be from its progenitors, and even tho the new production breeds perfectly true to its type, if it originated in a garden as a result of cultivation it must not be considered a new species but only a variety. Even the great botanist Asa Gray declared of a certain group of garden plants that they are "too much mixed by crossing and changed by variation to be subjects of botanical study."

The morphological history of the tomato is interesting. Among our cultivated tomatoes of the species *esculentum*, the nearest approach we probably have to the wild type is the cherry tomato. The fruit of this tomato is small, spherical, and two-celled. From it, according to Bailey, have probably evolved the pear-shaped or oblong types, the angular, the flat, the yellow, and the apple-shaped sorts, and finally the red smooth types which in turn are giving rise to several variations by breeding and selection. One of the very noticeable phases of this evolution of the tomato from the small cherry type to our present commercial varieties has been the increase in the number of cells or seed cavities, from two to about a dozen. Furthermore, the shape has changed from regularly spherical to irregular, flat, oblong, or angular in certain varieties.

But what we want to-day is a smooth, round, solid tomato of medium size and of few cells or seed cavities. It should be attractive in appearance and with a skin sufficiently tough to prevent ready cracking and consequent injury. It should be a heavy yielding strain that matures early and that carries a large proportion of high-grade fruit and a small proportion of culls. Such a tomato will meet the demands of the canners as well as those of the general market. The result will be a better keeping and a better shipping tomato. These are the ideals that the tomato breeder of to-day has in mind and toward which he is working. We predict that time will see their satisfactory realization.

Tho the tomato is more generally grown in the United States than any other country, it is even here of comparatively recent use. A century ago the cherry, pear, and angular tomatoes were the only varieties known. The Apple and Tilden varieties were introduced in 1865. In 1870, Colonel George E. Waring Jr., of Newport, R. I., developed the Trophy variety, a large, early, smooth, fleshy, and well-flavored tomato that really marks an epoch in tomato history. As a result of Colonel Waring's production, the cultivated tomato industry took on enthusiastic life and great impetus was given the art of breeding new varieties of tomatoes.

The tomato is a very plastic organism and responds readily to changes in its environment. Hence the work of breeding has progressed with great rapidity. To-day there are about 200 varieties of tomatoes in cultivation and the fruit is daily gaining in popularity. There are estimated to be from 600,000 to one million acres of tomatoes now grown in this country. But because the tomato readily responds to a changed environment, new forms are constantly arising and replacing the old. Thus tomato varieties tend rapidly to "run out" or disappear.

By nature in its tropical home the tomato is a perennial plant. As grown in the North it is of necessity an annual. But it is a noticeable characteristic of the tomato in our climate that if grown under favorable conditions it will continue bearing fruit until the frost checks its activity. Breeding and cultural methods are therefore being developed that will most surely advance the fruiting season in order to get the greatest possible yield before the coming of destructive frosts.

A considerable amount of notable work has been done in recent years in ascertaining facts pertaining to tomato improvement.

Price and Drinkard of Virginia, (1908) crossed over twenty varieties and found that the common characters of tomatoes, such as shape of fruit, color of fruit, type of foliage, and stature, conformed in general to Mendel's Law.

Wellington of the New York (Geneva) Experiment Station (1912) ascertained that crossing closely related varieties resulted in increasing the vigor and yield of the progeny, particularly in the F_1 generation, and persisted in proportion to the heterozygous condition.

White of Maryland, (1913) carried on experiments calculated to induce variations in the tomato by culture. Using the small red cherry tomato and fertilizing with dried blood he induced permanent increase in size of both plant and fruit and an improvement in the quality of the fruit which persisted to the sixth generation.

Myers of Pennsylvania, (1914) in testing out numerous strains of six varieties of tomatoes, found variations in yield between strains which amounted to more than thirteen tons per acre of marketable fruit.

Groth of New Jersey, (1911-1915) published a series of bulletins on heredity and correlation of structural characters in tomatoes. He studied the heredity of size, shape, and number of leaves, cotyledons, and fruits, and reached the conclusion that "the constancy of unit factors of size and shape must be gravely doubted in view of the influence which supposedly absent factors may have upon the development of those present."

Hayes and Jones of Vermont, (1916) obtained results in agreement with the fact that the tomato is naturally almost completely self-fertilized. They self-fertilized four commercial varieties for three and four years with no resulting decrease in the size or yield of fruit. They verified the findings of others—that carefully chosen crosses gave an increase in both the number and weight of fruits over the parental average amounting to from 3 to 17 per cent. Along with the hybrid vigor they also obtained a hastening of the time of production.

Stuckey of Georgia, (1916) working on disease resistance of tomatoes found that both resistance and susceptibility to blossom-end rot were apparently transmitted from parent to progeny.

At the Utah Agricultural Experiment Station, we began in 1918 a preliminary study of tomatoes from the standpoint of yield, earliness, and quality of fruit. The work was begun with seeds of sixty-six varieties from sixteen reliable seed companies and there was a total of ninety-four strains of these varieties. The object of the work was to select and breed early maturing, high yielding, and high quality strains of tomatoes more suitable than the kinds now used in Utah.

One of the outstanding features of the first two years of study is the difference in yield between different varieties, the difference in yield between plants of different strains of the same variety, and the difference in yield between plants of the same strain. In the case of the "Stone" a difference of nine pounds per plant of ripe marketable fruits was recorded from separate strains. On the basis of 6,000 acres of tomatoes in Utah, this would mean a loss of about 67,500 tons of fruits if all the farmers bought the poorer strain of "Stone". In the case of Earliana a difference of twelve pounds per plant between strains was recorded. Chart No. 1 [Charts shown but results not here entered] indicates a difference in yield of twenty-five pounds per plant, between different varieties.

Another outstanding feature is the difference in earliness of maturity between different varieties, different strains of the same variety and different plants of the same strain. Chart No. 2 shows the relative earliness of three varieties. "Chalk's Early Jewel" begins its heavy production September 1st; "Landreth's Red Rock," September 13th; Stone, September 20th. Up to the mean frost date, September 25th, these varieties yielded respectively 12, 8, and 6 pounds of marketable fruit per plant. Obviously, if the excellent quality and firmness of the Stone could be combined with the earliness and high yielding character of the Chalk's Early Jewel, a very desirable variety would be obtained.

Although the resemblance between many varieties was striking, there were outstanding differences between others from the standpoint of shape, size, firmness and quality of the fruit. There were many variations from the deeply furrowed and irregular Earliana to the extremely smooth Favorite; from the one ounce Burbank Preserving to the eleven ounce Ponderosa; from the soft Yellow Queen, to the firm Stone; from the acid Earliana to the sweet Yellow Pear.

EXPERIMENTS ON CAPACITIES OF SOILS FOR IRRIGATION WATER.

BY O. W. ISRAELSEN [1] AND F. L. WEST.[2]

(Abstract).

INTRODUCTORY.

More information on capacities of soils for water is essential to its economical use. Previous work on subject largely under laboratory conditions, and results not rigorously applicable to field problems. Work done in field heretofore usually on cropped plats and with variation in time of collecting samples after irrigation, so that capacity is not completely and fully defined. Further, samples of soil for capacity observations have been taken after irrigations, in which the amounts of water applied have varied greatly and have frequently been insufficient fully to saturate the soil. The experiments here reported were planned to overcome these difficulties.

PLAN OF EXPERIMENTS.

Three rectangular plats on the Greenville Farm, North Logan, 33 feet wide and 38 feet long were surrounded by levees about 2 feet high. The plats were numbered A, B, and C. To Plat A, 12 surface (3) inches were applied; to Plat B, 24 surface inches; and to Plat C, 36 surface inches.

The water was applied thru small ditches in heads varying from 0.1 to 0.2 cu. feet per second, measured over a triangular weir. As soon as water disappeared from surface of plats, an 8-inch straw mulch was applied to reduce evaporation losses to a minimum.

Soil samples were taken from each foot section

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(3) Surface inches equivalent to acre-inches per acre.

with a 2-inch post hole type soil auger to a depth of 12 feet. The soil taken from each foot was thoroughly mixed on an oilcloth, and from the mixture a 250 c. c. sample can was well filled. In the laboratory 200 gm. samples of moist soil were dried at 110 to 115 degrees centigrade. The moisture content is reported in percentage of the weight of water-free soil, and also in acre-inches for each acre-foot of soil.

RESULTS OF OBSERVATIONS.

The results of the observations show that an appreciable downward movement of water continued in each plat from June 14th, the date of irrigation, to October 11th, the date of the last sampling. To show most clearly the amounts of water retained and the rate of capillary movement, the observations are platted first as percentages moisture in each of the upper 12 feet of soil on the different dates, and second, as acre-inches of water in different soil depths as determined by the time after irrigation.

The first group of curves show that the 12 inches of water applied to Plat A did not reach the 12-foot depth of soil for several days, but that some of the 24 inches passed thru the upper 12 feet of soil the third day after irrigation, and that much of the 36 inches had gone below the 12-foot point one day after the water was applied.

The plats reporting inches of water in the various depths platted against time show that from the upper 6 feet of soil there was a gradual loss of water as the season advanced. These curves show further that the quantities of water found in Plats B and C are not appreciably influenced by the depth of soil selected as the index of capacity.

The moisture content curves platted against time also show that the rate of downward movement of water decreases rapidly after the fifth day after irrigation. This is brought out by a comparison of the moisture content in each foot section on the dates of sampling immediately following the fifth day after irrigation to the moisture equivalent of the soil taken from the respective depths.

RATIO MOISTURE EQUIVALENT TO MOISTURE CONTENT.

On Plat A the maximum ratio of the moisture equivalent to the moisture content increased from 1.09 on June 20th to 1.17 on June 26, and the minimum increased from 0.86 to 0.92; considering only the upper 6 feet of soil. The average ratio ranged from 0.98 on June 20th to 1.05 on the 26th of June. The average maximum and minimum for the individual foot sections in Plats B and C are almost exactly the same as for Plat A. The average of the upper 6 feet for Plats B and C being 0.96 to 1.06, and 0.94 to 1.05, which is also very nearly the same as for Plat A.

In the soil from 7 to 12 feet of Plat A, the ratio decreases after June 20th because water was moving into this soil from the upper 6 feet but it was not during this time moving out below the 12-foot plane. The decrease in Plat A was from 1.21 to 1.09, whereas Plat B increased from 0.86 to 0.92 and in Plat C it increased from 0.85 to 0.93.

HYDROMETALLURGY AS APPLIED TO THE MINERAL INDUSTRY.

BY CLARENCE A. WRIGHT.*

It is rather difficult to cover the field of hydrometallurgy as applied to the mineral industry in such a short space of time, but I shall try to point out in as brief a manner as possible just where hydrometallurgy may be applied in the treatment of ores.

Hydrometallurgy can include, of course, hydromechanical methods in the treatment of ores, but it is generally referred to as a process or method of treatment involving the solution of metals by chemical means, such as leaching or amalgamation, and the recovery of the metals either in metallic form or as a chemical compound.

The applicability of any solvent process to the extraction of metals depends largely on the character of the ore, as the solvents such as acids, react more or less with the gangue constituents or elements contained in the ore. These gangue constituents not only consume the solvents, but elements detrimental to the process are frequently brought into solution.

The effectiveness of a solvent is generally improved by roasting the ores and the leaching processes have been applied principally to oxidized ores. Although the application of any chemical process may be more or less limited, higher extractions are generally possible than by the usual methods of concentration and subsequent smelting. It also has the advantage in cutting down the cost of haulage and transportation to a minimum in that the final product is in the form of metal or chemical compound desired. Leaching in comparison with smelting requires little fuel, but on the other hand the cost of chemicals may prove to be prohibitive so that it comes down to a case of dollars and cents as to which is the most economical method of treatment.

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There are many ores containing minerals which are not only difficult but often impossible of separation by gravity concentration owing to the intimate association and fine dissemination of the different minerals. Then again there are low-grade ores which lack sufficient mineral values to permit concentration and subsequent shipment to the smelter on account of the distance of haulage and transportation. Such low-grade ores may include gold-silver ores which worked in the earlier days were free-milling and could be treated by stampmills followed by amalgamation, but with depth the ore gradually became more base and could no longer be profitably amalgamated. This necessitated changes and alterations in the mills, especially the addition of cyanide plants in order to effect higher extractions and produce bullion, thus eliminating the cost of haulage and transportation as much as possible. Cyanidation of gold ores, however, is by no means limited to low-grade ores but is applicable to gold ores in general, although its application may involve modification of the cyanide process in order to overcome the effects of detrimental ingredients present in the ores.

Oxidized copper ores have yielded to hydrometallurgical methods of treatment and the leaching processes have been especially desirable in the treatment of low-grade ores as they have effected high extractions which otherwise would not have permitted economical treatment and on account of the simplicity with which the copper can be recovered from solution. Aside from the application to ores, hydrometallurgy has, of course, also been applied to the refining of copper by electrolytic means as well as to the refining of some of the other metals. In fact a solvent process may serve as a process complete in itself or it may serve only as part of a process in the treatment of an ore.

A great deal of experimental as well as practical work has been done in the hydrometallurgy of zinc during the past few years. Perhaps of greatest importance to the mineral industry along this line has been the application of electrolytic methods to zinc ores. In this method of treatment the ore or concentrate is given a dead-roast the product containing only a few tenths of one per cent of sulphur. The roasted ore is leached with dilute sulphuric acid and after neutralizing the solution, precipitating the ferric hydrate, settling and filtering, and removing other metals, the purified solution passes to electrolytic cells where the metallic zinc is deposited on aluminum cathodes. This method, although it may be limited in its application to zinc ores, especially as it requires cheap hydro-electric power, has permitted the treatment of complex zinc ores which formerly were not amenable to the usual methods of concentration and retort smelting without prohibitive losses and high costs.

Hydrometallurgical processes by which the metal is recovered from solutions in the form of a crystallized salt might also be mentioned. Concentration of the metals by this method is accomplished by evaporation which may require redissolving of the crystallized salts in order to free the crystals from impurities and recrystallizing after clarifying the solution.

The Bureau of Mines has done a great deal of research work in applying hydrometallurgical processes to the treatment of low-grade lead ores, and to the recovery of zinc from low-grade and complex zinc ores. Such work is valuable in that commercial processes may be developed by which the metals may be recovered from ores that are not amenable to present methods of treatment. It is believed that many of the present complex ore-treatment problems will be solved by hydrometallurgical processes.

OIL SHALES AND THEIR ECONOMIC IMPORTANCE.

BY MARTIN J. GAVIN.*

The twentieth century has often been spoken of as the age of petroleum, and from many viewpoints it can be justly considered so. Certain it is that the petroleum industry is one of great importance to this country, industrially, financially and economically. The United States, however, at present producing over sixty per cent of the world's total output of petroleum, is not producing petroleum at a sufficient rate to provide for its own domestic consumption. For several years this country has been importing ever increasing quantities of crude and partly refined oils from Mexico, and has been drawing heavily on domestic stocks of petroleum. Although domestic production of petroleum is increasing it is not increasing at the same average rate as domestic consumption, nor is it probable that in the future domestic production will increase sufficiently to satisfy the demands of domestic consumption, but on the contrary, in the opinion of those best qualified to know, the peak in the curve of domestic production of crude petroleum will be reached in a comparatively few years, while the rate of increase in consumption of petroleum and its products, will rise at a continually growing rate. This country then must turn, and as a matter of fact, as the increasing imports from Mexico indicate, is turning to other sources than the crude petroleum produced in this country to make up the deficit between domestic production and domestic consumption of petroleum and its products.

The chief products of petroleum are motor fuels, kerosene, fuel oils, and lubricating oils. Of these, the increasing demand for motor fuels or gasoline is perhaps the greatest, and that of fuel oils probably next greatest. The ever growing use of the internal combustion motor,

*Refinery Engineer, United States Bureau of Mines. Presented by permission of the Director, United States Bureau of Mines.

especially in automobiles, accounts for the first, and the increasing use of fuel oil, chiefly for steam raising purposes, accounts largely for the second. Lubricating oils are, of course, of prime importance, as machinery must be lubricated if it is to operate.

To help make up the deficit in our supply of petroleum we can expect to draw on the enormous potential petroleum supplies of Mexico at an increasing rate, and by the use of new and improved processes of manufacture a greater percentage of the petroleum products for which there is the greatest demand will undoubtedly be obtained from petroleum. The more efficient utilization of these products, as for example, through the development and use of the Diesel engine and the gradual change in the design of our present internal combustion motors, enabling them to use lower grade fuels will perhaps tend to relieve the growing shortage. Hydroelectric power or electricity otherwise produced can be expected to take the place, to a certain extent at least, of fuel oil installations on land; but all these expedients have their practical limitations, and it is to be expected therefore that in the comparatively near future, new sources of products similar to those now being derived from oil well petroleum will have to be developed. As a matter of fact, some are already being developed.

These are possibilities of importance in the development of the production and use of benzol as a motor fuel and other coal tar products as Diesel engine fuels and as substitutes for other petroleum products. There are also important possibilities in the commercial production of alcohol as a motor fuel. In fact, blends of alcohol, benzol, and petroleum distillates are being marketed in the east at the present time as motor fuels, and are giving satisfaction in use. Taking all these considerations into account, however, it is the opinion of many, including myself, that the oil shales of Utah, Colorado, Wyoming and Nevada and possibly other states are extremely important as new sources of products similar to those now obtained from petroleum. These states contain enormous deposits of oil shales which by proper treatment yield gas, oil, and also if desired, ammonia, of value as a fertilizer. The oil in many respects is similar to oil well petroleum and yields products similar to those of petroleum.

Oil shales have been worked in Scotland and France for upwards of sixty years. In the former country the industry has been a succssful one from a financial standpoint, especially of late years, although it is passing through a difficult period at present. The industry in France has not been nearly so successsful as that in Scotland. The success of the Scotch shale industry has been brought about by the development of successful and cheap processes for treating the shales and oils produced from them, but mostly by local conditions, such as competition only with high priced imported petroleum products, low labor costs and the fact that the industry grew up in a densely populated region, where a ready market for oil and ammonium products was available. A recent reorganization of the Scotch shale companies, combining them into one organization, is hoped to better the present condition of the industry in Scotland.

Oil shale contains little or no oil as such, but it contains substances which when the shale is subjected to destructive distillation yield gas, crude oil and nitrogen-containing compounds, notably ammonia, as well as other products in small and probably of unimportant value for the most part. Oil shale as a rule must be mined much as coal is mined, crushed, and heated to a relatively high temperature in closed retorts, which may operate continuously or intermittently. These steps are necessary to produce the gas, crude oil and ammonia, the latter of which is in solution in the water obtained along with the oil.

The ammonia water is then distilled, and the released ammonia passed into sulphuric acid, producing ammonium sulphate. The crude oil must be refined, much as petroleum is refined, to produce the various commercial products. The refining of shale oil is more complex and in all probability more costly than the equivalent refining of petroleum. The shale oils can be refined undoubtedly, however, and can be made to yield many products similar to those produced when petroleum is refined. The oils produced from the oil shales of this country will yield gasolines, burning oils, and paraffin wax, all of which when properly treated will undoubtedly be satisfactory commercial products. There is considerable doubt regarding the possibility of producing the more viscous grades of lubricating oils such as internal combustion motor lubricants from shale oils, but it may be possible to do so. Little is known in this country as to the refining of shale oils at the present time, and this statement can be applied generally to the possibilities and technique of oil shale operations in the United States.

The development of an oil shale industry to one of considerable importance in this country will demand the expenditure of many millions of dollars and take a period of many years. Much research work and technical study will be necessary in its development and it will require the services of trained executives and experienced technicians. Nevertheless, when economic conditions become favorable, it is reasonable to believe that oil shales will be of great value as a source of oils similar to those now derived from petroleum. An idea of what large scale development of the oil shale industry means may be gained from the consideration that to produce one barrel of crude oil from shale, on the average at least one ton of a tough rock must be mined, crushed, heated to a relatively high temperature and finally the residue, amounting to about seventy-five per cent of the original weight of the raw shale must be disposed of, as valueless. The United States now produces over one million barrels of crude petroleum per day.

From an economic standpoint our oil shale deposits practically assure us that come what may, this country will still have its own sources of petroleum products. We should never have to be wholly dependent on foreign countries in this respect. From another standpoint the shales are also of great economic importance. The oil shales especially of the Rocky Mountain country, occur in sparsely settled regions. Their development on a large scale means the bringing into these regions of a great number of miners and other laborers, often with their families, who will earn their living in the shale fields, and spend their money in the same locality. Millions of dollars must be spent in erecting plants, developing mines and the like, much of which will be spent in the states in which the oil shales occur. The shale oil refineries will require sulphuric acid and other chemicals and supplies which logically will be produced as near to the shale fields as possible, thus bringing in more capital and labor. Transportation facilities will be extended to meet the requirements of the shale operators, thus benefiting the regions now inadequately supplied in this regard. Prices of petroleum products in the regions contiguous to the shale operations can be expected to be relatively lower than they would be if similar petroleum products had to be shipped in. The list could be extended, but it is impossible to go further in my limited time.

It must be emphasized however that development of an oil shale industry to a scale sufficient to be of so much economic importance, will require much study, time and money. The oil shale industry is no game for the man of small experience and capital. We have often compared it with the development of the low grade copper ores of this State, and the comparison, in that it is a large low-grade chemical manufacturing enterprise, requiring capital, time and trained men, is undoubtedly a true one. The investor in oil shale operations should know that he will probably have to wait for a long time for a return on his investment, and that returns in all probability will be conservative. In spite of this, I believe the day of the oil shale industry is coming. When, it is difficult to predict, but some day it will undoubtedly be one of great importance to the country and state.

PYROMETALLURGY AND ITS FUTURE POSSIBILITIES.*

BY JOHN C. MORGAN.[1]

Pyrometallurgy is that part of metallurgical processes or operations carried on at elevated temperatures. It may consist of steps in the branch of metallurgy known as ferrous metallurgy and having to do with the manufacture of iron and steel, or of non-ferrous metallurgy involving the treatment of ores of copper, lead, zinc, precious metals, rare metals and so on for the production of these metals in marketable form.

Inasmuch as we of the West are chiefly concerned with non-ferrous metallurgy, I will limit my remarks to that branch of the subject. I am also omitting any remarks concerning the pyrometallurgy of non-ferrous alloys.

Pyrometallurgy consists chiefly of ([2]) drying to remove hygroscopic water, calcining to remove combined water and other volatile components, roasting to effect chemical change without fusion, smelting when chemical change is brought about with fusion, liquating, crystallizing, distilling, subliming to effect either separations or purifications.

Modern smelting practice and the operations incident thereto is a highly developed art. Its problems have been many in the past. One in particular is the successful treatment of fine material in the blast furnace, a problem which has been brought about by the ever decreasing amount of ore as mined reaching the smelter together with the constantly increasing amount of finer material resulting from concentration processes. Sintering machines and briquetting are so far meeting this situation.

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[1]Assistant Chemist, U. S. Bureau of Mines.

[2]Hoffman, General Metallurgy, 1913, p-379.

Of interest in blast furnace practice is the use of pulverized coal as a fuel. Such use has, during the past two years, been brought to actual commercial experimentation both in Canada and the United States ([3]) and the experiments have been most promising. The pulverized coal is introduced into the furnace through the tuyeres thus decreasing the quantity of coke which it is necessary to add to the charge. Results indicate that a considerable saving in cost of operation can be effected.

Having direct bearing on the utilization of pulverized coal in blast furnaces is the problem of smelting lead and copper ores with high zinc content. In the past, the smelting of ores high in zinc in the blast furnace has offered considerable difficulty due to liability to freezing of the furnaces with continued operation on such ores. Its direct result has been to exclude lead and copper ores heavy in zinc by a penalty on the zinc content. Hall has concluded ([4]) after extensive experimentation that the difficulty is due not to the high viscosity of zinc slag as is popularly supposed but to the condensation on the coke of zinc oxide brought up from the smelting zone in the charge which renders the coke much more difficult of combustion so that proper heat is not developed later on in the smelting zone. The use of powdered coal may bring about the solution of this old problem.

Another phase of present smelting practice which has in the past few years received much attention, due in no small part to external pressure brought to bear by surrounding communities, is the treatment of flue gases. Such gases carry, besides the ordinary products of combustion, mechanically carried dust, volatalized metallic compounds, and sulphur dioxide gas. Large installations of bag houses and Cottrell electrostatic precipitators have been made to remove the solid material which is retreated to recover the values contained. As a result quantities of arsenic, so necessary in insecticides, and cadmium are being recovered from material which previously was belched forth in smoke clouds

[3]Bull. Can. Mining Inst. No. 87, p-737, (1919).

[4]Hall, Min. and Sci. Press, 1919, Vol. 119, p-699.

into the atmosphere. Thallium has also been produced in small amounts from this source. The sulphur dioxide, however, is still a problem. In some cases sulphuric acid is now being produced from these gases as well as some liquid sulphur dioxide. These products find their way back into metallurgical and other industries and become a source of revenue instead of a menace. Considerable experimental work has been done with the production of elemental sulphur from these gases. Further advancement in the treatment of smelter gases may be expected.

Turning now to the pyrometallurgy of ores which do not lend themselves to direct smelting or concentration methods, we are confronted with two general types of ores, the complex sulphide and the oxidized ore. We can have a sulphide ore containing sufficient value in metals to ship if all of that value could be realized but having its value distributed in lead, zinc, copper and precious metals. Now such an ore would best be handled by a lead smelter, but its zinc content becomes a deficit rather than an asset and the seller instead of receiving remuneration for the zinc is penalized for it, an amount dependant upon the quantity present. Two possibilities of solution of this problem present themselves, the initial stage of which is pyrometallurgical.

The first of these is the roasting of the ore followed by lixiviation and further hydrometallurgical treatment. The actual roasting of the ore, to accomplish high extractions of zinc, is not an easy operation; but recent work, chiefly in connection with the electrolytic zinc industry, has established a promising practice which with some modifications for certain ores may offer a solution to this problem. The residue, after leaching the zinc, can be smelted or otherwise treated to recover the other values.

A second line of attack is the chlorination of the metals of the sulphide by chlorine gas at elevated temperatures, producing a product which should be amenable to hydrometallurgical treatment. Chlorination should command more than a passing interest in the next few years.

The second type of ore which offers particular difficulty of treatment is the low grade oxidized ore. It is too low in value to ship and treat at a smelter and does not lend itself well to gravity methods of concentration so far developed. There is an abundance of this kind of ore awaiting some suitable method for the extraction of its values. Included with the unmined low grade ore bodies are also tailing dumps from previous metallurgical treatment. Two methods of handling such ore which are receiving much attention give promise; these are choridizing roasting and volatilization, though of course there are other possibilities.

