ELEVENTH REPORT

(Seven annual, four biennial)

OF THE

BOARD OF TRUSTEES

OF THE

ILLINOIS INDUSTRIAL UNIVERSITY,

URBANA, CHAMPAIGN COUNTY, ILLINOIS,

For the Two Years ending September 30th, 1882.

SPRINGFIELD, ILL.:  
H. W. Rokker, State Printer and Binder.  
1882.
Studies serve for delight, for ornament and for ability. Their chief use, for delight is in privateness and retiring; for ornament, is in discourse; and for ability, is in the judgment and disposition of business;—for expert men can execute, and perhaps judge of particulars, one by one; but the general counsels and the plots and marshalling of affairs come best from those that are learned.—Lord Bacon.

The grand result of schooling is a mind with just vision to discern, with free force to do: the grand schoolmaster is Practice. * * * He that has done nothing has known nothing. Vain is it to sit scheming and plauably discoursing: up and be doing! If thy knowledge be real, put it forth from thee; grapple with real Nature; try thy theories there and see how they hold out.— Carlyle.
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(Seven annual, four biennial)

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OF THE

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FACULTY.

SELIM H. PEABODY, Ph. D., LL. D.,
Regent, and Professor of Mechanical Engineering and Physics.

THOMAS J. BURRILL, M. A., Ph. D.,
Professor of Botany and Horticulture, and Vice-President,

SAMUEL W. SHATTUCK, M. A., C. E.,
Professor of Mathematics.

EDWARD SNYDER, M. A.,
Professor of Modern Languages.

DON CARLOS TAFT, M. A.,
Professor of Geology and Zoology.

JOSEPH C. PICKARD, M. A.,
Professor of English Language and Literature.

N. CLIFFORD RICKER, M. Arch.,
Professor of Architecture.

JAMES D. CRAWFORD, M. A.,
Professor of History and Ancient Languages, and Secretary.

HENRY A. WEBER, Ph. D.,
Professor of Chemistry.

GEORGE E. MORROW, M. A.,
Professor of Agriculture.

FREDERICK W. PRENTICE, M. D.,
Professor of Veterinary Science and Physiology.

PETER ROOS,
Professor of Industrial Art and Designing.

WILLIAM T. WOOD,
SECOND LIEUT. 18TH INFANTRY, U. S. A.,
Professor of Military Science and Tactics.
IRA O. BAKER, C. E.,
Professor of Civil Engineering.

MELVILLE A. SCOVELL, M. S.,
Professor of Agricultural Chemistry.

CECIL H. PEABODY, B. S.,
Assistant Professor of Mechanical Engineering.

CHARLES E. PICKARD, B. A.,
Assistant in English and Ancient Languages.

EDWIN A. KIMBALL,
Foreman of Machine Shop.

NELSON S. SPENCER,
Foreman of Carpenter Shop.

JEROME SONDERICKER, B. S.,
Instructor in Right Line Drawing.

J. C. FEITSHANS, M. A.,
Instructor in Elocution.

CHARLES J. ROLFE, M. S.,
Instructor of Mathematics and Botany.

JAMES E. ARMSTRONG, B. S.,
Instructor in Natural Science, and Taxidermist.

MRS. ABBIE WILKINSON,
Teacher of Vocal and Instrumental Music.

CHARLES C. BARNES,
First Assistant in Chemical Laboratory.

HOWARD SLAUSON,
Second Assistant in Chemical Laboratory.
LIST OF GRADUATES.

Those whose names are prefixed by an * died at the date mentioned. Graduates who have the rank as Captain have received commissions from the Governor of the State as Captain in the Illinois National Guard.

### 1872.

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<tr>
<th>Name</th>
<th>Occupation</th>
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<tr>
<td>Burwash, Milo B.</td>
<td>Farmer</td>
<td>Champaign</td>
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<tr>
<td>Davis, John J. B. S.</td>
<td>Physician</td>
<td>Racine, Wis.</td>
</tr>
<tr>
<td>Drewry, Henry N.</td>
<td>Physician</td>
<td>Altamont</td>
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<tr>
<td>Flagg, Alfred M. Captain</td>
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</tr>
<tr>
<td>Hatch, Miles F.</td>
<td>Lumberman</td>
<td>New Lacoma, W. T.</td>
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<td>Hill, Edgar L., Captain</td>
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<td>Watson</td>
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<tr>
<td>Lyman, George H.</td>
<td>Civil Engineer</td>
<td>Cairo, Ill.</td>
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<tr>
<td>Matthews, James N.</td>
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<td>Mason</td>
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<tr>
<td>Reiss, Willis A.</td>
<td>Teacher</td>
<td>Belleville</td>
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<tr>
<td>Reynolds, S. A., Captain</td>
<td>Lawyer</td>
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<tr>
<td>Ricard, Thomas E., Captain</td>
<td>Farmer</td>
<td>&quot;Springfield&quot;</td>
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<tr>
<td>Bicker, N. Clifford, M. Arch, Professor of Architecture, Illinois Industrial University</td>
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<tr>
<td>Rolf, Charles W., M. S., Instructor Mathematics and Botany, Illinois Industrial University</td>
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<tr>
<td>Silver, Howard, Principal Public Schools</td>
<td></td>
<td>Hutchinson, Kan.</td>
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<tr>
<td>Silver, Charles W., County Supt. of Schools</td>
<td></td>
<td>Newton, Kan.</td>
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<tr>
<td>Temple, Jared</td>
<td>Merchant</td>
<td>Marengo</td>
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<tr>
<td>Wharton, Jacob N.</td>
<td>Machinist</td>
<td>Bement</td>
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<tr>
<td>Whitecomb, Alonzo L.</td>
<td>Physician</td>
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<td>Wood, Reuben O., Captain</td>
<td>Farmer</td>
<td>Woodburn</td>
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### 1873.

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<thead>
<tr>
<th>Name</th>
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<tbody>
<tr>
<td>Graham, Charles P.</td>
<td>Clergyman</td>
<td>New Salem, Kansas</td>
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<tr>
<td>Hatch, Frederick L.</td>
<td>Farmer</td>
<td>Binns Mills</td>
</tr>
<tr>
<td>Hayes, Charles L., B. S., Superint. Mining Works</td>
<td>Miner</td>
<td>Buck Hills, Col.</td>
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<tr>
<td>Hennessy, Augustus L.</td>
<td>Editor</td>
<td>Chicago</td>
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<tr>
<td>Hook, Samuel H.</td>
<td>Miner</td>
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</tr>
<tr>
<td>Ockerson, John A., B. S., Engineer U. S. Lake and River Survey</td>
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<tr>
<td>Phillips, Parley A.</td>
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<td>Damascus</td>
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<tr>
<td>Platt, Franklin C., Capt.</td>
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<td>Don City, Iowa.</td>
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<tr>
<td>Porterfield, Elijah N.</td>
<td>Civil Engineer</td>
<td>Eureka Springs, Ark.</td>
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<tr>
<td>Robbins, Henry E., Principal Public Schools</td>
<td>Teacher</td>
<td>Lyons, Iowa</td>
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<tr>
<td>Williams, Lewis E.</td>
<td>Farmer</td>
<td>Montrose, Iowa</td>
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<th>Name</th>
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<tr>
<td>Baker, Ira O., C. E., Professor of Civil Engineering, Illinois Industrial University</td>
<td>Druggist</td>
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<td>Campbell, John P.</td>
<td>Farmer</td>
<td>Enfield</td>
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<td>Dreyer, Ebenezer D.</td>
<td>Lawyer</td>
<td>Effingham</td>
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<tr>
<td>Eaton, Herbert</td>
<td>R. B Contractor.</td>
<td>Las Vegas, N. M.</td>
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<td>Ellis, William C.</td>
<td>Civil Engineer.</td>
<td>Olympia, W. T.</td>
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<td>Estep, Harvey C.</td>
<td>Lawyer</td>
<td>Chicago</td>
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<td>Foster, Charles W.</td>
<td>Missionary</td>
<td>Asia Minor</td>
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<tr>
<td>Gabriallal, Gregory</td>
<td>Gennadius Panagiotiss, B. S., Com. of Agriculture</td>
<td>Athens, Greece</td>
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<td>Jowers, Charles P.</td>
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<td>Pierce, John L. B. A.</td>
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<td>Storey, George</td>
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<tr>
<td>Smith, Charles A. B. S.</td>
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<td>Wharry, Walter W., Capt.</td>
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<td>Watts, William</td>
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<td>Sylvan, O</td>
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<td>Cheever, Alice</td>
<td>Mrs. A. H. Bryan</td>
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<td>Potter, F. Adelia</td>
<td>Mrs H B Bryan</td>
<td>Wickes, M. T.</td>
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<tr>
<td>Barnard, D. E.</td>
<td>Tanner</td>
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<tr>
<td>Barnes, Arthur E., B. S.</td>
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<tr>
<td>Brown, Dillon S.</td>
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<td>Brown, Ralph L., M. L., Principal of Public Schools</td>
<td>Teacher</td>
<td>Wyandotte, Kansas</td>
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<td>Cobbing, Charles W.</td>
<td>Architect</td>
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<td>Dunlap, Henry M.</td>
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<td>Savoy</td>
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<td>Dunlap, Berleigh A.</td>
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<td>Eaton, Ernest</td>
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<td>Everhart, Winfield S., Capt.</td>
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<td>Toledo</td>
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<td>Faulkner, James, Capt., Principal Public Schools.</td>
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<td>Gridley, George, N A.</td>
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<td>Half Day</td>
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<td>Lyford, Charles C., B. S.</td>
<td>Vet. Surg.</td>
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<td>Muller, John</td>
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<td>Robinson, Eliza A.</td>
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<td>Seovell, Melville A., M. S., Professor of Agricultural Chemistry, Illinois Industrial University</td>
<td>Mrs Gr'nhalgh</td>
<td>Champaign</td>
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<td>Shawhan, George R., B. L., County Superintendent of Schools, Champaign County.</td>
<td>Mrs Milton Moore</td>
<td>Dixon</td>
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<td>Mrs H E Robbins</td>
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<td>Stewart, Maggie E., B. L.</td>
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<td>Steele, Mary C., B. L.</td>
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<td>Clark, Charles W.</td>
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<td>Drake, James F.</td>
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<td>Mahan, H. Weston</td>
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<td>Mann, Frank L.</td>
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<td>Gilman</td>
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<td>Mann, A. Howard</td>
<td>*April 23, 1879</td>
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<td>Noble, Louis B., B.</td>
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<td>Starr, Frank A. E.</td>
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<td>Stookey, D. Wesley</td>
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<td>*Wild, George A.</td>
<td>Nov. 1881, at</td>
<td>Las Animas, Colo.</td>
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<td>Williams, Thomas T.</td>
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<tr>
<td>Holton, Mattie S.</td>
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<td>Champaign</td>
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<td>Abbott, Theodore S.</td>
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<td>Laredo, Texas</td>
</tr>
<tr>
<td>*Allen, Charles W.</td>
<td>July 8, 1880</td>
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<tr>
<td>Barry, Charles H.</td>
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<tr>
<td>Blackall, C. H. M.</td>
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<td>Bumstead, James E.</td>
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<td>Clay, Luther G.</td>
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<td>Crow, Benjamin F.</td>
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<td>Council Bluffs, Ia.</td>
</tr>
<tr>
<td>Faulkner, Richard D.</td>
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<tr>
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1877.

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<td>Skinner, Velma B.</td>
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<td>Switzer, Gertrude</td>
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1878.

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<td>&quot;Nov. 30, 1881&quot;</td>
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<td>Ziesing, August B., S., Capt.</td>
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<tr>
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1879.

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<td>Beardsley, Henry M., M. L.</td>
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<td>Bourne, Henry P., B. S., U. S. River Survey</td>
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<td>Butler, Wm. N., Capt.</td>
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<tr>
<td>Kimble, Willis P., B. S.</td>
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*Note:* The text appears to be a list of names, occupations, and residences from different years (1877-1879), with entries typically consisting of a name, an occupation, and a residence. The occupations range from lawyers, to doctors, to teachers, and more. The residences listed include various cities and towns across the United States. The text is formatted as a table, with columns for Name, Occupation, and Residence.
### 1879—Continued.

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<td>Clerk</td>
<td>Girard</td>
</tr>
<tr>
<td>Birney, Frank L.</td>
<td>Medical student</td>
<td>Urbana</td>
</tr>
<tr>
<td>Boothby, Arthur, B. S.</td>
<td>Farmer</td>
<td>Pittsfield</td>
</tr>
<tr>
<td>Boyd, Comma N., Captain</td>
<td>Farmer</td>
<td>Shofield</td>
</tr>
<tr>
<td>Coddington, Arch. O., B. L.</td>
<td>Teacher</td>
<td>Wyandotte, Kansas</td>
</tr>
<tr>
<td>Cooper, Frederick E., B. S.</td>
<td>At home</td>
<td>Girard</td>
</tr>
<tr>
<td>Davis, Arthur E., B. L.</td>
<td>Telegrapher</td>
<td>Crawfordsville, Ind.</td>
</tr>
<tr>
<td>Dennis, C. H., B. L., Captain</td>
<td>Farmer</td>
<td>Chicago</td>
</tr>
<tr>
<td>Dressor, John C., B. S.</td>
<td>Farmer</td>
<td>Cottonwood Grove</td>
</tr>
<tr>
<td>Forsyth, James</td>
<td>Student</td>
<td>Champaign</td>
</tr>
<tr>
<td>Frum, W. W., B. S., Captain</td>
<td>Farmer</td>
<td>Camargo</td>
</tr>
<tr>
<td>Hill, Fred L.</td>
<td>Surveyor</td>
<td>Pullman</td>
</tr>
<tr>
<td>Hill, T. C. B. A., Captain</td>
<td>Teacher</td>
<td>Tolono</td>
</tr>
<tr>
<td>Kingman, Arthur H.</td>
<td>Assayist</td>
<td>Wakefield, Mass</td>
</tr>
</tbody>
</table>
### 1881—Continued.

<table>
<thead>
<tr>
<th>Name</th>
<th>Occupation</th>
<th>Residence</th>
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</thead>
<tbody>
<tr>
<td>McKay, Francis M., B. L., Principal West Jackson Street Public School</td>
<td>Student of Med.</td>
<td>Chicago</td>
</tr>
<tr>
<td>Mansfield, Willis A., B. L.</td>
<td>Farmer</td>
<td>Buda</td>
</tr>
<tr>
<td>Mason, William K., B. S.</td>
<td>Teacher</td>
<td>Metamora</td>
</tr>
<tr>
<td>Morse, John H., Captain</td>
<td>Medical student</td>
<td>Champaign</td>
</tr>
<tr>
<td>Pearman, J. Ora, B. S.</td>
<td>Draftsman</td>
<td>Chicago</td>
</tr>
<tr>
<td>Philbrick, E. B. S., Captain</td>
<td>Medical student</td>
<td>Chicago</td>
</tr>
<tr>
<td>Peepoon, Herman S., B. S.</td>
<td>Clerk</td>
<td>Jamestown, Nebraska</td>
</tr>
<tr>
<td>Pletcher, Francis M., B. S.</td>
<td>Teacher</td>
<td>Lewisburg, Kansas</td>
</tr>
<tr>
<td>Porter, Frank H., Captain</td>
<td>Clerk</td>
<td>Cottonwood Grove</td>
</tr>
<tr>
<td>Ross, Sprague D., B. S.</td>
<td>Clerk</td>
<td>Salem</td>
</tr>
<tr>
<td>Schwartz, Joseph</td>
<td>Naturalist</td>
<td>Normal</td>
</tr>
<tr>
<td>Seymour, Arthur B., B. S.</td>
<td>Clerk</td>
<td>Wabasha, Minn</td>
</tr>
<tr>
<td>Slade, Byron A., B. S., Captain</td>
<td>Teacher</td>
<td>Princeton</td>
</tr>
<tr>
<td>Stacey, Morelle M., B. L.</td>
<td>Teacher</td>
<td>Chicago</td>
</tr>
<tr>
<td>Sturman, James B., B. S.</td>
<td>Stenographer</td>
<td>Chicago</td>
</tr>
<tr>
<td>Talbot, A. N. B. S., Captain</td>
<td>Teacher</td>
<td>Chicago</td>
</tr>
<tr>
<td>Weston, William S., B. L.</td>
<td>Student</td>
<td>Champaign</td>
</tr>
<tr>
<td>Wilson, Maxwell B. B.</td>
<td>Farmer</td>
<td>East Paris</td>
</tr>
<tr>
<td>Baker, Kittie M.</td>
<td>Music student</td>
<td>Chicago</td>
</tr>
<tr>
<td>Barnes, Bertha E., B. L.</td>
<td>Teacher</td>
<td>Pullman</td>
</tr>
<tr>
<td>Davis, Marietta, E. L.</td>
<td>Music teacher</td>
<td>Monticello</td>
</tr>
<tr>
<td>Elder, Loretta K., B. L.</td>
<td>At home</td>
<td>Chicago</td>
</tr>
<tr>
<td>Hammett, Jennie M., B. S.</td>
<td>At home</td>
<td>Camargo</td>
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<tr>
<td>Lawhead, Lucie M., B. L.</td>
<td>Teacher</td>
<td>Champaign</td>
</tr>
<tr>
<td>Lauver, Nettie E.</td>
<td>At home</td>
<td>Belvidere</td>
</tr>
<tr>
<td>Macknet, Metta M., B. A.</td>
<td>*At home</td>
<td>Girard</td>
</tr>
<tr>
<td>Thomas, Darle, B. L.</td>
<td>Clerk</td>
<td>Bloomington</td>
</tr>
<tr>
<td>Wright, Jessie A., B. L.</td>
<td>Teacher</td>
<td>Champaign</td>
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### 1882.

<table>
<thead>
<tr>
<th>Name</th>
<th>Residence</th>
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<tbody>
<tr>
<td>Bailey, Samuel G., Jr., B. S.</td>
<td>Chicago</td>
</tr>
<tr>
<td>Barnes, Charles C.</td>
<td>Champaign</td>
</tr>
<tr>
<td>Bridg, Arthur M.</td>
<td>La Moille</td>
</tr>
<tr>
<td>Bullard, Benjamin F., B. L.</td>
<td>Mechanicsburg</td>
</tr>
<tr>
<td>Bullard, George W., B. S.</td>
<td>Springfield</td>
</tr>
<tr>
<td>Carman, William B., B. L.</td>
<td>Urbana</td>
</tr>
<tr>
<td>Cole, Edward E.</td>
<td>Champaign</td>
</tr>
<tr>
<td>Cowles, Willis G.</td>
<td>Warren</td>
</tr>
<tr>
<td>Davis, Jeph H.</td>
<td>Monticello</td>
</tr>
<tr>
<td>Eichberg, David, B. L.</td>
<td>Atlanta</td>
</tr>
<tr>
<td>Eisenmayer, Andrew J., B. S.</td>
<td>Trenton</td>
</tr>
<tr>
<td>Harrison, Samuel A., B. A.</td>
<td>Alton</td>
</tr>
<tr>
<td>Merritt, Charles H.</td>
<td>Waterman</td>
</tr>
<tr>
<td>Neely, John R., B. L.</td>
<td>Du Quoin</td>
</tr>
<tr>
<td>Noble, Thomas</td>
<td>Todd's Point</td>
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<tr>
<td>Orr, Robert E., B. S.</td>
<td>Champaign</td>
</tr>
<tr>
<td>Peabody, Arthur, B. S.</td>
<td>Champaign</td>
</tr>
<tr>
<td>Palmer, Charles W., B. L.</td>
<td>Watseka</td>
</tr>
<tr>
<td>Richards, George W., B. S.</td>
<td>Quincy</td>
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<tr>
<td>Roberts, Charles N., B. S.</td>
<td>Jefferson</td>
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<tr>
<td>Bugg, Frederic B., B. L.</td>
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<tr>
<td>Sharp, Abia J., B. S.</td>
<td>East Lynne, Mo.</td>
</tr>
<tr>
<td>Slauclman, Frank, B. S.</td>
<td>Decatur</td>
</tr>
<tr>
<td>Sluason, Howard, B. S.</td>
<td>Bloomington</td>
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<tr>
<td>Smith, Charles L., B. L.</td>
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<tr>
<td>Spencer, Nelson S., B. S.</td>
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<tr>
<td>Taft, Florizel A., B. S.</td>
<td>Champaign</td>
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<tr>
<td>Todd, James, B. S.</td>
<td>Elgin</td>
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<tr>
<td>Turner, Herbert</td>
<td>Quincy</td>
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<tr>
<td>Wadsworth, John G.</td>
<td>Madison, Dakota</td>
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<tr>
<td>Andrus, Dora A., B. L.</td>
<td>Ashton</td>
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<td>Avery, Kitty C., B. L.</td>
<td>Champaign</td>
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<tr>
<td>Cole, Fronia E.</td>
<td>Champaign</td>
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<tr>
<td>Bailey, Arvilla K.</td>
<td>Granville</td>
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## SUMMARY OF STUDENTS.

**For the Year Ending June, 1881.**

<table>
<thead>
<tr>
<th>By Classes</th>
<th>Gentlemen</th>
<th>Ladies</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td>Seniors</td>
<td>39</td>
<td>11</td>
<td>50</td>
</tr>
<tr>
<td>Juniors</td>
<td>41</td>
<td>6</td>
<td>47</td>
</tr>
<tr>
<td>Sophomores</td>
<td>54</td>
<td>24</td>
<td>78</td>
</tr>
<tr>
<td>Freshmen</td>
<td>85</td>
<td>31</td>
<td>116</td>
</tr>
<tr>
<td>Preparatory</td>
<td>73</td>
<td>4</td>
<td>77</td>
</tr>
<tr>
<td>Special</td>
<td>7</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>299</strong></td>
<td><strong>80</strong></td>
<td><strong>379</strong></td>
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**For the Year Ending June, 1882.**

<table>
<thead>
<tr>
<th>By Classes</th>
<th>Gentlemen</th>
<th>Ladies</th>
<th>Total</th>
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<tbody>
<tr>
<td>Res. Grad.</td>
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<td>0</td>
<td>9</td>
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<tr>
<td>Seniors</td>
<td>31</td>
<td>4</td>
<td>35</td>
</tr>
<tr>
<td>Juniors</td>
<td>33</td>
<td>16</td>
<td>49</td>
</tr>
<tr>
<td>Sophomores</td>
<td>72</td>
<td>19</td>
<td>91</td>
</tr>
<tr>
<td>Freshmen</td>
<td>63</td>
<td>24</td>
<td>87</td>
</tr>
<tr>
<td>Preparatory</td>
<td>60</td>
<td>11</td>
<td>71</td>
</tr>
<tr>
<td>Special</td>
<td>8</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>276</strong></td>
<td><strong>76</strong></td>
<td><strong>352</strong></td>
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</tbody>
</table>

**By Courses.**

<table>
<thead>
<tr>
<th></th>
<th>Gentlemen</th>
<th>Ladies</th>
<th>Total</th>
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</thead>
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<tr>
<td>Agriculture</td>
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<td></td>
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<tr>
<td>Mechanical Eng.</td>
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<td></td>
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<tr>
<td>Civil Eng.</td>
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<tr>
<td>Mining Eng.</td>
<td>3</td>
<td></td>
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</tr>
<tr>
<td>Architecture</td>
<td>14</td>
<td></td>
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<tr>
<td>Chemistry</td>
<td>41</td>
<td>1</td>
<td>42</td>
</tr>
<tr>
<td>Natural History</td>
<td>5</td>
<td>9</td>
<td>14</td>
</tr>
<tr>
<td>Art and Design</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Eng. and Mod.</td>
<td>57</td>
<td>50</td>
<td>107</td>
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<tr>
<td>Ancient Lang.</td>
<td>12</td>
<td>4</td>
<td>16</td>
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<tr>
<td>Elective</td>
<td>10</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>Not specified</td>
<td>19</td>
<td>7</td>
<td>26</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>267</strong></td>
<td><strong>76</strong></td>
<td><strong>343</strong></td>
</tr>
</tbody>
</table>

Res. Graduates: 9

**Total:** 276

The whole number matriculated as students since the opening is 1,969. The number graduated from the several colleges, including the class of 1882, is 337.
THE UNIVERSITY.

THE ORGANIZATION AND EQUIPMENT.

BUILDINGS AND GROUNDS.

The domain occupied by the University and its several departments embraces about 623 acres, including stock farm, experimental farm, orchards, gardens, nurseries, forest plantations, arboretum, ornamental grounds, and military parade ground.

The University buildings, fifteen in number, include a grand main building for public use, one large and two small Dormitory buildings, a spacious Mechanical building and Drill hall, a large Chemical laboratory, a Veterinary hall, a small Astronomical observatory, three dwellings, two large barns, and an ample green-house.

The Mechanical building and Drill hall is of brick, 126 feet in length and 88 feet in width. It contains a boiler, forge and tank room; a machine shop, furnished for practical use, with a steam engine, lathes, and other machinery; a pattern and finishing shop; shops for carpentry and cabinet work, furnished with wood-working machinery; paint room and rooms for models, storage, etc. In the second story is the large Drill hall, 124 by 80 feet, sufficient for the evolutions of a company of infantry, or a section of a battery of field artillery. It is also well supplied with gymnastic apparatus. One of the towers contains an armorer's shop and military model room, an artillery room and a band room. The other contains a printing office and editor's room.

The large Dormitory building is 125 feet in length and five stories in height. This was so badly damaged by storms in the spring of 1880 that it is not fit for use. It afforded 80 private rooms for students. Two smaller Dormitory buildings contain eight rooms each. The new Chemical building, erected in 1878 at a cost, including furniture, of $40,000, contains five laboratories, and is one of the best and largest in the United States.

ADMISSION AND GRADUATION.

CHOICE OF STUDIES.

It has been a favorite aim of the University from the outset, to allow as much freedom as possible in the selection of studies.

A University is designed not for children, but for men and women, who may claim to know something of their wants, powers,
and tastes. It is not useful to require every student, without regard to his capacity or practical wants, to take entire some lengthened "course of study." Each student should weigh carefully his own powers and needs, and counsel freely with his teachers as to the branches he may need to fit him for his chosen career, and then should pursue them with earnestness and perseverance, without faltering or fickleness.

It is necessarily required:—that the student should be thoroughly prepared to enter and keep pace with the classes in the chosen studies, and that he shall take these studies in the terms in which they are taught. Candidates for a degree must take the course of study prescribed for that degree.

Each student is expected to have three distinct studies, affording three class exercises each day. On special request, the Faculty may allow less or more.

No change in studies can be made after the beginning of a term, without permission of the Faculty.

Due care will be taken to prevent, as far as possible, all abuse of the liberty of choice. Students failing to pass satisfactory examinations in their chosen studies, will not be permitted to remain and take other studies without a vote of the Faculty.

REQUIRED STUDIES.

To secure the diffusion of the sciences relating to the great industries, the State Legislature, in 1873, prescribed that each student should be taught some of those sciences.

The Trustees accordingly require that each student shall take, each term, one study at least from the following list:


EXAMINATIONS FOR ADMISSION.

Examinations of candidates for admission to the University, or any of its departments, are held at the University itself, the day previous to the opening of each term. These examinations embrace the following studies:
1. English Grammar, Arithmetic, Geography, and History of the United States, for all the Colleges. These examinations are as thorough as those required for second-grade certificates for teachers in the public schools.

2. Algebra, including equations of second degree and the calculus of radical quantities; Geometry, plain and solid. These are required also for all the Colleges.

3. Physiology, Botany, Natural Philosophy, English Rhetoric and Composition. These are required in addition to 1 and 2 for candidates for the Colleges of Agriculture, Engineering and Natural Science.

4. Physiology, Botany, Natural Philosophy, Latin Grammar and Reader. Cæsar, Cicero, Virgil, and Latin Prose Composition, in addition to 1 and 2, for School of English and Modern Languages.

5. Latin (as in 4), Greek Grammar and Reader, four books of Xenophon’s Anabasis, and Greek Prose Composition, in addition to 1 and 2, for candidates for School of Ancient Languages.

For further information concerning terms of admission, see “Admission” under the several Colleges; also “Preliminary Year.”

COUNTY SUPERINTENDENT’S CERTIFICATES.

To prevent loss to those who are not prepared to enter the University, but might come, hoping to pass the examinations for admission, the following arrangement has been made:

County Superintendents of Schools will be furnished with questions and instructions for the examination of candidates in the four common branches, Arithmetic, Geography, English Grammar, and History of the United States; those who pass creditably will, when they present the Superintendent’s certificate to that effect, be admitted to the classes of the Preliminary year.

ACCRREDITED HIGH SCHOOL.

The Faculty, after personal examination, appoint accredited High Schools, whose graduates may be admitted to the University without further examination. These must be schools of first rate character, whose courses of instruction include all the studies required for admission to some one of the colleges of the University. On application, a member of the faculty is sent to examine the school making application, as to its facilities for teaching, its course and methods of instruction, and the general proficiency shown. If the report is favorable, the name of the school is entered in the published list of High Schools, accredited by the University. The graduates of these schools are admitted to any of the colleges for which their studies may have prepared them. The appointment continues as long as the work of the school is found satisfactory. Annual reports are asked from these schools.
ACCREDITED HIGH SCHOOLS.

Princeton High School ........................................ H. C. McDougall, Principal.
Lake View High School ........................................ A. F. Nightingale, Principal.
Champaign, West High School ................................ M. Moore, Principal.
Decatur High School ............................................ J. N. Wilkinson, Principal.
Champaign, East High School ................................ J. L. Betzer, Principal.
Urbana High School ............................................. J. W. Hayes, Principal.
Oak Park High School ........................................... E. L. Dodge, Principal.
Chicago South Division High School ......................... Jeremiah Slocomb, Principal.
Chicago North Division High School ......................... H. H. Bellfield, Principal.
Chicago West Division High School ......................... George P. Welles, Principal.
Hyde Park High School ......................................... Leslie Lewis, Superintendent.
Marengo High School ........................................... C. J. Allen, Principal.
Kankakee High School .......................................... F. M. Tracy, Principal.
Mattoon, East Side High School .............................. John T. Hall, Principal.
Springfield High School ....................................... F. R. Feitshans, Principal.
Monticello High School ........................................ H. T. Baker, Principal.
Warren High School ............................................ D. E. Garver, Principal.
Peru High School ................................................ Joseph Carter, Principal.
Peoria High School ............................................. Charles A. Smith, Principal.
Galena High School ............................................. R. L. Barton, Principal.
Shelbyville High School ....................................... Florence B. Webster, Principal.
Sycamore High School .......................................... A. J. Blanchard, Principal.
Rochelle High School .......................................... P. B. Walker, Principal.
Rossville High School ......................................... W. A. Chamberlain, Principal.
Bement High School ............................................. L. N. Wade, Principal.
Oakland High School ........................................... Charles I. Parker, Principal.
Jacksonville High School ..................................... D. H. Harris, Superintendent.
Danville High School .......................................... S. Y. Gillian, Principal.
Marshall High School .......................................... D. S. Kilborn, Principal.
Ottawa High School ............................................ H. L. Boltwood, Principal.

EXAMINING SCHOOLS.

The Trustees have authorized the Faculty to designate one or more High Schools in each county of the State, of sufficiently high grade and good reputation, whose certificates of examination, in the branches required of candidates for the University, may be received in lieu of the usual examination of the University.

These must be Graded, or High Schools of good reputation, and of sufficiently extended course to prepare students for the University. The principal teachers of the schools selected will be authorized to prepare questions and conduct examinations of any of their students desirous of entering the University, but the papers must be sent to the University for final decision.

EXAMINING SCHOOLS.

Rockford, West High School .................................. W. W. Stetson, Principal.
Sterling, 2d Ward High School ................................ Alfred Baylies, Principal.
Belvidere High School ......................................... H. J. Sherrill, Principal.
La Porte High School .......................................... E. T. Oift, Principal.
Belleville High School ........................................ Henry Knab, Principal.
Dwight High School ............................................. Jesse Hubbard, Principal.
Macon High School ............................................. J. F. Gowdy, Principal.
Monticello High School ....................................... N. J. Betzer, Principal.
Kewanee High School .......................................... E. C. Rossiter, Principal.
Arcola High School ............................................ T. C. Clendenin, Principal.

PREPARATORY WORK.

To meet an urgent demand, the Trustees consented to provide for teaching the preparatory studies lying between the work of the common school and that of the University.

Candidates for these classes should not be less than fifteen years old. They must pass satisfactory examinations in Arithmetic, Geography, English Grammar, and History of the United States. The examination in these branches should be equal to that usually
required for a second grade certificate for teachers. This examination may be made by county superintendents. The studies taught in the preliminary year are as follows:

PREPARATORY STUDIES.

For the Colleges of Engineering, Agriculture, and Natural Science.

First Term.—Algebra—(Olney's Fundamental rules, Factoring, Common Divisors and Multiples, Powers and Roots, Calculus of Radicals, Simple Equations, Proportion and Progression. Physiology—(Dalton's or an equivalent.) Natural Philosophy—(Norton's or an equivalent.)

Second Term.—Algebra—Quadratic equations, etc. Geometry—Plane Geometry, Lines, Circumferences, Angles, Polygons, as far as equality in Olney's Geometry. English.—Elements of Composition. (Gilmore's Art of Expression or equivalent.) Orthoepy and Word Analysis. (Introduction to Webster's Academic Dictionary.)

Third Term—Geometry completed, including solid Geometry and the Sphere. English as is the second term, with addition of Goldsmith's Traveler, or an equivalent, read for analysis. Botany—Gray's Lessons in Botany, or an equivalent.

FOR COLLEGE OF LITERATURE AND SCIENCE.

First Term.—Algebra, as above. Latin, Caesar. Greek, Grammar and Reader.

Second Term.—Algebra and Geometry, as above given. Latin, Cicero's Orations. Greek, Xenophon's Anabasis.

Third Term.—Geometry, completed. Latin, Virgil's Æneid. Greek, the Anabasis.

N. B.—Greek is required only for the School of Ancient Languages. The School of English and Modern Languages requires Physiology, Natural Philosophy, and Botany instead of Greek.

Students in the preparatory studies are not matriculated as University students. They pay no entrance fee, but are charged a tuition fee of five dollars a term, and the incidental fee of seven and a half dollars a term. They have all the privileges of the library and of the public lectures.

N. B.—No student is matriculated as a college student until all preparatory studies are completed.

DEGREES AND CERTIFICATES.

The law provides that, "on recommendation of the Faculty, the Trustees may authorize the Regent, as President of the University, to issue diplomas to such persons as shall have completed satisfactorily the required studies, and sustained the examination therein, conferring such Literary and Scientific Degrees as are usually conferred by Universities for similar or equivalent courses of studies, or such as the Trustees may deem appropriate." Approved May 11, 1877.
In accordance with the law, the following system of degrees has been adopted for the University:

1. All studies will remain as heretofore, free. Each student may choose and pursue such studies as he may desire, subject only to such conditions as to preparation, times of study, and number of studies, as may be necessary to secure efficiency in classes and economy in teaching.

2. But students who wish to be candidates for any degree must complete fully the course of studies prescribed for such degree.

3. Students not candidates for any degree will be enrolled as special students, and will receive at the close of their attendance, if not less than a year, the certificates provided by law, with statements of work done and credits attained.

4. It is designed that the requirements for all the Bachelor's Degrees shall be, as nearly as possible, equal in amount and value.

5. The Degree of Bachelor of Science, B. S., will be given to those who complete either of the courses of studies in the Colleges of Engineering, Agriculture, or Natural Science. The name of the School will be inserted after the degree.

7. The Degree of Bachelor of Letters, B. L., will be given to those who complete the course in the School of English and Modern Languages.

8. The Degree of Bachelor of Arts, B. A., will be given to those who complete the course of the School of Ancient Languages.

9. The Masters' Degrees, M. S., M. L., and M. A., and the equivalent degrees of C. E., M. E., etc., will be given only to those who have pursued, and passed examinations on a year of prescribed post-graduate studies, or after a term of successful practice. In either case an accepted thesis will be required.

EXPENSES.

The Tuition is free in all the University Classes.

The matriculation fee entitles the student to membership in the University until he completes his studies, and must be paid before he enters. Amount. $10 00

The term fee for incidental expenses is, for each student... 7 50

Room rent in University dormitory, each student per term. $2 00 to 6 00

Each student in the Chemical and Physical Laboratories, and in the Draughting and Engineering Classes, is required to make a deposit varying from 50 cents to $8, to pay for chemicals and apparatus used, and for any breakages or damages.

All bills due the University must be paid before the student can enter classes.

The following are the estimated maximum and minimum annual expenses, exclusive of books and clothing, of a residence of thirty-six weeks at the University:
Term fees and room rent for each student | $28.50 | $34.50
Table board in boarding houses and clubs | $72.00 | $144.00
Fuel and light | $10.00 | $18.00
Washing, at 75 cents per dozen | $13.50 | $27.00
Total annual amount | $124.00 | $220.50
Board and room in private houses, per week | $4.00 | $6.00

FEES IN THE PRELIMINARY YEAR.

Tuition, per term | $5.00
Incidental fee, per term | 75 cents

SPECIAL FEES.

For music, for 20 lessons | $10.00
For painting or drawing, to special students | $10.00
Graduating fee | $5.00

CALENDAR FOR 1882-'83.

Examinations for admission | Monday, September 11
First or Fall term begins | Wednesday, September 13
First term ends | Wednesday, December 20

WINTER VACATION.

FOR 1883.

Examinations for admission to advanced classes | Tuesday, January 2
Opening of the second or Winter term | Wednesday, January 3
Anniversary Day | March 11
Second term ends | Wednesday, March 21
Third or spring term begins | Wednesday, March 21
Baccalaureate address in University Chapel | Sunday, June 3
Class Day | Monday, June 4
Alumni Day | Tuesday, June 5
Commencement | Wednesday, June 6

SUMMER VACATION.

Examinations for admission | Monday, September 10
First or Fall term begins | Wednesday, September 12

APPARATUS AND EQUIPMENTS.

The College has, for the illustration of practical agriculture, a stock farm of 410 acres, provided with a large stock barn fitted up with stables, pens, yards, etc., and an experimental farm of 180 acres, furnished with all necessary apparatus. It has fine specimens of neat cattle, Short-horns and Jerseys, with several breeds of swine, to illustrate the problems of breeding and feeding. The Experimental Department exhibits field experiments in the testing of the different varieties and modes of culture of field crops, and in the comparison and treatment of soils. It includes experiments in Agriculture and Horticulture, under the direction of the Professors of Agriculture and of Horticulture, and experiments in feeding animals of different ages and development, upon the various kinds of food. In common with similar departments in the several Agricultural Colleges of the country, it attempts to accumulate knowledge preparatory to the development of an agricultural science.
Read from "Apparatus and Equipments" through pages 20, 21 and 22, after page 24.
The barn on the stock farm has north and west fronts of 80 feet each. Each limb, or L, is 40 feet wide. It is of the kind known as the side-hill barn. The barn on the experimental farm is of less size, but is fitted up with great convenience, and is supplied with a mill for grinding feed, run by a large wind-mill.

A Veterinary hall and stable has been provided, and a clinic is held to illustrate the lectures on veterinary science. The Department has Dr. Auzoux’ celebrated complete model of the horse, in 97 pieces, exhibiting 3,000 details of structure; also papier-maché models of the foot and teeth of the horse at different ages.

Surveying and Drainage are illustrated by field practice with instruments, and by models. Agricultural chemistry is taught by lectures and laboratory practice, in the analysis of soils, fertilizers, foods, etc.

Upon the grounds devoted to the use of the College, there are:
1. An apple orchard planted in 1869, containing about 1,000 varieties, with pears, cherries, grapes and small fruits. 2. A nursery of young trees, in which students have regular work in grafting, etc. 3. A forest-tree plantation of the most useful kinds of timber. 4. An arboretum, in which hardy indigenous and exotic trees are planted as fast as they can be secured; it now contains nearly 100 species. The ornamental grounds which surround the University building occupy about twenty acres, kept in neat and attractive style. These, with the adjuncts of trees and flowering shrubs, lawn and beds of flowers and foliage plants, walks of different material and styles of laying out, illustrate the class-room work in landscape gardening. A green-house contains a collection of plants of great value to the classes in floriculture and landscape gardening, and furnishes practice in hot-house and green-house management.

Among the more notable may be mentioned a variety of palms, specimens of coffee, tea, banana, sugar cane, custard apple, orange, rubber tree, maranta, fig, aloe, pine-apple, pepper, New Zealand flax, camphor, cinchona, encolyplus, tamarind, cactus, acacia orchis.

Aside from the general library, museums and cabinets, the College has collections of soils, seeds, models of implements, photographs and engravings, a series of colored plaster casts of fruits prepared at the University; models elastiques of fruits and flowers from Paris; collections of specimens of woods, of beneficial and injurious insects; numerous dry and alcoholic specimens, etc. The herbarium is rich in specimens of useful and noxious plants, including many of the fungous parasites destructive to cultivated plants.

INSTRUCTION.

The full course occupies four years, and includes special agricultural, horticultural and veterinary studies. The first are designated: Elements of Agriculture, Agricultural Engineering and Architecture, Animal Husbandry, Rural Economy and General Farm Management, and History of Agriculture. The special horticultural studies are: Elements of Horticulture, Pomology and Forestry, Floriculture, Plant Houses and their Management, and Landscape Gardening. The veterinary studies are: Anatomy and Physiology of Domestic
Animals, Veterinary Medicines, Principles and Practice of Veterinary Science, Veterinary Sanitary Science, etc. During the Spring term there is a clinic at the infirmary, where numerous cases of diseased animals are presented and treated before the class free of charge to the owners. Instruction is usually given by lectures and illustrations from the College grounds and collections. The diversified farm crops, the living animals and plants, the collection of machinery, the buildings and appointments, are all useful in making instruction practical and possible. For those whose time is limited, a one year's course of technical study is provided. Special horticultural studies may also be chosen for one year's work.