Chloridizing roasting is a pyrometallurgical operation followed by some such hydrometallurgical process as brine leaching. While chloridizing roasting itself is not new, its application to extraction of lead, copper, and silver from oxidized ores in connection with brine leaching has recently come in for much experimentation. The process consists in blast roasting a mixture of ore, salt, pyrite, or other sulphur bearing material, and in some cases fuel such as coal. The reactions involved are those taking place between the salt, sulphur products, gangue, water vapor, and metal-bearing mineral, all or in part, to produce a chloride of the metal. This renders the metals soluble in brine and the process from this stage is a hydrometallurgical one. The Tintic Milling Company is operating such a process on a copper-silver ore at Silver City in the Tintic District in Utah.

The volatilization process is a chloridizing process differing from that just mentioned in that the chlorides are leached with the furnace gases rather than with the brine solution. A further difference is that sulphur is not essential to the chloridizing reaction, and in amounts much above 5 per cent, is a detriment. The following steps are involved: furnacing a mixture of ore with some chloridizer such as salt or calcium chloride at sufficient temperature to effect volatilization of the chlorides of the metals as formed; collection of the volatilized chloride and reduction of the fume with lime and carbon to form bullion and calcium chloride slag. The calcium chloride slag may be returned to the first step in the operation. The furnacing may be carried on in a cement kiln and the fume may be caught by a standard Cottrell precipitator. The type of furnace best adapted to fume reduction is still a matter of experimentation.

At the present stage of experimental development, the process seems best suited to oxidized ores, the gangue of which is of such a nature that it will withstand the necessary temperature in the roasting operation without excess clinkering. Zinc is not volatilized successfully, results so far being very erratic with this element. Lead, copper, gold, and silver are volatilized readily once the proper conditions are obtained and work already done indicates that the process may be extended to some of the other metals. The leach tailings from the extraction of zinc from certain lead-zinc ores should be a promising source for experimentation though little work has been done on such material so far as I am aware.

The plant necessary for operation is simple and composed wholly of equipment which is already well standardized. It consists of an adequate crushing and grinding plant with facilities for cheaply handling the ore, a cement kiln, a flue system, a Cottrell precipitator and a furnace for the treatment of the resulting fume. This simplicity and standardization of equipment should be a thing decidedly in the favor of the process since it makes possible the erection of the plant near the source of the ore, a most desirable feature in the treatment of low grade ores. Further, the plant will require little water and it can therefore be operated in places where wet concentrating methods are excluded through lack of water.

Although the process is as yet in the experimental stage, four plants of commercial size will soon be in operation. Two of these will handle an ore carrying copper, one a zinc-lead product, and one a tailing carrying values in silver, mercury, copper, lead and zinc.

In conclusion it is of interest to note that these plants are all the direct results of the work carriel on at the Salt Lake City station of the Bureau of Mines and the Department of Metallurgical Research of the University of Utah. Their successful outcome will be a worthy contribution to metallurgy.

RELATION OF CHEMISTRY TO METALLURGY.

BY EDWARD P. BARRETT.[1]

Metallurgy by definition is the art of extracting metals from their ores, refining them and separating them from one another.

From the chemists' view-point metallurgy is simply an application of chemical processes and metallurgists might well be known as chemical engineers or industrial chemists. In this sense of the word we do not include mechanical concentration or separation of minerals.

In discussing most metallurgical operations we readily see that these operations depend upon some certain definite chemical ractions.

One of the most important metallurgical operations is the manufacture of iron and steel.

In the United States the most common treatment is smelting in a blast furnace in which the ore is mixed with proper fluxes which have been calculated from their chemical analysis to produce a fluid slag of a definite chemical composition. Sufficient fuel, in the form of coke, to melt the charge is also added, the amount of fuel depending upon the temperature required to melt the charge. In burning this fuel a large amount of carbon monoxide is formed which reacts with the iron oxides to reduce them to metallic iron. Some iron oxide is reduced to iron by direct action of the carbon.

The high temperature obtained keeps the iron and slag in a molten condition. They separate due to difference in specific gravity and are then drawn off through tap holes.

This molten pig iron carries impurities, generally silicon, manganese, and carbon, which must be removed in order to change the iron into steel.

The simplest way to remove them is based upon the chemical reactions of oxidization processes. The molten pig iron is poured into a large tank-like container so

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arranged that air can be blown through the charge. This air oxidizes the impurities and this rapid oxidization maintains the high temperatures. After the impurities have been removed the proper amounts of carbon, silicon, manganese, chromium, etc., are added to make a grade of steel, having a definite chemical composition.

Here we have seen that every step is controlled, chemically, and depends upon a chemical reaction.

One of the products obtained by smelting of copper ores in a blast furnace is copper matte, a copper iron sulphide which is purified by oxidization of the sulphur and iron. This oxidization process is carried out in a convertor similar to the one used in the manufacture of steel from pig iron but in this case the sulphur burns to sulphur dioxide and the iron oxide combines with the silica in the lining of convertor and forms a slag which is poured off. This purification is based upon the chemical fact that oxygen and sulphur will combine at increased temperatures to form sulphur dioxide and at the same time furnish sufficient heat to keep the charge melted.

All roasting operations depend upon the chemical reaction between oxygen and sulphur at increased temperatures. There are many types of roasting furnaces in use but they all depend upon the same chemical reaction for their successful operation.

In the metallurgy of zinc we smelt the oxidized material, either a natural product or one obtained by roasting a sulphide ore, in a closed fire clay retort in which the ore is mixed with a large excess of carbon.

Zinc oxide is reduced to metallic zinc at about 1030° C and since the boiling point of zinc is 930° C the reduced zinc vapors pass off and are condensed as the liquid metal. By increasing the temperature of the retorts to 1200-1300° C it is possible to increase the capacity of the retorts. Zinc vapors condense to liquid metal in the range of temperatures between 420-860° C so in practice the temperature of the condensors is kept about 500° C so that the zinc can be tapped off in the liquid state.

These peculiar chemical properties of zinc form the basis for this means of extracting the metal from its ores.

The separation of silver from lead in lead silver bullion by the Pattinson process depends upon the chemical theory of fractional crystallization.

In this case the bullion is melted and upon cooling we have crystals of pure lead forming and separating from the mixed crystals of silver and lead.

The chemical reaction between metallic gold and mercury form the basis for the amalgamation process for recovering gold from a free milling ore; that is, one in which the gold exists as the metal. In the recovery of the gold from this amalgam we use another chemical reaction, namely, that mercury is easily volatilized at about 360°C and passes off as a vapor leaving the gold in the retort. The mercury is condensed and used again.

This ease of volatilization of mercury is used as a means of extracting mercury from its ores. These mercury ores are heated and the fumes upon cooling gives us metallic mercury.

The cyanide process depends upon the chemical reaction of Ag and Au and cyanide in the presence of oxygen.

All leaching processes are based upon the chemical solubilities of the metallic compounds in the solutions used and the recovery of these dissolved metals is again dependent upon the chemical properties of the respective elements.

The chloride volatilization process for the recovery of gold, silver, lead and copper from the lower grade oxidized ores depends upon the chemical reaction of these elements with chlorine.

Lead chlorine boils at about 860°C, cuprous chloride at about 950°C and the chlorides of gold and silver dissociate at temperatures somewhat lower than these.

The most important reagents are salt or sodium chloride and calcium chloride which melt at 805°C and 780°C respectively, so that they are brought into intimate contact with the ore particles before the temperature of volatilization, 900-1000°C is reached.

These statements show that every one of the processes mentioned are dependent upon some definite chemical reactions and justify the assertion that metallurgical operations are only applications of chemical processes.

A CAPILLARY TRANSMISSION CONSTANT AND METHODS OF DETERMINING IT EXPERIMENTALLY.

BY WILLARD GARDNER. [1]

(Abstract).

In an article on The Movement of moisture in Soil by Capillarity, published in Soil Science, Vol. VII. No. 4, April, 1919, the author has implicitly defined a capillary transmission constant, involving the dimensions and arrangement of the soil particles, and, as a linear factor the ratio of the surface tension and the coefficient of viscosity of the soil solution. From theoretical equations there given, this constant may be expressed,

$$K = \frac{f\rho^{\frac{1}{3}}}{p}$$

where f is the intensity of the capillary stream, i. e., the quantity flowing past unit area per unit time; ρ is the moisture density in quantity of moisture per unit aggregate volume in the soil, and p is the moisture density gradient.

The present article is concerned primarily with a discussion of methods of measuring this constant, including a preliminary value for Greenville soil, and an example of a practical application.

[1]Utah Experiment Station.

MID-TERTIARY DEFORMATION OF WESTERN NORTH AMERICA.

BY HYRUM SCHNEIDER.

(Abstract).

It is quite generally conceded that the Tertiary period in North America was ushered in by a marked deformation most conspicuous in the Rocky Mountain region and was ushered out by another deformation which probably affected to some extent most of North America, but in its more marked features was confined to the Pacific Coast. Somewhere near the middle of the Tertiary there was a deformation somewhat analogous to the opening and closing disturbances.

The problems of this thesis are an investigation of the middle Tertiary deformation:—(a) To locate it as nearly as possible in time; (b) To investigate its nature and extent; (c) To determine some of its effects; (d) To study its relation to Mid-Tertiary deformations in other parts of the world.

As shown by structure sections there began in Western North America, near middle Miocene time, a period of disturbance which affected profoundly the Pacific Coast region from Southern California to Puget Sound and probably extended along the coast to Northern Alaska. From Southern California it probably extended south to Central America. Passing east from California the Great Basin was markedly affected and the disturbance practically died out in the Great Plains east of the Rocky Mountains.

The Coast Ranges, part of the Cascade Range, the Olympic Mountains, and a part of Alaska were closely folded. In the Coast Ranges horizontal thrust faulting accompanied the folding. At least a part of Alaska, the Coos Bay region of Oregon, the John Day Basin of Oregon and the Western part of the Great Basin were moder-

ately folded. In the western part of the Great Basin folding was probably accompanied by faulting on a large scale. The Sierra Nevada Mountains were uplifted bodily without folding. The eastern part of the Great Basin and the Rocky Mountain region were uplifted and locally faulted.

In the Pacific Coast region the disturbance was most pronounced with consequently more diverse effects. Submerged areas were elvated thousands of feet above sea level while other areas were submerged. In general there was a marked increase in relief and a new active cycle of erosion was begun.

In the Great Basin and Rocky Mountain region the disturbance probably began the development of the major topographic features of today.

While the main problem of this thesis deals with the Mid-Tertiary deformation of Western North America, the disturbance was by no means limited to North America. It is, for the world as a whole one of the most profound and extensive recorded in geologic history. That its effects have not yet entirely died out is strongly suggested by the close relationship between the area affected and the present distribution of active or relatively recently active volcanoes. Also the area most frequently affected by earthquakes is closely related to that portion of the world most affected by the Mid-Tertiary disturbance.

THE RESISTANCE OF THIN METAL FILMS WHEN EXPOSED TO ULTRA VIOLET LIGHT.

BY ORIN TUGMAN.

When a metal is exposed to violet light, negatively charged bodies are emitted with velocities proportional to the frequency of the light waves. These electrons are emitted in all directions. Inasmuch as the electrical conductivity of a metal is a function of the number of free electrons in a metal it is expected that the resistance of a metal will be changed by the action of light. If the metal is thin the number of electrons liberated by the light may be large enough in proportion to those moving in the ordinary conduction to make a measurable effect.

The conductivity is measured by an electrometer. The metal film is sputtered in vacuo and measured in place.

IS DISINFECTION A REACTION OF THE FIRST ORDER?

(Preliminary Communication)

BY L. F. SHACKELL.

In an extended research upon the velocity with which bacteria are killed by various disinfectants, Miss Chick (1) concluded that the progress of disinfection is similar to that of a monomolecular reaction. Arrhenius (2) in reviewing the data obtained by Miss Chick and by others says: " . . . . on the whole these reactions show such a regular progress with time, that their monomolecular nature is obvious. This circumstance indicates that every bacterium or yeast cell or red blood-corpuscle acts as if it were a single molecule in regard to the substance reacting upon it. This seems from a biological point of view extremely difficult to understand." Although Arrhenius takes into consideration the question of variability of the organisms in their resistance to deleterious substances, he concludes that "the different lifetime of the different bacteria does not depend in a sensible degree on their different ability to withstand the destructive action of the poison. Instead of this a certain fraction of the bacilli still living dies in one second, independent of the time during which they have been in contact with the poison."

In a more recent investigation of this same question Lee and Gilbert (3) attempt to show that the law of mass action may be applied to the process of disinfection. In the majority of their experiments, however, the constants evaluated by Lee and Gilbert from the equation for a monomolecular reaction are not convincingly "constant". In fact, from the data in Table V of Lee and Gilbert's paper the writer has deduced an expression of the second degree which describes the progress of the disinfection of *B. typhosus* with 0.2 per cent phenol with considerably greater accuracy than does the expression for a reaction of the first order. This is shown in Table I below. In the third column are the values calculated by Lee and Gilbert for the constant, k, in the general expression for a monomolecular reaction. In the fourth column are the values for the constant, c, calculated from the equation deduced by the writer. In spite of the constancy of these last values, however, the writer does not believe that the expression from which they are calculated represents the true course of the reaction. Rather, could the distribution frequencies of the microorganisms, in respect both of age and of resistance to the poison, be taken into account, it is not improbable that the course of disinfection could be expressed by a simple linear equation of the first degree. This is indicated in some experiments made by the writer.

In the course of an extended investigation of marine wood borers the writer has collected many data bearing on the toxicities of a number of phenols for the small crustacean borer, *Limnoria.* This form is admirably adapted for such experiments. The adults average 2.5 mm. in length, and can be obtained in great numbers. In *Limnoria* all the phenols investigated produced motor paralysis, the onset of which in any individual could be accurately noted. When paralyzed *Limnoria* are washed and returned to fresh sea-water, the return of motor activity is rather sharply defined, unless the animals are moribund.

If, for a given poison, the values of r, the average time for beginning recovery, be plotted as ordinates against corresponding values of t, the time the animals are in the solution of the poison, a discontinuous curve is obtained. The first, short portion is presumed to cover the time taken for establishment of equilibrium of poison between the sea-water and the animals. The next portion of the curve, extending in a number of cases over a very considerable range of t, is a straight line. In one or two instances the curve becomes again discontinuous as the animals begin to die off in considerable numbers. Tables II to V illustrate these points. The calculated values for r are obtained by substitution of the values for t in the equation for a straight line at the top of each table. The observed values of r, which lie on the first, short portion of the curve, are put in parentheses. Each observed value for r is the mean time of recovery for a large number of animals (50 to 100), each observed individually. In this way the factor of variability in resistance to the poison was largely controlled.

The general agreement between observed and calculated values of r from the writer's data is such as to justify the conclusion that the action of a phenol upon living protoplasm is a simple linear function of the time during which the poison has been allowed to act. If this is true, it follows that disinfection is not a reaction of the first order. Rather, the writer's data raise the question whether poisoning by phenols is not due fundamentally to a progressive physical alteration in the state of aggregation of protoplasmic colloids.

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[3]Lee and Gilbert, Journal of Physical Chemistry, vol. 22, p. 348 (1918).

TABLE I.

Disinfection of B. typhosus with Phenol–0.2%
(Lee and Gilbert's data)

t minutes	N=number surviving	$k=\frac{1}{t_n-t_0}\log\frac{N_0}{N_n}$	$c=\frac{t}{(1+t)\ (5800-N)}$
0	5800	....	....
2(t_0)	1800(N_0)	....	0.000167
4	1360	0.060	0.000180
6	1075	0.056	0.000181
8	800	0.058	0.000178
10	670	0.053	0.000177
15	400	0.050	0.000174
20	290	0.044	0.000173
25	180	0.043	0.000171
30	110	0.044	0.000170
35	60	0.044	0.000169
40	30	0.046	0.000169

TABLE II.

Phenol–0.25%. $r=10.85+1.47t$

t minutes	r–obs. minutes	r–calc. minutes
8.5	(16.8)	23.3
17.0	36.1	35.8
34.0	60.4	60.8
51.0	85.5	85.8
68.0	110.9	110.8

TABLE III.

Orothocresol–0.125%. r=10.7+1.98t

t minutes	r–obs. minutes	r–calc. minutes
9.2	(17.5)	28.9
18.4	46.8	47.1
27.6	66.4	65.3
36.8	82.3	83.6
46.0	102.4	101.8
55.0	119.5	119.6

TABLE IV.

Pyrocatechin–0.5%. r=2.52t–36.3

t minutes	r–obs. minutes	r–calc. minutes
16.3	(16.2)	4.8
32.0	44.9	44.3
48.0	83.7	84.7
65.0	128.1	127.5

TABLE V.

Resorcin–0.25%. r=9.03+0.15t

t minutes	r–obs. minutes	r–calc. minutes
70	19.8	19.5
140	29.9	30.0
210	40.6	40.5

SOME PROBLEMS IN DAYLIGHT ILLUMINATION.

BY C. ARTHUR SMITH.

(Abstract).

Only two of the many problems of daylight illumination were taken up in this investigation, viz. Daylight Factor and Distribution.

The work was mainly carried on at the Liberty school during the summer and fall of 1918. This building was selected because of the ideal conditions both as to location and architectural design. It is free from obstructions, natural and artificial. All rooms except those in the four corners of the building are unilaterally lighted. The corner rooms are bilaterally lighted. The desks are arranged in rows parallel to the windows. The external walls of the rooms are mainly occupied by windows which extend from about 18 inches above the tops of the desks to within about 2 inches of the ceiling. The walls are finished in light cream and the window shades are a light tan.

The daylight factor, i. e. the per cent of light indoors to that out of doors, was found to be independent of the time of day, of the season of the year, and of atmospheric conditions. That is to say, any change in outside illumination produces an exactly corresponding change inside. It differs, however, in different places, even in different places in the same room. For unilaterally lighted rooms, the variation from the row of desks nearest the windows to that farthest away is shown by the curve, fig. 1.

For bilaterally lighted rooms, the change in daylight factor in different parts of the room are not regular, i. e. taking rows of desks along either side of the room in which the windows are situated, it is found that the daylight factor does not diminish regularly to the far side

of the room. Hence variation in this case cannot be represented by a smooth curve.

As is to be expected, the distribution of illumination intensity diminishes regularly to the far side of the unilaterally lighted rooms. The ratio of diminition for successive rows, starting with the row nearest the window, is a constant, and found in this investigation to be about 1.3, meaning that the intensity on a given row is 1.3 times that on the next row farther on. The variation for a unilaterally lighted room is shown in fig. 2. This curve has the same characteristics as the curve plotted from the equation $I_n=I_0/N$ where I_0 is the intensity on the row nearest the window, I_n the intensity on any given row, N the number of the row, and k a constant, in this case 1.3. Hence, by knowing the daylight factor for the first row, and the value of k it is possible to obtain the amount of illumination for any row of desks at any hour of the day, for any season of the year and for any kind of a day, by merely measuring the outside intensity adjacent to the room considered.

To illustrate: Let the daylight factor for the first row be 15% and k=1.3. Suppose, now, on a certain day the outside illumination is found to be 300 foot candles. Then $I_0=45$ foot candles. If there are six rows of desks, the intensity on the last row, $I_n=45/6^{1.3}=4.38$ foot candles.

Distribution is affected by the time of day. It was found from the average of a large number of readings that the illumination on the first row was about 1½ times as much in the afternoon as in the forenoon and about 3 times as much on the last row in the afternoon as in the forenoon. This seems to indicate that the afternoon sun gives a higher intensity than does the forenoon sun and that the afternoon light penetrates farther into the room. This conclusion is further borne out by a comparison between the light intensities on the first and last rows for mornings and afternoons. In the morning hours, it was found that the intensity on the first row was more than four times as much as that on the last row, while in the afternoon it was less than twice as much.

It goes without saying that distribution is affected by the position of the shades. We find that by lowering the shades to where we usually find them in school rooms, i. e. about 1/3 down from the top, reduces the amount of light on the remote side of the room about $1\frac{1}{2}$ times as much as it does when the window is entirely exposed, while the first row is affected very little. Frosting the upper part of the window reduces the difference on the last row somewhat. The important point to note is that shades, as usually hung, do not cut down the intensity on the side nearest the window where the need for reducing is greatest, but they do very effectively reduce it on the remote side where even under the best conditions is there ever more light than is needed. Perhaps the ideal arrangement of shades would be to hang double shades at the center of the window so that either the upper or lower half could be covered as occasion requires.

Distribution is affected by the height of the window-sill. For this study, a room in the new addition at the Summer school was selected and a comparison made with a room at the Liberty school. The height of the sill in the room at the Summer school was about twice that at the Liberty. The results show that the range of distribution in the Liberty school is nearly four times that in the Summer, which seems to indicate that high sills are better for evenness of distribution than are low sills. But this advantage is more than offset by the effect that high sills have on the feelings of the pupils and teachers who work in these rooms. The general sentiment seems to be that high sills give a feeling of prison-like confinement.

A secondary problem was considered in connection with those above because of its economic bearing on the subject of illumination with special reference to the relation of daylight to artificial light. It was found by a series of careful measurements that when artificial light is turned on in daylight that the resultant intensity is the sum of the two intensities. This is an important point in the matter of compensating for insufficient daylight which is more or less prevalent in school buildings. Thus, by employing the daylight factor for the first row, the value of k, and the outside intensity adjacent to the room, it is possible by certain empirical formulæ to arrive at a close approximation of the number of lamps of a given capacity to compensate for any deficiency in daylight.

For example, in the problem above, we found that the intensity on the last row of desks was about 4.4 ft. candles. Suppose it were required to increase this to 7.5 ft. candles, thus making 3.1 ft. candles to be provided for. By the empirical equation $N=AI/LE$, where $A=$ area of the room, $I=$illumination per sq. ft. $L=$illumination per lamp and $E=$ utilization factor, i. e. the effective illumination to be considered, then N, the number of lamps, is readily calculated, thus avoiding the wasteful tendency of guessing at the number of lamps to install. Usually more lamps are installed than are necessary in order to be sure that there shall be sufficient light for the worst possible conditions. This is not only uneconomical, but it is positively injurious since too much light produces brilliancy and leads to a dazzling effect, thus injuring the eyes. But the problems of brilliancy and dazzling lie outside the range of this investigation and cannot be considered here.

Perhaps it has already been noticed that no attention has been paid to absolute values either in foot candle illumination or per cent of daylight factor. This study was primarily made to work out the relations which have been given above, that being deemed the problem of first importance. Absolute values may come later.

CURVE SHOWING VARIATION IN DAYLIGHT FACTOR ACROSS A UNILATERALLY LIGHTED ROOM. Liberty School.

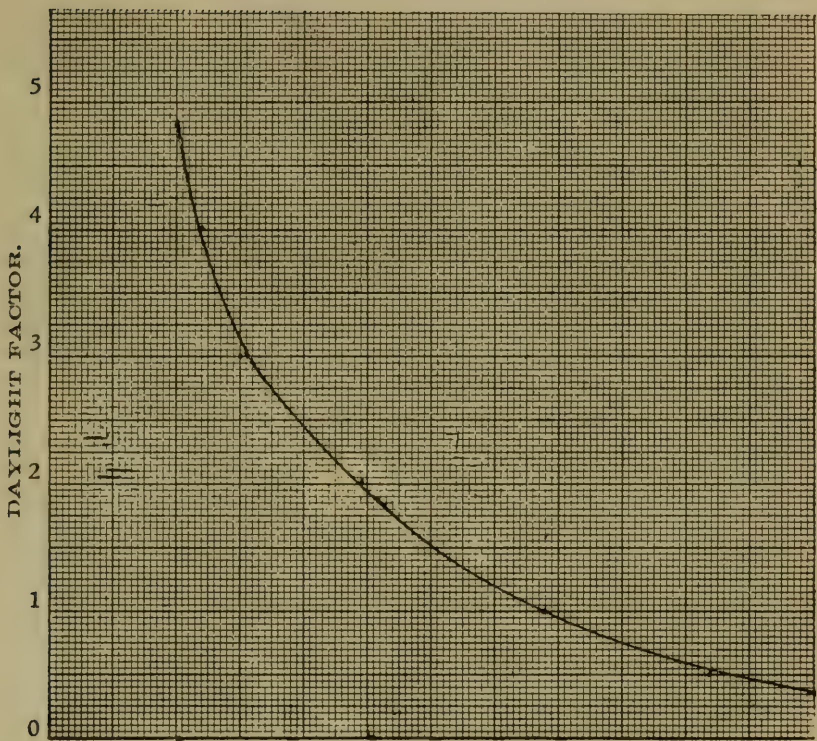

Fig 1. ROWS OF DESKS.

DISTRIBUTION CURVE.

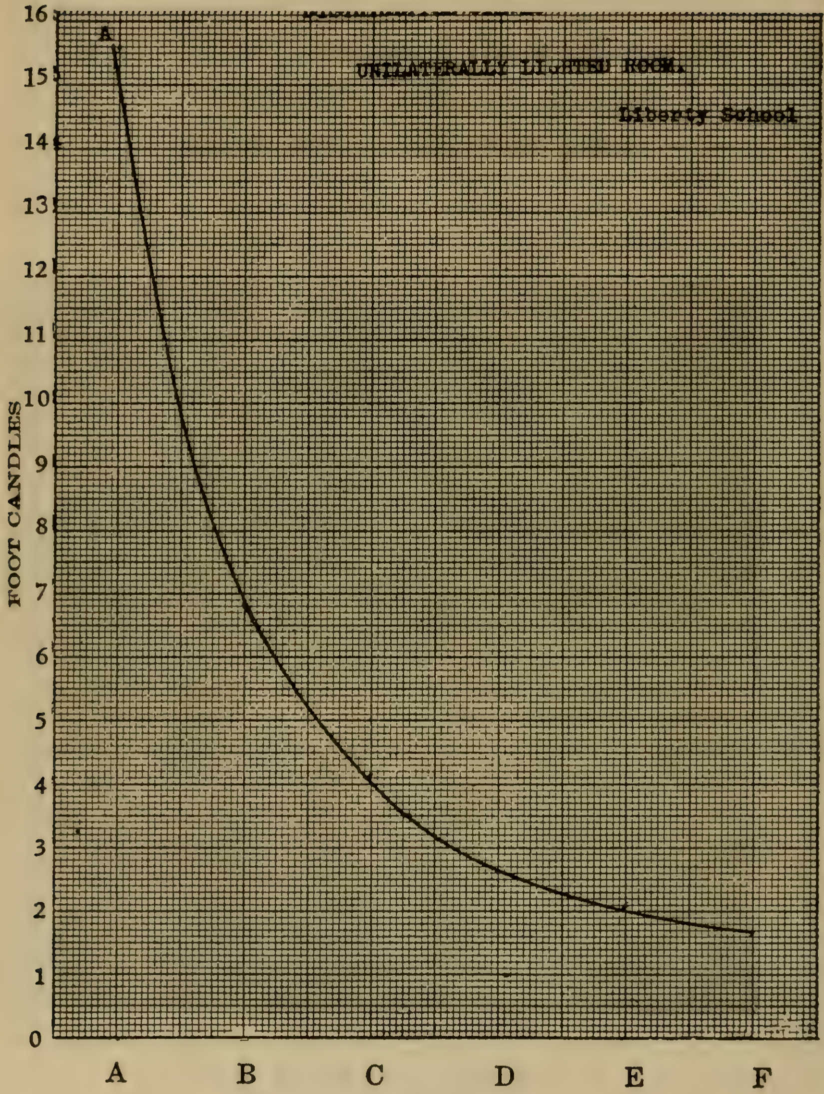

Fig. 2. ROWS OF DESKS.