The instruction unites, as far as possible, theory and practice—theory explaining practice, and practice illustrating theory. The technical studies are taught mainly by lectures, with careful readings of standard agricultural books and periodicals, and frequent discussions, oral and written, by the students, of the principles taught. These are also illustrated by demonstrations and observations in the fields, stables, orchards, gardens, plant-houses, etc.
THE ORGANIZATION AND EQUIPMENT OF THE UNIVERSITY.

WITH SOME ACCOUNT OF ITS WORK.

COLLEGES AND SCHOOLS.

The Institution is a University in the best American sense, though differing designedly in the character of some of its Colleges from the older institutions of this country. It embraces four Colleges, which are sub-divided into Schools. A School is understood to embrace the course of instruction needful for some one profession or vocation. Schools that are cognate in character and studies, are grouped in the same College. The following are the Colleges and Schools:

I. COLLEGE OF AGRICULTURE.
School of Agriculture.

II. COLLEGE OF ENGINEERING.
School of Mechanical Engineering. School of Architecture.
School of Civil and Mining Engineering.

III. COLLEGE OF NATURAL SCIENCE.
School of Chemistry. School of Natural History.

IV. COLLEGE OF LITERATURE AND SCIENCE.
School of English and Modern Languages.
School of Ancient Languages.

V. ADDITIONAL SCHOOLS.
School of Military Science. School of Art and Design.
Vocal and Instrumental Music, Elocution and Photography are also taught, but not as parts of the regular courses.
COLLEGE OF AGRICULTURE.

SPECIAL FACULTY.

The Regent, Professor Prentice,
Professor Morrow, Dean, Professor Scovell,
Professor Burrill, Charles W. Rolfe.

OBJECT OF THE COLLEGE.

The aim of this College is to educate scientific agriculturists and horticulturists. The frequency with which this aim is misunderstood, demands that it shall be fully explained. Many, who look upon agriculture as consisting merely in the manual work of plowing, planting, cultivating, and harvesting, and in the care of stock, justly ridicule the idea of teaching these arts in a college. The practical farmer who has spent his life in farm labors, laughs at the notion of sending his son to learn these from a set of scientific professors. But all this implies a gross misunderstanding of the real object of agricultural science. It is not simply to teach how to plow, but the reason for plowing at all—to teach the composition and nature of soils, the philosophy of plowing, of manures, and the adaptation of the different soils to different crops and cultures. It is not simply to teach how to feed, but to show the composition, action, and value of the several kinds of food, and the laws of feeding, fattening, and healthful growth. In short, it is the aim of the true Agricultural College to enable the student to understand thoroughly all that man can know about soils and seeds, plants and animals, and the influences of light, heat, and moisture on his fields, his crops, and his stock; so that he may both understand the reason of the processes he uses, and may intelligently work for the improvement of those processes. Not "book farming," but a knowledge of the real nature of all true farming—of the great natural laws of the farm and its phenomena—this is the true aim of agricultural education. Agriculture involves a larger number of sciences than any other human employment, and becomes a fit sequence to any collegiate training.

The steady aim of the Trustees has been to give the College of Agriculture the largest development practicable, and to meet the full demand for agricultural education, as fast as it shall arise. Agricultural students are especially invited to the University. Boards of Agriculture, Agricultural and Horticultural Associations, State and county, are invited to co-operate with the University in its efforts to awaken a more general appreciation of the value of education, and to add, by the establishment of scholarships, or other means, to the number of those who avail themselves of its facilities for instruction.
AGRICULTURAL COURSE.

Required for the Degree of B. S., in College of Agriculture.

FIRST YEAR.
1. Elements of Agriculture; Chemistry; Trigonometry; Shop Practice (optional).
2. Elements of Horticulture; Chemistry; British Authors, or Free Hand Drawing.
3. Vegetable Physiology; Chemistry; Rhetoric.

SECOND YEAR.
1. Agricultural Chemistry (Soils and Plants); Botany; German.
2. Agricultural Chemistry (Tillage, Fertilizers, Foods); Botany; German.
3. Economic Entomology; Zoology; German.

THIRD YEAR.
1. Agricultural Engineering and Architecture; Animal Anatomy and Physiology; Geology or Ancient History.
2. Animal Husbandry; Veterinary Science; Physics or Medieval History.
3. Landscape Gardening; Veterinary Science; Physics or Modern History.

FOURTH YEAR.
1. Meteorology and Physical Geography; Mental Science; History of Civilization.
2. Rural Economy; Constitutional History; Logic.
3. History of Agriculture and Rural Law; Political Economy; Laboratory Work.

ONE YEAR COURSE.

Students will be admitted to this course on passing a satisfactory examination in the common school branches, but they will receive greater benefit from it if they have made better preparation, especially if they have a good knowledge of Botany and Chemistry. They should not be less than eighteen years of age.

The studies are taught in the following order:

1. Elements of Agriculture; Agricultural Engineering and Architecture; Animal Anatomy and Physiology; Shop Practice.
2. Animal Husbandry; Rural Economy; Veterinary Science.
3. History of Agriculture and Rural Law; Veterinary Science; Practical Entomology or Landscape Gardening.

HORTICULTURAL COURSE.

Students wishing to make a specialty of Horticultural studies will in the third and fourth years of the Agricultural course substitute for certain of the above the following:

1. Pomology and Forestry.
2. Floriculture; Plant Houses and their Management.
3. Landscape Gardening.
SCHOOL OF MECHANICAL ENGINEERING.

OBJECT OF THE SCHOOL.

This School seeks to prepare students to invent, design, construct and manage machinery for any branch of manufactures.

APPARATUS AND EQUIPMENTS.

The Machine shop is a substantial brick structure, erected in 1871, for the purposes of this School, with that of Architecture and Military Tactics. It has a sixteen-horse power engine, and the machine tools most needed, including a planer, two engine and three plain lathes, drilling machines, etc. There is a pattern shop, a blacksmith shop, and the requisite amount of vises and bench-room. A collection of models and machines serves to illustrate peculiar structures and methods of applying force. This School is provided with plates and a cabinet of models, illustrating mechanical movements and elementary combinations of mechanism. This collection is rapidly increasing by our own manufacture, and by purchase from abroad. It includes many of Riggs' models, and others from the celebrated manufactory of J. Schroeder, of Darmstadt, Germany. About two hundred valuable models from the United States Patent Office are also included in the cabinet.

INSTRUCTION.

The elementary course in Mechanics begins with the second term of the Freshman year, following a term of elementary plane drawing, and continues to the end of the year. The student begins in the Pattern-shop, and is taught to produce simple forms of wood, and wood-turning. From this work he goes to the Blacksmith shop, where he practices drawing, squaring, bending, welding, and otherwise fashioning iron. Returning to the Machine shop, he learns to cut off, center and drill wrought and cast iron. He gives much
time at the bench in finding surfaces and forming shapes with the cold chisel and the file. His next lessons are at the hand lathe in turning iron and brass, and afterward at the engine lathe and the planer in turning, cutting screws, and in facing up various forms. In all this work he is under the constant supervision of a watchful master, who holds him strictly to correct methods, and makes him accountable for accurate results.

The object of this work is to teach correct ideas of the use and care of tools, and the development of forms, and the only result sought is accurate workmanship. The pieces, when finished, may go upon the scrap-pile, or into the melting-pot, if not wanted for samples.

In the second year, the student is employed upon some form of actual construction. The interest pertaining to doing a new thing is increased by giving that new thing a recognized utility. Some form of machine is chosen, such, for example, as the need of the shop itself may require. The subject is taken into the Drawing-room, its purposes and requirements are fully discussed, and the steps of the design are worked out. If at all complex, the whole class works upon the same drawings until the design has crystal-lized into definite shape. Then the parts are assigned to individuals. One takes a wheel, another a piece of the frame, or if the item be large, two persons work together upon it; detailed drawings are made and offered for inspection. If found satisfactory, the drawing is taken to the Pattern shop and the pattern is made, which must also undergo rigid inspection before it can go forward to the Foundry. Thence the rough casting goes to the Machine shop, and receives such finishing, by such methods and with such tools, as the case may require. Thus the Sophomore class of 1879–80 have built the heavier parts of a large drill press. The standard of this machine is 84 inches high; its circular table, 25 inches in diameter, swings on the main pillar, and is raised and lowered by rack motion; it will be adapted for automatic or hand feed; its spindle will have a quick return motion; it has the usual fast and loose pulleys and back gears for use in boring large openings. In all respects the machine will be first-class. Having furnished class instruction to the class of last year, it is now doing a similar service to the present class, which will finish it during the present term. When complete all the work upon it will have been done by the students of the University, except the cutting of the gears, for which the shop has, as yet, no suitable machinery. The building of a milling machine will furnish useful instruction to classes yet to come.

The students of higher classes have a greater proportion of the-oretical work, which their practical training will the better enable them to appreciate and profit by, with drawing and as much construction as time will permit. The commercial work which comes to the shop gives paid employment to the older pupils, whose elementary and practical courses have prepared them for such work. There is usually as much such work as the students have time for.

As in the other Schools, the time required to complete this full course is four years; the student taking, with the above, literary and scientific studies sufficient to keep him busily occupied during this time.
PHYSICS.

This subject is connected, in the professorship, with the foregoing; hence introduced in this place.

THE LABORATORY.

The apparatus has cost about five thousand dollars. Much of it is adapted for investigation, rather than illustration. The room is over the chapel, and like it is 60 feet by 80 feet; a transverse partition divides it equally. The northern part is used as a lecture room, and is capable of seating 350 persons, if necessary. The southern room is the laboratory, a beautiful apartment, having abundant light from the east, south and west. In the center of this room a case for apparatus has been enclosed, 16 by 20 feet, the upper part being made useful by a gallery. This case is glazed on three sides; the lower part affords abundant opportunity for the display of pieces of interest, while the gallery gives place for many things not less useful, though less attractive. Between the apparatus room and the lecture room is a space designed, primarily, as an ante-room for the lecture room, and having its floor on a level with the lecture platform. This room communicates, both above and below, with the apparatus room in its rear, and by ample sliding doors with the lecture room in front. Even if the lecture room is occupied, preparation may be made in the ante-room for a succeeding exercise, and at the time for change the required apparatus may be transferred in an instant, through the broad doorway. The ante-room, when closed, becomes a dark room, admirably adapted to such experiments as require total absence or perfect control of light. The ante-room and apparatus room occupy the center and on one side of the laboratory, leaving a space on the remaining three sides in which 50 students could work together, if occasion should require. Here are arranged the several forms of apparatus required for the experiments.

The study of physics occupies two college terms, in which there are each week five recitations from a text-book, one lecture and four hours of laboratory practice. In the latter, a series of about forty experiments are performed by each student, two working together according to a programme arranged for the purpose. Besides the written directions for the method of procedure, the student has the aid of the Professor and his assistants, when needful. Careful notes and calculated results are required, on paper of a given size.

MECHANICAL ENGINEERING COURSE.

Required for the Degree of B. S., in School of Mechanical Engineering.

FIRST YEAR.

1. Trigonometry; Projection Drawing; Shop Practice; French or German.
2. Analytical Geometry; Descriptive Geometry or Lettering; Shop Practice; French or German.
3. Calculus; Free Hand Drawing; Shop Practice; French or German.
SECOND YEAR.
1. Designing and Construction of Machines; Advanced Algebra; German or French.
2. Advanced Analytical Geometry; Designing and Construction of Machines; German or French.
3. Advanced Calculus; Astronomy; German or French.

THIRD YEAR.
1. Mechanism and Mechanical Laboratory; Advanced Descriptive Geometry; Chemistry and Laboratory Practice.
2. Analytical Mechanics; Chemistry and Laboratory Practice; Physics.
3. Analytical Mechanics; Modern History; Physics.

FOURTH YEAR.
1. Resistance of Materials and Hydraulics; Geology; Mental Science.
2. Prime Movers; Constitutional History; Construction Drawing.
3. Mill Work; Designing and Laboratory Practice; Political Economy.

In this course the student will take two years of French or German, but not one year of each.

SCHOOL OF CIVIL ENGINEERING.

OBJECT OF THE SCHOOL.

The School is designed to furnish a course of theoretical instruction, accompanied and illustrated by a large amount of practice, which will enable students to enter intelligently upon the various and important duties of the engineer.

INSTRUCTION.

The instruction is given by lectures, text-books and reading, to which are added numerous problems and practical exercises, as serving best to explain completely subjects and fix them in the mind. Models and instruments are continually used, both in lectures and by the students themselves.

COURSE OF STUDIES.

The studies taught in this School, as belonging specially to it, are as follows: Projection Drawing, Ornamental Drawing and Lettering, Topographical Drawing and Mapping, Descriptive Geometry, Land Surveying, Topographical Surveying and Levelling, Road and Railroad Engineering, Geodetic Surveys, Practical Astronomy, Descriptive Astronomy, Analytical Mechanics, Bridge Analysis and Designing, Bridge Construction, Foundations and Stone Work. Students of this School pursue studies in other schools of the University. Arrangements are making for an advanced or post-graduate course in Civil Engineering, which will include the following special subjects: Advanced Bridges, Tunnelling, Water Supply Engineering, Harbor and River Improvements, Arches and Stone Work, Drainage and Sanitary Engineering, Practical Astronomy, Theory of Least Squares.
APPARATUS.

For Field Practice.—The School has an equipment of instruments for instruction in Engineering in field work, including chains, tapes, compasses, plane tables, transits, stadias, levels, base rods and comparing apparatus, barometer for barometrical levelling, sextants, engineer's transits arranged for astronomical observations, an observatory which is provided with an equatorial telescope, an astronomical transit, a zenith telescope, a chronometer, and a set of meteorological instruments.

A portable altitude and azimuth instrument of the latest and best form has lately been received from the celebrated makers, Troughton & Simms, of London. It is read by micrometer microscopes to single seconds, both of altitude and azimuth. This instrument will be used for instruction in Geodesy and Practical Astronomy.

To facilitate practice in trigonometrical and land surveying, an area has been specially prepared in which the difficulties of plane surveying are presented to the beginner as he is able to meet them, and where he is taught practical methods of overcoming them.

For the Lecture Room.—Models for illustrating the subjects of Descriptive Geometry, Astronomy, Roof and Bridge Trusses, Arches and Stone Work, and Railroad Superstructure. The School has a collection of students' manuscripts and drawing, and of authentic designs of bridges, roofs and engineering structures. It has also a complete set of maps of both the Coast and Lake Surveys. The College of Engineering has received the very large and excellent collection of lithographs of the lectures and drawings used in the Governmental Polytechnical Schools of France. The students of this School are steadily growing in favor with those seeking engineering services. During the past summer the demand was greater than the supply. Nearly all of the graduates are filling positions of responsibility and trust in their profession.

Students in Mining Engineering have all the facilities of the School of Civil Engineering, but instead of pursuing the special studies not closely related to their course, they have instruction in Metallurgy and Analysis of Coal, Mineral Waters, etc. The Geological and Mineralogical cabinets are well furnished with useful specimens, and the Metallurgical and Assaying laboratories have stamp-mill, furnaces, and other apparatus required for practical instruction in this department.

CIVIL ENGINEERING COURSE.

Required for Degree of B. S., in School of Civil Engineering.

FIRST YEAR.

1. Trigonometry; Projection Drawing; French or German.
2. Analytical Geometry; Descriptive Geometry and Lettering; French or German.
3. Calculus; Free-Hand Drawing; French or German.

SECOND YEAR.

1. Advanced Algebra; Land Surveying; German or French.
2. Advanced Analytical Geometry; Theory of Instruments and Surveying; German or French.
3. Advanced Calculus; Topographical Surveying and Drawing; German or French.
THIRD YEAR.
1. Advanced Descriptive Geometry; Chemistry and Laboratory Practice; Railroad Engineering.
2. Analytical Mechanics; Chemistry and Laboratory Practice; Physics.
3. Analytical Mechanics; Astronomy; Physics.

FOURTH YEAR.
1. Resistance of Materials and Hydraulics; Mental Science; Geodesy and Practical Astronomy.
2. Bridges; Constitutional History; Geology.
3. Stone Work; Political Economy; Bridge Construction.

In each of these two courses the student will take two years of German or French, but not one year of each.

SCHOOL OF ARCHITECTURE.

OBJECT OF THE SCHOOL.

The School prepares students for the profession of Architecture. For this a thorough knowledge of scientific principles applied to building, ability and correct taste in design, and a technical knowledge of the various building trades, with skill in the use of tools, are necessary, and are prominent objects of the course of instruction.

INSTRUCTION.

The work of the School of Architecture, in imparting instruction and its aims and methods, may be classified under four heads:

1. The imparting of technical information.
2. Training in the use of the tools and methods employed in the building trades.
3. Training in the use of drafting instruments and materials.
4. Training in the art of original design.

1. Technical Information—Is given as to the materials and methods employed in the various building trades; a knowledge of the preparation of legal papers, contracts, agreements, specifications and estimates of cost; also a knowledge of the various architectural styles and their most prominent examples. This knowledge is almost wholly imparted by lectures, as few text-books are available, and they are illustrated by engravings, photographs and sketches with reference to work in the library. The lectures are concise, written with a type-writer on transparent paper, and are then copied by the "blue" process. In this way each student can obtain a complete copy at much less cost than he can write it out for himself. The text is read more easily than manuscript, being in print. The lectures can be made as full and complete as desired, instead of being limited by the time of delivery, as is usually the case. Illustrations are also drawn on transparent paper and printed in the same way.

Training in the use of Tools.—The object of this is two-fold:
1. To give the student such knowledge of a trade, that if he meet with reverses in life, he will still have a means of honestly earning a living, or that he may do the work which is often required about a residence on a farm.
2. To teach the student practically the methods of construction which are in use in building, the proper use of the tools, and above all to know how work should be done, and the difference between good and bad work, so that he may know that good materials have been used and that the work has been well done. The special object of this is to prepare a student for taking charge of the construction of a building, as superintendent or architect, rather than to fit him merely for working at a trade. One year of honest work in the classes in shop practice proves sufficient to attain this result.

3. Training in the use of Drafting Instruments.—This study develops manual skill, cultivates habits of neatness and accuracy, ascertains the peculiarities of the materials and colors employed, and presents methods of finishing drawings and of distinguishing the different materials when these are required to be shown. The system of instruction is progressive. It commences with accurate line-drawing, then takes up shading in ink, sepia, line, and finishing in full color. About one-half the time is spent in making sets of the working drawings which are required for a building, from copies, from small sketches, and, when the student has become more proficient, from a small plan and a sketch in perspective, which is usually taken from one of the architectural journals.

4. Training in the art of Design.—Correct taste and the power of designing necessary to make the indispensable things of life beautiful, form the keystone in the education of the architect. After a student can make a good set of drawings from a sketch or small perspective, a programme of conditions and requirements for a small building is given to him. This is followed by others, increasing in difficulty as he acquires power, and ending with the most difficult structures which an architect is called upon to erect, except public buildings, which are reserved for the post-graduate course. In studying these problems, sketches at a small scale are first made and changed until satisfactory, great attention being paid to arrangement and convenience of plan. From these the student prepares a full set of working drawings neatly colored and shaded. Working drawings, similar to those made in architects' offices, are preferred to fine drawings, though as much time as can be spared is given to this branch of the art.

APPARATUS AND EQUIPMENTS.

The facilities for instruction at the School of Architecture are: 1. An excellent library. 2. The use of a fine art gallery, containing casts of sculptures, ornaments, and many photographs of buildings. (See School of Art and Design). 3. A good and rapidly increasing collection of models illustrating construction. 4. Tools and materials and instruction furnished in shop practice free of charge. 5. American, English, French and German architectural periodicals are regularly taken in the library.

The new Chemical laboratory was designed by the Professor of Architecture, assisted by students of the course. Many other pieces of work for the University have originated in the same way. A
school house at Rankin, Ill., was designed by an undergraduate student. It has given good satisfaction. Graduates are becoming well established as architects in several Western cities.

**ARCHITECTURAL COURSE.**

*Required for the Degree of B. S., in School of Architecture.*

**FIRST YEAR.**

1. Trigonometry; Projection Drawing; Shop Practice; French.
2. Analytical Geometry; Descriptive Geometry and Lettering; Shop Practice; French.
3. Calculus; Shop Practice; French.

**SECOND YEAR.**

1. Elements of Construction; Advanced Algebra; Free Hand Drawing and Modeling.
2. Elements of Construction; Advanced Analytical Geometry; Architectural Drawing and Designing.
3. Advanced Calculus; Graphical Statics; Water Color Sketching.

**THIRD YEAR.**

1. Architectural Drawing; Descriptive Geometry and Drawing; Chemistry and Laboratory Practice.
2. History of Architecture; Analytical Mechanics; Physics.
3. History of Architecture; Analytical Mechanics; Physics.

**FOURTH YEAR.**

1. Esthetics of Architecture; Resistance of Materials and Hydraulics; History of Civilization.
2. Architectural Designing; Constitutional History; Geology.
3. Estimates, Agreements and Specifications; Heating and Ventilation; Architectural Designing; Political Economy.

**BUILDER'S COURSE.**

The Trustees allow persons desiring to fit themselves for master builders to take a course of a single year, pursuing such technical studies of the course in architecture as they may be prepared to enter upon with profit, and as will be most advantageous to them.

Candidates for the Builder's course must pass the examinations in the common branches, but need not pass in the studies of the preliminary year unless they shall desire to pursue other studies than those marked in the following schedule. Fee, $10 per term.

1. Wood Construction; Projection Drawing; Shop Practice (Carpentry and Joinery.)
2. Stone, Brick, and Metal Construction; Agricultural Drawing; Shop Practice (Stair Building).
3. Estimates, Agreements and Specifications; Heating and Ventilation; Architectural Designing; Shop Practice (Cabinet Making).
COLLEGE OF NATURAL SCIENCE.

SPECIAL FACULTY.

The Regent, Professor Taft,
Professor Weber, Dean, Professor Prentice,
Professor Burrill, Mr. J. E. Armstrong.

SCHOOLS.

School of Chemistry School of Natural History.

SCHOOL OF CHEMISTRY.

This School aims to impart such knowledge of Chemistry as will enable the student to apply the principles of the science to the related arts, and to fit him for the field of original research, or for the practical business of the druggist, pharmacist and practical chemist.

INSTRUCTION.

Text-book instruction in the principles of Chemistry and Chemical Physics occupy six weeks of the first term of the first year. Afterward the recitations alternated with laboratory practice. During the next three years each student is expected to work two hours daily in the laboratory, five days in the week. In order to graduate, each is required, at the close of his course, to make an original investigation, and present a thesis.

Students who pursue Chemistry as a part of other courses work at least two consecutive hours daily during such time as their specialty may require.

The special Chemical course requires for its completion four years of study. Associated with this there have been established a four years' course in Pharmacy and three years' courses in Agricultural Chemistry and Metallurgy.

APPARATUS.

The facilities offered for obtaining a practical knowledge of Chemistry are believed to be unsurpassed by those of any other institution in the West. A large laboratory building 75x120 feet, and four stories in height, was erected 1877-8, at an expense, including furniture, of $40,000. It is excellently lighted, heated and ventilated and contains the following apartments: One large lecture room, with seating capacity for two hundred students; one small lecture room for advanced students; a large laboratory for qualitative analysis, containing one hundred and four desks; a large laboratory for quantitative analysis, etc., containing sixty-four desks; a pharmacy, with
collection of specimens for *materia medica* and of officinal preparations made by students; a room for gas analysis; an assay room; store rooms, and a photographic gallery and other apartments.

The apparatus for general use includes a large platinum retort for the preparation of hydrofluoric acid; a Dove's polarizer, with a complete suit of accompanying apparatus; a Geissler's mercurial air pump; Hoffman's apparatus for illustrating the composition of compound gases; a Soliel-Scheibler's saccharimeter; an excellent set of areometers; a Hauy's goniometer; a camera with Ross' lenses; a Ruhmkorff's coil; galvanic batteries of Grove and Bunsen; also a potassium dichromate battery, a galvanometer, a spectroscope, and a large binocular microscope; a Hartnack microscope; a gas combustion furnace for organic analysis, etc.

**COURSE IN CHEMISTRY.**

*Required for Degree of B. S., in School of Chemistry.*

**FIRST YEAR.**

1. Chemistry and Laboratory Practice; Trigonometry; American Authors or French.
2. Chemistry and Laboratory Practice; Analytical Geometry; British Authors or French.
3. Organic Chemistry and Laboratory Practice; Free Hand Drawing; Rhetoric or French.

**SECOND YEAR.**

1. Agricultural Chemistry: Laboratory Practice; Physiology or Botany; German.
2. Agricultural Chemistry; Laboratory Practice; Microscopy; German.
3. Laboratory Practice; Zoology; German.

**THIRD YEAR.**

1. Laboratory Practice; Mineralogy; German.
2. Laboratory Practice; Physics; German.
3. Laboratory Practice; Physics; German.

**FOURTH YEAR.**

1. Laboratory Work; Mental Science; Meteorology and Physical Geography.
2. Constitutional History; Laboratory Work; Logic.
3. Political Economy; Geology; Laboratory Work.

Four courses of Laboratory work have been arranged, as follows:

**CHEMICAL COURSE.**

**FIRST YEAR.**

*First Term.*—Qualitative Analysis; Tests and Separation of the Alkalies, Alkaline Earths, N H S Group, and 1st and 2d Divisions of H S Group.
*Second Term.*—Qualitative Analysis Complete; Tests, and the Separation of 3d Division of H S Group, and the Acids; Analysis of 20 Simple Salts, and 20 Compound Substances.
*Third Term.*—Qualitative Analysis of Sodium Sulphate, Dolomite, Ammonium, Alum, Potassium Chloride, Bone Ash, Iron Ore.

**SECOND YEAR.**

*First Term.*—Quantitative Analysis of Calamite (Zinc Carbonate), Copper Pyrites, Galena, Spathic Iron Ore, Nickel Ore, Clay, Soil; Determination of Iron, Copper, etc. both volumetrically and gravimetrically.
*Second Term.*—Volumetric Analysis; Alkalimetry and Acidimetry; Preparation of Standard Solutions; Analysis of Sodium Carbonate, Sodium Hydroxide, Potassium,
Hydroxide, Pearl Ash, Cream of Tartar, Sulphuric, Hydrochloric, Oxalic, and Citric Acids; Analysis of Corn and other Grain.

**Third Term.**—Preparations of Salts, Acids, etc. Electroplating with Silver, Gold, Copper, Nickel.

**THIRD YEAR.**

**First Term.**—Ultimate Analysis; Determination of Carbon, Hydrogen, Oxygen, Nitrogen, Chlorine, Phosphorus, and Sulphur in Organic Compounds; Analysis of Urine.

**Second Term.**—Blow Pipe Analysis; Determination of a collection of minerals representing over thirty of the Metals; Assaying in both the dry and wet way of Gold, Silver, and Lead ores.

**Third Term.**—Photography; Preparation of Ether; Absolute Alcohol, Gun Cotton, Cadmium Iodide, Ammonium Iodide, Glacial Acetic Acid, Siver Nitrate, Collodion, Taking Negatives, Printing Positives, Toning and Mounting.

**FOURTH YEAR.**

**First Term.**—Gas Analysis; Calibration of Eudiometers; Analysis of Air from Lungs, Atmospheric Air, Marsh Gas, Illuminating Gas, and Crude Coal Gas; Analysis of Mineral Waters.

**Second Term.**—Toxicology; Micro-Chemistry of Poisons; Testing for Minerals and Vegetable Poisons; Separation from Organic Mixtures.

**Third Term.**—Original Researches.

**PHARMACEUTICAL COURSE.**

**FIRST YEAR.**

Same as in Chemical course.

**SECOND YEAR.**

**First Term.**—Quantitative Analysis of Commercial Drugs, White Lead, Red Lead, Paris Green, Sodium, Nitrate, Oxalic Acid, Tartar Emetic, Commercial Hydrochloric, Nitric, and Sulphuric Acids.

**Second Term.**—Analysis of Mineral Waters; Preparation of Tinctures, Solid and Fluid Extracts; Reading and Compounding Prescriptions.

**Third Term.**—Isolation of Alkaloids, Atropine, Strychnine, Quinine, Nicotine, Aconitine, Morphine; Preparation of Salicylic Acid; Examination of Alcoholic Liquors; Reading and Compounding Prescriptions.

**THIRD YEAR.**

**First Term.**—Same as second term, second year of Chemical course.

**Second Term.**—Same as first term, third year of Chemical course, without Analysis of Urine; Reading and Compounding Prescriptions.

**Third Term.**—Preparation of Salts, Perfumes, Flavoring Extracts, Cosmetics; Electroplating with Gold, Silver, Copper and Nickel.

**FOURTH YEAR.**

**First Term.**—Same as second term, fourth year, of Chemical course.

**Second Term.**—Analysis of Urine, normal and pathological; Reading and Compounding Prescriptions.

**Third Term.**—Original Researches.

**AGRICULTURAL COURSE.**

**FIRST YEAR.**

Same as Chemical course.

**SECOND YEAR.**

**First Term.**—Quantitative Analysis of Feldspar, Soil, Ashes of Plants and Grains.

**Second Term.**—Analysis of Commercial Fertilizers, Manures, and Minerals used for Fertilizers.

**Third Term.**—Preparation of Organic and Inorganic Salts; Starch from Potatoes, Corn, Wheat, etc., Sugar, Dextrine, Alcohol.

**THIRD YEAR.**

**First Term.**—Same as Chemical course.

**Second Term.**—Analysis of Milk, Corn, Wheat, Potatoes, Fruits, etc.

**Third Term.**—Silt Analysis of Soils; Analysis of Mineral Waters.
METALLURGICAL COURSE.

FIRST YEAR.
Same as in Chemical course, with the Quantitative Analysis of Brass, Solder, and Type Metal in third term.

SECOND YEAR.
First Term.—Same as Chemical course.
Second Term.—Assaying of Gold, Silver, and Lead Ores, both dry and wet ways; Blow-pipe Assaying.
Third Term.—Analysis of Malachite, Azurite, Cinnabar, Tin Ore, Cobalt and Nickel Ore containing Arsenic, Bog Manganese, Grey Antimony.

THIRD YEAR.
First Term.—Analysis of Pig Iron, Wrought Iron, Steel, Furnace Slags, Rolling Mill Slags and Cinders.
Second Term.—Same as in Chemical course, with Analysis of Mineral Waters in place of Assaying.
Third Term.—Same as second term, fourth year, of Chemical course, with Analysis of Coal in place of Mineral Waters.

SCHOOL OF NATURAL HISTORY.

The aim of this School is to give a liberal scientific education. It acquaints the student as far as possible with what is known in respect to the structure of the earth and to the origin and distribution of its organic products; teaches him to collect and preserve specimens and arrange them for study, and to conduct original investigations.

The special studies of the course are: Botany and Vegetable Physiology, three terms, after one of preparatory study; Anatomy and Physiology; Zoology, two terms; and one term each of special Entomology; Osteology and Taxidermy; Geology and Palaeontology, three terms; Physical Geography and Meteorology; Mineralogy; Astronomy, and Microscopy. The course occupies four years.

INSTRUCTION.

The methods of instruction vary according to the subjects taught, the time given to them, the facilities at hand and the aims of the instructors. It is the constant endeavor to make the course thoroughly practical and useful from an educational stand-point as well as to give the kind of knowledge necessary for the mastery of the material world.

APPARATUS AND EQUIPMENTS.

The Botanical laboratory has a growing herbanium, containing about eleven hundred and fifty species of flowering plants out of the fifteen hundred known in Illinois, a large number of flowering plants from other States and countries of the world, and a considerable collection of flowerless plants. Among these the Ferns and Fungi are the most important. There are compound microscopes and apparatus sufficient for use in the classes, so that during certain portions of his course every student has ample practice with them.
Collections of woods, of fruits, dry and alcoholic, of plaster casts, of microscopic preparations, of charts and drawings, make up, together with the green house and its specimens and the library, the facilities for the study of Botany and Vegetable Physiology. A considerable collection of insects, especially of those inhabiting our own State, aids in the study of Entomology. Most prominent, however, in the equipments of the School is the

NATURAL HISTORY MUSEUM.

The room for the Natural History collection is on the first floor of the west wing of the main building. From north to south it is seventy-six feet long; it is sixty feet wide and sixteen feet high. On the west side are six large windows, and on the south, three, which ordinarily afford abundant light.

Covering the entire wall on the east, and the spaces between the windows on the south and west, are two stories of wall cases; they are separated by a gallery on the three sides of the room, which is reached by iron stairs at the northeast and northwest corners. These cases, with continuous shelving, are eight feet high, provided with glazed doors.

There are also on each side of the room, opposite the spaces between the windows, five upright glazed cases, for the reception of such large specimens as could not be accommodated in the wall cases. The two extreme ones on either side are 10 feet 8 inches by 6 feet; and the three middle ones are 10 feet 8 inches by 3 feet 6 inches; all 8 feet high.

Directly opposite the windows, so as not to obscure the light, and between the floor cases on each side of the room, are table cases, glazed at top, sides and ends, for the reception of shells, minerals, or any small specimens. All this work of wood and iron was done at the University shops, and chiefly by the students of the architectural and mechanical classes.

A large case, 15 feet by 6 feet, and uniform with the rest, occupies the south end of the room, for the preservation of archaeological specimens, Indian relics, and whatever else may be deemed worthy or instructive, in teaching the progress of civilization.

Arrangement of Contents.—On either side of the central space are arranged the large casts of Ward's collection of remarkable fossils, directly in front, towards the south end, stands the gigantic Mегааrthrum. Largely covering the north wall hang the slabs of the immense Saurian reptiles. The remainder of this remarkable collection of casts of fossils, numbering in all three hundred and twenty-six, are arranged in the lower wall cases at the south end of the room, and on the tops of the floor cases. This most valuable set of casts was presented to the University, when it had almost no cabinet, by Hon. Emory Cobb, President of the Board of Trustees.

The entire east side wall cases are occupied by small mammals, birds and skeletons; the mammals beginning on the north below, and occupying about one-third the length of the room. The birds follow, arranged at present according the system of Dr. Cones.
These occupy the remaining east cases below, and about two-thirds of the north part of the gallery. The remaining third is filled with skeletons of such animals as can be accommodated there.

On the south in the gallery, beginning at the east end, the first case contains the articulates; the second, the reptiles; the third, the fishes; the fourth, the radiates.

The floor cases on the west side contain the large ruminants (elk, deer, moose, mountain sheep and antelopes.) On the east a mounted buffalo with its skeleton, and skeletons of other large mammals. Part of the table cases contain sea, land and fluvial shells, of about 1,700 species. The rest contain minerals and fossils. The cases on the west wall, below and above, are appropriated to geological specimens, rocks and fossils.

Almost the entire collection of mounted specimens has been put up at the University, and chiefly by the students themselves, many of whom are very expert. The skins have been bought or donated, and skilled labor applied at home. Thus all the large ruminants and the smaller mammals are home products. The birds, also, excepting six or eight, are products of the University. By this means half or more of the expense has been saved.

In Osteology, where specimens are usually expensive, many fine and valuable skeletons have been mounted at a comparatively small expense. The bones of the larger animals are macerated for six to twelve months; neatly cleaned, bleached, and properly fastened together by wires. These are called "artificial skeletons." Small mammals, birds, fishes and reptiles have their bones carefully scraped, leaving the joints connected by their natural ligaments; hence, these are called "ligamentous skeletons."

The Museum is peculiarly fortunate in its collections in Zoology, possessing, in mounted specimens or skeletons, nearly all the ruminants of North America, except the musk ox; and representatives of all orders of mammals, except Probocidae; exhibiting 50 species by 80 mounted specimens, with numerous skeletons. In birds, it represents all the families of North America, having 240 species represented by over 300 specimens. Its fishes are about 1,000. Its articulates and radiates have received valuable accessions from the Smithsonian Institute.

All donations which are preserved as specimens in the Museum, have the contributor's name placed upon the label, as donor. Also, a book is kept, in which these names are entered, alphabetically, with specimen contributed. For contributions valued at more than fifty dollars, there is a special bulletin hanging in the Museum upon which the names of such contributors are written, with a statement of the donation and its valuation.

COURSE IN SCHOOL OF NATURAL HISTORY.

Required for the Degree of B. S., in School of Natural History.

First Year.

1. Chemistry; Free Hand Drawing, (optional); Trigonometry; French.
2. Chemistry; Free Hand Drawing, (optional) Conic Sections; French.
3. Vegetable Physiology; Chemistry, or Free Hand Drawing; Rhetoric; French (extra.)
SECOND YEAR.
1. Anatomy and Physiology; Botany; German.
2. Zoology; Botany; German.
3. Zoology; Economic Entomology; German.

THIRD YEAR.
1. Geology; Mineralogy; German; Ancient History (optional, extra).
2. Geology; Physics; German; Mediaeval History (optional, extra).
3. Geology; Physics; Modern History.

FOURTH YEAR.
1. Meteorology and Physical Geography; History of Civilization; Mental Science.
2. Microscopy and Fungology; Constitutional History; Logic.
3. Political Economy; Astronomy; Natural History; Laboratory Work.

In this course three terms of University Latin will be accepted in lieu of three terms of French; and five terms of such Latin for five terms of German.

COLLEGE OF LITERATURE AND SCIENCE.

SPECIAL FACULTY.

THE REGENT,
Professor Snyder, Dean,
Professor Pickard,

| Professor Shattuck, |
| Professor Crawford, |
| Chas. E. Pickard. |

SCHOOLS.

English and Modern Languages.
Ancient Languages and Literature.

OBJECT OF THE SCHOOLS.

The object of the Schools in this College is to furnish a sound and liberal education to fit students for the general duties of life, and especially to prepare them for those business pursuits which require a large measure of literary and scientific knowledge and training. They meet the wants of those who wish to prepare themselves for the labors of the press as editors or publishers, for teachers in the higher institutions, or for the transaction of public business.

Students in the Agricultural and other technical Schools, desiring to educate themselves as teachers, writers, and professors, in their special departments, require a knowledge of the ancient, as well as the modern languages, to give them a full command of all the instruments and facilities required for the highest proficiency in their studies and proposed work. The University seeks through these Schools to provide for this important part of its mission—the furnishing of teachers to the industrial schools of the country, and investigators and writers for the arts.

INSTRUCTION.

The plan of instruction embraces, besides the ordinary text-book study, lectures and practical exercises in all the departments, in-
cluding original researches, essays, criticism, proof-reading and other work intended to illustrate the studies pursued, and to exercise the student's own powers. It is designed to give to all the students voice culture and a training in elocutionary practice.

A prominent aim will be to teach the right use of books, and thus to prepare the student for self-directed investigation and study, which will extend beyond the curriculum of his school and the period of his graduation. With this view, constant use of the already ample and continually enlarging stores of the library will be required and encouraged. As a further aid in this direction, members of the advanced classes are usually selected to act as assistant librarians. In this service they are able to obtain much valuable knowledge of various departments of literature and science, of prominent authors, and to the extent and scope of their writings. Of special value, as an incentive to, and the means of practice in, English composition, should be mentioned The Illini, a semi-monthly paper edited and published by the students of the several Colleges, each of which is appropriately represented in its columns. A printing office has been provided in the Mechanical building, and is furnished with all requisite material.

THE LIBRARY.

This is a general collection of books and papers for the use of all departments of the University. It contained September 1, 1882, thirteen thousand five hundred and ten volumes, an increase in two years, since the last report of the Trustees of the University, of one thousand and sixty volumes. There are also between two and three thousand pamphlets. The number of the latter varies, since the more valuable ones are bound from time to time.

The library receives regularly, at present, eight periodical publications, divided as follows:

- Agricultural, etc. ................................................. 21
- Natural Science .................................................. 17
- Engineering, etc .................................................. 18
- All other ............................................................ 24

Of the last class, the most are free contributions, including the papers of Champaign and some of the adjoining counties.

The amount expended in the library has been fifteen hundred dollars a year, for the two years, being the State appropriation for the library.

The fine Library hall is used as a reading room, from which, however, students are not allowed to take books, except by special permission. It is open five days in the week, from eight A. M. to five P. M., and Saturdays from two to five P. M.

The use of the library is urged upon students in all the classes; and any person is welcome to consult the books, under the same conditions as are imposed upon students.

GENERAL STUDIES.

Mathematics, History, Philosophy and Logic, are more or less included in all the courses of study in the University; they are as appropriately mentioned here as elsewhere.
PURE MATHEMATICS.

The completion of this course requires two years of study.

Advanced Geometry.—Applications of Algebra to Geometry; Transversals; Harmonic Proportions, etc. Trigonometry—Analytical and Plane. Relations between the functions of an arc. Formation and use of tables; Solution of plane triangles. Analytical Geometry.—Construction of equations; Discussion, in a plane, of the point, right-line, circle, ellipse, parabola and hyperbola; Higher plane curves, cycloid, cissoid of Diocles, etc. Differential Calculus.—Differentials of algebraic and transcendental functions; Maclaurin's Theorem; Taylor's Theorem; Maxima and Minima of functions of one variable; Equations of tangents, normals, sub-tangents, subnormals, etc.; Differentials of lines, surfaces of volumes. Integral Calculus.—Integration of elementary forms and of rational fractions; Rectification of plane curves; Quadrature of plane areas and surfaces of revolution; and Cubature of solids of revolution.