STANDARDIZATION FROM CONSTANT BOILING HYDROCHLORIC ACID

BY J. T. BONNER AND T. B. BRIGHTON.

(Abstract).

A method for preparing standard solutions from constant boiling hydrochloric acid had been worked out for altitudes near sea level. There had, however, been no work done on the problem at this altitude.

The object therefore of this investigation was to determine the composition and properties of constant boiling acid at this altitude and to correlate the results obtained with those obtained at or near sea level, thus if successful making the method a general one.

To obtain the necessary data we have procured samples of constant boiling acid, both from chemically pure and from commercial acid. These samples were analyzed for chloride content, the specific gravity, and the coefficient of expansion determined. From the data on the coefficient of expansion we expect to be able to plot a graph from which the specific gravity at any temperature may be read directly. Such a graph will greatly simplify the process of standardization.

COMPARISON OF THE ACTION OF POTASSIUM CYANIDE AND SODIUM CYANIDE ON ALKYL HALIDES.

BY W. D. KLINE AND W. D. BONNER.

(Abstract).

Because of the scarcity of potassium cyanide in the laboratory sodium cyanide was substituted when attempting to prepare ethyl cyanide from ethyl bromide. Instead of obtaining propanonitrile, as expected, the mixture yielded ammonia, di-ethyl ether, and a small amount of ethyl propanate.

A general investigation was therefore undertaken in order carefully to compare the actions of potassium cyanide and sodium cyanide under identical conditions.

FOURTEENTH ANNUAL CONVENTION OF THE UTAH ACADEMY OF SCIENCES

Physics Lecture Room, University of Utah, Salt Lake City
April 1 and 2, 1921.

FRIDAY, APRIL 1, 1921, 8 P. M.

SYMPOSIUM ON "FOREST CONSERVATION IN UTAH."

"Making the Forests of Utah a Permanent Resource,"..................................By C. F. Korstian, U. S. Forest Service.

"Forest Tree Diseases" ....By A. O. Garrett, East High School, Salt Lake City.

"Forests and Fish and Game Conservation" ....By S. B. Locke, U. S. Forest Service.

"Forests in Relation to Climate and Water Supply of Utah" ....By J. Cecil Alter, U. S. Weather Bureau.

SATURDAY, APRIL 2, 1921, 9:15 A. M.

"Analytical Distillation of Shale Oil" ....By M. J. Gavin, U. S. Bureau of Mines.

"The Use of the Microscope in Ore Dressing" ....By R. E. Head, U. S. Bureau of Mines.

"Destructive Distillation of Oil Shale" ....By L. C. Karrick, U. S. Bureau of Mines.

"Chemistry of the Volatilization Process" .... By Thomas Varley, and C. M. Bouton, U. S. Bureau of Mines.

"Metallurgy of the Volatilization Process" ....By C. C. Stevenson, University of Utah.

"Function of Steam in Retorting Oil Shales" ....
By M. J. Gavin, U. S. Bureau of Mines, and J. J. Jakowsky, University of Utah.

"Reduction of Copper from Chloride Fumes" ....
........................By R. H. Bradford, University of Utah.

SATURDAY, APRIL 2, 1921, 12 M.

Luncheon to members of the Academy and their friends at University Dining Hall. Address by F. S. Harris, U. A. C.

SATURDAY, APRIL 2, 1921, 1 P. M.

"Decomposition of Green Manure at Different Stages of Growth" ....By Thos. L. Martin, Millard Academy.

"The Normal Temperature as a Function of the Time, Elevation above Sea Level and the Latitude" ......
....By Frank L. West, U. A. C.

"Vitamines in Relation to Nutrition" ....
....By W. E. Carroll, U. A. C.

"Relation of Precipitation to Height Growth of Forest Tree Saplings." ....
........By Clarence F. Korstian, U. S. Forest Service.

MAKING THE FORESTS OF UTAH A PERMANENT RESOURCE.[1]

BY CLARENCE F. KORSTIAN.[2]

We read in the ancient Greek and Latin classics that the need for forest conservation was felt in one form or another even before the advent of the Christian era. By the eleventh century before Christ, in the vicinity of the thriving cities of Palestine, Asia Minor and Greece, the forest cover had to a large extent disappeard and building timber for the temples at Tyre and Sidon had to be brought long distances from Mount Lebanon, where the wealth of cedar was also freely drawn upon for ship and other structural timbers. Artaxerxes I, having recognized the impending exhaustion of this mountain forest, about 465 B. C., attempted to regulate the cutting of timber. When the Romans brought Macedonia under their sway in 167 B. C., the cutting of ship timbers in the extensive forests of that country was prohibited.

The early ordinances restricting the use of timber issued in the United States in the seventeenth century by the town governments of Exeter, Kittery, Portsmouth and Dover, may be likened to the early European forest ordinances. However, they were probably not dictated by any impending scarcity of this class of material, being intended merely to secure a proper and systematic use of the town property. In the United States as in ancient and medieval times the cutting of ship timbers was one of the first forms of regulation because of a threatened depletion of timber resources.

History repeats itself many times, and as was the case with the advance of civilization and the conquest of central Europe, the British Isles and eastern North America, so it was in Utah. When the first pioneers arrived in the State via the prairie schooner route, they found the

[1]Presidential address delivered before the Utah Academy of Sciences, April 1, 1921.

[2]U. S. Forest Service.

mountains covered with dense bodies of timber and areas of heavy brush and high mountain meadows in which tall luxuriant grasses and succulent herbs flourished. The mountain streams were clear, filled with fish and maintained a fairly even flow throughout the year. When Utah was first settled the mountains supported more natural resources than the people of the State had need for but as the region developed the utilization of the timber and forage resources became more intensive. The local forests supplied all the lumber that was used in the development of the State up to the advent of the railroad. Bancroft, the historian, tells us that in 1883 one of the main drawbacks to the industrial development of Utah was the scarcity of timber suitable for hard and finishing lumber. The settlers were not allowed to acquire title to timber lands and even were nominally forbidden to use timber except on mineral lands, and then only for domestic purposes. With the continued development of the State, these conditions were further changed through the denudation of the mountains as a result of unregulated timber cutting, unrestricted grazing, fires and the resultant erosion. Floods and uncontrolable high water became increasingly and alarmingly frequent in many localities, reservoirs and irrigation systems silted up rapidly, washouts were numerous, fields were covered with boulders and debris brought down from the adjacent mountains, and the streams became too muddy during flood periods for fish to live in them. The denuded watersheds also lost much of their original grazing value through the dissappearance of many of the palatable forage plants and on account of the decreased carrying capacity larger areas were needed each year to furnish range for the great herds of cattle and sheep which have given Utah such a prominent position in the live stock industry. These are some of the extreme conditions existing when most of the forested public domain of the west was placed under federal control with the creation of the National Forests. They were authorized by congress under the organic and administrative acts of March 3, 1891 and June 4, 1897. The majority of the National Forests were established mainly through the subsequent untiring efforts and far-sighted policy of President Roosevelt. It is thus that the forest conservation movement came to Utah *en masse*.

Let us consider for a moment the forests of Utah in relation to the economic development of the State. The mountains of Utah form the foundation of the wealth of the State, and its continued prosperity will depend to a large extent upon the manner in which these mountain lands are managed. Since the National Forests of Utah are confined almost wholly to the mountainous areas or high plateaus, the management of the National Forests for all time on a permanent sustained yield basis is of the utmost importance in the economic and sociological welfare of the State. The National Forests furnish irrigation water, timber products and summer range for live stock, all three of which have a most direct bearing upon its economic development.

The National Forests of Utah provide summer range for the grazing of nearly 190,000 cattle and horses and more than 800,000 sheep and goats. Other uses having both a sociological and economic bearing on the prosperity of the State include the development of forest roads and trails, the reservation of forest areas for recreational activities and the preservation of fish and game.

The National Forests of the State comprise approximately seven million acres, the greater part of which is potential forest land, which is estimated to bear a stand of about ten billion board feet, composed of pine, spruce, fir, aspen and cedar. There is now manufactured annually in Utah approximately twenty-six million board feet of lumber besides minor forest products. This material is mainly rough lumber, being cut by small portable sawmills from areas already culled over and from those of virgin timber remote from industrial centers. The consumption of lumber and allied products in Utah amounts to over two-hundred million board feet per annum, or approximately eight times as much as is manufactured locally. It requires about eighty years to grow a crop of aspen and in the neighborhood of 200 years to grow western yellow pine sawtimber. It is of course true that pulpwood, excelsior material, match stock, railroad ties and mine props can be grown in a much shorter time, but for the purpose of the present discussion let us consider that an average of 150 years is necessary to grow a new crop of timber suitable for the market. The ten billion feet then, will give us an allowable annual cut of sixty-seven million board feet from our National Forests in Utah without depreciating the present forest capital or stand of growing timber. On this basis the present forest resources of the State could meet only about 34 per cent of the present demand. How will the increased demand which is certain to come with an increase in population and further colonization be met? Of the present demand approximately 87 per cent is now supplied from the Pacific Coast. The present supply could accomodate an increased demand of about forty million board feet without changing the amount imported, or it could reduce the present importations to about one hundred thirty-five million board feet with the consumption remaining as at present. It is therefore evident that Utah is not now and never will be self-sustaining in the matter of lumber and forest products.

We should here stop to consider the logic of relying upon the Pacific Coast to supply the greater part or all of our needs indefinitely. The East is already cut out. The Lake States are now making large importations of lumber and other forest products. The best data available show that the great southern pineries will be cut over in not to exceed ten years. The Pacific Coast, therefore, is the only region left from which the country as a whole can draw its supply. Will this region, whose supply is popularly considered inexhaustible (as has also been the case with the East, the Lake States and the South) be able to supply the increasing demand forever? The best statistics available do not bear out this assumption. It is probable that the Pacific Coast region will also be cut out in something like 50 years. With prevailingly high freight rates, increased settlement of agricultural land and the depletion of the forests of the Northwest, it is becoming very evident to students of forest economics, that each State will be required to provide its own timber to the extent of maintaining all potential forest land in a productive condition.

The rough, spiral grained, knotty product available today is scarcely a fair sample of the class of material our forests are capable of producing under proper silvicultural management. Our accessible forests have suffered from being repeatedly culled of the best material so that in many cases inferior trees are left. Clear, straight-grained spruce and fir grown in the State has been used in the manufacture of musical instruments possessing excellent tone qualities, and one familiar with the earlier buildings erected in Salt Lake City from large timbers secured on the Wasatch mountains appreciates something of the potentiality of the forests of Utah.

The continued prosperity of the agricultural communities is of paramount importance to the State. This is one of the primary aims of the Forest Service and is being fostered through watershed protection, timber production and properly regulated grazing. Watershed protection and timber production were really the basic statutory reasons for establishing National Forests in Utah. The management plans of the Forest Service contemplate adequate fire protection, increasing the productivity of the present cut-over stands, and judiciously cutting the virgin timber on a conservative basis with ample provision for regenerating the stand, the keynote of which is expressed in the fundamental principle of preserving the continuity of the watershed cover and still permitting as great a production and utilization of the timber and forage crops as is compatible with necessary watershed protection.

It is very evident, therefore, that every acre of potential forest land in Utah must be adequately protected and made to produce the greatest amount of merchantable material in the shortest possible time and improve the vegetative cover, soil conditions and the streamflow of the watersheds.[3]

[3]This paper was followed by a series of lantern slides which illustrated more clearly what the Federal Government is actually doing to conserve the forests of Utah through the practice of forestry.

FOREST TREE DISEASES.

BY A. O. GARRETT.

The subject of "Forest Tree Diseases" is indeed a very comprehensive subject to be discussed in the very brief time allotted to me for this paper. For such diseases fall under two general heads: those caused by insects and other animals, and those caused by plants, (not considering still a third type caused by physiological disturbances, etc.)

In order to limit the content of the paper, I shall discuss only those diseases caused by plant parasites and saprophytes and further limit this to those which have been found in Utah.

Of plant parasites which are Spermatophytes, or flowering plants, doubtless the most conspicuous are those belonging to the mistletoe group. As occurring in Utah, these are found on coniferous trees only; and so far as I can recall, in the southern portion of the state only, Manti being my northernmost Utah locality. Mr. I. E. Diehl informs me that he has collected *Razoumofskya divaricata* on *Pinus monophylla* and *Phoradendron juniperinum* on *Juniperus utahensis*, both in the Tintic Mts., Juab Co. At Manti is found *Razoumofskya divaricata* (Engelm.) Kuntze (*Arceuthobium divaricatum* Engelm.), the common mistletoe on *Pinus edulis*, the pinyon pine. I have also collected this species in the La Sal Mts., and it is probably to be found wherever the pinyon pine is to be found. Another species, *R. americana*, is found in Colorado, and probably occurs in Utah. Along the brink of Bryce's Canyon all the pines are "shot to pieces" by mistletoe infection. *Pinus edulis* has the first named mistletoe; *Pinus scopulorum* (the yellow pine) has *R. cryptopoda* (Engelm.)

Coville; *Pinus flexilis* (limber pine) and *Pinus aristata* (bristle-cone pine), *R. cyanocarpa* A. Nelson. *Pseudotsuga mucronata* (Douglas spruce) is parasitized by *R. Douglasii* (Engelm.) Kuntze, from Bullion Canyon, Marysvale and southward, being especially conspicuous in the Abajo Mountains in San Juan County. Our cedar trees, especially *Juniperus scopulorum* and *J. utahensis* have large bunches a foot or more in diameter of the cedar mistletoe, *Phoradendron juniperinum* Engelm., especially conspicuous in the southernmost tier of counties in the State.

Only the barest beginning has been made toward the collecting and determining of the fungi of Utah that attack forest trees. This is particularly true of the higher fungi which are classified together under the popular name of "wood-rotting fungi"—those that caused so much concern during the war for fear they had caused incipient decay in the lumber used for airplanes. Consequently experts examined the timber carefully to see if there was any trace of these insidious foes which would cause a wreck, possibly at the most critical moment. The mycelial threads of these fungi penetrate the wood, and then secrete enzymes which digest the lignin of the cell-walls. Of course when this is done, the strength of the piece of wood is a thing of the past. Among the conspicuous examples of these fungi occurring in Utah may be mentioned the "oyster-fungus", (*Pleurotus sapindus* and *Polystreatus*) found on poplar-trees wherever wounded, especially when pollarded. These fungi are stemless horizontal mushrooms. One sometimes finds *Fomes ignarius* occurring regularly by the old leaf-scars on the trunks of *Populus tremuloides*. The writer has made collections in Daniel's Canyon and in the Fish Lake Mountains. Again, a "punk" found on the birch (*Betula fontinalis*), is *Polystictus cinnabarinus*, easily recognized by its cinnabar-red color in contradistinction to the common *Polystictus versicolor* also occurring in the State on the same and other hosts. The latter fungus is often known as "shelf-fungus". *Polystictus stuppeus* often occurs on dead poplar stumps—quite common at Payson. *Poly-*

porus valvatus has been collected on dead *Picea Engelmanni* near Lake Mary, Big Cottonwood Canyon; *Polyporus adusta* on dead poplar stumps at Santaquin; *Polyporus alboluteus*, "cream puff fungus", common in our canyons; *Polyporus elegans; Fomes megaloma; Fomes ungulatus* (Schaeff.) Sacc.; *Fomes lobatus* Schw.; *Fomes ellisianus* on *Shepherdia argentea* Nutt. (buffalo-berry); *Lenzites sepiaria* Fr. on coniferous logs. These are but a few of the "wood-eating" fungi of the State.

Among the lower Basidiomycetes, there are a number of rusts that do more or less damage to the forest trees of the State. The list is far from complete, but as made up at present consists of the following twenty-two species:

1. Coleosporium ribicola (C. & E.) Arth.

I. (æcial stage) on needles of *Pinus edulis*. Not yet found in Utah.

II. (uredinial stage). On *Ribes inebrians* Lindl. Beaver Canyon above Beaver; Bears' Ears, Elk Mts., San Juan County; Maple Canyon, branch of Coal Canyon, near Cedar City, Iron County; First Left-hand Fork Parowan Canyon, near Parowan, Iron County; Fish Lake Mountains above Fish Lake, Sevier County.

2. Cronartium filamentosum (Peck) Hedg. & Long.

I. On *Pinus scopulorum* (Engelm.) Lemmon. Known only in Utah from Bryce's Canyon, where it is abundant, and rapidly killing the yellow pines.

II, III. On various species of *Castilleja, Orthocarpus, Pedicularis*. Collected in Utah on *Castilleja linariæfolia* Benth. near Monticello, San Juan County.

3. Cronartium occidentale Hedgc., Bethel & Hunt.

I. On *Pinus edulis*. Collected in Utah at Marysvale, Piute County; Parowan Canyon, near Parowan, Iron County; McKee's Ranch, near Vernal, Uinta County; Monticello, San Juan County.

II, III. On various species of *Ribes* and *Grossularia*

On *Ribes aureum* Pursh. Collected in Utah at Santaquin, Utah County; Richfield, Sevier County; Manti, Sanpete County; Marysvale, Piute County; Panguitch, Garfield County; Mt. Carmel, Kane County; Currant Creek, Duchesne County; Morgan, Morgan County; Lewiston, Hyrum, and Mendon, Cache County; Beaver, Beaver County; Parowan Canyon, Iron County; Hinkley, Holden, Oak City and Scipio, Millard County.

On *Ribes inebrians* Lindl. Beaver Canyon, Beaver County;

On *Grossularia leptantha* (A. Gray) Cov. & Britton: Beaver Canyon just below Upper Telluride Plant, about twelve miles above Beaver, Beaver County.

On *Ribes odoratum* Wendl. Springdale, Washington County.

On *Grossularia inermis* (Rydb.) Cov. & Britton: Monticello, San Juan County.

This rust is of especial interest because the unredinial and telial stages, found on currants and gooseberries, are indistinguishable from the corresponding stage of the very destructive white pine blister rust of the east, against which the Federal Government is making such a determined fight.

4. Cronartium pyriforme (Peck) Hedg. & Long.

I. On *Pinus scopulorum* (Engelm.) Lemmon. One collection only has been made in Utah—headwaters Provo River, Wasatch County.

II, III. On *Comandra pallida* A. DC. Holiday Park, Uinta County; Spring Hollow, Logan Canyon, Cache County; near Vernal, Uinta County; near Salt Lake City.

5. Gymnosporangium Betheli Kern.

I. On *Cratægus rivularis* Nutt. Logan Canyon, Cache County; and Parley's Canyon, Salt Lake County.

III. On *Juniperus scopulorum* Sarg. Gilluly Station, Utah County.

6. Gymnosporangium clavariæforme (Jacq.) DC.

I. On *Amelanchier pumila* Nutt. Abajo Mts., San Juan County; on *Amelanchier* sp., Fish Lake Mts., above Fish Lake, Sevier County.

III. On *Juniperus Siberica* Burgsd. Not yet reported from Utah, although the host is abundant in the Fish Lake Mts. in immediate proximity with the infected Amelanchiers.

7. Gymnosporangium gracilens (Peck) Kern & Bethel

I. On *Philadelphus occidentalis* A. Nelson. Dry Wash, south of Abajo Mts., San Juan County and Zion National Park, Washington County.

III. On *Juniperus utahensis* (Engelm.) Lemmon: Witbeck's Ranch, near Vernal, Uinta County.

8. Gymnosporangium inconspicuum Kern.

I. On *Amelanchier prunifolia* Greene: Zion National Park, Washington County; on *Amelanchier Jonesiana* C. K. Schneider: Parowan Main Canyon above Parowan, Iron County; on *Amelanchier utahensis* Koehne: Zion National Park, Washington County, and head of Dry Wash near Abajo Mts., San Juan County; On *Amelanchier alnifolia* Nutt.: Head Dry Wash near Abajo Mts., San Juan County; Dry Canyon, Cache County; mouth Weber River.

III. On *Juniperus utahensis* (Engelm.) Lemmon: Maple Canyon branch of Coal Creek Canyon, above Cedar City, Iron County; Parowan Main Canyon opposite Second Left-hand Fork, above Parowan, Iron County.

9. Gymnosporangium juniperinum (L.) Mart.

I. On *Sorbus scopulina* Greene (mountain ash). Not yet reported from Utah.

III. On *Juniperus Siberica* Burgsd.; Bullion Canyon, above Marysvale, Piute County.

10. Gymnosporangium juvenescens Kern.

I. On *Amelanchier oreophila* A. Nelson, Bullion Canyon, near Marysvale, Piute County; On *Amelanchier Jonesiana* C. K. Schneider: Coal Creek Canyon, near Cedar City, Iron Co. On *Amelanchier polycarpa* Greene: Maple Creek Branch Coal Creek Canyon, near Cedar City, Iron County.

On *Amelanchier utahensis* Koehne: Coal Creek Canyon, near Cedar City, Iron County.

III. On *Juniperus scopulorum* Sarg.: Bullion Canyon, near Marysvale, Piute County; Parowan Main Canyon, near Parowan, Iron County; Coal Creek Canyon, near Cedar City, Iron County. This rust causes the leaves to become needle-like, and produces large fasciations or "witches-brooms", as they are often called.

11. Gymnosporangium Kernianum Bethel.

I. On *Amelanchier.* Not yet reported from Utah.

III. On *Juniperus utahensis* (Engelm.) Lemmon:

Witbeck's Ranch, near Vernal, Uinta County; Bullion Canyon near Marysvale, Piute County.

12. Gymnosporangium Nelsoni Arthur.

I. On *Amelanchier mormonica* C. K. Schneider: Beaver Canyon, near Beaver, Beaver Co.; on *Amelanchier polycarpa* Greene: Beaver Canyon above Beaver, Beaver County; on *Amelanchier alnifolia* Nutt.: Fish Creek Canyon, western Sevier County; City Creek Canyon, Salt Lake County; on *Peraphyllum ramosissimum* Nutt.: Asays, Garfield County.

III. On *Juniperus scopulorum* Sarg.: Mill D Flat, Big Cottonwood Canyon, Salt Lake County; Logan Canyon, Cache County; McGee Canyon near Santaquin, Utah County; Maple Canyon Branch of Coal Creek Canyon, above Cedar City, Iron County; Parowan Main Canyon near Parowan, Iron County; on *Juniperus utahensis* (Engelm.) Lemmon: Price, Carbon County; Manti, Sanpete County; head Mammoth Creek above Panguitch Lake, Garfield County; Maple Canyon branch of Coal Creek Canyon, above Cedar City, Iron County.

This *Gymnosporangium* is probably present wherever its telial hosts are to be found. It is the most widespread cedar-apple of the State.

13. Melampsora albertensis Arthur

I. On *Pseudotsuga mucronata* (Raf.) Sudw.: Coal Creek Canyon, about 14 miles above Cedar City, Iron County.

II. On *Populus tremuloides* Michx.: Abajo Mts., near West Mountain, San Juan County; Spring Hollow, Logan Canyon, Cache County.

14. Melampsora Bigelowii Thum.

I. On several species of *Larix*. Not yet reported from Utah.

II, III. Reported from Utah on various species of *Salix*, but probably in many cases confused with the following species. All collections should be carefully re-examined.

15. Melampsora confluens (Pers.) Jackson

I. On *Grossularia inermis* (Rydb.) Cov. & Britton: Gogorza, Summit County; Brighton Resort, Big Cottonwood Canyon, Salt Lake County; Henry Ranch above Panguitch Lake, Garfield County. On *Grossularia leptantha* (A. Gray) Cov. & Britton: Henry Ranch above Panguitch Lake, Garfield County. On *Ribes Wolfii* Rothr.: Brighton Resort, Big Cottonwood Canyon, Salt Lake County.

II, III. On *Salix Watsonii* (Bebb) Rydb.: Gogorza, Summit County; East Canyon, Summit County. On *Salix Schouleriana* Barratt: Parley's Canyon, Salt Lake County. This is one of the most congenial hosts for this rust.

16. Melampsora Medusæ Thum. ?

II. On *Populus angustifolia* James: Wasatch Resort, Little Cottonwood Canyon, Salt Lake County.

17. Melampsorella elatina (Albert & Schw.) Arth.

I. On *Abies lasiocarpa* (Hook.) Nutt.: Manti National Forest, Sanpete County; Strawberry Valley, Uinta County. On *Picea Engelmanni* (Parry) Engelm.: Manti National Forest, Sanpete County; Coal Creek Canyon above Cedar City, Iron County. On *Picea pungens* Engelm.: Manti National Forest, Sanpete County.

II. On *Cerastium scopulorum* Greene: Abajo Mts. near West Mountain, San Juan County; on *Cerastium Behringianum* Regel: Gold Basin, La Sal Mts., San Juan County. On *Stellaria borealis* Bigelow: Brighton Resort, Big Cottonwood Canyon, Salt Lake County.

18. Melampsoropsis Arctostaphyli (Dietel) Arthur.

I. Unknown—to be looked for on leaves and cones of *Picea*.

II. On *Arctostaphylos Uva-Ursi* (L.) Spreng.: Fish Lake, Sevier County. Very rare.

19. Melampsoropsis pyrolæ (DC.) Arthur

I. On cones of *Picea*. Not yet reported from Utah.

II, III. On *Pyrola uliginosa* Torr.: Big Cottonwood Canyon, Salt Lake County. On *Pyrola secunda* L.: Silver Lake, Big Cottonwood Canyon, Salt Lake County.

20. Pucciniastrum Myrtilli (Schum.) Arthur.

I. On *Tsuga*. Not yet reported from Utah.

II. On *Vaccinium cæspitosum* Michx.: above Brighton Resort, Big Cottonwood Canyon, Salt Lake County. On *Vaccinium globulare* Rydb.: Uinta Mts., Uinta

County. On *Vaccinium* sp., Strawberry Valley, Uinta County.