Advanced Algebra.—Binomial Theorem; Properties and summation of series; Exponential quantities, Logarithms; General theory and methods of solving equations. Analytical Geometry.—Loci in space; Surfaces of the second order. Differential Calculus.—Differentials and Maxima and Minima of functions of two or more variables; Osculatory curves; Radius of curvature; Evolutes, involutes and envelopes; Discussions of algebraic and transcendental curves and surfaces; Tangent and normal planes; Partial differentials of surfaces and volumes. Integral Calculus.—Integration of transcendental and irrational differentials; Differentials of higher orders; Differential equations; Rectifications, quadrature and cubature in general. Spherical Trigonometry.—General Formulas; Solution of Spherical Triangles. Calculus of Variations will be taught to advanced students.

HISTORY AND SOCIAL SCIENCE.

The historical studies are designed to afford a general view of the history, social organization and progress of the race. They embrace also the history of the arts and sciences, and of civilization, the principles of civil polity and law, the philosophy of history, and the principles of political economy and constitutional law. The course occupies six terms in the third and fourth years of the University courses.

PHILOSOPHY AND LOGIC.

Principles of Logic.—Conditions of valid thinking; forms of arguments; fallacies and their classification. Inductive and scientific reasoning; principles and methods of investigation. Practical applications of logic in the construction of argument, in the detection and answer of fallacies, and in the formation of habits of thinking, and the common judgments of life.

SCHOOL OF ENGLISH AND MODERN LANGUAGES.

English Language and Literature.—In the arrangement of the studies the endeavor is to present a thorough and extended drill in grammatical and philological study, and in the authors and history of the English language, affording a training equivalent to the ordinary studies of the classical language. This drill extends through three years of the course, but may be shortened according to the ability and preparation of the student.

The first two terms of the first year are given to a general survey of the whole field of British and American Literature from the middle of the sixteenth century to the present time. All the really representative writers come into notice, and representative specimens from the writings of each are carefully read in class. Moreover, each student is required each term to read the entire work of some classic author, making choice from a prescribed list. Frequent exercises in writing abstracts or original compositions on themes assigned are also required. The study of Rhetoric occupies the third term.

During the second year some four or five of the great masters are studied, their work analyzed, the shaping forces of their times and their influences upon succeeding times are investigated. Lectures are given from time to time on Poetry—epic, lyric, dramatic, etc. Writing and reading required as in first year.

In the Senior year attention is given to old English; to the Anglo-Saxon, for which the way has been prepared by the study of both English and German; to Philology; to the Philosophy of English Literature, and to Æsthetics. Essays, forensics and orations are required.

French and German.—The modern languages taught in this School are confined to one year of French and two years of German. Abundant practical exercises are given both in composition and translation, and the diligent student gains the power to read with ease scientific and other works in these languages, and may, with a little practice, write and speak them with correctness. A constant attention is also given to the etymologies common to these languages and the English, and thereby a large advantage is gained by the student in linguistic culture. "He who knows no foreign tongue," said Goethe, "knows nothing of his own."

In the first year the student passes over a complete grammar and reader, acquiring a knowledge of the technicalities of the idiom, with a sufficient vocabulary for the use of books of reference within the course. The second year is devoted to a critical study of the languages and philological analysis, and to a course of select classic reading, composition and conversation.
COURSE IN SCHOOL OF ENGLISH AND MODERN LANGUAGES.

Required for the Degree of B. L.

FIRST YEAR.
1. American authors or Cicero de Amicitia; French; Trigonometry.
2. British Authors or Livy; French; Conic Sections.
3. Rhetoric; French; Advanced Geometry, or Free-Hand Drawing; Horace (optional, extra.)

SECOND YEAR.
1. English Classics; German; Physiology, or Botany.
2. English Classics; German; Zoölogy, or Botany.
3. English Classics; German; Astronomy.

THIRD YEAR.
1. German; Chemistry; Ancient History.
2. German; Physics or Chemistry; Mediaeval History.
3. German; Physics; Modern History.

FOURTH YEAR.
1. Anglo-Saxon; Mental Science; History of Civilization.
2. Early English; Constitutional History; Logic.
3. Philology; Political Economy; Geology.

SCHOOL OF ANCIENT LANGUAGES AND LITERATURE.

In the school of Ancient Languages and Literature, the methods of instruction without swerving from their proper aim, to impart a sufficiently full and critical knowledge of the Latin and Greek languages and writings, will make the study of these tongues subservient, in a more than usual degree, to a critical and correct use of the English. With this view, written translations, carefully prepared, with due attention to differences, equivalences, and substitution of idioms, and the comparison and discrimination of synonyms, will form part of the entire course.

The study of Latin and Greek Composition will constitute a weekly exercise through the first year, and will be continued, to some extent, through the course. Essays, historical and critical, will be required from time to time, in connection with the works read, and a free use of the library is urged. It is intended that each student who contemplates the course in Ancient Languages shall have a clear knowledge of the history of Greek and Latin Literature, and of the principal authors in both languages. As an aid to the appreciation of the literature of the two peoples, Greek and Roman history will form an important part of the course, and will be taken up in the beginning, illustrating the works read. In the first term of the third year ancient history is taken up as a separate study, and especial attention is then given to the history of Greece and Rome, and the nations with whom they came in contact. Classes will be formed for students who wish to carry their classical study farther than the prescribed course, and every assistance will be given them.

For the studies in History, Philosophy, etc., see School of English and Modern Languages.

For the studies in Mathematics and Natural Science, see Schools of Mechanical Engineering and Natural History.
COURSE IN SCHOOL OF ANCIENT LANGUAGES.

Required for Degree of B. A.

FIRST YEAR.
1. Cicero de Amicitia and prose composition; Iliad and prose composition; Trigonometry.
2. Livy and prose composition; Boise and Freeman's selections from Greek authors and prose composition; Conic Sections.
3. Odes of Horace and prose composition; Memorabilia and prose composition; Advanced Geometry.

SECOND YEAR.
1. Satires of Horace; Thucydides or German; Physiology.
2. Terence; Sophocles or German; Zoology.
3. Tacitus; Demosthenes or German; Astronomy.

THIRD YEAR.
1. Juvenal or French; Chemistry; Ancient History.
2. Quintilian or French; Physics; Mediæval History.
3. De Officis or French; Physics; Modern History.

FOURTH YEAR.
1. History of Civilization; Mental Science; Meteorology and Physical Geography.
2. Constitutional History; Early English; Logic.
3. Philology; Geology; Political Economy.

ADDITIONAL SCHOOLS, NOT INCLUDED IN THE FOUR COLLEGES.

SCHOOL OF MILITARY SCIENCE.

Professor Wm. T. Wood,
Second Lieut. 18th Infantry, U. S. A.

By the law of Congress, and of the State, the University is required to teach Military Tactics to its students. All able-bodied male students of the college classes of the first, second and third years are enrolled in the companies of the University battalion, and receive instruction in the following military exercises:

School of the Soldier; Manual of Arms.
School of the Company; Movements by Platoons, Firing, etc.
School of the Battalion; Ployment and Deployment of Close Columns.
Battalion and Company Skirmish Drill; Bugle Calls.
Bayonet Fencing; Target Practice.
Guard and Picket Duties; Duties of Sentinels.

CLASS IN MILITARY SCIENCE.

Classes in military science and tactics, as far as is requisite for officers of the line. From these classes are selected the officers of
the several companies, for which they act as instructors. The military instruction is now under the charge of Lieut. Wm. T. Wood, a graduate of the U. S. Military Academy, and an officer of the regular army of the United States. A full supply of arms and ammunition is furnished by the War Department, including 300 cadet rifles and accoutrements, two pieces of field artillery, 1,000 ball cartridges and 1,000 blank cartridges annually for target practice, with 100 cartridges and 300 friction primers for artillery.

No student is eligible to the military class till he has reached the third term of the Freshman year, and is in good standing in all his studies. The course of instruction is confined strictly to two years. No student will be permitted to retain a command who does not maintain a good standing in conduct and scholarship.

The instruction and class exercises occupy about three hours each week, arranged as far as possible so as not to interfere with any other courses of study, to allow the members of other courses to enter this. Students must be careful, however, to ascertain, before entering the military class, that the proper studies and exercises of their chosen courses will not be interfered with.

Commissions.—The Governor of the State is accustomed to commission as captains in the State militia, such graduates of the University as have completed the studies of the military classes and have obtained the requisite experience in command in the University battalion. In order to obtain the commission the student must be approved by the Faculty and pass satisfactorily an examination in military science and tactics before a committee appointed by the Faculty of the University. It is expected that in order to get the required experience in command, the members of the military class of the third or Junior year will serve as commissioned officers of the several companies of the battalion.

University Uniforms.—Under the authority of the acts of incorporation, the Trustees have prescribed that all male students, after the first term, shall wear the University uniform. The University cap is to be worn from the first. The uniform consists of a suit and a cap of cadet gray cloth. Students can procure them ready-made on their arrival here. The University cap is ornamented in front with the initials I. I. U., surrounded by a wreath. Students will always wear their uniforms on parade, but in their rooms and at recitations may wear other clothing.

The University Library contains many books on Military Science, Military History and Engineering.

Gymnasium.—The Drill Hall is furnished with a full set of gymnastic apparatus, and classes in gymnastic exercises are organized in the fall and winter terms under careful leaders. Fee 50 cents.

The University Cornet Band is composed of students, who, while members of the band, are excused from drill and other college exercises.
COURSE IN SCHOOL OF MILITARY SCIENCE.

FIRST YEAR.
1. School of the Soldier and Company; Bayonet Fencing.

SECOND YEAR.
1. School of Battalion; Skirmish Drill.
2. Ceremonies and Reviews; Military Signalling; Sword Fencing.
3. Guard, Outpost and Picket Duty; Military Signaling; Sword Fencing.

THIRD YEAR.
1. Military Administration; Reports and Returns; Theory of Fire Arms; Target Practice; Artillery Drill.
2. Organization of Armies; Art of War: Field Fortifications; Artillery Drill.

SCHOOL OF ART AND DESIGN.

The School of Art and Design, begun in 1876, occupies a large, well appointed apartment in a wing of the main University building. Light is admitted from three sides and managed by will by curtain partitions. The necessary tables, desks, easels, etc., are provided for large classes of students. In the center is a room of glazed sash for the convenient storing of copies and of examples of class work as well as the exhibition of objects requiring protection. In an adjoining smaller room there is a valuable collection of paintings and sketches, the property and mostly the work of the Professor in charge of the School. Students have access to this room.

The importance of having in the Illinois Industrial University a practical course of art instruction, was duly recognized by the authorities of the University. The exhibits made by the different art schools, both foreign and American, at the Philadelphia Exposition, revealed the fact that the most useful results had been attained by a mode of teaching quite different from that commonly practiced in our schools. During the years 1876 and '77, by direction of the Trustees, the classes in industrial drawing and designing were formed into a regular school, called the School of Art and Design. Its object was stated to be to assist in the general college work, and to furnish a thorough artistic education to those who should wish to pursue industrial or fine arts as a specialty, either as designers, teachers or artists. Such work as tends directly or indirectly to aid the general student is here briefly stated:

1. To develop the power of observation, that the eye may become susceptible to the beauties of the surroundings in nature, so as quickly to perceive and understand the laws of harmony, perspective, shades and color, and to realize complex forms, such as are found in plants, insects, etc.

2. The training of the hand to delicacy and skill in the use of mediums or implements wherewith to accomplish what the mind directs.

3. To familiarize the student with classical forms of objects, and ornamentation, so as to distinguish different styles, and to cultivate a correct taste.
A two years' elementary course embraces such studies as are especially important to various professions, and therefore meets the wants of the several colleges having free-hand drawing in their courses; besides, it qualifies for entering the higher course in Designing or Fine Arts.

The advanced course, instead of being arranged for a definite length of time, requires a more specific amount and quality of work. An important feature is the opportunity that students have for fitting themselves as practical teachers. Those who have acquired sufficient knowledge are frequently called upon to assist beginners. Lessons are prepared, which, after being criticised and approved, are delivered before the class. This inspires the student with confidence, makes a thorough review of a subject, and stimulates him to do his very best.

As soon as the student fairly appreciates decorative forms, he is taught to combine them artistically, so as to form original designs suitable for some practical purpose. The instruction is by lectures, illustrated by rapid drawings upon the board. Each student also receives individual attention after the lecture; this prevents any error passing unnoticed.

With very few exceptions, the students in attendance have proved themselves earnest workers, and many have exhibited marked talent; a number of ladies and gentlemen have produced some good work in oil colors and crayon. This last branch of art might be carried to a high state of success, even without special encouragement. It is, however, not so important to the industries of the State as the branch in designing.

* ART GALLERY.

There is no more attractive place for great numbers of visitors at the University than its large and finely arranged Art Gallery, in the west wing of the main building, on the third floor. The cost has been about three thousand dollars, but this sum has been so expended that a display is made equal to that obtained by many times the outlay in many kindred collections. There are no paintings, for the limited means would not permit their purchase, nor could the results of the sum expended prove nearly so interesting and instructive by thus dividing it. The gallery owes its existence, in the first instance, to Dr. John M. Gregory, who originated the scheme, and, aided by the liberality of the citizens of Champaign and Urbana, selected and purchased the art objects. The larger portion of these were secured in Paris, France. To secure the needful means, lectures were given, whose proceeds went for this purpose; a subscription was taken up among citizens, including members of the Faculty, and other ways resorted to for raising the amount. The University furnishes the room; otherwise, the State has been at no expense for the valuable and beautiful gallery. The following figures show the liberality of the donors; many contributed smaller amounts:

<table>
<thead>
<tr>
<th>Amount</th>
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<td>Six each gave</td>
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The hall is 61 × 78 feet. The wall is tinted a dark maroon color, making a beautiful background for the white casts. The arrangement is such that a view is obtained, on entering, of nearly every thing in the room, the first sight being impressive, and ordinarily eliciting exclamations of surprise from the hundreds of visitors passing the threshold.

**Statues.**—There are sixteen full-sized statues, among which are the Laocoon Group, Venus de Milo, Venus de Medicis, Diana de Gabies, Faun of Praxiteles, Gibson’s Venus, Dying Slave of Michael Angelo, etc. Of the reduced size statues, there are forty-two, including the Apollo Belvidere, Diana the Huntress, Achilles, Minerva, Dying Gladiator, etc. There are ninety-two full-sized busts, representing famous persons of all ages, from Homer to many now living. Among these, we find ten Roman Emperors, Hippocrates, Socrates, Demosthenes, Cicero, Lord Bacon, Dr. Johnson, Gladstone, Washington, Webster, Douglas, Lincoln, etc. There are twenty-eight busts of smaller size from the best artists.

**Bas-Reliefs.**—Forty-two pieces. We name, as among the prominently noticeable ones, the Architrave of the celebrated Ghiberti gates in the Baptistery at Florence, Garden of Eden, Cain and Abel, Assyrian Sculpture excavated in 1848, Lion Hunt, Four Seasons, etc.

**Medallion Beads.**—Large size, twenty-seven; smaller, four hundred and ninety. These have their names stamped upon them.

**Engravings.**—There are fifty-four beautiful engravings from paintings by Raphael, Landseer, David, Hessig, Turner, Hogarth, etc.

**Photographs.**—Two hundred and thirty-two. Roman views, views of Venice, Switzerland, of noted paintings, of bas-reliefs, etc.

**Portraits.**—Four hundred and seven lithographs of eminent personages, mostly French, with name, date and other information marked on each.

### COURSE OF INSTRUCTION IN SCHOOL OF ART AND DESIGN.

Students not seeking a professional training may yet avail themselves of the two years’ course in industrial art. Any person of ordinary ability who faithfully completes this course will be qualified to teach drawing and designing in the public schools, or enter professions with great advantage in the various branches of industry, where artistic skill and taste are indispensable to success.

#### FIRST TERM.

(Exercises in outline.)

Elements of Form; Analysis of Compound Forms; Elementary Designs; Elementary Perspective by aid of objects; Elements of Historic Ornaments; Memory Exercises.

#### SECOND TERM.

Enlargement and Shading from copy; Ornamental Designs from plant form; Naturalistic and Conventional Arrangement; Harmonious Lines and Distribution of Form; Perspective Drawing of Objects, Plants, etc. Features of the Human Head; History of Early Art.

#### THIRD TERM.

Outline Drawing and Shading from Casts of Ornament; Application of Decorative Forms to flat and round surfaces under various conditions; Designs for specified objects; Advanced Perspective and Shadows; Harmony and Contrast of Color; (Lectures on Art and its History).
FOURTH TERM.
( Clay and Wax Modeling.)

Basso Relievo Ornament from the Solid. Features and the Human Head from description; Relievo Ornament from shaded copies or Drawings; Original Designs for decorative purposes; Enlargements and Reduction from casts; History of Styles of Ornament.

FIFTH TERM.

Shading from Statuary, Casts, etc.; Drawing of Landscape and Animals from copy in charcoal and sepia; color applied to Decorative Art; designs for useful objects; perspective drawings of interiors of rooms.

SIXTH TERM.

General review of the principal work done; Specimen plates to be completed; Optical and Physical principles of color in Nature; Aerial Perspective; Sketching from Nature in charcoal and color; Artistic Anatomy of Form and Proportion, by illustrated lectures; famous artists and their principal works.

Students having passed satisfactorily in the above course will be permitted to enter the advanced classes.

The following course is for those who wish to become accomplished either as designers, painters or teachers. In order that the student may acquire thoroughness in the branch he wishes to pursue as a specialty, the subject has at this stage been formed into two divisions, decorative and pictorial. The teacher student must give attention to both branches, and with him theory will necessarily supersede practice. Opportunities will be afforded such pupils to teach in the elementary classes, whereby greater efficiency will be acquired.

SPECIAL COURSE IN PAINTING.

Trees, Animals and Figures from copy and from nature, in Pencil, Charcoal, and Sepia; Aerial Perspective.

Anatomy of Expression; External muscular development; Shading from Statuary in Charcoal and Monochrome; Composition drawing from description; Memory Exercises.

Water-color Painting from pictures; Sketching from Nature in Sepia and Water colors; Copying from Oil Paintings of Portraits and Landscapes.

Sketching from Nature in Oil-colors; Rapid studies of interiors with varied arrangement of light and shade; Pictorial composition, introducing figures or animals: Theory and History of Art.

Portrait Painting from life; Pictures finished from sketches; Studying of Groups of Still Life subjects; Painting of ideal compositions of one or more heads; Chemistry of color.

ADVANCED COURSE IN DESIGNING.

Studies in Clay, or Wax.

Ornaments and Plant form in Basso Relievo from flat examples; Designs adaptive to useful objects; The Human Figure from cast or original composition, reproduced by casting in metal or plaster; Process of manufacture; Monumental designs.

Shading from cast and from nature; classic objects and furniture enlarged from copy; Designs finished with Pen, Brush, and Distempera color; Architectural construction.

Design for Church Decoration in Historic Styles; Memorial Windows for stained glass; Decorative designs; Commemorating events in History; History of manufactures, and important inventions.

ADVANCED TEACHERS' COURSE.

A teacher must be prepared for emergencies for which the professional designer or artist has no experience. A general knowledge of the several subjects is therefore recommended. The decorative and painting courses will be worked together so as to form a thorough course for teachers.

The authorities of the University have provided that persons not connected with the institution may join the drawing and painting classes on very moderate terms.
MUSIC.

Music constitutes no part of any University course of studies, and is therefore not provided by the Trustees. But as many students, especially young ladies, desire instruction in music, competent teachers are selected by the Trustees, and rooms set apart for instruction.

COURSE OF INSTRUCTION.

Bertini's Instructor; Clementi's Sonatines, Op. 36, 37, 38; Heller's Studies, Op. 36, Books 1 and 2; Duverney's Studies, Books 1, 2, 3; Loschhorn's Klavier-Technik; Czerny's Etudes de la Vélocité, Op. 299, Books 1, 2, 3, 4; Czerny's Fifty Finishing Studies, Op. 740, Books 1, 2, 3; Cramer's Studies, Books 1, 2, 3, 4; Mendelssohn's Lieder ohne Worte; Clementi's Gradus ad Parnassum.

TUITION.

Instruction term of ten weeks—2 lessons a week............... $10.00
For term of ten weeks—one lesson a week.......................... 6.00
Practice on piano, one hour daily, per term..................... 2.00

MRS. ABBIE WILKINSON,
Teacher of Vocal Music and Voice Culture, follows the Italian method, giving individual instruction.

TERMS.

Ten weeks—two lessons a week...................................... $12.00
Ten weeks—one lesson a week...................................... 7.00

No deductions on account of absence in either course, except in case of protracted illness.
Special students in music will also be charged the regular term fee charged other students of the University.
PAPERS TO ACCOMPANY REPORT.

I. What Work is Legitimate to the Institutions founded on the Congressional Grant of 1862.
   By Dr. Peabody.

II. Experiment in Cattle Feeding.
    By Professor Morrow.

III. Notes on Farm Machinery.
    By Professor Morrow.

IV. Bacteria—their Nature and Effects.
    By T. J. Burrill.

V. Report on the Manufacture of Sugar, etc., from Sorghum.
    By Professors Weber and Scovell.
WHAT WORK IS LEGITIMATE TO THE INSTITUTIONS
FOUNDED ON THE CONGRESSIONAL GRANT OF 1862.

By Selim H. Peabody, Ph.D., LL.D., Regent.

[Read at a Convention of Agriculturists, Washington, D.C., January 11th, 1882.]

The great exposition in London, in 1851, was the first of those gatherings in which the workmen of the world have competed for supremacy in those arts which mark the development of mankind in the nineteenth century. It proved to be a grand awakening of the thought of the nations, America included, to the fact that those peoples who had most faithfully fostered the advancement of scientific discovery, with its application to practical arts, were making the most rapid stride in every line of material progress. Especially was it apparent in America that there was an imperative demand for higher technical instruction in every direction of human art, enterprise, and labor; in agriculture, in engineering, in architecture, in mining, and in all departments of manufactures. In a few particulars we had demonstrated the wonderful versatility of the American mind, its ready adaptability to new circumstances amid untried conditions; its fertility of invention; its quickness of acquisition; its grasp and strength, and tireless activity. With this demonstration came also the conviction that the need of the time, the inexorable demand of the nation, was the need and the demand for technical instruction, such as could then be found nowhere on this side of the Atlantic. This leaven was fermenting in every thinking mind. A few schools were in operation. Efforts were everywhere made to open others. There was a school of engineering at Troy. There were scientific departments at Harvard, Yale, and Dartmouth. Pennsylvania and Michigan had founded schools of Agriculture. Other schools of applied science were contemplated. There was great difficulty in securing the endowments, without which such enterprises could not thrive. As the want to be supplied was of national extent, as the benefits to be secured were such as would increase the nation's wealth and develop the nation's prosperity, the idea was born—some say in Illinois—to seek aid of the nation at the hands of the Federal Government.

During President Buchanan's administration a bill was introduced into Congress by Mr. (now Senator) Morrill, of Vermont, which bill provided that a part of the public domain should be distributed to the several States for the foundation of schools in which technical instruction should be given. The bill was advocated before the House in an able speech by Mr. Morrill; was thoroughly discussed and
bitterly opposed in the Senate, and finally passed by a close vote, only to fail by reason of the veto of the President. During the first year of President Lincoln's administration the measure was again proposed; again passed both houses of Congress, and became a law on the 2nd of July, 1862. Nothing could have been more significant of the abiding faith which Congress then cherished as to the perpetuity of the Federal Government than the passage of this act in one of the darkest hours of the terrific struggle then going forward. No part of this act is more thoroughly familiar to each person who hears me, than that section which so briefly, so concisely, yet with such generous provision, such breadth of permission, describes and defines the purposes to which the funds donated in the act shall be devoted. Apparently, as clear as the day, as luminous as light, the interpretations given to this section are marvelously diverse, and often diametrically opposite. I had almost come to think the subject trite and its consideration needless, and yet the discussions of yesterday have led me to believe that even now it may be wise to pause, hunt up the statute, and see how reads the law.

"The leading object shall be, without excluding other scientific and classical studies, and including military tactics, to teach such branches of learning as are related to agriculture and the mechanic arts, in such manner as the legislatures of the States may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life."

What may be done legitimately in carrying into operation the instructions of this law? As has been suggested, each person has his own interpretation, and I crave brief forbearance while I present mine.

First. The business of each institution resting on this grant is to teach.

An institution of learning, especially of scientific learning, has usually a twofold function, namely, the acquisition of knowledge and its dissemination. Either function may predominate, or the two may be made co-ordinate and mutually helpful. If, however, I read this law rightly, the end it requires is instruction. While it permits, by inference, in another place, that effort may be expended in the acquisition of knowledge, this permission is only by inference, and the labor so employed should be such only as may be made directly useful in stimulating and broadening and assisting instruction. If it be possible to draw a line sharply and distinctively between a school for the instruction of students, in which their mental growth and their scientific training shall be the absorbing interest, and an experimental station, in which the development of science in and for itself shall be the chief business, then the institutions founded on this act should be schools, and not experimental stations. A purely experimental station, however essential to science, however useful to the general welfare, however practical in the results which it may procure, if it be divorced from the instruction of pupils, does not answer the spirit of the requirements of this law. If the experiments can be so conducted as to help the advancement of the student, to quicken his perception, to broaden
his judgment, to stimulate his energies, to illustrate the science in
which he strives for the mastery, to assist even indirectly in the
instruction which it is the real business of the institution to impart,
then they are legitimate and should be fostered. The greater part
of such experiments will not be found developing new science or
breaking up new ground. The ground will be new to the pupil;
the work will offer to him absorbing interest, because it is novel,
and it will be imperatively needed by him either as teaching him
how to conduct similar work in the future, or as illuminating the
ground over which he must tread and with which he must be
familiar before he can be fitted to enter upon fields wholly unex­
plored.

I dwell upon this point because it seems to have been assumed
on one or two occasions, in our discussions, that if any institution,
for want of opportunity, or of means, or because of other occupa­
tion, is not at work at some unsolved problem, and developing
something new in science, it is therefore derelict in duty and is to
be condemned as a failure. On the contrary, I believe that the
time and strength of a professor, and in so far of an institution,
may be so absorbed in that most interesting and fascinating
employment, the pursuit of new science, and the solution of new
problems, that he may neglect the more important duties of teach­
ing the students who have been confided to his care. In most
cases I apprehend that the conscientious teacher will find the time
at his disposal all too short in which to conduct his pupil over the
well-known ground of clearly established truth, and that the
illumination which he can and must shed upon that truth will
absorb all the means and time and strength at his disposal. His
first and paramount duty is instruction. If his investigation will
help his instruction, let him investigate; if it interferes with his
instruction, let him obey the law and TEACH.

Second. What shall be taught?

With its wide latitude of permission, the law specifies but one
subject which shall be taught, and that is military tactics. Possibly
some of those who conduct the institutions in question would be
glad if the act had been signed at its first passage, when this item
was not included. Yet there may be grave question whether the
schools would indeed be better if this requirement were omitted.
The discipline, the physical culture, the development of manly
vigor and gentlemanly bearing, the training in the use of arms
and in the management of men, is worth, in my judgment, all it
costs in a course of other study. The government, in all cases
that I have known, has furnished the equipment when asked, and in
most cases has detailed an instructor, free of cost, to the institution.
I believe that good faith and simple honesty requires from every
institution under this act, obedience to this item of the law, and
that each student not physically incapacitated should be required
to learn the manual of arms and the maneuvers and command of
a company. The evasion of this law, on the part of college govern­
ments is an unfortunate lesson to their students as to the doctrine
and the duty of obedience.

But this item of military tactics is merely an incidental thing put
into the act under the inspiration of the conflict which was raging
when the act became a law. The grand purpose of the enactment is stated in the words, "to teach such branches of learning as are related to agriculture and the mechanic arts * * * in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life."

What does this mean? Why, says my farming friend, that means agriculture. The agricultural press throughout the country proclaims that it means agriculture. It has been so urged by members of this convention. The bill was known during its first and second passage through Congress as the Agricultural College Bill. The institutions founded thereon are commonly called the agricultural colleges. There is a large body of people in the country who insist that these colleges (1) ought to teach agriculture; (2) ought to teach nothing but agriculture, and (3) that they do not teach agriculture. Those who adhere to either of these propositions are in error in some greater or less degree.

It is certain that agriculture, as a topic to be taught in these institutions, is a topic of first importance. The law so states and so intends. But with equal precision the law requires that instruction shall be given in subjects which pertain to "the mechanic arts," that the students thereof may be prepared to enter the "several pursuits and professions of life." The law uses the same emphasis and the same authority in specifying the one item, which it uses in stating the other. If the Massachusetts Institute of Technology, which enjoys a part of the income from the grant of 1862 to that State, errs in not teaching subjects which relate specifically to agriculture, the Massachusetts Agricultural College, which has the remainder of that income, errs just as grievously in that it does not teach subjects which relate specifically to the mechanic arts. But, nevertheless, the State of Massachusetts, having provided in these two institutions for instruction in both agriculture and the mechanic arts, fulfills her whole duty under the law. Her sons may choose the line of study which seems to them best suited to their capacities, their aspirations, or their hopes for gaining a livelihood. If, at Amherst, they have learned the principles and practice of agriculture, they have done well. If, at Boston, they have learned the theories and the arts which make them skillful mechanicians, they have also done well. The State will be benefited by the genius and the skill of either. If the requirements of the law may thus without doubt be satisfied by these separate institutions, these requirements may with equal fullness be satisfied by the conduct of two or more departments in the same institution. The graduate who leaves such a school is not to be blamed even if he has not learned agriculture. He is to receive credit for faithful study and useful acquisition if he has perfected himself in any technical learning which has promoted his liberal and practical education for any of the several pursuits and professions of life.

For the term "mechanic arts," in the light of its subsequent amplification and explanation, is not by any means to be restricted to the arts of devising, building and operating machinery, unquestionably included in that term. The art may be that of constructing the railway, as well as of building and running the locomotive that treads its iron track. It may erect the bridges that span the stream
that track crosses. It may and should include the designing and construction of the stations that make its termini; or of any other edifices that men need to use in business, or want to love as homes, or to admire as monuments of public munificence. The science of the chemist that may develop the art of the dyer, or the skill of the assayer and the metallurgist, or of the refiner of sugar, or of use in the thousand forms of usefulness to which chemistry reaches forth its helping hand; the science of the electrician that builds our telegraphs, or will illuminate our cities and brighten our homes; the art of the designer that lends beauty to the products of the loom, that shapes the clay of the potter into things of perennial joy, that sheds its halo of delight over all things precious or commonplace, adding untold wealth to the crude products of rude mechanical toil—these, and a myriad more, in ways that science alone has opened and will open as the avenues to a livelihood or to a competency, are the lines of work that legitimately have place in the instruction of institutions of learning which the State has founded for the education of the industrial classes in the several pursuits and professions of life. Nay, more: unless the institutions in question do provide in some manner and to some extent for instruction that shall bear fruit in some of these ways, as well as in agriculture, they are delinquent in their duty towards the law which created them and towards the needs of the public for whose benefit they were and are founded, for it needs no argument before this body to show that the greater the number, and the more diversified the nature, of the industries which occupy the labor and skill of a people, the greater will be the prosperity of that people. It is no more fitting that all men shall be farmers, than that every farmer should raise only corn, or cotton, or hogs. When all farmers have learned how to make two blades of grass grow where but one grew before, there will not be occupation for as many grass-growing farmers as were required before that consummation had been reached.

It is true that these colleges, save as teaching may be divided as before indicated, are bound to teach agriculture. It is equally true that they are required to teach a wide curriculum of science and art beside agriculture. But it is said that they do not teach agriculture, and that they draw the sons of farmers away from agriculture, and teach them to despise labor. Most statements of this sort are based upon observation limited to individual cases, and so far as I am able to observe, lack breadth of information. From the earliest days of the republic, farmers' sons have turned their backs upon the farm to enter upon pursuits which required less manual toil. That the farm has furnished largely the fresh blood that has enriched the learned professions with strong and noble exemplars, has been the boast alike of the farmers and of the professions. From the farms went the Washingtons and Jeffersons, the Clays and Websters, the Lincolns and Garfields, whose renown has been the aureole about the brow of our nation of free laborers. Never have I heard that even the farmers have mourned because such men exchanged the labor of their hands for the severer and more exhaustful labor of their brains. But even these men have never lost their affection for the soil whence they sprung; when wearied with the conflicts of the arena, whether victors or vanquished, they
sought renewed vigor in the embracing arms of the dear mother
who had nourished their sturdy youth.

It is sometimes asserted that enough of labor is not required at
the hands of students, and that students who are not so made to
work are not taught agriculture. If the work which can be put
before students is something which develops manual skill, in which
practice leads to perfection, in which brain has its part, then it is
useful to the student, he loves it, and is always ready to attack it.
Our American boys will always work when they can see the profit
of it. They will not work kindly in school or after they leave
school, at things which a dullard, or a brute, or a machine can do
as well, and for the very sensible reason that they know it does not
pay. The manual labor that is put regularly and systematically
before the boys in one of the very best schools where this system
prevails—work which was provided because no other was to be had
—consisted mainly of such labor as spreading heaps of manure,
chopping brush, digging potatoes and ditches, and other occupa­
tions of like drudgery, which most knew all about before they came
to college, and which any of the others learned to do perfectly in
the first hour's trial. That which the boy comes to college to learn
is not that which he has already learned or can learn at home; he
were foolish to go from home for such instruction. He goes to
learn something which his farm work will not bring to his knowl­
edge.

Nor is it true that these colleges educate the boys away from the
farm or away from labor. Of the students who attend the Illinois
Industrial University about 15 per cent. come from farmers’ families;
80 per cent. are young men. About 55 per cent. choose technical
courses, divided with considerable uniformity between agriculture,
chemistry, architecture, mechanics, mining, and civil engineering.
It rarely happens that a student leaves a technical course for a
literary course, while it is a common occurrence that one who has
witnessed the practical work about him, the fullness of experiment,
and the interest it awakens, it is common that such a student turns
from a literary to a technical course. Our paths lead toward science,
rarely from science. Farmers’ sons who come to us and enroll their
names as taking other courses of study very frequently pursue some
parts of the agricultural course, as collateral work, intending at the
end of their college life to go back to the farm, so that it is now
ture that a much greater per cent. of our alumni are farmers, than
the percentage of our students who are, or were, special students of
agriculture.

As a rule, young men choose such course of study as they be­
lieve, from the best information in their possession, will lead them
to immediate and lucrative employment. Especially is this true of
students in technical schools. If young men could be brought to
believe that trained agriculturists could command wages commen­
surate with the expense of the training, ten would undertake this
course of discipline for one who now enters upon it. Such demand
for educated farmers as has been described at this convention may
exist; but such knowledge of it as will help intending graduates to
find business after graduation, does not come to those who have
charge of institutions, who would gladly bring employers and em-
ployés into communication. During the last year the officers of the institution I represent furnished fifteen to twenty assistants to engineers of lake and river surveys, and of railway lines, applying for such help. This year the engineering classes are crowded. There is a like demand for machinists and architects, and with like results. The same conditions do not exist for agriculturists.

The Illinois Industrial University offers a wide opportunity for choice of studies to those who knock at its portals. First and completist has been its equipment for agriculture. It has one hundred and fifty acres of land devoted entirely to experimental uses in agriculture, horticulture, aboriculture, orcharding, vineyards, small fruits, druggists' herbs, anything which may promise useful variety to tillers of the ground. It has a stock farm of 400 acres, on which students are shown the conduct of the business of raising crops and feeding cattle with a view to economy and profit, and this farm yields annually a fair remuneration to the treasury of the college. It keeps constantly from 150 to 200 head of cattle of all ages; some of gentle breeding, others of graded stock of various qualities and strains, by which to illustrate their relative value for profitable handling. It is well supplied with tools and implements that are carefully managed and tested. The department is under the charge of a professor (Prof. George E. Morrow), of whom I would gladly say more if he were not here present to object. We have yet to learn of his superior in the West. The professor of botany and horticulture is equally master of his specialities. Competent collateral instruction is fully provided.

The courses in agriculture are greatly varied. If a student can afford time for a complete course of four years, he will find every term thereof crowded with profitable work. If one year is all that he can give, a course of special technical work is arranged for him. If he would choose a course for himself, of greater or less length, the choice is limited only by his own advancement, or by the current programmes of the terms. If the winter term is one which he can spare from active labor on the farm, a series of lecture courses is open to him, for which no special preparation is required. Finally, in most years, a farmers' institute of one week is held in January, to which all farmers are invited. If there is any way in which agriculture can be offered by which it can be more attractive, or more profitable, or better adjusted to meet the wants of the recipient, we shall be glad to be advised of that way. Yet the fact remains that comparatively few students out of our whole number take a course of agricultural instruction in any of the forms mentioned. The truth is that our Illinois farmers cultivate a soil so fertile, so sure to honor their drafts, that they cannot abuse it so badly but it will give them always a support, and generally bountiful profits. These farmers cannot realize that agricultural education can increase their profits, or improve their situation.

I will not take space to detail the equipment of our university, in other technical departments. Our laboratories and shops, the machine-shop, and the carpenter's shop, are full beyond our means of supplying room and tools. The young men are eager to work in these specialties. One year ago, through the liberality of the Secretary of State, a room in the State Capitol at Springfield, spacious,
elegant, and most conveniently situated, was placed at my disposal, in which was arranged an exhibit showing the products of students’ work alone, all other being strictly excluded, which required two freight cars to transport from Champaign to Springfield. Each school of technical art was represented—agriculture and horticulture, with fruits and grains and wood and models. Chemistry, with a long list of chemical and pharmaceutical preparations, and an exhibit of sorghum products of great variety, and of good quality. Mechanism, with a complete set of its shop-practice objects, and a large collection of mechanical models, all made by student workmen. A like set of shop-practice objects from the carpenter-shop, with accurate models of roofs, bridges, stairs, and every form of joiner and cabinet work. Specimens of natural history, mounted with life-like grace and beauty, and drawings from all schools, conspicuous for accuracy, perfection and adaptation to useful art.

This university has passed the time of telling what it proposes to do and what it hopes to accomplish. It has entered upon the stage where it can show something which it has done; yet it is to be hoped, without being in any sense content to rest upon any laurels it may have won.

I have thus far spoken of the duty of the so-called agricultural colleges to furnish instruction in branches which may lay the foundation for a means of getting a living. But this is not the noblest function of an institution designed to train the young, whatever may be the practical end immediately sought. The first business of any school is to develop men. Those whom the honorable Commissioner (Mr. Loring) described to us yesterday as wanted, as in eager demand, a demand far beyond the supply, for agricultural employment as florists and gardeners and farm managers; those whom the distinguished gentleman from South Carolina (General Aiken) desired to transplant to his sunny fields as farm superintendents, were in every case to be men. Men of good brain, of good muscle, in full health and stalwart vigor, physically, mentally, morally. They must be men of fair culture, ready in business, in the market, in society, in the discharge of every duty as citizens, to meet and wrestle with the men who are trained in other schools and by other methods. A fatal error will have been committed if their training has been confined to the technical studies which, however useful they may be, are useful in only a narrow and limited scope. There must have been developed a power to think clearly and quickly; to reason logically; to express fluently and intelligibly the ideas which have been gathered in the school, or have germinated in their own minds. There is value in all the culture of finer grain which comes from any acquaintance with the humanities, with the thoughts of men who lived in other ages, and spake in other tongues. If there be any form of education that makes any man stronger and wiser and nobler, the farmer and the artisan, the machinist and the engineer, the architect and the designer, and especially he who in any capacity is to be the guide and director and controller of men, needs that culture, that education in its fullest extent.

And so it was that the man who drew this act under which our schools have the right of life and of maintenance, added that these
things which were specified, and which we have at some length discussed, should be done and taught “without excluding other scientific and classical studies.” The technical studies are to be first provided for, but there shall be no prohibition or exclusion of other scientific subjects, or even of the classical studies which so many who affect to be practical, pretend to despise. Practical training is demanded, and liberal culture, as well, is to be cherished. If the farmer’s boy tastes a little Latin*, it will not harm him. Even if, as is rarely the case, he unearths a Greek root, phosphorescent with age, it will not destroy him. If the mechanic or the engineer, or the technical student in any specialty, would open the doors which look into French or German apartments in the temple of science, he will find there stored vast accumulations of precious learning in the very things which he most earnestly covets, which, possessed, will add vastly to his stores of knowledge, while the act of acquisition will give keener edge and quicker play to the weapons of his mental armory.

For every mind a discipline is needed, which comes from an acquaintance with other subjects than those pertaining to pure science, or to applied science, however useful those may be. The graduate of any higher school ought to know something of the laws of his own mental activity; something of the principles and methods of the government of which he is a part, and which, in some of its higher or lower departments, he may be called to administer; something of the laws of wealth and the great economies which govern production and distribution and consumption; something of the physical history of the world and of its relation to the rest of God’s creation; something of the history of his own race, as it has lived on this earth, with the details of the grand march of history along the highway of nations; something of his own language and its literature, the thought, pregnant with power which the creative minds of his own and of elder days have produced, and which now, in many unrecognized but forceful influences, make up so much of the staple of our thinking and of our present culture. Never does the student gain all his acquisitions at the feet of his preceptors. The outlines only are there acquired; the impulse is received; preferences established, mental bent obtained; the development progresses while the thinking mind endures. But the doors into all these apartments of human knowledge, and to all these sources of higher culture, should have been opened to all young men and women that they may at least know what munificence of intellectual wealth lies within their reach, and these opportunities should be furnished in the technical, as well as in the literary or the classical school.