21. Pucciniastrum pustulatum (Pers.) Dietel

I. On leaves of *Abies*. Not yet reported from Utah.

II, III. On *Epilobium adenocaulon* Haussk.: Red Butte Canyon, Salt Lake County; Upper Falls, Provo Canyon, Utah County; Fish Creek Canyon, Sevier County; on *Epilobium anagallidifolium* Lam.: Silver Lake, Big Cottonwood Canyon, Salt Lake County; on *Epilobium Drummondii* Haussk.: near Silver Lake, Big Cottonwood Canyon, Salt Lake County. On *Epilobium brevistylum* Barbey: Silver Lake, Big Cottonwood Canyon, Salt Lake County; on *Epilobium stramineum* Witbeck's Ranch, near Vernal, Uinta County.

22. Pucciniastrum pyrolæ (Pers.) Dietel

I. Unknown; to be looked for on leaves of *Picea Abies* and *Tsuga*.

II, III. On *Pyrola uliginosa* Torr.: Red Butte Canyon, Salt Lake County; on *Pyrola secunda* L.: Silver Lake, Big Cottonwood Canyon, Salt Lake County.

Among the Ascomycetes, or sac-fungi, perhaps the most conspicuous is the black knot on wild choke cherries, etc., caused by *Plowrightia morbosa*.

Among the Fungi Imperfecti there are a great many leaf-spots attacking the leaves of the trees, in some cases doing serious damage. For several years one of these leaf-spots has seriously affected the leaves of the cultivated horse-chestnuts in Salt Lake City. Another (*Septoria negundinis* Ellis & Everh.) was so bad on the leaves of the box-elders in front of the entrance to the Wiley Camp at Zion National Park, Washington County, that every leaf seemed to be diseased. It was said at the Park that the leaves "had been frosted"!

Little can be done toward developing an effective program of forest conservation until the occurrence and distribution of the plant diseases in the State are definitely known. More attention should be given to this phase of the subject, which offers so much in the way of discovery to the individual who would follow it, and still so much more in the way of increased forest yields to the generations to come.

FORESTS AND FISH AND GAME CONSERVATION.

BY S. B. LOCKE.[1]

THE NATIONAL FOREST POLICY AND FISH AND GAME.

As stated by other speakers the principles governing the establishment of the National Forests are the protection of timber and of watersheds. The general policy as far as is consistant with the above principles is to have them serve their highest use. There has been a definite recognition of the value of the fish and game, particularly in connection with the recreation uses of the Forests. Although not assuming jurisdiction over the fish and game, the latter being in the State, the Forest officers have been expected to give all the attention possible to game protection, stocking streams and to creating a public sentiment favorable to wild life protection. Through cooperative agreements with the State Game Department they have received appointments as game wardens and in many section have been the sole protectors of fish and game.

The National Forests in Utah include the greater part of the big game areas and at least the headwaters of all the best fishing streams. The management of these areas to perpetuate the forests and maintain a constant stream flow will at the same time provide conditions necessary for the existance of our birds, animals and fish. In fact, there will no doubt be a modification of the management for timber production purposes, grazing, etc., on areas having a very high value for recreation

[1]Fish and Game Cooperation, Forest Service, Ogden, Utah.

purposes, which is closely connected with the maintenance of the fish and game supply.

VALUE OF FISH AND GAME.

There have been reported in 1920 from the National Forests of Utah, 13,480 deer, 660 elk, 196 mountain sheep and 5 antelope. Of these the deer and the elk are on the increase, the others being stationary. The production of trout may be realized when a conservative estimate places the catch from Fish Lake alone as about thirty tons. With proper management there could be produced annually a half million pounds of fish and several thousand big game animals.

The greatest value of the fish and game is not from a food production standpoint, however, but from the recreation which is furnished. No matter how wonderful the scenery in any section, the tourist will enjoy it much more if there is an abundance of wild animals whose habits may be observed under natural conditions or if fishing may be enjoyed. One soon tires of mere scenery but there is always something new to be learned in wild life study and the further one goes in this the more fascinating such studies become. For the fisherman there is always a big trout to be caught in the next pool; or for the hunter, a better trophy to be obtained next season.

The fishing and hunting instincts are firmly implanted in man and their exercise provides recreation highly prized. It might be mentioned here that as early as 200 B. C., Theocritus mentions "The bait fallacious suspended from the rod." Martial in about 100 A. D. writes "Who hath not seen the sarus rise, decoyed and caught by fraudful flies." This illustrates the antiquity of the fly fishing which by most people would be considered a modern development.

Utah has wonderful attractions for the tourist but the length of time and the amount of money such people spend in the State will depend on the fishing and the opportunity for wild life study. Over 90,000 tourists visited the National Forests of Utah in 1920 and spent over $300,000. Practically every tourist's car has its supply of fish rods. One of our supervisors in reporting on the number of tourists visiting his Forest makes the note, "Every tourist a fisher." Each day a tourist stays to fish or hunt means at least $5.00 spent in the State.

PRINCIPLES OF MANAGEMENT.

In order properly to manage our wild life resources, particularly the fish and game, certain definite action is necessary. Protective measures, as well as methods to increase the production of fish and game, must be based on correct information regarding natural history. The public and particularly the sportsmen, must appreciate the reasons for such measures and provide a public sentiment that will demand their being carried out. The administration of the game department must be such as will sincerely strive to improve conditions and have the interests of the sportsman at heart.

In this connection let me emphasize the necessity for the wild life enthusiast and the naturalist to recognize the great number of men who are just ordinary sportsmen. Working by himself the naturalist plays rather a lone hand but by active cooperation with the sportsmen he can give them much information they are anxious to obtain and can do considerable in encouraging better sportsmanship. In the end it is the attitude of the average man which governs the success of protective measures and it is through him that the greatest results can be obtained.

RESPONSIBILITY OF SCIENTIFIC MEN.

It will be clear to anyone that if we are to plan properly for a continuous supply of fish and game we must have an intimate knowledge of the life history of the various forms and their reactions to outside influences. As in other forms of conservation, dependance for such information must be made on scientific men.

There are very often proposals made and even enacted into laws which scientific knowledge can show are absolutely worthless or even a disadvantage to the perpetuation of fish or game species.

I could list many cases of wasted or ill directed effort that could have been prevented and also many unsolved problems. A scientific study of Douglas Lake, Wisconsin, showed that during August there was insufficient oxygen below the thermocline at about thirty feet to support fish life but thousands of deep water fish had been planted there in an attempt to establish such species. In fact very few attempts have been made to gather data that can be used in planning for the future of our wild life and most measures have been taken in a haphazard way.

The scientific man has an immense amount of important work ahead of him in this line, in investigations, experiments and education. Why does one game bird respond to protection while another increases scarcely at all under absolute protection? To what point may we allow the killing of the males of our big game animals? How can we save losing millions of ducks by alkali poison? In some waters trout thrive wonderfully while in others they do not. What governs this and how can we increase the productivity of our fish waters? There are many such questions and thousands of dollars will be wasted until we can make such investigations as will enable us to answer them.

When the scientific man takes an active interest in such problems and can cooperate with the sportsmen to enact laws and undertake plans of management based on correct biological principles, a great step in advance will be made in providing the opportunity for our sons to enjoy the rich heritage of wild life which has been ours.

FORESTS IN RELATION TO CLIMATE AND WATER SUPPLY.

BY J. CECIL ALTER.[1]

The modifying influence of forests on climate makes them a refuge in winter for wild fowl and game animals, and a retreat in summer for domestic livestock, and vacation seekers. Without their coolness and freshness in summer the forests would be far less attractive as resort regions; and without their alleviating influence on winter storms there would be less haven for the wild life that inhabits them.

Wind breaks have for many years been scientifically constructed about the farmsteads of the plains states. Smaller trees or large bushes are set to windward, and next to these are successive rows of higher varieties, the last line to the leeward being trees of some large type. This barrier causes the winds to glance aloft, and provide shelter for livestock and the premises to the lee.

Wind breaks and shelters composed of fruit and shade trees are carefully provided throughout the flatter, windier sections of Utah, where water is available. Some of the major projects in hand by certain commercial and development organizations in western Utah are the planting of trees to render the region more sheltered for birds, animals, and persons, in their meteorological aspects.

The cooling influence of the forests, noted in the formation of local clouds at times, and in the downdrafts encountered by aviators, may extend several thousand feet aloft, but the horizontal cooling influence does not extend far outside the forest confines.

This influence has been credited with causing precipitation, but while the theory has a few arguments and factors in its favor, the influence is very slight. The forests in general exist where they do as a result of favor-

[1]Meteorologist, United States Weather Bureau, Salt Lake City.

able precipitation, rather than as a result of their influence in attracting precipitation.

The great unbroken forest covers of the Sierras, and the Pacific northwest, are a result of the heavy winter rains and snows; and the beautiful forest blanket over the Yellowstone region is due to the ample moisture in both winter and summer. Indeed, there are limited regions where the canyon air movement prevents the seeding of trees, though moisture be abundant.

In the process of transpiration the loss of moisture in conifers amounts to from 100 to 200 times the weight of dry matter produced, according to an investigator. This amount is comparatively small, as will be noted in examining the weight of water actually escaping in this manner. Even in this western region where precipitation is light, and much needed, the transpiration losses do not seem greatly important.

A greater loss results from interception, in which process rain water is suspended on the foilage and subsequently evaporated. The conifers catch much greater amounts of water in this manner than do the broad-leaved trees. The amount may, according to a study by Robert E. Horton, reported in the Monthly Weather Review recently, amount to from 0.02 to 0.07 inch per shower, though manifestly the amount per acre will vary with the density of the forest cover, and the height of the trees.

The loss is estimated, from studies made by Mr. Horton, to range from 25% to 100% of the total rainfall, depending on the rate, duration, and amount of the rainfall. The average is given somewhere around 25% to 40%. This loss thus becomes rather important at times, since the rain interception comes in summer chiefly, when rain is most needed.

There is a modifying influence of the forest on the amount of general evaporation of the moisture that is comparatively important, due to the diminished wind movement, the lower temperatures, and diminished insolation. Evaporation losses in Utah from a free water surface may reach five feet in a summer. Raphael Zon, in a paper on forests and water conservation, uses the statement that the evaporation loss from an area covered by low vegetation will be about one-third the precipitation received, and in an evergreen forest about one-tenth the precipitation. Assuming a Utah mountain side to receive an average of 12.00 inches of precipitation in a summer, the forest areas would lose only 1.20 inches.

The greatest influence of the forest in this general respect is in controlling or modifying the streamflow. The spring freshet curves are greatly flattened, and the late summer depressions due to droughty weather are appreciably raised. The feeder streams that live through the summer, originate in the forests, as all fishermen and outdoor men well know.

The cooler weather in the forests retards the melting of the snows, and there is much less sunshine because the forests of Utah lie chiefly on the northerly slopes, away from the sun. Many glacier-like piles of snow accumulate in the lee of high ridges, and especially in amphitheatres from which several slopes shed their snowslides. The seepage from these piles of snow in important locations, like the district near Spanish Fork Mountain, maintains a thin cluster of trees a short distance below the tail of the snow pile. However, even assuming the drift to be several acres in extent, thirty to forty feet deep, and of a density of 60% to 75% at most, the actual number of acre-feet of water is not great, as compared with the snowfall over the watershed as a whole.

Forests retard surface runoff by offering material obstruction to the flow, and by preventing gulleying and hence the formation of large heads of water. They serve also to filter and purify to a certain extent, the water collected in the basins. At Jacob's Lake Ranger Station, on the Kaibab National Forest in Arizona, an unusually heavy downpour of rain caused broad sheets of water broken up by small waves, to advance from the forest to a natural reservoir.

The pine cones, needles, small sticks and grass served to keep the flowing water divided into relatively thin streams, though tiny white caps piled up everywhere as the heavy flow was temporarily blocked by the debris, here and there. After the storm ceased the pool of water was scarcely riled, and nearly clear.

Our camp on the previous night, at a desert watering place southeast of Kanab, Utah, was in a region mostly bare, but supporting some sage brush and greasewood. The rainfall from previous storms had been impounded by throwing a dam across an arroyo. This pool was so befouled by the collection of all the debris for many rods roundabout that stock drank from it reluctantly.

Cloudbursts, socalled, are reported more frequently from certain sections than formerly, though this is probably not so much a fact about the rainfall as about the condition of the watershed. A badly denuded watershed sheds its water abruptly and after heavy rains it accumulates with great rapidity and great power, befouling the water supply temporarily, silting reservoirs detrimentally, and endangering controlling works and other improvements in the path of the flood waters. Settling tanks are thus necessary in handling Salt Lake City's water supply originating in thinly forested watersheds.

An important instance of the effect of a denuded watershed in causing floods occured near Salt Lake City July 24, 1916. The shower at the Weather Bureau gage in Salt Lake City business district amounted to 0.43 inch; at the University on the east bench, 0.35 inch, and at the High Line intake in City Creek five miles northeast of the city, 0.85.

Assuming with reasonable safety that the storm over the adjacent mountain slopes was fairly uniform in City Creek and in Dry Canyon next to the south, the latter should have shown a lighter discharge of water, all other things being equal, because it is shorter, heads lower, and consequently would receive much less precipitated moisture.

As a matter of fact, the flood was so great in Dry Canyon, where forest and brush areas are scanty, and where grazing has been continuous many years over the lower sections, that several cattle were destroyed, and the bodies of some animals were washed out of the canyon. The roadways were also badly damaged. In City Creek, where there has been no grazing for many years, and the brush and vegetative cover has become comparatively heavy, and small areas of forest remain, the runoff from the storm was so light, as measured twice a day at the intake, its presence in the records was not observed.

THE ANALYTICAL DISTILLATION OF SHALE-OIL.[1]

BY MARTIN J. GAVIN.[2]

It may be well, before beginning the discussion of the subject of this paper, briefly to outline the nature of the investigations of the Bureau of Mines on the oil-shale resources of the United States. Investigations on oil-shale were begun by the Bureau in 1916 as it was realized that the shale resources of the country would ultimately become important sources of hydrocarbon oils, and possibly other products. Oil-shale studies were only getting well under way when the United States entered the Great War, and the full attention of the Bureau was directed to matters relative to the conduct of the war. After the armistice was signed, the staff working on oil-shales was increased, and the work reorganized. At the present time, the Bureau is conducting work on oil-shales in three laboratories, i. e., The Pittsburg, Pa., Experiment Station, where microscopic studies of different oil-shales are being made; The Boulder, Colorado, Cooperative Oil-Shale Laboratory, where work is being done on Colorado oil-shales in cooperation with the State of Colorado, and the Intermountain Experiment Station of the Bureau of Mines, Salt Lake City, Utah, under cooperative agreement with the Department of Metallurgical Research of the University of Utah.

The investigational work now being conducted may be grouped under three headings: First, the microscopic examination of different shales, which is expected to throw much light on the nature, origin and composition

[1]Presented by permission of Director, United States Bureau of Mines.

[2]Oil-Shale Technologist, United States Bureau of Mines.

of the shales and the mechanism of the thermo-chemical process by which the organic matter of oil-shale is converted into oils and gases; second, the determination of certain physical and chemical constants for various oil-shales, without which it would be impossible to design efficient apparatus for the treatment of this material; and third, the determination of those conditions of retorting—that is distilling the shale—which will produce the greatest yields of the best oils from different shales. This phase of the work is now receiving the greatest amount of attention at the Boulder and Salt Lake City laboratories. It might be remarked that all the work is directed by one technologist and that each laboratory is at all times kept well informed of the results and progress of the investigations in the others.

In making studies of the effects of different applied retorting conditions, it is necessary, of course, to determine the quantity and quality of products formed in any test, and from these to determine exactly what the effect of the applied condition or conditions of retorting has been. The quantity of gas recovered during the test is measured, and samples are taken at various intervals during the run, as well as a sample of the total gas produced. The gas samples are then examined in the customary manner. Water recovered from the retort is tested principally to determine its content of ammonia and other nitrogen compounds. The spent shale is examined to indicate completeness of oil production, and to determine percentage of fixed carbon, which gives information as to the nature of retorting. A high fixed-carbon percentage in the spent shale usually indicates that conditions of retorting were not favorable for production of either a maximum quantity of oil or oil of good quality.

Most attention is directed to the quantity and quality of oil recovered, as oil is the most important product recovered from oil-shale, and the quantity and quality of oil recovered differs with different shales, and with slight changes in the conditions under which the oil was produced. It is not difficult to determine the quantity of recovered oil, although shale oils emulsify with water with extreme ease, and the percentage of water in the oil must be determined by distillation of a portion of the oil with a light solvent, measuring the amount of water distilled, and applying this percentage as a correction to the total oil produced.

The oil is also examined to determine percentages of nitrogen and sulphur, as these indicate, to a certain extent, the suitability of the oil for refining or direct use. It may be said, as a general rule, that the presence of sulphur or nitrogen in shale-oil is not desirable.

The quality of a shale-oil can be best determined by subjecting it to a fractional analytical distillation, and examining the fractions so made.

The method in use in the oil-shale laboratories of the Bureau of Mines for the analytical distillation of shale-oil and petroleum has been developed, with the exception of minor details, by Dr. E. W. Dean, petroleum chemist of the Bureau, and has been described by him in various publications. Bulletin 209 of the Bureau of Mines, by Dr. Dean, now in press, describes the distillation apparatus and method in detail. Briefly, as applied to shale-oils, it is as follows:

The specific gravity of the oil is first taken, and as most shale oils are semi-solid at the temperature to which specific gravities of petroleum oils are referred (60°F), it is necessary to use a pycnometer or specific gravity bottle adapted for heavy oils or tars for this purpose. A low specific gravity ordinarily can be taken to mean that the oil contains a large percentage of paraffin hydrocarbons. The setting point of the oil is next taken. The setting point of the oil is that temperature at which a drop of oil frozen on the tip of a thermometer bulb melts and flows down the stem of the inverted thermometer. A high setting point is an indication of a high content of solid paraffin in the oil. Viscosity of the oil at a standard temperature is next taken, and is of present value as an indication of the quality of the lubricating oil fractions, and in the future will be of value in making calculations of pipe lines for shale oils.

The weight of 300 cubic centimeters of the oil is next calculated from its specific gravity and this quantity is placed in a standard fractionating flask. This flask is a round glass bulb from the top of which springs a vertical neck. Eight inches up the neck a side neck springs at an angle of 15°. This side neck serves as a vapor outlet, and is connected to a standard vertical water cooled condenser with a well fitting cork. After the oil has been poured into the flask, a wire support is placed in the bottom of the vertical neck, and the column filled for 6½ inches with a small iron chain—jack chain—which serves as a fractionating tower. The thermometer is then placed in the proper position through a cork in the top of the vertical column and distillation started.

The Bureau of Mines uses electrical resistance heaters for distilling petroleum and shale-oil, as the heat can be regulated closely and conveniently, and there is small danger of fire. A variable resistance placed in series with the heater makes for easy control of temperature.

As the oil starts to distill, the vapor temperature when the first drop falls from the delivery end of the condenser is noted, and the rate of heating so adjusted that about two drops of distillate fall into the receiver per second.

The receiver is placed under the delivery end of the condenser, and is usually a graduated glass cylinder. The volume distilled is noted beginning at 50°C, and thereafter for every 25°C rise in temperature. Usually, in the case of shale-oil, the oil distilled is allowed to accumulate in one receiver until the vapor temperature has reached 125°C, when the receiver is changed. Thereafter the receiver is changed for every 25°C rise in vapor temperature, so after the first fraction, each fraction or cut represents the oil distilled while the vapor temperature in the still was rising 25°C. Distillation is completed at a temperature of 275°C, as above this temperature there is danger of the oils decomposing or cracking.

The flask and contents are then allowed to cool so they may be handled without danger, then the chain is taken from the vertical neck of the flask, and two copper gauze cones substituted for it about midway in the neck. The flask is connected to the condenser as before, and to the delivery end of the condenser is connected a vacuum receiver, so the fractions may be taken off under reduced pressure, and that the receivers may be changed without breaking the vacuum. Distillation progresses, as before, under a pressure of 40 mm. absolute. The reduced pressure, of course, lowers the boiling temperatures of the oils in the still and makes possible their distillation without danger of decomposition.

The first fraction taken off under vacuum is that boiling up to 200°C at this reduced pressure, then the tube in the container is shifted by an external connection and successive separate fractions taken for every 25°C rise in temperature up to 300°C. As the distillation progresses the water in the condenser is heated; otherwise the solid paraffin that distills from many shale-oils at high temperatures would congeal in and clog the condenser tube.

The still and residual oil are then cooled and the volume of residue is determined from its weight and specific gravity. The character of the residuum is noted —whether it is of an asphaltic or paraffin nature—; its setting point taken as an indication of wax remaining in it; and a test made to determine the carbon deposited when it is burned under a definite set of conditions—the Conradson carbon test. This test serves to indicate the suitability of the heavy residues for making certain heavy lubricating oils.

All the separate fractions are then examined. Volume and specific gravities of the air distillation fractions are determined for the purpose of calculating percentages distilled and to give an indication of the chemical nature of the oil. Afterwards all the fractions distilled up to 200°C are combined, as are those distilling between 200°C and 275°C, and a test made to determine the percentage of "unsaturated hydrocarbons", or more correctly speaking, the percentage soluble in an excess of concentrated sulphuric acid under certain definite conditions[3] in each combined fraction.

The vacuum fractions are examined; volume and specific gravity of each cut determined, as are also the setting point and viscosity of each, the latter two tests

[3]Unsaturation test is described by E. W. Dean and H. H. Hill, The Determination of Unsaturated Hydrocarbons in Gasoline: Bureau of Mines Tech. Paper 181; 1917, 25pp.

indicating the suitability of each particular fraction as sources of solid paraffin and lubricating oils.

The Bureau of Mines has examined hundreds of samples of petroleum from the different oil fields of the United States and has examined samples of shale-oil made in commercial operations in Scotland. All examinations were made in accordance with the procedure described above, and therefore in examining shale-oils a direct comparison can be made with many other oils whose properties and commercial products are known. Certain characteristics of shale-oils have not yet been directly tied up with corresponding properties of petroleum, but they will be in the course of time. Even now the method described affords an excellent method of determining the quality of a shale-oil.

In its oil-shale work, the Bureau is endavoring to ascertain those conditions most suitable for producing an oil with a high percentage of paraffin hydrocarbons, or in other words, a low percentage of unsaturated hydrocarbons. It is interesting to note that when an oil low in unsaturated hydrocarbons is produced, or rather an oil with a small percentage soluble in concentrated sulphuric acid, all the other desirable properties of the oil follow along with it; there is a high content of solid paraffin wax; the motor fuel fractions are fairly volatile; and the viscosities of the lubricating oil fractions indicate that the oils will be suitable for making lubricants. How durable shale-oil lubricants will be is as yet not known. In general, it is possible to say that the percentage of the oil removed by sulphuric acid under the conditions of the test applied, as applied above, can be used as an index number upon which to base the relative values of shale-oils produced from different shales or the same shale under different conditions.

THE USE OF THE MICROSCOPE IN ORE DRESSING*

BY R. E. HEAD.[1]

The microscope as an instrument for use in research work has long been recognized and its value in this capacity has been established in many branches of scientific endeavor. As an example of one of the more recent applications of the microscope in the field of research, the science of metallography or physical metallurgy is worthy of mention. This science is comparatively young, having been developed within the last fifty years, yet at the present time the use of the microscope as a means of observing and assisting in the determination of the physical properties of metals and alloys has been adopted and used by scientists and manufacturers the world over. Its use as a means of studying the physical characteristics of rocks and minerals has been recognized by geologists as a source for obtaining information which would otherwise either remain unknown or require the use of devious and uncertain methods of investigation for its acquisition. The almost universal use of the microscope in these branches of research has been given much publicity in numerous papers that have appeared in the scientific journals, and in view of the fact that the problems encountered in the treatment of ores possess many features in common with those described in these writings, it appears strange that so little has been published concerning its application and use in ore dressing.

The economic value of an ore deposit depends primarily both on the market price of its metallic content and also on the percentage of this value that can be recovered by general or special reduction processes. The metallic values may be readily ascertained by chemical

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*By permission of the Director, U. S. Bureau of Mines

[1]Metallurgical Assistant, Intermountain Experiment Station of the U. S. Bureau of Mines, Salt Lake City, Utah.

analysis. The treatment of the ore, and the recovery and separation of the minerals into commercial products are matters that in many instances can only be determined by experimental testing and research investigation. While the combined value of the minerals contained in an ore may make quite a respectable total yet the clean-cut separation of minerals from each other is extremely difficult. There are many causes for failure in the treatment of ores, some of which are perhaps unavoidable, but as the underlying principles on which the science of ore dressing is founded deal not only with the chemical nature of the ores but also with their physical properties and characteristics, a thorough knowledge of these factors is essential to intelligent and scientific concentration practice.

Since in so many instances the successful treatment and recovery of the values in the ores depends on the physical condition of the minerals composing them it is of the utmost importance that this information be obtained and placed at the disposal of those engaged in experimental ore testing. The general character of the minerals in an ore may perhaps be deduced from the appearance of the material together with the information gained by a study of the chemical analysis but there is often no means available for checking up on the deductions so formed without recourse to a visual examination of the ore itself by means of the microscope. Chemical analysis serves as an accurate and reliable method for ascertaining the percentage amounts in which the several elements exist in the material which is to be treated but it does not give the remotest clue to the manner in which the minerals, representing these values, are associated. In some ores the character of the constituent minerals is at once apparent from a casual examination, but ores in which the values exist in two or possibly three states of chemical combination it may be practically impossible to determine the relative amounts of the various minerals except by microscopic examination. Even though the ore which is to be treated is known to contain all the value carrying minerals in the sulphide form there is no assurance that these minerals are associated in such a manner that their separation and recovery may be successfully accomplished. It may be that the gangue minerals are of such a nature as to interfere materially with the treatment proposed as indicated by the character of the ore, or that the respective minerals exist in a condition of such intimate association that ordinary methods of treatment would prove unavailing.

The most logical way in which many of the physical characteristics of an ore and its components may be determined is by microscopic examination and it is important that these features should be known before experimental work has actually been commenced. A knowledge of the physical characteristics of an ore and the minerals composing it, gained by microscopic study, together with the information supplied by chemical analysis should form a basis for the experimental testing work which is to be conducted. Cut and try methods of ore testing are expensive since they not only consume considerable time but also require making hundreds of chemical analyses which are expensive and in the end the deductions based on these methods of procedure may be open to grave and well founded doubt. The difficulties encountered in testing may be caused by unknown physical characteristics of the minerals in the ore or their mode of association or may be of a mechanical nature. In many instances it is only after considerable sums of money have been spent in cut and try experimental work leaving results still in doubt that the microscope is applied as a means of last resort. While the microscope will not prove a means of solving all the problems which may arise in the treatment of ores yet it can be relied upon to furnish information that cannot fail to prove of value and when this information is available for application during the preliminary testing the value of its use is proven by the elimination of unnecessary time and labor involved in costly chemical analyses. If the physical characteristics of the minerals in an ore together with their mode of association are known the selection of a proper method of treatment and the creation of conditions most favorable for obtaining good results are a matter of much less experimentation.

It is only after all the obtainable information concerning the physical characteristics of an ore is in the possession of those engaged in conducting testing work that they are properly qualified intelligently to diagnose the difficulties which may arise in the actual testing operation and when thus equipped they may rest assured that in so far as a knowledge of the ore itself is concerned the work is being conducted in a logical and scientific manner.

During the time spent in microscopic work on ores from many widely separated localities the conclusion has been reached that except to somewhat limited extent too little attention has been given to obtaining detailed information concerning the character of the ores undergoing treatment or that when this information is known that it has been acquired only after the expenditure of large sums of money and time in the working out of innumerable cut and try expedients, much of which might have been avoided by applying scientific and logical methods from the beginning.

There are many works ([2]) published containing detailed descriptions of microscopic methods that have been used with success in the various sciences and are the result of years of careful and painstaking investigations by men who have devoted their entire energy to the field of microscopic research. Many of these methods may be applied to the study of ores and minerals from an ore dressing standpoint, some of them without any change or modifications, while others must be varied slightly to conform to the conditions existing in this particular field.

All ores do not present the same problems and in consequence many variations and combinations of microscopic methods may have to be applied during the preliminary work on any particlar ore. Much of the mineral wealth of the United States is represented by ore bodies whose exploitation is beset with difficulties, the greater portion of which are encountered in ore dressing and concentration. The complex sulphide ores are especially typical in this respect. These ores as a rule

[2]Manual of Petrographic Methods, Johannsen; Elementary Chemical Microscopy, Chamot; The Microscope, Gage.

are not particularly high grade, some of them being of such a lean character that it is a question whether means for their profitable treatment are at present in existence. There is one characteristic that these complex sulphide ores possess in common, that is, the minerals of lead, zinc, and iron which carry the values are very intimately associated. It is scarcely possible to conceive the extent to which this intimate association of the minerals exists without recourse to microscopic examination. The microscope shows that it is necessary to resort to extremely fine grinding to liberate the individual minerals, which is necessary in order that they may be recovered and separated into marketable products of lead and zinc. When polished surfaces of specimens of complex sulphide ores are examined under the microscope the nature and extent of this intimate mineral association is readily seen and in order to apply this knowledge in a practical manner it is but a logical step to apply the principles of micrometry.

The average size of the mineral grains as they exist in these ores can be measured by micrometric methods applied during the examination of polished surfaces prepared from representative specimens of the ores in question and with this information as a guide it is not a difficult matter to determine with approximate accuracy, the degree of grinding that will place the ore in a condition in which the mineral grains composing it are most amenable to recovery by the treatment selected. Thus by a small amount of preliminary investigation the basic requirement for successful concentration has been met, i. e.; the mineral particles are freed or unlocked and in a condition in which their separation and recovery is a matter of the application of proper methods of treatment. Nothing could be more simple than this method of gaining the desired information and since it is one of the vital essentials to success in actual practice this procedure should be made use of in mills and ore testing laboratories as a prerequisite to experimental or preliminary testing of ores by the processes of gravity concentration or flotation.

The same method of procedure is indicated in the case of ores in which the value-carrying minerals are disseminated in small grains and particles through the gangue matter. In occurances of this nature the grain sizes may be measured and their average size determined either by a study of polished sections of the ore or the same information may be obtained by the microscopic examination of representative thin sections. This latter procedure is indicated in the case of the disseminated ores, since it permits the determination of the non-metallic minerals composing the gangue and these minerals may have an important bearing on the after treatment of the ore. As a matter of fact the study of thin sections should constitute a preliminary method of analysis almost as essential as that of the study of polished sections.

It is a recognized fact that all sulphide minerals do not respond to like conditions of flotation treatment to an equal degree, some of them being much more readily floated than others which require the application of special methods of treatment together with the use of certain combinations of oils and other reagents which apparently render them more amenable to treatment and increases their recovery. Taking for example a copper ore in which the copper exists in the sulphide condition and is carried by the three minerals, chalcopyrite, chalcocite, and bornite. Each of these minerals contain copper in a different amount and it may be desired to ascertain the relative amounts in which these minerals occur in the ores, both from a mineralogical standpoint and also from a basis of copper content so represented. It may be desired to obtain these data for use in experimental testing, having for its aim the improvement of the flotation practice in use. In addition to the copper sulphides the ore may also contain pyrite and it is obvious that the application of chemical methods in this instance do not offer a direct or satisfactory method of obtaining the desired data. Since the questions involved have a direct bearing on the physical character of the sulphide minerals in the ore visual examination by means of the microscope and the use of microscopic methods of analysis appears to offer the most satisfactory means to obtain the information required.

A modification of the Rosiwal ([3]) method can be

[3]Methods of Petrographic Research, Johannesen pp. 291-2.

applied to the case under consideration and the information gained from this mechanical analysis, if properly conducted, should be sufficiently accurate to be used as a basis for conducting the proposed experimental work. The Rosiwal method is by no means new and has been used by petrographers and others for making mechanical analyses of the rock constituents in thin sections and in the determination of the relative amounts of coarse gravel, sand, and cement in concrete. Briefly stated it consists of the measurement or estimation of the respective areas of the constituents in the material being studied and reducing these figures to terms of 100 which is designated as the relative volume percentages of the components as they occur in the areas studied. Multiplying these volume percentages by the specific gravities of the respective constituents and converting the results into terms of 100 gives the relative weights of the constituents which is the information required. In order to apply this method of mechanical analysis to the study of crushed sulphide material or products obtained by screen sizing or concentration, it is first necessary to briquette the crushed material with sealing wax. The briquette is ground and polished in the same manner as an ordinary ore specimen and can be examined and studied under the microscope and when thus prepared the application of various microscopic methods of manipulation to crushed sulphide grains is no more difficult than their application to solid uncrushed material.

A detailed discussion of the uses of the microscope in ore dressing is beyond the scope of this paper which is intended to treat the subject in a general manner only, but the emphasis placed on the necessity for a thorough understanding of the physical characteristics of the ores and the minerals composing them, together with the examples given, serve to illustrate its usefulness in this field. It may be stated that those engaged in ore dressing and concentration both from a research standpoint and in practice can ill afford to ignore the microscope and that the intelligent application of microscopic methods in these fields will prove to be a profitable investment.

DESTRUCTIVE DISTILLATION OF OIL-SHALES.*

BY LEWIS C. KARRICK.[1]

INTRODUCTION.

In studying the destructive distillation of oil-shales, it is desired to know primarily the nature of the pyrolytic influences of heat on the organic components of the shale. The impracticability of isolating the kerogen of the shale from the mineral matter in which it is imbedded so as to conduct separate experimentation on the kerogen, leaves the problem extremely complex.

The behavior of the kerogen of the shale while undergoing the heating process, is not what it would be, if it were isolated, under similar temperature conditions due to its own thermo-chemical properties, but is actually, that which is induced to take place under the influence of the mineral matter in contact with, and surrounding it. It must be remembered that the inorganic material of the shale is a heterogeneous mixture of minerals, and each mineral has a particular thermal conductivity which will differ from that of the kerogen, and hence heat will be conducted inwardly at rates which may greatly exceed that required in the heat consuming reactions of the pyrolysis of the kerogen. Furthermore, within the heat range of the shale distillation are included the temperatures of dehydration of gypsum and some hydrous silicates, these minerals being frequently present in the shales. The evolution of water vapors from them will

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[1]Assistant Oil-Shale Technologist, U. S. Bureau of Mines.

affect the partial pressures of the hydrocarbon vapors evolved from the kerogen, probably to the improvement of the quality of the oil distillates. Carbonates as well as sulphides, begin to decompose within this range of temperatures and the concentration of the gases produced may alter the chemical constitution of the oils produced from the kerogen. The mineral aggregation of the spent shale may be difficultly penetrated by the escaping oil vapors as they work their way from the inside of the distilling shale lump to the surface, and hence pressures will develop within the shale pieces with the result that the oil vapors will escape at higher temperatures than is necessary for their formation; conditions conducive to unregulated decomposition of the oil. These are a few of many possible effects on the products of decomposition of the kerogen that may be caused by the presence of the mineral matter of the shales, and consequently, results are very difficult to predict when new and unfamiliar shales are being destructively distilled.

EXPERIMENTAL METHODS OF THE BUREAU OF MINES.

The individual problems of destructive distillation or the retorting of oil-shales, therefore, must be solved, largely, by "cut" and "try" methods. In the research work of the Bureau of Mines, oil-shales are treated in various states of fineness and under many conditions in which the temperature, duration, rate and method of supplying heat are varied. Conditions are brought about wherein the atmosphere surrounding the shale, while it is distilling, is made to contain definite proportions of certain auxiliary gases and vapors, which are used for their chemical influences and as scavenging mediums. The gases and oils evolved during distillation are caught and analyzed, and their properties are tabulated against the known conditions under which they were produced. The accumulation of data pertaining to any shale can be correlated finally and data valuable for use in the design of retorts is thereby obtained, wherein correct principles of chemistry, thermo-dynamics, and engineering practice may be employed.

Many varying products can be obtained from the destructive distillation of kerogen. The character and quality of the materials produced depends greatly on the temperature to which the vapors produced from the kerogen are heated within the retort. The duration of the time that the vapors remain in the retort seems also to have a decided decomposing action on the vapors and resulting products. It does not follow, however, that all shales will yield the same products when heated similarly, because shales differ physically, and the oil-forming material may be of an entirely different origin in different shales. The organic matter of the oil-shales of the eastern part of the United States, occuring in the Devonian formations, is made up almost entirely of spore matter, as are also some of the Scotch shales. The western shales of the Green River formation seem to be more complex, and contain, in addition to the spore matter, resenic and cellulosic materials. Some of the cannel coals and cannel slates of the east belong to this latter class. All of these give different oils under the same retorting conditions, which facts have been brought out by much experimental evidence. However, information is in no wise complete as to whether the principal cause of difference is due to the character of the included organic material, or to the percentage and character relation of the minerals associated with it.

INFLUENCE OF PHYSICAL STRUCTURE OF SHALE ON DISTILLATION PRODUCTS.

It is quite probable that in all shale retorting methods, the actual decomposition range for a given shale, begins at comparatively low temperatures, but the ultimate products produced owe their characteristics principally to chemical and physical reactions occuring while the products of distillation are passing from the primary decomposition state, which is probably a viscous fluid, into the vapor state, or while in the vapor phase. This alteration from the primary decomposition state is evidently a cracking phenomenon and the products will be influenced largely by some of the causes mentioned above, but such changes may also be due to properties inherent in the retort design.

The first action of heat upon the shale begins to take place at a very low temperature and results in the removal of some of the occluded gases which exist in very small quantities. Next the actual distillation of the kerogen or change of state takes place, wherein a heavy fluid apparently is produced which is soluble in organic solvents. The decomposition temperature range of this substance may be influenced to some extent, as has been attributed, to the influence of pressures developed within the shale pieces so that the evolved vapors are produced at excessively high temperatures. Finally as the vapors are produced within the shale pieces they immediately become subject to the destructive or damaging effects caused by their passing through zones of higher temperatures before they escape from the retort. The vapors are certain to become superheated somewhat, since they will readily absorb heat from the hotter shale surrounding, due to their low specific heats. The vapors on passing outwardly from a lump of shale will move in a direction opposite to the flow of heat, and will obviously become hotter as they pass outwardly through the lump, since the lump is transmitting the heat inwardly. Consider, for instance, that a piece of oil-shale the size and shape of a brick, is being heated and that the heat is being supplied equally to all portions of one of the larger faces. When the temperature of oil production is reached, neglecting side radiation, the entire surface starts distilling simultaneously, it being the first part to reach distillation temperature. If the temperature of the heat supply does not increase, the distillation on the heated surface will soon become negligible although only a portion of the total possible oil has been produced from the kerogen, which was first subjected to the distilling temperature. However, the distilling zone will work on through the shale until the entire mass has reached the same initial degree of decomposition. An increase of temperature will renew the evolution of oil vapors, but the final oil will not be produced until the temperature reaches approximately

525°C., about 200°C above the temperature of first oil production.

EFFECT OF TEMPERATURE LAG.

Commercial considerations require that the heating of the shale be fairly rapid and that the heat be supplied increasingly. Given these requirements, the temperature difference between the hot surfaces of the shale pieces and the inside temperatures where distillation is in its early stages, will become increasingly greater until a state of equilibrium is reached, whereby the temperature difference between the inside and outside surface of a lump becomes constant. Now this temperature difference for unit depth of heat penetration will depend, to a large degree, on the amount of heat supplied, the thermal conductivity and specific heat of the shale, the heat consuming reactions, and the heat carried out by convection in the escaping oils and gases. As experimental evidence of the amount of the temperature lag, the writer has performed retorting tests on shales where the temperature was taken at the hot surface and at a point within the charge two inches from the hot surface. Data taken showed that there was a lag of 250°C between the remote shale particles and those next to the heating surface. Had lumps of shale four inches in diameter been heated similarly, there would have been oil vapors liberated in the center, which on working to the surface, would have passed through a layer of partially spent shale two inches thick, and up to 250°C hotter than that at which the vapors were produced. Obviously it is probable that the superheat received by the vapors in penetrating the hotter exterior, will alone greatly decompose the oil vapors, but there are present factors working simultaneously to augment the cracking. Some of these factors are, the finely divided or capillary condition of the vapor streams, the pressure which the vapors must be under before being released from the shale pieces, and the catalytic influence of the carbon deposition in the pores of the shales.

Economic considerations prevent the employment of extremely long retorting periods, which would largely remove the causes of decomposition outlined in the preceding paragraphs. Another alternative will accomplish the same results as increased retorting time, that is, the grinding of the shale extremely fine and thereby reducing the depth for heat penetration in the individual shale particle. This could actually cause the pyrolysis practically to become a surface reaction. This expedient has its economic objections also, but for the sake of research possibilities, it offers an opportunity to eliminate many of the deleterious factors of retorting, the extent of whose importance is not yet fully known.

The oil-shale assay retort which was developed by Mr. L. A. Anderson, "Research Fellow", University of Utah, in cooperation with the writer was designed for extreme accuracy in quantitative determinations of oil yield, and to produce oil of good quality. The dimensions of the shale container, which is a pint capacity amalgam retort, are small in order to minimize the distance for the heat to penetrate. The time for completion of a retorting test is only four hours when treating the richest shale. The method of operating the retort requires that the shale used be ground to minus one-quarter inch size. The result is that during the distillation, in no piece of shale will the vapors have to travel more than one-eighth of an inch, (one-half the thickness of the shale granules), toward the source of heat, before reversing their direction and moving into a cooler zone and thence to the exit. The vapors from the finer shale particles will move a much shorter direction toward the source of heat before reversing direction. Variations in rate of retorting are employed in order to study the different properties of oil produced.

When shale is retorted very slowly and there are no means provided for scavenging, the gases and vapors tend to stagnate within the retort and are thus subjected to prolonged pyrolytic effects resulting in much decomposition. The Scotch process uses lumps of shale the size of building bricks and consequently the shale is allowed eight hours in which to complete distillation. Under this condition of a long period of heating, there would be ample time for much decomposition of the vapors were it not for the fact that a great quantity of steam is used in the retort as a scavenging medium and also for its chemical benefit to the oil. If the shale is retorted very rapidly the destructive results which characterize the high temperature coking of coals are approached, wherein all the oil vapors are decomposed to gas, tars, and carbon.

Any oil-shale retort that exposes a large heating surface to the vapors, whether it be a horizontal, inclined, or vertical type, and though the shale be rabbled, rotated or stirred, unless it uses an efficient scavenging medium, will probably produce much gas, much carbon deposition, and inferior oil in relatively smaller quantities.

CHEMISTRY OF THE VOLATILIZATION PROCESS.[1]

BY THOMAS VARLEY[2] AND C. M. BOUTON.[3]

To the lowlands dweller an excursion to the highlands may prove both adventurous and instructive, and a prolonged stay in the strange environment may compel a sweeping reconstruction of fundamental ideas—not so much a substitution of new ideas for old as an expansion of the old ideas to accomodate new facts and conditions. The chemist accustomed to reactions at ordinary temperatures may be pardoned a somewhat similar feeling when he ventures among the peaks of high temperatures. Our everyday experiences lie within a rather narrow temperature range, from about forty degrees below zero to forty-five above on the centigrade scale. Any temperatures outside this range are ordinarily the result of a definitely planned excursion which offers elements of novelty and appeals to the imagination. It is true that history hardly reaches back beyond the time when men made use of fire for the cooking of their food, and the smelting of their metals, but the formulation of exact laws governing the behavior of matter and energy at high temperatures is strictly a modern achievement, while the mere obtaining of very low temperatures at will is altogether recent.

The formulation of such laws is necessary for continued metallurgical progress. Through all time up to

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[1]Published by permission of the Director U. S. Bureau of Mines.

[2]Metallurgist, U. S. Bureau of Mines.

[3]Physical Chemist, U. S. Bureau of Mines.

and including the present, recovery of metals from ores has been a wasteful process, the amounts of metal lost in slags and dross and in fumes ranging from a fraction of a percent in the rare best instances to fifty percent or more in the worst cases. So great is the world's demand for metals that the easily worked deposits are rapidly being exhausted and economical and conservative treatment of the vast deposits of low grade ores is becoming absolutely essential.

The history of metallurgy is that of an art and not of a science. To be sure the facts of metallurgy have contributed much to science but progress in the working of metals has been very largely through the efforts of men who knew little and cared less concerning the sciences. Much progress may still be expected from the same type of empiricists. But more and more the art of metallurgy is looking for guidance to the sciences of chemistry and physics.

The traditional method of securing pure metals from ores has been to mix the ore with certain substances which experience had shown to be appropriate, to subject to heat and to obtain the metal first in a molten state and finally in solid form. This is the typical metallurgical process applied to all the most important metals: iron, copper, lead, gold, silver and tin. In the case of a few metals, however, the practice reaching back into antiquity has been to separate the metal by converting it into vapor and condensing the fumes. This is notably true of zinc and mercury. In the treatment of all the metals certain reagents, certain appliances and certain procedures, have been found best adapted to each ore. No one method has been developed which would free all the common metals which might be present in a mixed ore, though methods for separating metals from each other after they have been reduced to the metallic state, have been very well worked out. Temperatures suitable for the reduction of one metal are not suitable for another; reagents which are helpful in one case are harmful in another, etc.

Among pyrometallurgical processes the alternative of converting the metals into the vapor state and condensing the vapors seems to offer possibilities. The process of thus separating the mixed metallic content of an ore from the other constituents by converting the metals into chlorides and vaporizing these chlorides has been under experiment for about thirty years. It shoud be borne in mind that to present smelting processes are economically satisfactory for the richer grades of ore, but that to meet the world's future demands for metals it is becoming increasingly necessary to do two things; first, reduce losses in the smelting of ores, and second, develop methods of economically treating poorer grades of ore. Present experimentation on the chloride volatilization process is directed rather more to the second of these objects, but it is to be noted that success is hardly to be achieved in any treatment of low grade ores unless recoveries are fairly complete. The fact that metal chlorides may be vaporized from ores of several types is well established, but this is not sufficient. It must also be established that the vaporization, and subsequent recovery of the vapors can be quite complete. Pure science may perhaps be of assistance here in describing the conditions under which the maximum completeness may be expected. Let us first consider briefly the physical principles which underlie the process of vaporization.

Every solid or liquid substance may be considered to have some tendency to send out molecules from its own body into any space surrounding it A metal, such as gold, appears to have no tendency to waste its substance by evaporation, for an actual decrease in weight of a piece of gold has never been authentically recorded. Our belief that it is, nevertheless, continually wasting away by evaporation, though at a rate far too small to detect, rests upon an abstraction.

The first general law of evaporation is to the effect that evaporation into any enclosed space continues until a certain fixed pressure of vapor is attained, after which a condition of equilibrium persists unless the temperature is changed or part of the vapor is removed.

The change in the characteristic vapor pressure with change in temperature is of great importance. The law governing this relation is capable of mathematical expression and may be stated in words as follows: The logarithm of the vapor pressure is a linear function of the reciprocal of the absolute temperature. That is, if we plot the logarithms of a set of vapor pressures of any substance against the reciprocals of the corresponding absolute temperatures, the curve connecting the various points in order will be a straight line. Since two points only are necessary to define a straight line we need know the pressures corresponding to two temperatures only, in order to determine the pressure at any temperature. Although the law thus stated is only approximate the approximation is so close as to be of great value. If, now, having determined from the above plot the pressures corresponding to a wide range of temperatures, we plot pressures as ordinates directly against temperatures as abscissas, the curve rises imperceptibly from the origin at absolute zero until at a certain temperature it begins to diverge and from there it rises at a constantly increasing rate. In other words, the pressure-temperature curve is at first coincident with the temperature axis, and then concave upwards. This means that if we wish to volatilize any substance we must heat it to such a degree that its vapor pressure becomes appreciable and that relatively small increases of temperature above that point will produce constantly increasing rates of evaporation.

The vapor pressures of several metals have been experimentally determined and those of others have been estimated by assumptions of greater or less validity. J. Johnston[4] has tabulated these and finds the temperatures at which the vapor pressure is equal to that of one millimeter mercury, barometer column to be as follows: Silver 1320°C; copper 1520°C; iron 1590°C; lead 960°C; zinc 500°C; mercury 123°C.

To obtain vapor pressures of 50 mm. the temperatures must be about 400° higher in the cases of silver, copper and iron, 300° higher for lead and 200° for zinc.

These temperatures seem too high for practical application of a distillation process except in the cases of zinc and mercury. However, the vapor pressures of

[4]Jour. Indus. and Eng. Chem., Vol. 9, 1917. p. 874.

the chlorides of the metals are in general much higher than the pressures of the metals themselves at the same temperatures and if the metals can readily be converted into chlorides volatilization of these compounds may possibly prove a desirable process.

The vapor pressures of but few metal chlorides have been experimentally determined. The Pacific Station[5] of the Bureau of Mines has found the vapor pressure of lead chloride to be 1 mm. at 567° and 50 mm. at 747°. The vapor pressure of Ag is 1 mm. at about 850° and 50 mm. at about 1200°. Since silver is usually present in minor quantities it is not so essential that it should have a high vapor pressure. The vapor pressures of cuprous chloride, of zinc chloride, of iron chloride and of gold chloride are not known but it is known that these compounds volatilize even more readily than lead chloride. Temperatures of 1000° Centigrade or even higher are readily obtainable and the mere volatilization of the metal chlorides therefore, offers no theoretical difficulties.

Formation of the metal chlorides and keeping them undecomposed once they are formed present more difficult problems.

The process of forming metal chlorides by subjecting them to the action of chlorine gas has long been known and it is entirely feasible in the laboratory but the engineering difficulties associated with the handling of this very corrosive gas as well as its relatively high cost and small production have thus far prevented its wide application. Instead, attention is centered on the direct metathesis of metal compounds with the comparatively cheap sodium chloride.

Formation of copper chlorides by the roasting of calcined cupriferous pyrite mixed with common salt has been in use for over seventy years as the Longmaid-Henderson process for the lixiviation of copper. The chloridizing roasting of gold and silver ores preparatory to lixiviation has been practiced nearly as long. It is thus evident that gold, silver and copper minerals

[5]Located at University of California, Berkeley, California.

may be converted into chlorides by merely heating with sodium chloride. Beyond the fact that the heavy metal chlorides are formed, however, comparatively little is known as to the actual chemistry involved. Rarely is all the gold, silver or copper extractible by leaching. A part is almost always retained because of physical or chemical reasons not at all obvious and the particular ore used, the mechanical preparation, such as degrees of fineness, and the details of roasting procedure all affect the recoveries.

The various explanations offered as to the chemistry of chloridizing roasting,—and these have been rather numerous and conflicting,—must therefore be regarded as hypotheses only. It has, for example, been claimed that the presence of a certain small percentage of sulphur in the ore is essential and that this sulphur by first forming sulphates of the metals makes possible the formation of chlorides by direct metathesis. Others claim that the chlorine must be liberated as free chlorine gas to be efficient in combining with the metals. The hypothesis has also been advanced that the formation of sulphur chlorides is an essential intermediate step in the process.

In order to make progress in a problem so complex it is necessary to analyze it and subdivide it into as many and as simple problems as may be necessary for the securing of convincing answers. The obvious primary subdivision in this case is a study of each metal in its reactions with sodium chloride. In the studies of the Bureau of Mines the greatest progress has thus far been made with silver. It has been shown that all the commonly occurring silver minerals, with the exception of the chloride, dissociate at elevated temperatures in the presence of oxygen giving metallic silver. The problem then becomes how may metallic silver be converted into its chloride. If chlorine gas or hydrochloric acid gas is passed over heated silver, chloride of silver is formed. If water vapor is passed over heated silver chloride metallic silver is produced and hydrochloric acid, oxygen and chlorine gas pass off. The reaction between silver chloride and water vapor is therefore a reversible reaction and the complete volatilization of silver chloride depends upon the relative concentrations of water vapor, hydrochloric acid, oxygen and chlorine in the gases passing over the chloride. Too great a concentration of water vapor and too small a concentration of the chlorine gases will convert silver chloride into metallic silver and prevent its volatilization. The value of the equilibrium constant for this reaction has been obtained by the Bureau of Mines at the Pacific Station, Berkeley, California, and it is found that the concentration of water vapor sufficient to hydrolyze silver chloride and produce metallic silver, lies well within the range of possibilities in current metallurgical practice.

The hydrolysis of lead chloride or of copper chloride has so far received less attention because experience with ores shows that it is probably a less important factor with these metals. Experience in chloride volatilization with zinc-containing ores has demonstrated that the zinc is very little volatilized. This fact is not due to non-volatility of the zinc chloride for this compound is very readily liquified and boiled. It is undoubtedly largely due to the readiness with which zinc chloride hydrolyzes, though other causes may be contributory.

The problem of the chemistry of the volatilization process may also be attacked from another direction, namely, by studying the behavior of sodium chloride at high temperatures. The vapor pressure curve of salt has never been determined. Data do exist which show that salt hydrolyzes to a considerable extent with water vapor, but more information is desired upon these problems and experiments are under way to secure it.

To summarize, it seems that physical chemistry may contribute to the development of the chloride volatilization process by stating the conditions under which each metallic chloride will be formed from mixtures of common salt and the commonly occurring minerals of that metal; the chemical stability of the chloride in the presence of oxygen water vapor and other substances which may possibly react with it, and the vapor pressure of the chloride at various temperatures.

The question of recovery of the vaporized chlorides has not been discussed here. Originally the weakest link in the chain of operations involved in the volatilization process, it is now, thanks to the Cottrell process of precipitating fumes, probably the least uncertain step. Treatment of the precipitated chlorides in order to recover the separate metals has also been passed over in this paper. This is not because the step is not important, but rather because the questions involved are more those of practical metallurgical procedure than of theory, for example, what is the best type of furnace to use to avoid losses by revolatilization.