What is legitimate to the schools resting on the grant of 1862?

All forms of technical education, and in the wide scope of possibilities, every form of human learning which it has fallen to the fortune of mankind to devise or acquire.
NOTES ON FARM MACHINERY.

G. E. Morrow, Professor of Agriculture.

American farm implements and machinery deservedly take a high rank. Lacking the weight and strength of those of Great Britain, most classes of machinery used by American farmers are remarkably well adapted to the work to be done. The general use of improved machinery is one of the most striking features of American farming, especially in the West. Even in the Territories where farm settlements have been made within a year, there are to be found agricultural implement stores in which are exposed for sale implements and machines, in number, variety and excellence far beyond what was to be found in any country a half century ago. The work of inventors and manufacturers has brought several classes apparently near perfection, unless radical changes in form or principle be made. The best plows of to-day seem incapable of great improvement so long as an implement working on the principle of the plow is what is desired. Any one of a half dozen patents of self-binding harvesters is nearly as perfect as almost any class of machinery that can be named. Their workmanship seems coarse in comparison with that of a watch, for illustration; but, drawn by horses moving at irregular speed, over rough ground, these machines do all the different kinds of work asked of them with remarkable efficiency.

Of many classes of farm machinery there are many styles of almost equal value. A farmer need not trouble himself much in purchasing plows, reapers, mowers, etc. etc., for any one of a dozen or score of manufactories can supply him with a machine which will do nearly as good work as any other one. In minor points one will surpass another, but in essentials, there is little room for choice.

The excellence and abundance of farm machinery is not without its dangers to the farmer. To stubbornly cling to old styles, refusing to make use of recent inventions and improvements, is a fault of some farmers, but there are many cases in which the opposite extreme is to be found. Unless provided with abundant means, the farmer cannot afford to purchase all the "good things" offered him. The question of what and how much machinery to buy, is one which may often puzzle the farmer. Before deciding to buy it should be clearly decided whether the machine will do the work needed to be done; whether it will do it better, or more cheaply, or more quickly than it can be done by means already at hand, and whether the gain in any one of these points will repay the cost of the machine.
On small farms, or on large farms where but little of a given class of work is required, it is often better economy to hire the work done, or do it even by primitive means, rather than buy improved machines. A mowing machine is a great labor saver, but the purchase of one is not wise if there be but a half dozen acres of grass to cut. The use of old and inefficient tools is to be discouraged, but sometimes the old machine will accomplish the work nearly as well as a new and much more costly one. When a purchase is to be made the advice to, "get the best" is generally sound; but it does not follow that it is wise to discard the old because a better can be obtained.

Of two machines designed to do the same class of work, the simpler, stronger, more easily adjusted, is to be preferred in a large majority of cases, even if there be some admitted advantages in the more complicated machine. Every movable part in a machine probably increases the danger of breakage. Complicated arrangements adjusting farm machinery should usually be avoided. The average farm laborer is not an especially intelligent person, and is certainly not a trained machinist.

In a majority of cases purchasing machinery of established reputation is much safer than investing in newly introduced kinds even though they seem to possess advantages. Experimenting and trial is every way commendable, and some must do this if we are to have improvements; but a farmer of limited means can no more wisely make a practice of buying all the promising newly-invented machinery than can a poor student buy all the new books he finds commended to his attention.

In some classes of farm machinery prices are higher than they should be; in many, however, the competition between manufacturers has brought the prices as low as can reasonably be expected. Sometimes the apparent reasonableness of price is accompanied by poor workmanship or poor material. In the case of most patented articles of farm machinery the prices charged for "repairs" can only be classed as outrageously exorbitant. In some cases the prices for the separate parts aggregate a half dozen times the cost of the complete machine.

While manufacturers are not free from blame in all cases, it often is true that complaints of failure to perform work satisfactorily or of breakages arise from improper usage on the part of the owner. Implements are often put to work for which they are not fitted; their strength over-taxed, or direct carelessness results in breakage. Much has been said concerning the proper care of implements, yet the cases in which they are most improperly neglected are still common.

*Chicago Screw Pulverizer.*—One of these awkward-looking machines has been in use two years, and has given good satisfaction in many respects. It has been used in preparing land for and sowing rye and oats and in preparing land for corn; for each crop being used both without previous plowing and following such plowing. Good crops have followed its use. The seeder has worked well; apparently as well as any broadcast seeder could be expected to work. For working over fall plowing we have found it do excellent work. The disadvantages of the machine are that its cost, over $200, and
the fact that four horses are needed, make it adapted only to large farms. It is heavy to handle; is not suited for working in small fields, on hilly or stony or stumpy ground; nor when the ground is at all wet. It will not work well when there is much grass, stubble or weeds on the surface. The cultivators made from it do good work in corn; but, especially in weedy ground, the tendency is to ridge the ground more than desirable. When run deep, the land is left ridged more or less, sometimes objectionably so. Thus, while its purchase for the University farms was not unadvisable, it would be a great mistake for the average “small farmer” to invest in one. It will not enable him to dispense with the plow, and for many purposes other and less costly implements will answer perhaps equally as well.

For six years past there has been on one of the University barns a large windmill, used for grinding grains, shelling corn, cutting hay, straw or corn stalks. It is a good mill; has stood well, and almost without repairs. With a fair wind it gives sufficient power for any of the uses specified. Yet it is not certain that a similar mill should be recommended even for large farms generally. It frequently happens that when needed there is not sufficient wind; it is costly, and farmers may secure either tread or sweep powers to be worked by the horses necessarily kept on the farm, at less cost. One advantage of the latter class of powers is that they can easily be moved from place to place. A two-horse tread power has recently been purchased, and, while it has disadvantages, it is working well so far as tested, and has the great advantage of being suited for working where there is not sufficient room for the use of sweep powers.

For two or three years we have been using a McCormick wire binder. It does good work, and can do much more. There are some advantages in the use of twine binders; but these do not seem sufficient to make it best to discard this machine and purchase another. With reference to the commonly made objection that stock will be injured by eating the wire left in the straw at threshing, it is to be said that we have seen no injury either to horses or cattle, although timothy straw as well as oat straw, so bound, has been freely used.

We are using walking plows of three different makers in this State, and it would be hard to find a reason for giving any decided preference to any one over the others, either in quality or work done, or draft. We are using, and like well, the Gilpin Riding Plow. The fact that it has one lever instead of two, as have most riding plows, is one point counted in its favor. We have tried the Cassady plow, and were much pleased with its work, dispensing with the “landside,” which doubtless reduces the draft, and the inclination of the wheel in the furrow seems to admirably regulate width of furrow and prevent pressure against the landside. The arrangements for adjusting, to regulate any possible condition, are complete—possibly more numerous than some who use the plow will make good use of.

In filling a silo recently, a feed-cutter of good size, and which had done good work, was made use of. The large corn stalks and the larger ears, far from mature though they were, proved too great
a strain, and a breakage was the result, through no fault of the machine, but because it was asked to do more than it was fitted for.

Of farm machinery for which there is demand as yet unsupplied, may be named a field corn-husker; a harvester for corn stalks; a ditch-digging and tile-laying machine. Ingenious and partially successful attempts have been made in each of these directions, but success has not been attained.
A CATTLE FEEDING EXPERIMENT.

G. E. Morrow, M. A., Professor of Agriculture.

In the spring of 1880 an attempt was made to purchase a pair of yearling steers of each of the breeds kept in the State, for the purpose of comparing their progress under the same treatment—that approximating the treatment given cattle by the mass of farmers.

J. Patterson, of Rock Falls, furnished a pair of full blood but unregistered Ayrshires, sired by a somewhat noted show bull. The steers were of good form, but not large for age. Gen. L. F. Ross, of Avon, furnished a pair of good high grade Devons, sired by bulls in use in his well-known herd. Messrs. E. O. & E. E. Chester, of Champaign, furnished a pair of Short-horns, one pure bred, the other three-fourths. They were sired by a good but plainly bred bull of medium size, and were out of fairly good cows. Difficulty was found in securing Herefords. The only ones found were a pair of half bloods, bred by Messrs. Burnham & Son, of Martinton. They were out of common cows. They differed much in age. The younger one was counted much the better animal. None of the cattle were in high flesh, the grade Short-horns being in the best condition. Thanks are due the breeders for selling at reasonable prices—the Hereford grades being valued highest.

May 1, 1880, one of each pair was placed on pasture, with light feeding of corn meal; the others were kept on pasture alone. The season was not favorable for grass, and the pasture on which the first lot was kept was not good. At the first of November, all were turned in the corn stalk fields for a few weeks; then kept in open yards with thresher timothy hay, oat straw, and a very little ear corn—the design being to give a fair sample of allowing cattle to "rough it" during the winter. The winter was a severe one for cattle so exposed, there being a number of violent storms and much disagreeable weather.

May 1st, the cattle were put on pasture, and feeding ear corn twice a day began, commencing with about one-fourth bushel each per day, and increasing to almost a half bushel at the last. The summer was almost unprecedentedly dry and warm. Pastures
failed; the water supply was unsatisfactory. During the hot weather the steers had access, during the day, to a dark shed. During August the younger Ayrshire steer met with an accident which made it necessary to kill him.

The seven steers were taken to the Fat Stock Show in Chicago, in November. During the week they were sold to a prominent butcher of the city and were slaughtered in the building, the weights of different parts being taken. By invitation a committee of butchers informally classed the carcases in order of merit.

In tables below are given the names, ages and weights of the steers at different dates; also the results of the slaughter test. The second steer of each pair, as given in the first table, is the one which had some grain during the first summer:

<table>
<thead>
<tr>
<th>Name</th>
<th>Breed</th>
<th>Birth</th>
<th>Weight May 1</th>
<th>Weight July 1</th>
<th>Weight Sept. 1</th>
<th>Weight Nov. 1</th>
<th>Gain in 6 months</th>
<th>Weight, Aug. 1</th>
<th>Weight May 1</th>
<th>Weight July 1</th>
<th>Weight Sept. 1</th>
<th>Weight Nov. 1</th>
<th>Gain in 6 months</th>
<th>Weight, Aug. 1</th>
<th>Weight May 1</th>
<th>Weight July 1</th>
<th>Weight Sept. 1</th>
<th>Weight Nov. 1</th>
<th>Gain in 6 months</th>
<th>Weight, Aug. 1</th>
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<tr>
<td>Jock</td>
<td>Ayrshire</td>
<td>Feb. 3, 79</td>
<td>605</td>
<td>770</td>
<td>820</td>
<td>885</td>
<td>290</td>
<td>920</td>
<td>1,200</td>
<td>1,215</td>
<td>1,305</td>
<td>385</td>
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<td></td>
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</tr>
<tr>
<td>Jo</td>
<td>Ayrshire</td>
<td>March 1, 79</td>
<td>555</td>
<td>715</td>
<td>790</td>
<td>815</td>
<td>215</td>
<td>765</td>
<td>990</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
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<td></td>
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<tr>
<td>Thomas</td>
<td>Devon, Ayrshire</td>
<td>March 1, 79</td>
<td>560</td>
<td>780</td>
<td>880</td>
<td>950</td>
<td>260</td>
<td>850</td>
<td>1,100</td>
<td>1,145</td>
<td>1,300</td>
<td>400</td>
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<tr>
<td>My D'ke</td>
<td>Devon</td>
<td>May 1, 79</td>
<td>495</td>
<td>635</td>
<td>690</td>
<td>715</td>
<td>215</td>
<td>800</td>
<td>1,070</td>
<td>1,125</td>
<td>1,215</td>
<td>415</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burnham</td>
<td>Hereford</td>
<td>Oct. 1, 78</td>
<td>755</td>
<td>990</td>
<td>1,150</td>
<td>1,375</td>
<td>420</td>
<td>1,190</td>
<td>1,550</td>
<td>1,580</td>
<td>1,720</td>
<td>480</td>
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<tr>
<td>Junior</td>
<td>Hereford</td>
<td>Aug. 30, 79</td>
<td>540</td>
<td>630</td>
<td>740</td>
<td>780</td>
<td>210</td>
<td>840</td>
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<td>490</td>
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<tr>
<td>Ezra</td>
<td>Short Horn</td>
<td>April 1, 79</td>
<td>635</td>
<td>880</td>
<td>900</td>
<td>990</td>
<td>355</td>
<td>1,100</td>
<td>1,400</td>
<td>1,420</td>
<td>1,500</td>
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<tr>
<td>Oscar</td>
<td>Short Horn</td>
<td>March 1, 79</td>
<td>725</td>
<td>845</td>
<td>865</td>
<td>960</td>
<td>235</td>
<td>915</td>
<td>1,200</td>
<td>1,335</td>
<td>1,430</td>
<td>515</td>
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Totals: 4,810, 6,215, 6,550, 7,080, 2,280, 7,380, 3,135

<table>
<thead>
<tr>
<th>Name</th>
<th>Merit of carcase</th>
<th>Weight at home</th>
<th>Live weight at slaughter</th>
<th>Weight dressed carcass</th>
<th>Tallow</th>
<th>Weight and t of carcase—hide allowance</th>
<th>Blood</th>
<th>Livers, lungs, heart, tongue, trimmings</th>
<th>Feet</th>
<th>Paws and hocks</th>
<th>Blood, lungs, heart, tongue, trimmings</th>
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<tr>
<td>Jock</td>
<td>2</td>
<td>1,305</td>
<td>1,280</td>
<td>733</td>
<td>886</td>
<td>71</td>
<td>82</td>
<td>192</td>
<td>216</td>
<td>173</td>
<td>34</td>
</tr>
<tr>
<td>Thomas</td>
<td>4</td>
<td>1,305</td>
<td>1,280</td>
<td>727</td>
<td>850</td>
<td>56</td>
<td>83</td>
<td>188</td>
<td>236</td>
<td>167</td>
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<td>May Duke</td>
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<td>1,315</td>
<td>1,335</td>
<td>677</td>
<td>808</td>
<td>55</td>
<td>76</td>
<td>182</td>
<td>215</td>
<td>156</td>
<td>34</td>
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<td>7</td>
<td>1,670</td>
<td>1,545</td>
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<td>1,151</td>
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<td>98</td>
<td>555</td>
<td>228</td>
<td>227</td>
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<tr>
<td>Junior</td>
<td>6</td>
<td>1,335</td>
<td>1,250</td>
<td>759</td>
<td>894</td>
<td>56</td>
<td>88</td>
<td>197</td>
<td>219</td>
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<td>21.5</td>
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<tr>
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<td>1,300</td>
<td>815</td>
<td>960</td>
<td>58</td>
<td>87</td>
<td>212</td>
<td>298</td>
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<tr>
<td>Ezra</td>
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<td>1,400</td>
<td>880</td>
<td>1,046</td>
<td>76</td>
<td>90</td>
<td>232</td>
<td>286</td>
<td>207</td>
<td>22.0</td>
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</table>

Among the points suggested by these results may be named:

1. In no sense can this be counted a conclusive comparison of breeds; it is obviously unfair to compare half-bloods with pure bred animals. So far as the opinion of the butchers who examined the carcases has value, it goes to show that the greater the proportion of "improved blood," the better the carcase. The two pure bred steers stand at the head; the two half-bloods at the foot of the list.

2. The percentage of weight of dressed carcase to live weight shows the fact that none of the steers were very fat. These per-
percentages range from 59 to nearly 63; they are all creditable. It was the general opinion of those who examined the carcases that they were as profitable to the butcher, and more profitable to the consumer, than were any of those of much fatter animals slaughtered, as the latter had too large a proportion of fat.

3. The shrinkage from full home weight to that after being shipped and fasted, is greater than many persons would have expected, ranging from 80 to 130 pounds, and averaging 104 pounds. "Full weight" is a somewhat unsatisfactory thing, as one animal may have drank much more or more recently than another.

4. The weights taken the first six months show that no one of the steers having some grain made as much growth as did his mate on better pasture without grain. In both years but little gain was made during the hot, dry weather of mid-summer. The fluctuations in gain are not always easily explained. This case furnishes further evidence, if this be needed, that the practice of keeping young stock through the winter in open yards and with little or no grain, is not profitable. Two of the steers lost in weight from November to May, and the total gain of the eight during these six months was only 300 pounds; the average gain per steer during the first summer was 285 pounds; during the second summer, 448 pounds, or a little less than 75 pounds per month; the largest gain in this time was 515 pounds, or nearly 86 pounds per month. These gains are not so large as should be expected in profitable feeding.

The table giving the weights of the different portions of the several carcases may be studied with profit. The task of cutting up the carcases was executed with unusual skill. It will be noticed that there is only the slightest variation in the weight of the pairs of quarters.
REPORT ON THE MANUFACTURE ON SUGAR, SYRUP AND GLUCOSE FROM SORGHUM.

BASED UPON EXPERIMENTS MADE IN 1880 AND 1881, AT THE ILLINOIS INDUSTRIAL UNIVERSITY.

By Henry A. Weber, Ph. D., Professor of Chemistry, and Meville A. Scovell, M. S., Professor of Agricultural Chemistry.

[A portion of this paper was published in the Report of the Trustees for the year 1880, but as it forms the basis of the later work now presented, the whole is included.]

INTRODUCTION.

The object of the investigations made upon sorghum cane at the Illinois Industrial University, was to settle, if possible, the much disputed question, whether sugar could be made from this plant on a manufacturing scale and with commercial success. From the many conflicting reports relating to this matter no definite conclusions could be drawn, and it was found necessary, in order to prosecute our work in an intelligent manner, to treat the whole subject as an entirely new field of investigation. It has been claimed by many that the proper sphere of the sorghum industry is the production of syrup, and a great deal of good work has been accomplished in improving the quality and yield of this article; but what may have been true for sorghum a few years ago, does not hold good to-day. The sorghum industry is, at the present time, confronted by another, namely, the glucose industry, which, although still in its infancy, has already shown its superiority in the production of syrup, both in regard to quality and quantity. This
statement is made with due consideration of the many attacks which the glucose industry has of late received. Glucose, as an article of food, is equal to if not superior to cane sugar, and its artificial production from corn or other amylaceous substances, is a perfectly legitimate business. It is true, that in the decolorization of the glucose injurious substances may be employed, and if the products sent to market are not perfectly free from them, great injury may be done to the consumers. The same thing may be said for the refining of cane sugar. But in either case the employment of injurious substances is not a necessity, and should be condemned by every one who is interested in public welfare. Glucose, when made as it should be, is perfectly harmless, and no valid objection can be made to it in a sanitary point of view, when employed for any legitimate purpose to which it is adapted. The sorghum industry must regard the manufacture of glucose as a fair competitor, and the latter will never lose in importance by any unjustifiable attacks or criticisms. From these considerations it seems evident that the production of syrup alone can no longer maintain the cultivation of sorghum on a scale which would suffice to give it the name of an industry.

To accomplish this, sorghum growers should turn all their attention and energy to the production of crystallizable sugar, which glucose, on account of its inherent properties, can never replace, and which will always find a ready market free from all competition.

These circumstances led to the investigations about to be described, and the results obtained have exceeded our most sanguine expectations. Our experiments, both scientific and practical, have shown beyond a doubt, not only that the manufacture of sugar from sorghum in our own State is practicable, but also that it will be highly remunerative, when undertaken on a large scale.

Up to the present time sorghum seed has never found a proper utilization. Although in its general composition it resembles other grain as corn, the amount of tannin contained in it, as our analysis given farther on shows, will no doubt prevent its liberal use as food for animals. Knowing that immense quantities of seed will necessarily be produced as soon as the sorghum sugar industry is introduced, we have given this matter careful study, and have found that the seed is eminently adapted for the production of glucose. We have prepared the glucose directly from the ground seed, without the tedious and expensive process of first separating the starch. The great advantage of this industry to the sorghum industry will appear from the fact, that as the seed is practically ripe when the cane is cut it can be stored up till the sugar season is over, and can afterwards be manufactured into glucose with the same machinery now used in making sugar from the cane, thus giving employment for the balance of the year to the works, which otherwise would have to lie idle for eight or ten months annually.
Our work occupied two distinct fields of experiments: first, scientific investigations, in which the nature of sorghum cane was studied; second, practical experiments in making sugar.

PERIODICAL EXAMINATION OF THE CANES FOR SUGAR.

The objects of these analyses were:
1. To note the development and changes of the sugars in the plant during its growth.
2. To notice the changes which the cane undergoes after reaching this maximum stage in the quality and quantity of its saccharine matter: first, while standing in the field untouched; second, standing stripped two weeks; third, cut and lying under shelter.
3. To ascertain the portion of the stalk richest in sugar.
4. To study the effect of different varieties of soils on the development of sugar in the cane.
5. To determine the effect of freshly manured soils on the development of sugar in sorghum.
6. To compare the different varieties of sorghum as sugar producing plants.