METALLURGY OF THE CHLORIDE VOLATILIZATION PROCESS.

BY C. C. STEVENSON.[1]

GENERAL STATEMENT.

The chloride volatilization process is a metallurgical method, which experiments have indicated to be especially well adapted to the treatment of low-grade, oxidized and semi-oxidized complex ores—those classes of ores which are difficultly treated with methods employed in our present practice. Furthermore, there are vast quantities of such ores, as are found in our western regions, that are lying idle for want of a suitable metallurgical treatment and which are most probably amenable to the volatilization process.

HISTORICAL BRIEFS.

Chloridizing roasting of metalliferous ores has long been in practice. In 1854 M. Becquerel, of Paris, roasted argentiferous galena with salt and extracted the silver chloride thus formed with a brine solution. Owing to the lack of a suitable means of recovering the silver from the salt solution, the scheme at that time had no economic value. Later investigations, however, resulted in effecting improvements that have made chloridizing roasting an important metallurgical process.

The main disadvantage that accompanied the chloridizing roast preparatory to leaching was the loss of metals due to volatilization. The losses sustained during the roast are usually high, in some cases 30 per cent of the metal values have been dissipated and lost, depending primarily on the temperature of the roast.

[1]Assistant Metallurgist, Department of Metallurgical Research, University of Utah.

INVESTIGATIONS BY STUART CROASDALE.

It was about 1892 when Stuart Croasdale[2], while working on flue and stack deposits from a chloride roasting plant, first recognized the possibilities of making volatilization a major instead of a minor event of the roast. Subsequently Mr. Croasdale conducted experiments on a large number of different ores; results of which showed that a high percentage of the metalliferous values could be chloridized and volatilized with comparative ease. In concluding his exhaustive investigations, which were made to include semi-commercial tests in a rotary kiln 25 feet long and 3½ feet inside diameter, Mr. Croasdale's chief difficulty was experienced in not being able satisfactorily to collect the fumes from the furnace gases.[3]

INVESTIGATIONS OF BEN HOWE.

Mr. Howe's experiments were conducted during 1910 and 1912, on antimonial gold ores from the Gwalia Consolidated Mining Company's properties in western Australia. Uninformed of Mr. Croasdale's work in America, Mr. Howe conducted an original investigation and published[4] the results of his experiments, believing at the time that he was introducing a new metallurgical method.

The experiments made by Mr. Howe were very similar to those conducted by Mr. Croasdale. Also the size and kind of equipment employed by each was practically the same. A most interesting feature in the com-

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[2]Eng. & Min. Jr. Aug. 29, 1903, vol. 76, p. 312, and Sept. 19, 1903, vol. 76, p. 420.

RELATING PATENTS.—U. S. Patent No. 741,712, issued October 20, 1903, to Edwin C. Pohle and Stuart Croasdale, Denver, Colorado. Assignors to Metal Volatilization Company, Philadelphia, Pa., a corporation of New Jersey. U. S. Patent No. 811,085, issued January 30, 1906, to Edwin C. Pohle.

[3]Mining Magazine, March, 1914, vol. 10, p. 200.

[4]Western Australian Chamber of Mines, December, 1912. According to Editor, Mining Magazine, Howe is fully quoted in Mining Magazine, March, 1913, and Min. & Sci. Press, March 29, 1913.

parison[5] of their results, is the fact that both were able to volatilize a high percentage of the metal contents from their ores, and that both concluded their experiments facing the same principal difficulty, of being unable satisfactorily to collect the metallic fumes from the gases.

COTTRELL ELECTROSTATIC PRECIPITATOR.

It was about 1912 when Dr. F. G. Cottrell successfully developed the electrostatic principle of separating solid constituents from gaseous bodies[6].

The use of the precipitator as a fume condensor, found a ready application in connection with the chloride volatilization process.

METALLURGY OF THE CHLORIDE VOLATILIZATION PROCESS.

PREPARATION OF THE ORE CHARGE.

The ore is first crushed to a size depending on the physical occurrence of the metal-bearing minerals in the ore gangue, usually .046 inch or 14 mesh is sufficient.

The ore with part or all of the chloridizing reagent or reagents, usually sodium and calcium chloride, are thoroughly mixed and admitted to the furnace for the chloridizing roast.

CHLORIDIZING ROAST.

The roast is usually conducted at a temperature ranging from 850 to 1000° C. Most experiments have been conducted in a rotary furnace similar to the cement kiln type. The ore charge is continuously fed into the furnace at one end and the roasted product discharged out of the opposite end. The ore charge in the kiln becomes heated as it approaches the discharge and heated end of the furnace. As a result there is a chemical reac-

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[5]Mining Magazine, March, 1914, vol. 10, p. 200.

[6]U. S. Patent No. 1,016,476, issued Feb. 6, 1912. U. S. Patent No. 1,035,422, issued August 13, 1912.

tion caused to take place between the chloridizing reagents and the metal bearing minerals. The metallic haloids thus formed are volatilized and carried away by the furnace gases.

DUST CHAMBERS.

The gases from the furnace are passed through suitable dust chambers where the heavier dust particles that were mechanically carried from the charge are deposited; this dust being recovered and returned to the furnace.

FUME PRECIPITATION.

From the dust chambers the gases carrying the metal chlorides are passed through a Cottrell electrostatic precipitator, where the metal chlorides together with all other solid constituents are deposited.

There are several types of electrostatic precipitators, the most common of which is the tube treater. The so-called pipe or tube treater is quite simple in construction; the essential features being an iron pipe usually four or six inches in diameter with an insulated metal wire suspended through the center. The suspended wire is usually charged with 25,000 to 50,000 volts of direct current electricity, while the pipe is simply connected to the ground. The electrostatic pressure on the insulated wire causes an electric corona brush discharge which sweeps the gases clear of all solid constituents.

METAL CHLORIDE FUMES.

The character of the product from the treaters depends on the metal values carried in the ore. In general, however, the metals thus recovered are present as chlorides, oxychlorides or in the elemental form. Gold is usually present in the latter state. Other constituents of the fume may be small quantities of iron, lime and insoluble, together with relatively large quantities of salt (sodium chloride). Considerable salt is dissipated during the roast, which is due to hydrolysis or direct evaporation.

TREATMENT OF CHLORIDE FUMES.

Three principal methods may be used for recovering the metals from fumes:

(a) Reduction by fusion.
(b) Leaching with subseqeunt precipitation.
(c) Combination of leaching and fusing.

The method employed will usually depend on the metal content of the fume; however, as each individual ore will constitute a problem, it is not feasible to discuss details of these methods in this paper.

ORES IN GENERAL.

TECHNICAL CONSIDERATION.

The process may be applied to the treatment of both oxidized and sulphide ore. The latter, however, usually requires a preliminary desulphatizing roast, in case it should contain a high percent of sulphur.

ARSENICAL ORES.

Ores of any kind carrying appreciable quantities of arsenic, antimony, or bismuth, are readily treated by volatilization. The procedure is to give the ore a preliminary roast at about 850° C for the purpose of expelling the arsenic, antimony, bismuth, etc. This can usually be accomplished in about thirty minutes of heating, the fumes from the roast being recovered either in an electrostatic precipitator or by filtration of the gases through woolen bags.

Basic fumes are best separated from basic gases by filtration through bags. In case the electrostatic precipitator is used, there is a non-conducting film of the basic fume that covers the electrodes and prevents the essential functioning of the corona discharge. What really happens is a condenser effect in which there is an intermittent building up of potential and electrical discharge which is not effective in precipitating fumes from gases. In the presence of an acid gas, basic fumes are readily precipitated electrostatically.

ZINC ORES.

One of the many valuable features of the process is the fact that zinc in oxidized ores is practically non-volatile in an oxidizing atmosphere. Thus with an ore carrying zinc, silver, and lead, the object of the treatment would be to chloridize and volatilize the silver and lead and to leave the zinc in the calcines.

The decrease in weight of the ore, due to heating, causes a concentration of the zinc in the calcine. Thus an ore assaying 30 per cent zinc, after such treatment, would in some cases assay 36-38 per cent zinc, depending of course on the character of the ore.

ADVANTAGE OF THE PROCESS.

1. The plant can be installed and operated near the mine, as the water consumption is not great.

2. Transportation costs are greatly reduced.

Importation of fuel and chloridizing reagents together with the exportation of bullion and possibly some by-products, would include the bulk of transportation.

Relative weights would be, for each ton (2000 pounds) of ore treated, it would require not to exceed 200 pounds of fuel and 300 pounds of chloridizing re-agents.

The bullion to be exported would possibly not exceed 300 pounds. Thus for each ton of ore the transportation necessary would in all probability not exceed 800 pounds.

3. Elimination of smelter charges.

4. High per cent recovery of the metal values from the ore could be effected with relatively low operating costs.

5. The advantage of converting practically all of the valuable contents of the ore into commercial products.

6. Laboratory experiments indicate that the process is flexible and can be applied to a large variety of ores.

THE USE AND FUNCTION OF STEAM IN RETORTING OIL-SHALES.[1]

BY MARTIN J. GAVIN[2] AND J. J. JAKOWSKY.[3]

The increasing demand for petroleum and its products has turned attention, during the past few years, to the oil-shale deposits of the United States. A considerable amount of material has been written regarding the methods of treating the shale for the recovery of the crude shale-oil and many processes and methods have been advocated.

Outside of different mechanical arrangements and devices, the proposed retorts and methods for treating the shales by destructive distillation may be grouped, in a general way, under one of two heads; dry destructive distillation methods, and distillation in an atmosphere of superheated steam or gas.

There are at the present time, a large number of shale retorting processes and methods being advocated, some using steam and others claiming that a good oil can be secured without the use of steam in the retort.

Scotch oil-shale processes and practices may or may not be a criterion to be followed in this country, but since these plants are the only ones operating today on a large commercial scale, a brief description of the Scotch retorts is presented to make more clear an understanding of the discussion to follow on the uses and purposes of steam in retorting oil-shales.

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[1]Presented by permission of the Director, U. S. Bureau of Mines.

[2]Oil-shale Technologist, U. S. Bureau of Mines.

[3]Assistant Chemical Engineer, Dept. of Metallurgical Research.

[4]"The modern Scotch retorts are all of one general type, the main points of difference between those used in different plants being in the shape of the cross section of the retort and the means used for discharging the spent shale from the bottom of the retorts. Time will not permit a complete description of the Scotch retorts, but briefly, they are vertical and consist in descending order, of a (1) fresh shale hopper attached to a (2) cast iron retort, which is fourteen feet high, and tapered, being smaller at the top than the bottom. At the juncture of the hopper and the iron retort a vapor discharge line, protected by a lip to prevent its being clogged with shale, leads to the vapor main. The iron retort is usually round or oval in cross-section and is, if round, two feet in diameter at the top and two feet four inches at the bottom. At the bottom of the iron part of the retort it is joined to a (3) brick part, also vertical and tapered, and made of a single tier of specially shaped fire brick. The joint between the iron and brick parts of the retort is made of a special kind of fire clay, and in operation considerable care must be exercised in firing, to prevent the joint from pulling apart or cracking. The brick part of the retort may be rectangular or round in cross section. If round, the diameter at the bottom is about three feet; usually the height of the brick part is about twenty feet.

"Below the brick part, and attached to it, is the (4) spent shale discharge mechanism, which differs in different types of retorts. In one type of retort the discharge apparatus is either a pair of toothed cast iron rolls, which rotate slowly towards each other and drag the spent shale from the retort. The discharge mechanism in a more commonly used retort, consists of a flat iron plate, on which the shale column in the retort rests, while a curved arm moves slowly over the plate and forces the spent shale from the plate as the arm rotates. The arm is operated by a shaft passing through the plate and actuated by a system of ratchets and pawls, as are also the other types of discharge mechanisms, the motion of the lever arms

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[4]Garvin, Martin J., The Past, Present and Future of the Oil-Shale Industry: Unpublished manuscript to appear in an early issue of California Oil World.

driving the ratchet wheels, and thereby the rate of discharge, being controllable at will.

"The discharge mechanism drops the shale into the (5) spent shale hopper, into which exhaust steam is passed, and as the hoppers fill, the spent shale is discharge into cars which carry it to spent shale dumps or 'bings'. No practical use has ever been found for spent shale in Scotland.

"Shale feeds continually from the fresh shale hopper into the cast iron part of the retort, and in this part the bulk of the oil is distilled, at a temperature of about 900° F. Descending, the shale, in the brick part of the retort, gradually heats up until at the bottom of the retort its temperature may reach 1500° to 1800° F."

In Scotland, large quantities of steam are used in the oil-shale retorting process but accurate data are not available regarding the percentage of the steam decomposed during its passage through the retorts.

"The exact chemical role of the steam in producing increased ammonia recovery and oil of better quality is not definitely known. The following purposes,[5] however, are fairly definitely established and agreed upon in the use of steam: (1) to reduce the temperature of the spent shale at the bottom of the retort; (2) to carry the heat, which has been recovered from the spent shale up into the retort, in the form of superheated steam; (3) to form water-gas from the fixed carbon remaining in the shale; (4) to aid in the recovery of ammonia from the shale; (5) to add greater volume to the oil vapors, thereby giving them a greater velocity in the retort and causing them to be swept out of the hot zone of distillation, preventing their further decomposition to a large extent; (6) decreasing the partial vapor pressure of the heavier hydrocarbons and allowing them to be vaporized or removed at a lower temperature; and (7) to counteract, by convection, the poor thermal conductivity of the shale, thereby allowing a better transfer of heat from the walls of the retort to the center of the shale column."

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[5]Jakowsky, J. J., Uses and Supply of Water for the Oil-Shale Industry: Unpublished manuscript. The remainder of this paper has been abstracted from this manuscript.

Taking up the purposes enumerated: we find that the first two are important from engineering and thermodynamic viewpoints. Reducing the temperature of the hot spent shale just before its discharge from the retort simplifies the problem of designing the mechanical discharge devices and also allows a better recovery of heat than could be obtained by the use of any practical form of heat exchange device to recover and utilize the heat from the spent shale before its discharge from the retort. The design of the Scotch retort is such that the heat recovered from the hot spent shale is almost wholly utilized in the retorting process.

The third purpose enumerated: the formation of water-gas from the fixed carbon remaining in the shale, may make the use of steam, or possibly air, advantageous. Present available data indicate that the uncondensible gases recovered during the retorting process where steam or air is not used in the retort, will usually not furnish enough heat when burned as fuel to carry on the distillation process. The volume of gas recovered during the retorting probably depends upon the nature and character of the shale undergoing distillation and the conditions of retorting. Different volumes of gas, due to dissimilar pyrolytic conditions, are usually recovered from the same shale undergoing distillation in different retorts. It seems probable that shale retorting processes recovering large quantities of gas, during dry destructive distillation, do so at the expense of the quantity and quality of recovered oil. A minimum non-condensible gas production should make toward a better grade of crude oil and especially will this be true in retorts where the hydrocarbon vapors are subjected to undue decomposition before condensation. The formation of large quantities of inflammable uncondensible hydrocarbon gases is usually an indication of excessive decomposition or cracking of the heavier hydrocarbons of the shale oil.

The use of steam or air in the retort will, by the formation of carbon monoxide and hydrogen, increase the quantity of combustible gases recovered during the retorting process, and not at the expense or decomposition of the hydrocarbons.

Exact data regarding the action of steam or air upon incandescent spent shale are not available at this time, but the effects of each upon carbon, coal and coke, are known. The amount of carbon monoxide and hydrogen formed from each of these substances, at a given temperature, depends largely upon the time of contact. Under similar conditions and during equal intervals of time, the percentage of carbon monoxide formed from coke is less than that from charcoal, while the percentage formed from anthracite coal is less than that formed from coke. It will be noted that the surface exposed to the action of the gases is greatest in charcoal, less in the case of coke, and least in anthracite. Where the time of contact is great enough to allow equilibrium to be reached in the reaction, the percentage of carbon monoxide formed is practically the same in every case. When superheated steam is passed through incandescent carbon, the composition of the gas obtained as well as the quantity of steam decomposed in a given time depends largely upon the temperature, rate of flow or time of contact, and the nature of the carbon. Practically 100 percent of the water vapor can be decomposed at a temperature of 1100°C. where the time of contact is great enough.

Investigations indicate that the fixed carbon content of American oil-shales varies from less than three to possibly 28 per cent; the average for most average American shales varying from 7 to 9 percent, and this amount, together with the uncondensible hydrocarbon gases will, in most cases, be sufficient to furnish fuel for the retorting process, if the retort is of average thermal efficiency.

The amount of ammonia recovered during the retorting process seems to depend almost directly, up to a certain quantity, upon the amount of steam used. Experiments indicate that as high as ninety-five percent of the total nitrogen content of a shale can be recovered as ammonia by the use of proper amounts of steam at correct temperatures. In the Scotch retort about sixty percent of the nitrogen in the shale is recovered as ammonium-sulphate under their conditions of operation.

The fifth purpose enumerated: to add greater volume to the vapors, is an important function of the steam.

Present knowledge of the pyrolytic distillation of the kerogen—the source of the oil—in the shale indicates that the dead vapor space within the retort should be reduced to a minimum. Excessive decomposition or cracking results when the vapors are allowed to stagnate or form eddy currents in hot pockets. Good oil can be recovered from small laboratory and assay retorts where comparatively fine ground shale is used and the vapor space reduced to a minimum by carefully filling the retort to its maximum capacity, but for large scale continuous commercial operation some form of gaseous sweeper or scavenger probably will have to be used in order to clear the vapors from the larger interstices and dead vapor pockets which form constantly during a continuous movement of the shale mass and the use of steam or the uncondensible gases recovered during the retorting process will probably prove one of the most successful means of increasing the velocity of the hot hydrocarbon vapors distilling from the shale column.

In the sixth purpose enumerated, steam serves another important function during the distillation process by decreasing the partial vapor pressure of the heavier hydrocarbons. There is little doubt but that the boiling point of the kerogen of the shale is above the decomposition or cracking temperature of the hydrocarbons produced, and since cracking is a dehydrogenation process, it seems hardly possible to secure a good saturated paraffin base oil from a retort where excessive thermal decomposition of the vapors takes place. Microscopic study of the decomposition of the kerogen under the influence of heat shows that the solid kerogen first softens or melts and then vaporizes. Generally speaking, the temperature at which an oil dissociates or cracks, depends mainly on its molecular weight and constitution; and speaking broadly, the more complicated the molecule, the easier it undergoes dissolution, and also the more unsaturated the compound, the more easy it disintegrates. The velocity of the dissociation reactions during cracking is greatly dependent upon the temperature, and even a slight increase in temperature may greatly accelerate the dissociation reaction. In other words, the distillation should be carried out at as low a temperature as possible in order to recover an oil as little decomposed as possible, and which, commercially speaking, gives the maximum amount of refinable products. The hydrocarbons formed from kerogen, boil at a lower temperature by a decrease in the external pressure on the system and the use of steam or gas in accordance with the law of partial pressures, will give an effect similar to a reduced pressure or a vacuum. Generally speaking, the evaporation into a vacuum is, to a certain extent, a measure of the escaping tendency of the molecules of the liquid. Kinetic theory sets a superior limit to the rate of evaporation.

"Evaporation is a rapid process approximating within, at most, one or two powers of ten the maximum rate of evaporation as calculable from kinetic theory. The apparently slow rate of evaporation is really due to the slowness of diffusion of the vapors from the liquid surface."[6] The use of steam in the retort will increase the diffusion of the heavier hydrocarbon vapors, and because of the different characteristics of the different shales, the amount of steam used will likely vary with the shale being treated and the type of retort used. In addition, the use of steam, by lowering the partial pressure of the oil vapors, undoubtedly prevents, to a large extent, the condensation of vapors which many believe takes place in the Scotch retort when the outgoing vapors come in contact with the incoming cool shale. Thus the use of steam largely prevents the condensation and redistillation of oil in the retort, which would undoubtedly take place without its use.

Because of the scarcity of water in some of the shale regions, it has been proposed to re-use the water recovered during the retorting process. A large percentage of the water in the form of steam used in the retort will not be decomposed and will be condensed and collected with the hydrocarbon and other vapors. A few experiments have been run where the untreated water recovered during previous retorting tests has been used to furnish retorting steam. The data available at the present time are not complete enough to warrant the drawing of defin-

[6]Bouton, C. M., Personal communication.

ite conclusions regarding the effect of such water upon the quality of the oil recovered. It seems probable, however, that the use of water containing large amounts of sulphur, nitrogenous and other compounds, such as is recovered when oil-shale is distilled, will have a detrimental effect upon the oil produced. The use of such water will increase the concentration of these compounds within the retort and probably accelerate the formation of undesirable sulphur and nitrogenous oil-compounds. As the water is re-used the concentration of these compounds in the water will increase.

Fresh water, in the form of steam, introduced into the retort may (in addition to other effects) hinder the formation of some of the undersirable oil compounds by decreasing, by dilution, the concentration of the deleterious sulphur and nitrogenous compounds in a unit volume. Besides the effect of steam upon the sulphur content of the recovered oil, a decided difference is noticed in the composition of the uncondensible gases recovered. During the retorting process, considerable quantities of hydrogen sulphide and other sulphur compounds are formed and the percentage of these undesirable sulphur compounds in the gas and oil can be greatly decreased by the use of excessive quantities of steam. During dry destructive distillation, the gas recovered contains many times the sulphur content than gas recovered during the distillation when using steam. Many of the sulphur compounds are soluble in the water.

As stated previously, the ammonia recovery, up to a certain percentage, can be increased by the use of steam, but the actual chemical effect of the steam upon the nitrogenous compounds in the shale cannot be stated at this time. In the Scotch plants the waste waters from the retorting process are not usually re-used but are allowed to trickle over the spent shale dumps, and then waste.

COMMERCIAL REDUCTION OF COPPER FROM COPPER CHLORIDE FUME.

BY ROBERT H. BRADFORD.[1]

Copper is extracted from its ores by fire methods, by wet methods, and by methods involving the gasification or volatilization of the copper compounds.

We have been dependent mainly on the furnace methods or pyrometallurgy for many years. At present there are important reduction plants extracting copper by wet methods, and continued service may be confidently expected from such processes in the future. Up to date there have been no commercial installations making copper at a profit by the gas methods—volatilization. This latter statement should not carry with it the inference that no early work was done on volatilization of copper, for such is not the case.

In the sixties of the last century Henderson of England received letters patent for a process which aimed at the recovery of copper as well as other metals from ores by volatilizing the metals as chlorides.

Others followed him with experimental work in the same line and the U. S. patent of Pohle & Croasdale, issued in October, 1903, describes quite fully the volatilization of copper from sulphur-bearing ores as chloride by heating such ores with salt or other halogen compounds. Attempts at practical reduction of the red metal under these patents did not meet with success.

The metal chloride was driven from the ore and a tailing of satisfactory grade was obtained but economic means for collecting the chloride fumes were not available. Research investigation has been prominent of late to adapt the Cottrell precipitator and the bag-house to the

[1]Professor of Metallurgy, University of Utah.

work of collecting the copper chloride fumes from the chloridizing furnace.

The results of these efforts have been decidedly promising. The copper chloride fumes are readily collectable and the dry material is obtained in a convenient form for further treatment.

Copper is quite readily eliminated from coarsely ground ore and the tailings disposed of in granular condition. The temperature of dull redness required is not sufficient to melt nor even to sinter ordinary silicious copper ore.

The operation of grinding the ore and mixing with salt, the feeding of the mixture to the rotary kiln of ordinary cement-burning type, need not be more than briefly referred to, nor need I do more than to mention the settling of mechanical dust, and the precipitation of the copper chloride fume in the Cottrell treater or the bag house. These are operations already standardized and their uses with the chloride fumes need no comment here.

The fume recovered from whichever collector is used is a light fluffy powder of yellow-gray to green color. Its content in copper when free from the ore dust suggests a predominence of cuprous chloride, the cupric material seems to be present in greater or lesser amounts. Analyses show that the copper content may reach above 50% of the whole. The remaining half of the collected fume is largely chlorine. The presence of sulphate of copper, and of silica may be expected but each of these is dependent upon the nature of the ore and the conditions of treatment.

It is entirely possible to get a favorable extraction from an ore carrying no appreciable amount of sulphur, and the settling chambers may be designed quite satisfactorily to eliminate the mechanically carried siliceous fine ore.

Now the treatment of these chloride fumes presents to the metallurgist a set of new problems. Can this new concentrate of fifty per cent metal be sent to the smelter for further treatment? What is the process in pyrometallurgy ordinarily employed on a fifty per cent copper product? The reverberatory furnace or even the blast furnace may produce a copper matte of this grade copper. This matte is then reduced to metal in a copper converter by having a blast of air blown through the molten stuff, the oxygen burning the iron and sulphur to their oxides. The copper resulting is called blister copper and assays as high as 98 to 99 per cent pure. What would happen if this fifty per cent chloride fume were melted and treated as a similar grade matte? The fact that the fume was entirely volatile in the process of its formation would suggest that it would not be consistent to try to reduce it to metal by blowing air through it, because it no doubt would in larger part revolatilize; and again, of course, there is neither the sulphur nor the iron in sufficient amount to supply the combustible matter for heat. What fire method does suggest itself? The chloride of copper must be decomposed by some reagent with affinity for chlorine. Calcium, it is known, has such affinity but the cheap calcium salt has oxygen with it and simple replacement will produce copper oxide. The oxide of copper is readily reduced by introducing some carbon into the mixture.

The reduction to metal involves the reaction:

$$Cu_2Cl_2+CaO+C=CO+CaCl_2+Cu_2$$

Either limestone or burned lime will answer the purpose. With limestone there is produced from cuprous chloride 1.28 parts of copper for one part of limestone and from cupric chloride 0.64 parts of copper for one part of limestone. But 3/32 of a pound of pure carbon is needed per pound of copper in reducing cuprous chloride while 3/16 parts are needed with the cupric salt.

The reactions take place at a temperature below the melting point of copper. The thermo-chemical calculations show but a reasonable amount of heat consumed. The reduction of the chloride to metal by this method therefore is perfectly feasible.

The slag produced in the fusion method is principally calcium chloride. This chloride is readily fusible to a watery liquid. It is low in specific gravity enabling the copper readily to settle through it. It carries a high percentage of chlorine and is an active chloridizing agent that can be used on a further batch of raw ore. At least one-half of the chlorine necessary for the volatilization may thus be regenerated.

The calcium chloride slag is a very different material from the ordinary silicate slags dealt with in regular furnace methods for copper extraction. The pure chloride melts at 780°C and boils at a temperature not much above the melting point of copper. Care must be taken to carry on the process of reduction at a temperature not too high because of the danger of volatilizing and decomposing the chloride slag. The decomposition is fostered by hydrolysis of the calcium chloride in contact with the moisture of the gas or oil flame.

While the chloridizing furnace requires a non-reducing atmosphere in order to guarantee complete volatilization, the furnace for fume reduction requires a non-oxidizing atmosphere in order to prevent revolatilization of the chloride fume. The most satisfactory furnace to furnish the required conditions has yet to be determined. A reverberatory furnace promises satisfactory results.

In order to avoid any mechanical dusting of the fume mixture, we are experimenting with a feeding device to introduce the mix into the reverberatory by feeders arranged to discharge their product just underneath the surface of the slag layer. The design provides for melting the horizontal tube of fume and lime as it comes in contact with the slag on entering the furnace, so that the raw material may not come in contact at all with the direct flame or draught of the reverberatory.

The best kind of refractory lining for the furnace is yet a question. The chloride of calcium is neither a basic nor acid slag in the sense in which these terms are ordinarily used. The corroding action of the slag is not to be considered on the same principles that govern the action of acid and basic slag-forming and refractory substances. Chromite for example, which is neutral to acid and basic fluxes, is attacked by the chloride, while fireclay and silica bricks are more nearly neutral.

The per cent recovery of metal from the chloride fume is quite satisfactory, above ninety percent of the total copper in the fume appearing in the metal that results from the reducing fusion. The metal is crude metal carrying around 95 per cent copper with 2 per cent or so of each of the other elements, iron and sulphur. Gold and silver, if present in the copper ore, are volatilized and reduced to metal with the copper. Copper bullion that carries the precious metals should be partially refined in the reverberatory furnace where they are formed and then sent to the electrolytic plant for complete refining.

If the precious metals are not present in amounts sufficient to cover the cost of electrolytic refining, the crude copper may be completely refined in the reverberatory furnace by the usual processes of oxidation and poling. Such refining treatment of the crude metal gave a refined copper metal of above 99 per cent purity.

EFFECT OF GREEN MANURE AT DIFFERENT STAGES OF GROWTH UPON THE RELATIVE ABUNDANCE OF ACTINOMYCES, NON-SPORE-FORMERS AND SPORE-FORMERS IN THE SOIL.

BY DR. THOMAS L. MARTIN.

(Abstract):

PURPOSE:

According to some investigators there are three groups of organisms in the soil. Actinomyces, Non-Spore-Formers and Spore-Formers constitute these groups. They exist in a certain numerical relationship to each other. Every external influence affects the relative abundance of these organisms. It was desired in this work to determine what the effect would be on the relative abundance of these organisms when green manures at different stages of maturity were added to the soil.

METHOD:

Rye, oats and buckwheat were harvested at three different stages of growth. This material was cut into small pieces and incorporated at the rate of five tons of green manure to the acre in gallon pots filled with a clay loam soil. After decomposing for five months samples were taken, tap-water gelatin plates poured and counts made after ten days' incubation.

CONCLUSION:

1. Addition of manure resulted in an increased number of organisms.

2. The three groups were not affected to the same extent.

3. Actinomyces group was affected to the greatest, and the Spore-Formers to the least extent.

4. Younger the manure added, greater were the numbers of Actinomyces and Non-Spore-Formers. The percentage of increase was the greatest in the case of the Actinomyces.

5. These results, together with the works of previous investigators suggest the idea that Actinomyces are probably associated with decomposition of organic matter.

THE NORMAL TEMPERATURE AS A FUNCTION OF THE LATITUDE, ELEVATION, TIME OF DAY, AND DAY OF YEAR.

BY FRANK L. WEST.

The following empirical equation,

$$T=M+\frac{A}{2}\cos t+\frac{D}{2}\cos \Theta \qquad (1)$$

represents the normal temperature as a function of the time for the United States except for the arid west, where we must add the term $(\frac{V}{4}\cos t \cos \Theta)$. The constants are the mean annual temperature, the range of the annual march, and the range of the daily march, and are obviously easily obtained from the Weather Bureau Data for the place desired.

These constants may also easily be obtained from the following empirical equations,

$$M=110-1.4L-.002h \qquad (2)$$

where M is the mean annual temperature, and L is the latitude, and H is the elevation in feet above sea level. It applies to the United States east of the Rocky Mountains. For the arid west, the following equation applies.

$$M=121-1.4L-.0033h \qquad (3)$$

For the eastern part of the United States the following equation applies:

$$A=-24+1.8L \qquad (4)$$

where A stands for the difference in temperature between winter and summer. The other values in the first equation (1) are sensibly constant.

Equation (1) becomes on substitution of these values

$$T = 110 - 1.4L - .002h + (.9L - 12)\cos t + 9\cos\Theta \qquad (5)$$

which holds for the eastern division and

$$T = 121 - 1.4L - .0033h + 23\cos t + 11\cos\Theta + 3\cos\Theta\cos t \quad (6)$$

for the arid west.

The equations assume that the annual and daily march of temperature are cosine functions, and that the mean annual temperature and the annual range are linear functions of the latitude and elevation. The facts justify these assumptions. The mean error in using equation (1) was $\pm 2\frac{1}{2}$ deg. F. and in using equations (5) and (6) $\pm 3\frac{1}{2}$ deg. F.

VITAMINES IN RELATION TO NUTRITION.

BY W. E. CARROLL.

The adequacy of the human diet has until recently been measured by the amount of protein and mineral salts and the number of calories it could supply to the body during digestion. As investigations progressed due consideration has been given such questions as the source of the protein in its relation to the kind and amount of the amino acid supplied; the distribution of the total calories among the protein, carbohydrates, and fats; and the maintenance of the proper balance between the acid and basic constituents of the mineral ingredients. Many other factors have received attention and many dietetic fads have been advocated, but at the foundation of them all has been the question of how much protine and mineral salts are available as building materials, and how many total calories does the diet provide. The work of recent years, however, has proved beyond question that a diet meeting the above requirements may result in nutritional failure because of the absence of small amounts of as yet unidentified substances called vitamines.

Even before this discovery was made difficulty had been experienced in maintaining laboratory animals on rations of purified nutrients which supplied ample protein mineral salts, and total energy. The cause of such conditions was then unknown and the reason back of the remedy could not be explained.

Certain diseases, as beri-beri and scurvy, have been common in different countries and under different conditions for a long time. Attempts to discover a bacterial cause for these diseases failed, and the idea gradually developed that they were due to one-sided or deficient diets. Just what was lacking was not well understood, and the reason recovery followed certain changes in food intake was not at all clear. Sections of the world population, therefore, continued on their racial diets and continued to develop these diseases.

In 1897, C. Eijkman, a Dutch scientist working in Java, made the observation that chickens fed for a few weeks on polished rice developed a polyneuritis which, as he observed, closely resembled human beri-beri. Eijkman also discovered that this condition could be prevented and even overcome by the addition to the ration of the husks of the rice which are removed during the polishing process.

A case is also recorded where a newly appointed warden in a penitentiary in a rice-eating country determined to be more humane to his prisoners than his predecessor had been, and accordingly substituted white rice in their diets for the less favored unpolished kind. By this supposed kindness he brought on a severe outbreak of beri-beri among the prisoners.

Cases are also reported in which a diet made up very largely of highly milled wheat flour resulted in beri-beri. Substitution of whole wheat flour relieved the condition. As the diet is more largely restricted to flour and its products, this substitution is of course more necessary.

Eijkman's rather accidental discovery opened up a field which subsequent investigation has found to be very fertile, and from which has been built up our entire conception of so called deficiency diseases and vitamines in relation to nutrition.

No attempt will be made to give a complete historical sketch of the development of the question, but rather a brief survey of its present status.

The name "vitamine" was suggested by Casimir Funk, of England, about 1912 from his researches with the anti-beri-beri substance of rice polishings. His results led him to believe that this substance was an amine or that it was chemically very closely related to them. Hence the name, "amine essential to life, or vitamine." Unfortunately the chemistry of the vitamines is not so simply solved, and we seem no nearer an understanding of their chemical nature than we were in 1912.

At present vitamines can be recognized only by their physiological action. Based upon their effect in the body three vitamines are at present recognized: (1) Fat-soluable A, essential to growth, occurring with, if not actually dissolved in, fats from certain sources, as butter-fat, cod-liver oil, egg yolk, green leaves, and certain other foods. (2) Water-soluable B, essential for growth and for the prevention of beri-beri. It is rather widely distributed in nature, occurring in abundance in yeast and the germs of most seeds, fruits, many vegetables, greens, and other food materials. (3) Water-soluble C, or the anti-scorbutic vitamine, prevents and cures scurvy. It is present in living vegetable material as greens and to a smaller amount in roots and tubers. Orange, lemon and tomato juice contain it in abundance.

FAT-SOLUBLE A.

Function.—Fat-soluble A, as mentioned above, is essential to growth. Continued lack of this factor results also in xeropthalmia, or keratomalacia, a disease of the eye which may ultimately result in blindness. It is thought by some investigators that rickets may also result from lack of this factor in the diet. Others feel just as strongly that absence of this vitamine is not a cause of rickets. Some recent work by McCollum, however, reports increased deposition of calcium in the bones in cases of rickets, even on low calcium rations, upon the addition of fat-soluble A in cod-liver oil. In human rickets the calcium content of the blood remains approximately normal though the bones seem to lose their power to metabolize it. Whatever the cause of rickets, however, it has been shown rather conclusively that it can be prevented and cured, with rare exceptions, by cod-liver oil, which seems to be practically a specific for the disorder. Increased calcium utilization, even on lower calcium intake, has also been observed when cows have been turned from a dry ration to green pasture.

Occurrence.—Butter fat is the standard and usually the most convenient source of this factor, though its amount in butter fat depends upon the amount of A in the feed of the cow, being less on winter and dry rations than on summer grass. Cod-liver oil is also relatively rich in A. Whale oil contains it to a somewhat less extent as do fish oils generally. It is present, though by no means abundantly, in oleo oils and would therefore occur in oleomargarines made from these oils. This substitute cannot, however, be looked upon as being even in the same class with good butter as a source of this important factor. Nut margarines, on the other hand, made entirely from vegetable oils have been shown to be practically devoid of the fat-soluble growth promoting substance. It is present in egg yolk and in much less amounts in beef fat and in certain seeds, especially those carrying an abundance of yellow pigment. It is even present in yellow corn and absent in white.

It has been shown to be present in the oil from pig's liver, the liver and kidney tissue, and is thought by some to be present in all glandular tissue. Muscular tissue that we eat so abundantly, however, seems to carry this factor to a very slight extent. Lard lacks fat-soluble A, as does cottonseed oil and most other vegetable oils, red beets, parsnips, potatoes, etc.

Leafy vegetables and green plant tissue of many kinds such as spinach, alfalfa, clover, timothy have been shown to carry the A factor. Tomatoes carry it in considerable abundance, cabbage, carrots, and sweet potatoes to a less extent, and it seems to be present in peas and possibly bananas. Unsweetened evaporated milk and milk powders probably also contain it.

Stability.—Fat-soluble A seems to be relatively stable to the ordinary processes to which food products are usually subjected. Drying and ordinary cooking may destroy it to some extent, though substances which are relatively rich in it originally are not rendered completely inert by these ordinary processes. It can be destroyed by heating to 100°C or above for one hour or longer. Lower temperatures for longer periods, especially if the substance is exposed to light and air, seem detrimental. In fact, the length of the treatment seems to be as important as its intensity. Most of the above generalizations come from experimentation with butter fat.

In plant tissue this vitamine seems to be relatively stable and withstands ordinary heating and drying processes, and has been reported present after undergoing fermentation in the silo.

WATER-SOLUBLE B.

Function.—It will be recalled that the water-soluble B vitamine seems to be essential for growth and also prevents and cures polyneuritis in pigeons and chickens and beri-beri in human beings. These two functions are rather distinct and have led certain investigators to feel that more than one vitamine is involved. In fact, recent experimental evidence indicates that the antineuritic factor of unpolished rice may be destroyed without destruction of its growth-promoting property.

Occurrence.—Water-soluble B is found in general much more abundantly in plant sources than in foods of animal origin, though milk is a fair source of this factor. It is still present in pasteurized, condensed, and evaporated milks. Neither does the change from summer grass to a dry winter ration seem to affect its content in milks, probably because it is still present in the ration of the cows.

Lean meat contains relatively little water-soluble B, though liver, kidney, heart and brain tissues are satisfactory sources. Eggs also contain it. It is found in practically all natural foods of plant origin. In seeds it is found chiefly in the embryo or germ and may be entirely absent in highly milled flours, bolted corn meals, polished rice, and other prepared foods. In flours it is of little use to include the bran and omit the germ. On the contrary the bran might be omitted without danger if the germ and endosperm are included. All fruits, nuts, and vegetables so far tested are valuable sources of this vitamine. Orange, lemon and grape fruit juices are especially rich. Dried orange juice is as valuable as the fresh. Canned tomatoes are comparatively rich in B. Pears and apples contain somewhat less, and those who have worn mourning since prohibition became effective should find solace in the fact that even grape juice—Welch's brand—may legally, and does contain significant amounts of the water-soluble B vitamine.

Yeast is by far the richest known source of this vitamine—a fact that was not long left idle by manufacturers of fresh yeasts, until now grocers, as they sell a yeast cake, are beginning to ask, "Will you take it with you or eat it here?"

Stability.—Water-soluble B is apparently relatively stable to cooking heats. Wheat germ has been heated to 100°C. for two hours without noticable loss of this factor, yet when heated to 113°C. for forty minutes a loss of one-half of its power is recorded, and when heated two hours at 118°-124°C. as much as nine-tenths of its protective power was lost. These results point to the safety of our ordinary processes of cooking so far as the temperature is concerned. Pressure cooking and canning, however, may destroy this vitamine. Canned meats have been shown by laboratory tests to lack water-soluble B. The British Army in the Dardanelles and Mesopotamia verified this in a practical way when they developed beri-beri on a ration of white bread, canned meats and jam. The Indian soldiers in the same regions escaped because their ration included not white, but a coarsely ground wheat flour containing the germ and the aleurone layer of the kernel, and also a daily allowance of four ounces of small lentils. Another point which may need attention, however, is the fact that a large part of the water-soluble B is found in the cooking water. This indicates that steaming should replace boiling wherever possible.

This factor seems to be more sensitive to an alkaline than to an acid medium. In fact, experiments are reported in which it has been destroyed by cooking in relatively weak alkaline solutions. The results on this point, however, are extremely conflicting, indicating that possibly the source of the vitamine and the kind of alkali may be influencing factors.

Lack of B.—It is reported by some investigators that the amount of food eaten is influenced by this vitamine, in other words, that the appetite is dependent upon the presence of water-soluble B.

Even before definite symptoms of polyneuritis and beri-beri developed, pronounced changes in the system take place. Male rats on a diet adequate except for B prove sterile when mated to normal females properly nourished. Menstruation ceases in women whose diets lack in this factor. In Germany this secession of menstruation because of incomplete diet has come to be known as "war amenorrhœa" and is mentioned in recent publications with considerable concern. Much work along this line and upon the pronounced histological changes of the sex organs and other tissues due to lack of this factor is now being reported.

This particular vitamine is being used with marked success in cases of malnutrition and failure to grow in infants.

WATER SOLUBLE C.

Function.—From its power to prevent and cure scurvy, water-soluble C is called the antiscorbutic vitamine.

Occurrence.—Water-soluble C is probably present in most, if not all living plant and animal tissue. It is reported especially abundant in fresh fruits and green vegetables, and is present in smaller amounts in root vegetables and tubers. It is found in relatively small amounts in meats and milk and has been reported absent in yeast, fats, cereals, pulses, prunes, bananas, and cod-liver oil.

Vegetables are usually a cheaper source of this factor than fruits. Raw cabbage is reported as even better than orange juice as a source of C. The juices of swedes, beets and carrots if uncooked are valuable sources of this vitamine. Cooked as well as raw rhubarb is reported effective for C. Young or fresh vegetables are more valuable than old or stale ones. The water-soluble C content of milk of both the human and animal mother can be increased by vitamine-rich food.

The relationship between a failure of the potato crop of a region and scurvy has been repeatedly observed in Europe and our own country. Scurvy was a common thing on board the old-time sailing vessels on long voyages where fresh fruits and vegetables were not available. Because of restricted diets, scurvy developed among the inhabitants of Paris during the siege of 1871.

A recent striking illustration of the lack of fresh vegetables in the diet is reported in connection with the Indian troops in Mesopotamia. From "July 1, to December 31, 1916, 11,000 cases of scurvy occurred" among them. The British met the condition by sending over a "Gardner's Corps" of 256 men. Infantile scurvy, which is rather common in the United States, seems not to have been so well understood until recently.

Stability.—The antiscorbutic vitamine is reported much less stable than the other two. Ordinary cooking probably destroys this to a considerable extent. Cabbage, which will be recalled is very rich in C, lost 70 per cent of its antiscorbutic value on being cooked one hour at 60°C. or twenty minutes at 90° to 100°C., and over 90 per cent when cooked for one hour at 90°C. Potatoes cooked at 100°C. for fifteen minutes were effective antiscorbutics, but when cooked for one hour had lost this property. Long cooking at low temperature seems more injurious than quick cooking at higher temperatures. With young vegetables cooked while fresh the loss of vitamine is not so complete.

Added acids or alkalis hasten the destruction of water-soluble C.

In line with these results canned fruits and vegetables have been found so far to retain little if any of their antiscorbutic value. Tomatoes seem to be an exception to this and commercial canned tomatoes retain a considerable abundance of this factor. They are being very successfully used in infant feeding. A teaspoonful of the juice may be fed to babies only a few weeks old and the amount can safely be increased as the child grows older.

Drying also practically destroys the antiscorbutic properties of most foods. Orange and tomato juice seem to be exceptional in this regard, though dried vegetables practically without exception are valueless. Young vegetables blanched and dried while still very fresh retain some of this power for a short time.

Nutritive Results without C.—A diet deficient in water-soluble C ultimately produces scurvy. This is probably the minor portion of the danger. Those who have given this question a great deal of experimental and clinical attention report that it takes about six months for a case of infantile scurvy to develop to a point where it may be clinically recognized, and further that profound changes may take place in certain structures, especially the teeth, before the ordinary symptoms of scurvy appear.

From such experiments it is found that the teeth are one of the first if not the first structure to be affected by lack of water-soluble C in the diet. Even when scurvy symptoms are so slight as to be almost unrecognizable very profound and detrimental changes were found to have taken place in the teeth. A degeneration develops in the growing bone cells at the base of the pulp of the teeth, and may result in a complete replacement of the fine cellular structure of the pulp of the normal tooth by a fibrous growth devoid of cells and nuclei. The growth and composition of the protective enamel is also materially interfered with. Conditions very closely resembling pyorrhea in its various stages have been observed in laboratory animals on a scorbutic diet.

These results were obtained by experimentation on guinea pigs and monkeys, but are felt to apply almost wholly to human beings as well, especially as apparently identical conditions have been observed and described in human teeth.

Dental writings have many times recorded the fact that the teeth of primative races are not subject to decay to the same extent found under conditions of more highly developed civilization. For example one study reports that 68 per cent of the children of one of the tribes of the Philippines had perfect teeth. In the other 32 per cent the abnormalities were so slight as to escape entirely the notice of the layman. The Scottish Highlanders are reported practically free from tooth decay, while the condition of the teeth of the Lowlanders is extremely poor. These differences are ascribed to the simple diet of natural foods in the one case and to the more highly refined nature of the foods composing the diet in the other. It has been rather commonly observed by dentists that Swedish girls who came to this country as domestics have excellent teeth upon their arrival, but that our American diet of highly refined and cold storage foods soon brings about rapid decay.

Cases of abnormal and deformed dentition in young animals are reported on vitamine free rations and evidence indicates very strongly that many of the troubles which beset the teeth of our children today could be largely eliminated if proper attention were paid to the vitamine content of their diets.

And what of the practical application of all these recently accumulated facts? Are they of chief importance as weapons to ward off xeropthalmia, beri-beri, and scurvy? Certainly not, for these disturbances are already very rare among us locally. This newer knowledge of nutrition is of great importance to us, however, in its relation to growth, vigor, efficiency, general tone and resistance to disease.

Civilization has made some very dangerous changes in its food products and dietetic habits. Meat, cereals and especially sugar have been introduced in their present large quantities at the expense of vegetables, nuts and other natural products. The changes which have been introduced in the methods of milling cereals since earlier days, call especially for thoughtful planning of the new diet. Not only do the outer seed coats and the germ (which are so carefully and completely discarded as fit only for the lower animals) contain practically all of the vitamines of the seeds, but most of the mineral salts as well. Of course, both of these losses can be made good from other sources if care is taken. To accomplish this, however, will necessitate the adoption of a diet containing larger amounts of dairy products, eggs, vegetables—especially the leafy varieties—and raw fruits and vegetables than is now customary in many cases.

Fortunately as these various changes found place in the diet, man also became a dairy farmer and is thereby producing a very valuable supplement for the factors which these other changes crowded out.

Especially is a knowledge of vitamines necessary for those who supervise the growth and development of children. Adults also frequently develop a narrow appetite because of dislikes for certain classes of foods. The diet in such cases needs careful planning in order to avoid danger.

A lack of vitamines will prevent proper growth and may lay the foundations for weakness and disease in later life; which would materially reduce the efficiency and service of the individual. With the ordinary contagious diseases we either have them or do not have them, while the nutritional disorders become manifest without particular warning and only when conditions have become desperate and after irreparable damage has already been done. Especially does this seem true in relation to prevented growth and the early and unrecognizable stages of scurvy.

In conclusion, then, it must be recognized that a diet may contain protein, carbohydrates, fats, and mineral salts in proper proportions and still be deficient and dangerous. In addition to these, adequate amounts of the three vitamines are necessary to insure the most favorable state of nutrition.

Shortage of fat-soluble A in the diet can be prevented most easily by a liberal use of milk, milk products, eggs, and leafy vegetables.

An adequate supply of water-soluble B can be had in vegetables in general, eggs, liver and other glandular organs, and in flours and meals which contain the germ of the seeds. Danger of lack of B comes chiefly in cases where highly milled cereal products (not including the germ) are allowed to make up too great a proportion of the diet.

The supply of water-soluble C will probably need closer attention than that of the other vitamines. Vegetables should find a place in the diet as early in life as possible; and even earlier than this, the milk diet of the infant, whether breast fed or not, should be supplemented with orange juice or cooked tomato juice as a preventive against the unrecognizable, though none the less dangerous, early stages of scurvy. Later life can be safeguarded by a liberal use of fresh, uncooked fruits and vegetables.

RELATION OF PRECIPITATION TO HEIGHT GROWTH OF FOREST TREE SAPLINGS.

BY CLARENCE F. KORSTIAN.[1]

In passing through stands of coniferous saplings five to twenty feet tall, surprising variations are noted in the distance between the whorls of branches. The distance between whorls, usually corresponding with the internodes, represents the amount of height growth made during a given growing season. The growth of each season for the past thirty or forty years can be determined by measuring the length of the internodes. Various explanations supported by experimental data have been offered as to the cause of these variations, the most common and logical of which have taken into account the environmental conditions, especially the moisture relations between the plant and its habitat. The relation between the loss of water from the plant, or transpiration, and the available moisture supply of the soil is of vital importance in regions where arid or semi-arid conditions are prevalent. Probably the most satisfactory expression or summation of moisture conditions is to be found in the ratio between the evaporating power of the air and the available soil moisture as proposed by Fuller.[2] Unfortunately neither of these factors can be used in the discussion at

[1]U. S. Forest Service.

[2]Fuller, Geo. D. Evaporation and Soil Moisture in Relation to the Succession of Plant Associations. Botanical Gazette 59: 193-234. 1914.

hand because continuous records are not available. However, Shreve[3] has shown that in physiological plant geography, where soil moisture data are not available, the annual and seasonal distribution of precipitation has been used to good advantage as criteria of soil moisture and in conditioning the distribution and growth of various types of vegetation.

Mr. F. S. Baker and the writer[4] have found that the seasonal amount and distribution of precipitation is of unusual importance as a factor limiting the distribution of western yellow pine (*Pinus ponderosa* and *P. ponderosa scopulorum*) in the Great Basin. Douglass[5] has found that the width of the annual rings is a reliable index of rainfall and that double rings are indicative of the distribution of precipitation throughout the year. The writer[6] in a symposium on site classification, pointed out that the majority of foresters recognize relative height growth of young trees as a more sensitive indicator of the quality of habitat than diameter growth or any other single criterion.

Kirkwood,[7] in seeking evidence on the relation of the growth of western yellow pine and Douglas fir (*Pseudotsuga taxifolia*) to the distribution of rainfall, made a series of measurements in the vicinity of Missoula, Montana. After correlating the current annual growth of fifty western yellow pine and twenty-three Douglas fir saplings

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[3]Shreve, Forrest. Rainfall as a Determinant of Soil moisture. The Plant World 17: 9-26. 1914.

[4]The report of this investigation is awaiting publication.

[5]Douglass, A. E. A Method of Estimating Rainfall by the Growth of Trees. Bulletin American Geographical Society 46: 321-335. 1914.

——— Climatic Cycles and Tree Growth: A study of the annual rings of trees in relation to climate and solar activity. Pub. 289, Carnegie Institution of Washington, 127 pp., 40 figs., 12 plates. Wash., D. C. 1919.

[6]Korstian, Clarence F. Native Vegetation as a Criterion of Site. The Plant World 22: 253-261. 1919.

[7]Kirkwood, J. E. The Influence of Preceding Seasons on the Growth of Yellow Pine. Torreya 14: 115-125. 1914.

for the seasons of 1909 to 1913, inclusive, with the precipitation records for Missoula, the author concludes that the current growth is conditioned by the rainfall of the preceding growing season, namely, April to September, inclusive. This theory is supported by the argument that, in view of the fact that the main growth of trees is completed during the early part of the growing season, the season's growth must be largely dependent upon the nutritive substances which are elaborated and stored mainly in the buds and the extremities of the main shoot and branches during the preceding growing season. The author contends that the greater the supply of moisture, up to an optimum amount, the greater is the reserve of stored food and consequently the more vigorous are the shoots of the following season. The work of Pearson[8] at the Fort Valley Forest Experiment Station in northern Arizona is somewhat contradictory of Kirkwood's conclusions. Pearson's results, based on 95 carefully selected saplings and covering the period from 1909 to1917 inclusive, clearly show that the April and May precipitation is most important in determining the amount of height growth and presumably also the amount of available moisture in the soil during the period in which height growth actually occurs.

Brewster,[9] after correlating 153 measurements of height growth in western larch (*Larix occidentalis*) with temperature, relative cloudiness, and precipitation records at the Priest River Forest Experiment Station in northern Idaho for 1912 to 1916 inclusive, concluded that the most favorable conditions for rapid height growth in that region are produced by a combination of temperatures somewhat above average, coupled with a high percentage of clear days, with a normal amount of precipitation evenly distributed in the form of good rains at intervals

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[8]Pearson, G. A. The Relation Between Spring Precipitation and Height Growth of Western Yellow Pine Saplings in Arizona. Journal of Forestry 16: 677-689. 1918.

[9]Brewster, D. R. Relation Between Height Growth of Larch Seedlings and Weather Conditions. Journal of Forestry 16: 861-870. 1918.

of four to ten days preceded and followed by lighter showers.

The previously mentioned work on the occurrence of western yellow pine in relation to the seasonal distribution of precipitation led the writer to believe that in northern Utah, central and southern Idaho a correlation of current height growth with rainfall might give results more nearly agreeing with the conclusions of Kirkwood than with those of Pearson, because the seasonal distribution of precipitation resembles more closely that of Montana and northern Idaho, where the maximum amount is received in the winter months and the minimum in the summer, than the Arizona type, where the maximum occurs during the middle of the summer and the minimum in late spring.

For the purpose of throwing additional light on this subject, the writer in 1919 secured measurements on 143 western yellow pine and 111 Douglas fir saplings from 5 to 10 feet tall growing within a few hundred yards of the cooperative Weather Bureau station maintained at Grimes Pass, Idaho, at an elevation of 5,000 feet. The locality is toward the upper limit of the western yellow pine type and not far below the transition zone between the western yellow pine and Douglas fir types. No other convenient station within the western yellow pine type of the Intermountain region could be found having a continuous precipitation record for the period under study. The current annual height growth and precipitation for various periods of the year are shown graphically in Figure 1. The precipitation for other periods was also analyzed, but no correlation could be found. In general, a fairly close correlation is noted between the rate of growth and the rainfall during April and May of the same year, which in the main agrees with Pearson's findings. Similar results were secured near Garden Valley, Idaho, which is near the lower limit of western yellow pine, but the data could not be used because of the incomplete precipitation records.

A striking exception is seen in the case of Douglas fir in 1914. An analysis of temperature conditions for the spring of 1914 revealed the prevalence of high temperatures during most of April, the very last part of which was marked by freezing temperatures. May was also characterized by high temperatures, but with a heavy freeze the last of the month which did considerable damage to tender succulent vegetation. The writer[10] has recently described the effects of somewhat more severe conditions on the growth of Douglas fir in central Utah in 1919. From all information at hand this appears to be a parallel case, in which the greatly decreased growth is due to frost injury the latter part of May, 1914. Douglas fir appears more sensitive to changes in the moisture relations of the habitat mainly because of the higher moisture requirements of this species; the trees used in this study were growing near the lower altitudinal limit of Douglas fir and toward the upper limit of western yellow pine. The response to the unusually heavy rainfall in April and May, 1915, is found in an increased growth in both Douglas fir and western yellow pine.

It is also interesting to note that Engelmann spruce (*Picea engelmanni*) growing on a northern aspect in Big Cottonwood Canyon, twenty-five miles southeast of Salt Lake City, Utah, as its lower altitudinal limit in association with Douglas fir (*Pseudotsuga taxifolia*), alpine fir (*Abies lasiocarpa*), white fir (*Abies concolor*) and limber pine (*Pinus flexilis*), showed a decided reduction in the length of leaves formed on the tips of the growth of the dry season of 1919 in contrast with those formed either in 1918 or 1920. The leaves of the 1919 growth averaged only 0.36 inch long, while those of the 1918 growth averaged 0.71 inch long, and those of the 1920 growth were 0.71 inch long, based on the measurement of thirty typical leaves of each year's growth. The terminal twig growth also showed a similar and very noticeable shortening of the 1919 growth, although no measurements were secured.

Kirkwood's[11] data was analyzed and to afford a

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[10]Korstian, Clarence F. Effect of a late Spring Frost upon Forest Vegetation in the Wasatch Mountains of Central Utah. Ecology 2: 47-52. 1921

[11]Loc. Cit.

graphic comparison with the Grimes Pass data they are also plotted in Figure 1. It also appears to bear out Pearson's conclusions as well or possibly better than it does his own. Following his conclusions one should also expect to find a small amount of growth in 1912 following the low precipitation of 1911. On the other hand, the high growth rate in 1912 is accompanied by a heavy rainfall in April and May of the same year. Furthermore, it is difficult to conceive how the carbohydrates elaborated and stored during the preceding season are adequate for the main growth of the current season. It appears to the writer more logical to consider that the stored food materials are largely, if not wholly, consumed in the incipient stages of the current growth, and that, because the moisture originating from the winter snows has been largely dissipated, the amount of precipitation falling in April and May is largely responsible for the growth during the main part of the growing season, and therefore, largely determines the total amount of growth for a given year.

FIG. 1.

Current annual height growth of western yellow pine and Douglas fir saplings and seasonal precipitation from 1909 to 1919, at Grimes Pass, Idaho:

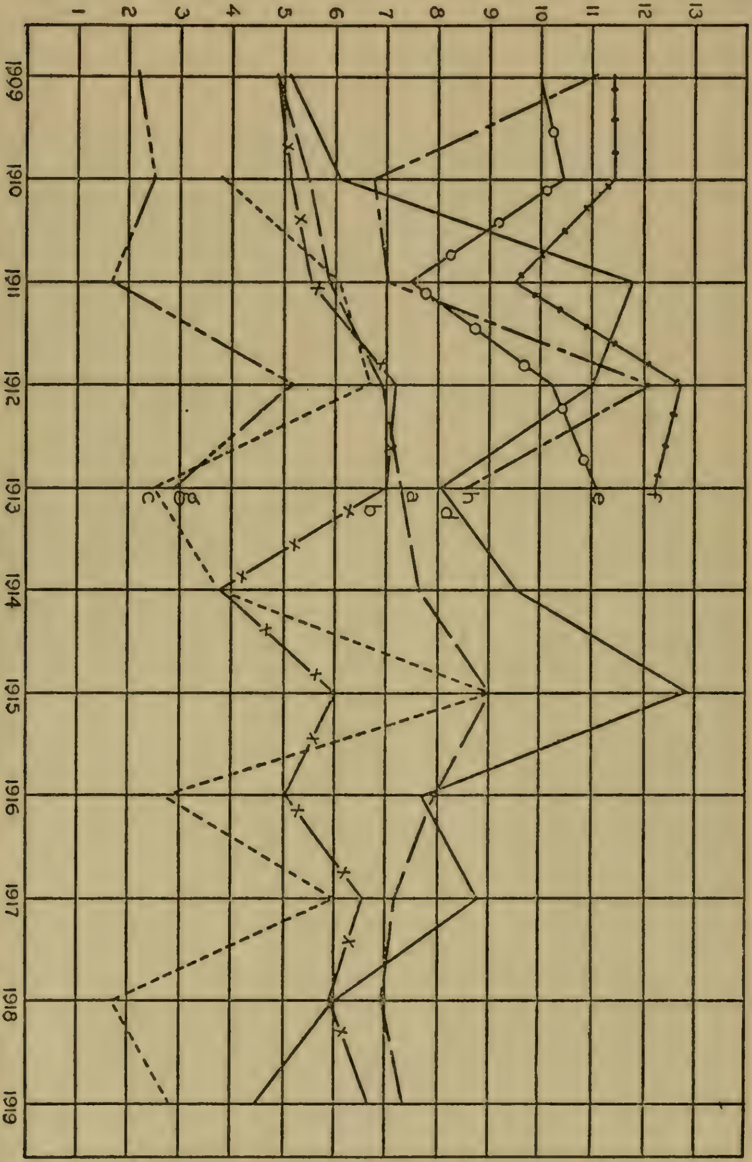
a=current annual height growth of western yellow pine.
b=current annual height growth of Douglas fir.
c=spring precipitation (April-May).
d=growing season precipitation (April-September).

At Missoula, Montana:

e=current annual height growth of western yellow pine.
f=current annual height growth of Douglas fir.
g=spring precipitation (April-May).
h=growing season precipitation (April-September).

(e-h inclusive after Kirkwood.)

Height Growth and Precipitation — Inches.



INDEX.

Abell, Tracy H.: Investigations in Dehydration 69
Abell, Tracy H., M. C. Merrill and: The Breeding of Canning Tomatoes 133
Alkali Soils, The Relation of the Method of Analyzing to the Limits of Toxicity, by D. W. Pittman 95
Alkali Water for Irrigation, by Frank S. Harris and N. I. Butt 87
Alter, J. Cecil: Forests in Relation to Climate and Water Supply 194
Analytical Distillation of Shale-Oil, The, by Martin J. Gavin 198
Anderson, Mark: Detection of Overgrazing by Means of Indicator Plants 56
An Equation of the Density Exposure Curve of a Photographic Plate Taking Reversal into Account (abstract), by Orin Tugman 36
A Theory of Capillary Flow, by Willard Gardner 100
Atomic Theory and the Atom, by W. D. Bonner 107
Automobile Headlights, Intensity and Distribution of Illumination from, (abstract), by Orson Smith 37
Ball, E. D.: mentioned 4
Barrett, Edward P.: Relation of Chemistry to Metallurgy 155
Beeley, Arthur L.: The Problem of Handedness 59
Bishop, Francis M.: Personal Reminiscences of John W. Powell 16
Bonner, J. T., and T. B. Brighton: Standardization from Constant Boiling Hydrochloric Acid 173
Bonner, W. D.: mentioned 5
Bonner, W. D.: The Atomic Theory and the Atom 107
Bonner, W. D., W. D. Kline and: Comparison of the Action of Potassium Cyanide and Sodium Cyanide on Alkyl Halides 174
Bouton, C. M., Thos. Varley and: Chemistry of the Volatilization Process 218
Bradford, Robert H.: Commercial Reduction of Copper from Copper Chloride Fume 240
Breeding of Canning Tomatoes, The, by M. C. Merrill and Tracy H. Abell 133
Brighton, T. B., J. T. Bonner and: Standardization from Constant Boiling Hydrochloric Acid 173
Butt, N. I., Frank S. Harris and: Alkali Water for Irrigation 87
By-Laws 12
Canning Tomatoes, The Breeding of, by M. C. Merrill and Tracy H. Abell 133
Capacities of Soils for Irrigation Water, Experiments on, by O. W. Israelsen and F. L. West 139

Capillary Flow, A Theory of, by Willard Gardner 100
Capillary Transmission Constant and Methods of Determining it Experimentally, by Willard Gardner 158
Cardiff, Ira D.: mentioned 4
Carroll, W. E.: mentioned 5
Carroll, W. E.: Vitamines in Relation to Nutrition 249
Cases of Exceptional Growth of Certain Species of Mammals, Reptiles and Insects (abstract), by L. Moth Iverson 28
Chamberlain, W. H.: Matter from the Point of View of a Personalistic Philosophy 128
Chemistry of the Volatilization Process, by Thos. Varley and C. M. Bouton 218
Chemistry to Metallurgy, Relation of, by Edward P. Barrett 155
Climate and Water Supply, Forests in Relation to, by J. Cecil Alter 194
Commercial Reduction of Copper from Copper Chloride Fume, by R. H. Bradford 240
Comparison of the Action of Potassium Cyanide and Sodium Cyanide on Alkyl Halides, by W. D. Kline and W. D. Bonner 174
Constitution 9
Constitution of Matter, The Theory of the, by Orin Tugman 120
Copper, Commercial Reduction of, from Copper Chloride Fumes, by R. H. Bradford 240
Cyanide and Sodium Cyanide on Alkyl Halides, Comparison of the Action of Potassium, by W. D. Kline and W. D. Bonner 174
Dehydration, Investigations in, by Tracy H. Abell 69
Desert, The Second Reclamation of the, (abstract), by R. A. Hart 40
Destructive Distillation of Oil Shales, by L. C. Karrick 211
Detection of Overgrazing by Means of Indicator Plants, by Mark Anderson 56
Determination of the Normal Temperature by Means of the Equation of Seasonal Temperature Variation and of a Modified Thermograph Record, by Dr. F. L. West, N. E. Edlefsen and S. P. Ewing 84
Diseases, Forest Tree, by A. O. Garrett 182
Disinfection a Reaction of the First Order, Is? by L. F. Shackell 162
Distillation of Shale-Oil, The Analytical, by Martin J. Gavin 198
Distilled Water as a Medium for Growing Plants, by M. C. Merrill 75
Ebaugh, W. C.: mentioned 4
Edlefsen, N. E., and S. P. Ewing, Dr. Frank L. West: Determination of the Normal Temperature by Means of the Equation of Seasonal Temperature Variation and of a Modified Thermograph Record 84
Effect of Green Manure at Different Stages of Growth upon the Relative Abundance of Actinomyces, Non-Spore-Formers and Spore-Formers in the Soil, by Dr. Thomas L. Martin 245
Electric Air Heating Feasible, Is? (abstract), by Jos. F. Merrill 103

Electricity, The Electron Theory of Conduction of, by Frank L. West 126
Entomology, Historical Outline of the Development of to 1800, by Harold R. Hagan 47
Evaporation and Soil Moisture in Relation to Forest Planting, by C. F. Korstian 116
Ewing, S. P., Dr. Frank L. West, N. E, Edlefsen and: Determination of the Normal Temperature by Means of the Equation of Seasonal Temperature Variation and of a Modified Thermograph Record 84
Exceptional Growth of Certain Species of Mammals, Reptiles and Insects, Cases of, (abstract), by L. Moth Iverson 28
Experiments on Capacities of Soils for Irrigation Water, by O. W. Israelsen and F. L. West 139
Eyring, Carl F.: mentioned 5
Fish and Game Conservation, Forests and, by S. B. Locke 190
Fledglings, Food and Feeding of (abstract), by Newton Miller.... 45
Fletcher, Harvey: mentioned 4
Food and Feeding of Fledglings, (abstract), by Newton Miller.... 45
Forest Planting. Evaporation and Soil Moisture in Relation to, by C. F. Korstian 116
Forests and Fish and Game Conservation, by S. B. Locke 190
Forests in Relation to Climate and Water Supply, by J. Cecil Alter 194
Forests of Utah a Permanent Resource, Making the (Presidential address), by C. F. Korstian 177
Forest Tree Diseases, by A. O. Garrett 182
Forest Tree Saplings, Relation of Precipitation to Height Growth of, by C. F. Korstian 260
Game Conservation, Forests and Fish and, by S. B. Locke 190
Gardner, Willard: A Capillary Transmission Constant and Methods of Determining it Experimentally 158
Gardner, Willard: A Theory of Capillary Flow 100
Garrett, A. O.: Forest Tree Diseases 182
Garrett, A. O.: mentioned 4, 5
Gavin, M. J., and J. J. Jakowsky: The Use and Function of Steam in Retorting Oil-Shales 232
Gavin, M. J.: Oil Shales and Their Economic Importance 145
Gavin, M. J.: The Analytical Distillation of Shale Oil 198
Hagan, Harold R.: Historical Outline of the Development of Entomology to 1800 47
Hagan, Harold R.: mentioned 5
Halides, Comparison of the Action of Potassium Cyanide and Sodium Cyanide on Alkyl, by W. D. Kline and W. D. Bonner 174
Handedness, The Problem of, by A. L. Beeley 59
Harris, Frank S. and N. I. Butt:Alkali Water for Irrigation 87
Harris, Frank S.: mentioned 4
Hart, R. A.: mentioned 5
Hart, R. A.: The Second Reclamation of the Desert (abstract) 40

Head, R. E.: The Use of the Microscope in Ore Dressing 204
Heating Feasible, Is Electric Air, by Joseph F. Merrill 103
Historical Outline of the Development of Entomology to 1800 by Harold R. Hagan 47
Hydrochloric Acid, Standardization from Constant Boiling, by J. T. Bonner and T. B. Brighton 173
Hydrometallurgy as Applied to the Mineral Industry, by Clarence A. Wright 142
Illumination from Automobile Headlights, Intensity and Distribution of, by Orson Smith 37
Illumination, Some Problems of Daylight, by C. Arthur Smith 167
Indicator Plants, Detection of Overgrazing by Means of, by Mark Anderson 56
Insects, Cases of Exceptional Growth of Certain Species of Mammals, Reptiles and, by L. Moth Iverson 28
Intensity and Distribution of Illumination from Automobile Headlights (abstract), by Orson Smith 37
Investigations in Dehydration, by Tracy H. Abell 69
Irrigation, Alkali Water for, by Frank S. Harris and N. I. Butt.... 87
Irrigation Water, Experiments on Capacities of Soils for, by O. W. Israelsen and F. L. West 139
Is Disinfection a Reaction of the First Order? by L. F. Shackell 162
Is Electric Air Heating Feasible? (abstract), by J. F. Merrill.... 103
Israelsen, O. W. and F. L. West: Experiments on Capacities of Soils for Irrigation Water 139
Iverson, L. Moth: Cases of Exceptional Growth of Certain Species of Mammals, Reptiles and Insects (abstract) 28
Jakowsky, J. J., M. J. Gavin and: The Use and Function of Steam in Retorting Oil-Shales 232
Jones, Marcus E.: mentioned 4
Karrick, L. C.: Destructive Distillation of Oil Shales 211
Kline, W. D. and W. D. Bonner: Comparison of the Action of Potassium Cyanide and Sodium Cyanide on Alkyl Halides 174
Korstian, C. F.: Evaporation and Soil Moisture in Relation to Forest Planting 116
Korstian, C. F.: Making the Forests of Utah a Permanent Resource (Presidential address) 177
Korstian, C. F.: mentioned 5
Korstian, C. F.: Relation of Precipitation to Height Growth of Forest Tree Saplings 260
Locke, S. B.: Forests and Fish and Game Conservation 190
Making the Forests of Utah a Permanent Resource (Presidential address), by C. F. Korstian 177
Mammals, Reptiles and Insects, Cases of Exceptional Growth of Certain Species of, (abstract), by L. Moth Iverson 28
Manure at Different Stages of Growth upon the Relative Abundance of Actinomyces, Non-Spore-Formers and Spore-Formers in the Soil, Effect of Green, by Thomas L. Martin 245

Martin, Thos. L.: Effect of Green Manure at Different Stages of Growth upon the Relative Abundance of Actinomyces, Non-Spore-Formers and Spore-Formers in the Soil, (abstract) 245
Matter from the Point of View of a Personalistic Philosophy, by W. H. Chamberlain 128
Matter, The Theory of the Constitution of, by Orin Tugman 120
Matthews, A. L.: Some Uncommon Plant Pests 41
Membership, Roster of 6
Merrill, Joseph F.: Is Electric Air Heating Feasible? 103
Merrill, M. C., and Tracy H. Abell: The Breeding of Canning Tomatoes 133
Merrill, M. C.: Distilled Water as a Means for Growing Plants 75
Merrill, M. C.: mentioned 5
Metal Films when Exposed to Ultra Violet Light, The Resistance of Thin, by Orin Tugman 161
Metallurgy of the Chloride Volatilization Process, by C. C. Stevenson 226
Metallurgy, Relation of Chemistry to, by Edward P. Barrett 155
Microscope in Ore Dressing, The, by R. E. Head 204
Mid-Tertiary Deformation of Western North America, by Hyrum Schneider 159
Miller, Newton: Food and Feeding of Fledglings (abstract) 45
Miller, Newton: mentioned 5
Mineral Industry, Hydrometallurgy as Applied to the, by Clarence A. Wright 142
Morgan, John C.: Pyrometallurgy and its Future Possibilities 150
Neal, W. D.: mentioned 4
Neal, W. D.: Our Country—a Retrospect (Presidential address) (abstract) 33
Normal Temperature as a Function of the Latitude, Elevation, Time of Day, and Day of Year, The, by Frank L. West 247
North America, Mid-Tertiary Deformation of Western, by Hyrum Schneider 159
Nutrition, Vitamines in Relation to, by W. E. Carroll 249
Officers, List of 4
Oil and Gas in Salt Lake and Cache Valleys, Possibilities of, by Hyrum Schneider 38
Oil Shales and Their Economic Importance, by Martin J. Gavin 145
Oil-Shales, Destructive Distillation of, by L. C. Karrick 211
Oil-Shales, The Use and Function of Steam in Retorting, by Martin J. Gavin and J. J. Jakowsky 232
Ore Dressing, The Use of the Microscope in, by R. E. Head 204
Our Country—a Retrospect (abstract). Presidential address, by W. D. Neal 33
Overgrazing, Detection of by Means of Indicator Plants, by Mark Anderson 56
Personal Reminiscences of John W. Powell, by Francis Marion Bishop 16

Philosophy, Matter from the Point of View of a Personalistic, by W. H. Chamberlain 128
Photographic Plates, Reversals in (abstract), by C. Arthur Smith 34
Photographic Plate Taking Reversal into Account, An Equation of the Density Exposure Curve of a, by Orin Tugman 36
Pittman, D. W.: The Relation of the Method of Analyzing Alkali Soils to the Limits of Toxicity 95
Plant Pests, Some Uncommon, by A. L. Matthews 41
Plants, Detection of Overgrazing by Means of Indicator, by Mark Anderson 56
Plants, Distilled Water as a Means for Growing, by M. C. Merrill 75
Plummer, Dr. Charles G.: The Quest of the Student of Nature 29
Possibilities of Oil and Gas in Salt Lake and Cache Valleys, by Hyrum Schneider 38
Potassium Cyanide and Sodium Cyanide on Alkyl Halides, Comparison of the Action of, by W. D. Kline and W. D. Bonner 174
Powell, John W., Personal Reminiscences of, by Francis M. Bishop 16
Program of the Eleventh Annual Convention of the Utah Academy of Sciences 15
Program of the Twelfth Annual Convention of the Utah Academy of Sciences 46
Program of the Thirteenth Annual Convention of the Utah Academy of Sciences 118
Program of the Fourteenth Annual Convention of the Utah Academy of Sciences 175
Pyrometallurgy and its Future Possibilities, by John C. Morgan 150
Quest of the Student of Nature, The, by Dr. Chas. G. Plummer.. 29
Relation of Chemistry to Metallurgy, by Edward P. Barrett 155
Relation of Precipitation to Height Growth of Forest Tree Saplings, The, by C. F. Korstian 260
Reptiles and Insects, Cases of Exceptional Growth of Certain Species of Mammals, (abstract), by L. Moth Iverson 28
Reversals in Photographic Plates, (abstract), by C. Arthur Smith 34
Roster of Membership 6
Schneider, Hyrum: mentioned 5
Schneider, Hyrum: Mid-Tertiary Deformation of Western North America 159
Schneider, Hyrum: Possibilities of Oil and Gas in Salt Lake and Cache Valleys 38
Shackell, L. F.: Is Disinfection a Reaction of the First Order? .. 162
Shale-Oil, The Analytical Distillation of, by M. J. Gavin 198
Smith, C. Arthur: mentioned 4, 5
Smith, C. Arthur: Reversals in Photographic Plates (abstract) 34
Smith, C. Arthur: Some Problems in Daylight Illumination 167
Smith, Orson: Intensity and Distribution of Illumination from Automobile Headlights (abstract) 37
Snoddy, Geo. S.: mentioned 5

Soil, Effect of Green Manure at Different Stages of Growth upon the Relative Abundance of Actinomyces, Non-Spore-Formers and Spore-Formers in the, by Dr. Thomas L. Martin (abstract) 245
Soil Moisture in Relation to Forest Planting, Evaporation and, by C. F. Korstian 116
Soils for Irrigation Water, Experiments on Capacities of, by O. W. Israelsen and F. L. West 139
Soils to the Limit of Toxicity, The Relation of the Method of Analyzing Alkali, by D. W. Pittman 95
Some Problems in Daylight Illumination, by C. Arthur Smith 167
Some Uncommon Plant Pests, by A. L. Matthews 41
Standardization from Constant Boiling Hydrochloric Acid, by J. T. Bonner and T. B. Brighton 173
Steam in Retorting Oil-Shales, Use and Function of, by M. J. Gavin and J. J. Jakowsky 232
Stevenson, C. C.: Metallurgy of the Chloride Volatilization Process 226
Temperature as a Function of the Latitude, Elevation, Time of Day, and Day of Year, The Normal, by Frank L. West 247
Temperature by Means of the Equation of Seasonal Temperature Variation and of a Modified Thermograph Record, Determination of the Normal, by Dr. Frank L. West, N. E. Edlefsen and S. P. Ewing 84
The Electron Theory of Conduction of Electricity, by Frank L. West 126
Theory of the Constitution of Matter, The, by Orin Tugman 120
The Problem of Handedness, by A. L. Beeley 59
The Quest of the Student of Nature, by Dr. C. G. Plummer 29
The Relation of the Method of Analyzing Alkali Soils to the Limits of Toxicity, by D. W. Pittman 95
The Ristance of Thin Metal Films When Exposed to Ultra Violet Light, by Orin Tugman 161
The Second Reclamation of the Desert (abstract), by R. A. Hart 40
Titus, E. G.: mentioned 4
Tomatoes, The Breeding of Canning, by M. C. Merrill and Tracy H. Abell 133
Tree Diseases, Forest, by A. O. Garrett 182
Tree Saplings, Relation of Precipitation to Height Growth of Forest, by C. F. Korstian 260
Tugman, Orin: An Equation of the Density Exposure Curve of a Photographic Plate Taking Reversal into Account, (abstract) 36
Tugman, Orin: mentioned 5
Tugman, Orin: The Resistance of Thin Metal Films When Exposed to Ultra Violet Light 161
Tugman, Orin: The Theory of the Constitution of Matter, (Presidential address) 120
Uncommon Plant Pests, Some, by A. L. Matthews 41

Use and Function of Steam in Retorting Oil-Shales, by M. J. Gavin and J. J. Jakowsky ... 232
Use of the Microscope in Ore Dressing, The, by R. E. Head ... 204
Varley, Thos. and C. M. Bouton: Chemistry of the Volatilization Process ... 218
Vitamines in Relation to Nutrition, by W. E. Carroll ... 249
Volatilization Process, Chemistry of the, by Thos. Varley and C. M. Bouton ... 218
Volatilization Process, Metallurgy of the Chloride, by C. C. Stevenson ... 226
Vorhies, C. T.: mentioned ... 4
West, Frank L.: mentioned ... 5
West, Frank L., N. E. Edlefsen and S. P. Ewing: Determination of the Normal Temperature by Means of the Equation of Seasonal Temperature Variation and of a Modified Thermograph Record. ... 84
West, Frank L., O. W. Israelsen and: Experiments on Capacities of Soils for Irrigation Water ... 139
West, Frank L.: The Electron Theory of Conduction of Electricity ... 126
West, Frank L.: The Normal Temperature as a Function of the Latitude, Elevation, Time of Day, and Day of Year ... 247
Wright, Clarence A.: Hydrometallurgy as Applied to the Mineral Industry ... 142