These examinations were conducted in the following manner:

On the dates specified, ten average stalks were selected from the given field, stripped, topped just below the uppermost leaf, and cut off one joint above ground. The stripped and topped cane was crushed in a thoroughly cleansed Victor mill. The juice was collected in a bottle and after being cooled down to 20° C, the sp. gr. was noted, then 10 c.c. were put into a graduated cylinder for the estimation of grape sugar, and 10 c.c. were put in a beaker for determining the amount of cane sugar.

For the estimation of grape sugar the 10 c.c. measured off for this purpose were diluted so as to measure exactly 100 c.c. and the grape sugar then determined by Fehling's solution.

The portion reserved for cane sugar was diluted, 12 drops of dilute sulphuric acid added, and the whole heated over a water bath for one hour. The mixture was then allowed to cool, sodium hydroxide added to alkaline reaction, diluted to 500 c.c., and the total amount of sugar determined with Fehling's solution. The difference between the grape and total sugar was estimated as cane sugar by multiplying by 0.95.
The results of the analyses are given in the tables which follow:

**TABLE SHOWING THE DEVELOPMENT AND CHANGE OF SUGARS IN SORGHUM.**

<table>
<thead>
<tr>
<th>Stage of Development</th>
<th>No.</th>
<th>Date</th>
<th>Variety</th>
<th>Sp. gr. of Juice</th>
<th>Grape Sugar</th>
<th>Cane Sugar</th>
<th>Av. of Cane Sugar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beginning to head</td>
<td>1</td>
<td>Aug. 14, '80</td>
<td>Orange</td>
<td>1.055</td>
<td>5.70</td>
<td>4.90</td>
<td>4.14</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Aug. 10, '81</td>
<td>Amber</td>
<td>1.058</td>
<td>8.39</td>
<td>3.38</td>
<td></td>
</tr>
<tr>
<td>In blossom</td>
<td>3</td>
<td>Aug. 25, '80</td>
<td>Orange</td>
<td>1.062</td>
<td>6.10</td>
<td>7.12</td>
<td>7.77</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Aug. 10, '81</td>
<td>Amber</td>
<td>1.066</td>
<td>5.43</td>
<td>8.42</td>
<td></td>
</tr>
<tr>
<td>Seed soft and milky</td>
<td>5</td>
<td>Aug. 14, '80</td>
<td>Amber</td>
<td>1.065</td>
<td>3.34</td>
<td>10.25</td>
<td>8.56</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Sept. 16, '80</td>
<td>Orange</td>
<td>1.068</td>
<td>5.00</td>
<td>9.13</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Aug. 10, '81</td>
<td>Amber</td>
<td>1.068</td>
<td>4.25</td>
<td>9.84</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Aug. 12, '81</td>
<td>Amber</td>
<td>1.070</td>
<td>3.75</td>
<td>12.75</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>Sept. 1, '81</td>
<td>Orange</td>
<td>1.048</td>
<td>6.11</td>
<td>3.71</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Sept. 2, '81</td>
<td>Orange</td>
<td>1.048</td>
<td>6.58</td>
<td>5.19</td>
<td></td>
</tr>
<tr>
<td>Seed in hardening dough</td>
<td>11</td>
<td>Aug. 25, '80</td>
<td>Amber</td>
<td>1.068</td>
<td>2.47</td>
<td>12.48</td>
<td>11.95</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>Sept. 16, '80</td>
<td>Orange</td>
<td>1.065</td>
<td>4.11</td>
<td>9.76</td>
<td></td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>Aug. 10, '81</td>
<td>Amber</td>
<td>1.074</td>
<td>3.65</td>
<td>10.10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>Aug. 12, '81</td>
<td>Amber</td>
<td>1.074</td>
<td>2.65</td>
<td>13.37</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>Aug. 16, '81</td>
<td>Amber</td>
<td>1.070</td>
<td>3.92</td>
<td>11.89</td>
<td></td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>Aug. 16, '81</td>
<td>Amber</td>
<td>1.072</td>
<td>3.00</td>
<td>13.66</td>
<td></td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>Aug. 19, '81</td>
<td>Amber</td>
<td>1.087</td>
<td>3.46</td>
<td>12.49</td>
<td></td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>Aug. 19, '81</td>
<td>Amber</td>
<td>1.074</td>
<td>3.10</td>
<td>13.18</td>
<td></td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>Aug. 19, '81</td>
<td>Amber</td>
<td>1.076</td>
<td>2.97</td>
<td>13.64</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>Aug. 19, '81</td>
<td>Amber</td>
<td>1.070</td>
<td>2.98</td>
<td>12.50</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>Aug. 19, '81</td>
<td>Amber</td>
<td>1.070</td>
<td>3.26</td>
<td>12.52</td>
<td></td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>Sept. 1, '81</td>
<td>Liberian</td>
<td>1.060</td>
<td>3.67</td>
<td>10.24</td>
<td></td>
</tr>
<tr>
<td></td>
<td>23</td>
<td>Sept. 1, '81</td>
<td>Amber</td>
<td>1.063</td>
<td>2.61</td>
<td>13.47</td>
<td></td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>Sept. 1, '81</td>
<td>Amber</td>
<td>1.056</td>
<td>2.18</td>
<td>11.14</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>Sept. 1, '81</td>
<td>Chinese</td>
<td>1.052</td>
<td>4.13</td>
<td>8.60</td>
<td></td>
</tr>
<tr>
<td>Seed ripe</td>
<td>26</td>
<td>Sept. 6, '80</td>
<td>Amber</td>
<td>1.064</td>
<td>2.13</td>
<td>11.42</td>
<td>11.18</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>Sept. 16, '80</td>
<td>Amber</td>
<td>1.065</td>
<td>2.79</td>
<td>11.02</td>
<td></td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>Oct. 2, '80</td>
<td>Amber</td>
<td>1.069</td>
<td>2.47</td>
<td>10.06</td>
<td></td>
</tr>
<tr>
<td></td>
<td>29</td>
<td>Oct. 6, '80</td>
<td>Orange</td>
<td>1.078</td>
<td>4.92</td>
<td>11.41</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>Sept. 9, '81</td>
<td>I. I. U.</td>
<td>1.070</td>
<td>2.93</td>
<td>12.48</td>
<td></td>
</tr>
<tr>
<td></td>
<td>31</td>
<td>Sept. 1, '81</td>
<td>Amber</td>
<td>1.070</td>
<td>2.71</td>
<td>10.77</td>
<td></td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>Sept. 2, '81</td>
<td>Amber</td>
<td>1.070</td>
<td>2.61</td>
<td>16.97</td>
<td></td>
</tr>
<tr>
<td></td>
<td>33</td>
<td>Sept. 5, '81</td>
<td>Amber</td>
<td>1.067</td>
<td>3.16</td>
<td>11.76</td>
<td></td>
</tr>
</tbody>
</table>

The analyses made in 1880, numbers 1, 3, 5, 6, 11, 12, 26, 27, 28, and 29, were from cane grown upon the University farm.

The following data in regard to the planting and cultivation of the cane were furnished by G. E. Morrow, Professor of Agriculture:

Two varieties, Orange and Early Amber; seed obtained from Hedges, St. Louis; planted by hand, May 14, 1880. The Orange was planted in a plot of nearly one acre (.955) in 24 rows four feet apart, in hills about four feet in a row. The Early Amber was planted in a plot of one and one-half acres (1.48) in 40 rows three and one-half feet apart, and with hills about same distance apart. Each plot was on good prairie soil which had been in corn two years, following a liberal application of barn-yard manure. The plots received ordinary field culture—a two-horse corn cultivator,—except hand-hoeing and thinning to four or five stalks when ten to twelve inches high. The suckers were not removed. The Orange averaged about seven feet in height, and over an inch in diameter at base. The Early Amber averaged over nine feet in height, and
rather less than three-quarters of an inch in diameter at base. The canes were cut about six inches from the ground. Of the Orange, from two to three feet of the top was taken off; of the Early Amber, rather more than three feet.

An analysis was made of the soil on which these two varieties of cane grew, and also of its subsoil and of a virgin prairie soil adjoining.

The following table gives the result of these analyses. No. 1 was prairie soil, No. 2 the soil on which the cane grew, No. 3 its subsoil:

<table>
<thead>
<tr>
<th>Soil</th>
<th>No. 1</th>
<th>No. 2</th>
<th>No. 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic matter</td>
<td>1.9414</td>
<td>2.4880</td>
<td>3.7551</td>
</tr>
<tr>
<td>Silicic acid</td>
<td>0.6798</td>
<td>0.9617</td>
<td>0.6975</td>
</tr>
<tr>
<td>Sesquioxide of iron</td>
<td>1.8367</td>
<td>1.4337</td>
<td>1.2606</td>
</tr>
<tr>
<td>Alumina</td>
<td>1.4775</td>
<td>0.5790</td>
<td>1.7150</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.1736</td>
<td>0.2290</td>
<td>0.1736</td>
</tr>
<tr>
<td>Phosphate of lime</td>
<td>0.1683</td>
<td>0.2103</td>
<td>0.1132</td>
</tr>
<tr>
<td>Carbonate of lime</td>
<td>0.3855</td>
<td>0.5845</td>
<td>1.2515</td>
</tr>
<tr>
<td>Carbonate of magnesia</td>
<td>0.5244</td>
<td>0.6757</td>
<td>0.7140</td>
</tr>
<tr>
<td>Potash</td>
<td>0.6733</td>
<td>0.6786</td>
<td>0.6585</td>
</tr>
<tr>
<td>Soda</td>
<td>0.0177</td>
<td>0.0211</td>
<td>0.0070</td>
</tr>
<tr>
<td>Sulphuric acid</td>
<td>0.1403</td>
<td>0.1519</td>
<td>0.2157</td>
</tr>
<tr>
<td>Soluble matter found</td>
<td>6.8327</td>
<td>7.5134</td>
<td>9.2745</td>
</tr>
<tr>
<td>Organic matter</td>
<td>4.1159</td>
<td>6.0590</td>
<td>8.9549</td>
</tr>
<tr>
<td>Silicic acid</td>
<td>72.1765</td>
<td>68.7127</td>
<td>68.0224</td>
</tr>
<tr>
<td>Alumina with trace of iron</td>
<td>12.7143</td>
<td>12.0520</td>
<td>9.3156</td>
</tr>
<tr>
<td>Lime</td>
<td>0.5729</td>
<td>0.7721</td>
<td>0.6444</td>
</tr>
<tr>
<td>Magnesia</td>
<td>0.4833</td>
<td>0.4833</td>
<td>0.4833</td>
</tr>
<tr>
<td>Potash</td>
<td>3.0441</td>
<td>3.0431</td>
<td>2.4561</td>
</tr>
<tr>
<td>Soda</td>
<td>0.5120</td>
<td>0.6344</td>
<td>0.5664</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.6933</td>
<td>0.0847</td>
<td>0.2628</td>
</tr>
<tr>
<td>Phosphoric acid</td>
<td>0.1978</td>
<td>0.1553</td>
<td>0.2628</td>
</tr>
<tr>
<td>Insoluble matter found</td>
<td>92.7867</td>
<td>91.9974</td>
<td>90.7062</td>
</tr>
</tbody>
</table>

Analyses Nos. 2, 4, 7, and 13, were made from cane grown upon the farm of Mr. J. W. Cushman, two miles south of Urbana. The field on which this cane was planted had grown seven consecutive crops of sorghum, without manure. It was high prairie land sloping towards the south. Seed planted April 25.

The cane of Nos. 8 and 14 was grown about one and one-half miles northeast of Urbana, on timber land. The field had been used as a barn-yard previous to its being planted with cane and was therefore richly manured. The seed came from Minnesota through Mr. LeDuc, ex-Commissioner of Agriculture. The seed was planted the first week in May. Cultivated as usual for corn.

Results Nos. 15 and 16 were obtained from cane grown three miles south of Champaign, on virgin prairie. Eight rows were planted along the roadside, bounded on the outer side by the road itself, and the inner by a tall, dense hedge-fence. Mr. Holmes, the owner of the cane, said the seed came from Mississippi, and was planted the last week in April. Land gradually rising from a slough near by. Two varieties of heads were present in this cane: the panicles of one (analysis No. 15) were clustered and erect; those of the other (No. 16) were spreading with pedicels drooping.

No. 21. University farm. Volunteer cane, from cane grown on the field last year.
The cane from which analyses Nos. 17, 18, 19 and 20 were made, was grown upon timber land about three miles N. E. of Urbana. The seed probably came from Minnesota.

No. 17. Cane grown by Mr. E. Bishop. Field ten years in cultivation, manured three or four years ago. Seed planted about the middle of May. Rows 3 1/2 feet apart in hills 3 feet apart. An average of eight stalks in a hill. Cane small.

Nos. 18 and 19, cane grown by Christ. Shuman. No. 18 was on high land, twelve years in cultivation, and had never been matured. An average of five stalks in a hill. Growth of cane medium. No. 19 was on low land, four years in cultivation. Average of eight stalks in a hill. Cane large and thrifty.

No. 20. Cane grown by Sam'l Wilson, on land four years in cultivation. Hills 3x3 1/2 feet apart. An average of eight stalks in a hill. Field on the top of a small hill.

Analyses Nos. 9, 10, 22, 31 and 32 were made in Macoupin county, Illinois, Nos. 9, 22 and 31 from cane raised about two miles north of Virden, by Mr. Chas. Rauch, and Nos. 10 and 32 one mile west of Girard, by Mr. D. C. Ashbaugh. The prairie soil in this county is very black, deep, and "mucky." No. 9. Cane grown on timber land. Seed planted May 12, 1881. Hills 3 by 3, an average of five stalks in a hill. No. 22. Volunteer cane. Prairie land. No. 31. Prairie land. Seed planted first part of May. No. 32. Prairie land; seed planted latter part of May.

The results of experiment No. 53 were obtained from cane grown by Christ. Lust, about a mile west of Monticello, Piatt county. The field was timber land—a poor, clayey soil. Seed planted first week in May.

Analyses Nos. 23, 24 and 25 were made of the juice of sorghum grown upon the so-called Mississippi sand-lands near Oquawka, Illinois. No. 23 was from cane grown by Dr. Park, one mile east of Oquawka. Nos. 24 and 25 were made from cane grown by Tom Ricketts, two miles N. E. of the same place.

Development of sugar. Analyses Nos. 5, 11, 26, 27 and 28 were made from the same field on the dates specified, and show conclusively that the cane sugar reached its maximum quantity when the seed was in the "hardening dough," and that it afterwards gradually diminished. The same fact appears on comparing the average under each division in the table.

Effect of stripping and allowing to stand. On October 2d, 1880, an analysis was made of the juice of cane, which had been stripped on the 18th of September—the cane not otherwise disturbed,—with the following result:

Specific gravity of juice ..................... 1.074
Grape sugar .................................. 1.82 per cent.
Cane sugar ................................... 13.11 " "

This subject needs further investigation.
Change of sugar after cutting the cane. On October 23, 1880, an analysis was made of the juice of the Orange cane which had been cut, stripped, and topped October 2d and placed under shelter until examined. Juice whitish.

Specific gravity ......................... 1.091
Grape sugar ............................... 14.66 per cent.
Cane sugar ............................... 3.55 " "

A sample of cane, cut August 25, 1880, without being stripped and topped, was preserved in a warm room where it had become dry long before it was examined. On April 3, 1881, it was analyzed and showed 12 per cent. of grape sugar and no trace of cane sugar.

Comparison of the upper and lower half of the cane. The following analyses were made to show what part of the cane is richest in sugar:

Amber—October 2, 1880. Juice obtained from the upper half of the stalks after topping as usual.

Specific gravity ......................... 1.069
Grape sugar ............................... 2.94 per cent.
Cane sugar ............................... 9.67 " "

Amber—October 2, 1880. Juice obtained from the lower half of stalks.

Specific gravity ......................... 1.070
Grape sugar ............................... 1.94 per cent.
Cane sugar ............................... 11.64 " "

Effect of Soils. The following analysis were made to study the effect of different varieties of soil upon the production of sugar in sorghum. But as other circumstances, as locality from which seed was obtained, time of planting, and manner of cultivation, may affect the amount of sugar, many more investigations would have to be made before definite conclusions could be reached. The table, however, shows that sorghum can be grown successfully on all varieties of soil specified.
Table showing the effects of different soils on the development of sugar in sorghum:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Prairie.</td>
<td>1</td>
<td>27</td>
<td>Manured 3 y's ago</td>
<td>Amber.</td>
<td>1.068</td>
<td>2.47</td>
<td>12.48</td>
<td>Grape.</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>7</td>
<td>No manure.</td>
<td>Amber.</td>
<td>1.074</td>
<td>3.65</td>
<td>10.16</td>
<td>Cane.</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>27</td>
<td>Manured 4 y's ago</td>
<td>No manure.</td>
<td>1.070</td>
<td>3.26</td>
<td>12.52</td>
<td>Grape.</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Unknown.</td>
<td>No manure.</td>
<td>Amber.</td>
<td>1.07</td>
<td>2.71</td>
<td>10.77</td>
<td>Grape.</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>Very old.</td>
<td>No manure.</td>
<td>Amber.</td>
<td>1.07</td>
<td>2.51</td>
<td>10.31</td>
<td>Cane.</td>
</tr>
<tr>
<td>Virgin prairie.</td>
<td>6</td>
<td>No manure.</td>
<td>Amber.</td>
<td>1.07</td>
<td>3.92</td>
<td>11.89</td>
<td>Grape.</td>
<td>2.39</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>No manure.</td>
<td>Amber.</td>
<td>1.072</td>
<td>3.00</td>
<td>13.65</td>
<td>Cane.</td>
<td>12.3</td>
</tr>
<tr>
<td>Timber land.</td>
<td>8</td>
<td>Unknown.</td>
<td>Barn-y'd manure</td>
<td>Amber.</td>
<td>1.074</td>
<td>2.65</td>
<td>13.37</td>
<td>Grape.</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>10</td>
<td>Manured 4 y's ago</td>
<td>Amber.</td>
<td>1.067</td>
<td>3.46</td>
<td>12.49</td>
<td>Cane.</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>12</td>
<td>No manure.</td>
<td>Amber.</td>
<td>1.074</td>
<td>3.10</td>
<td>13.18</td>
<td>Cane.</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>4</td>
<td>No manure.</td>
<td>Amber.</td>
<td>1.076</td>
<td>2.97</td>
<td>13.64</td>
<td>Cane.</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>7</td>
<td>No manure.</td>
<td>Amber.</td>
<td>1.07</td>
<td>2.98</td>
<td>12.89</td>
<td>Cane.</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>Many.</td>
<td>No manure.</td>
<td>Amber.</td>
<td>1.066</td>
<td>3.16</td>
<td>11.76</td>
<td>Cane.</td>
</tr>
<tr>
<td>Mississippi sand land.</td>
<td>14</td>
<td>No manure.</td>
<td>Amber.</td>
<td>1.063</td>
<td>2.61</td>
<td>13.47</td>
<td>Grape.</td>
<td>2.39</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td></td>
<td>Amber.</td>
<td>1.056</td>
<td>2.18</td>
<td>13.14</td>
<td>Cane.</td>
<td>12.3</td>
</tr>
</tbody>
</table>

**Effect of Manure.**—To ascertain the effect of manure a field was selected which had been used as a barn-yard for several years. A part of the cane was planted directly on the rotten manure pile. An analysis was made of a sample taken from this part of the field, as well as of a part away from a manure pile. The seed in each case was in the “hardening dough.” The following is the result of the analysis:

Manured—Sp. gr. 1.063. Grape sugar 2.65. Cane sugar 10.89.

**Variety of Cane.**—From the table it appears that the Amber is best adapted for the production of cane sugar. The Orange and Liberian can also be employed advantageously in the latter part of the season, as they mature later. Their yield is greater per acre, and this fact would no doubt compensate for the less proportion of cane sugar to grape sugar contained in them. Analysis No. 25 of the Chinese cane seems to indicate that it would be unfit for the production of crystallizable sugar.

**PROXIMATE ANALYSIS OF SORGHUM CANE.**

An average portion of the Orange cut at the same time—October 6, as that used in experiment 29 was reserved, with tops and leaves still remaining, for analysis.

The leaves and two feet of tops were removed, and cross sections taken between each joint of the remainder of the stalks. The proximate principles were then determined according to the following scheme. The sections, as soon as cut, were weighed and then dried in a water oven, allowed to cool in the air, weighed, finally pulver-
ized, and put in a stoppered bottle. Of the dried substance, ten grams were required for sugar, fiber, starch, gum and vegetable acids; one gram for hygroscopic water and ash; one gram for total albuminoids; five grams for oil. The gram of dried cane reserved for water and ash was heated in an oven at 110° C. until its weight was constant. It was then ignited and the ash weighed. The ten grams for the estimation of sugar, etc., were macerated with water in a mortar, the water decanted, and this process continued several times, the decanted liquids being filtered by Bunsen's method, and finally the residue was thrown on the filter and washed until the filtrate measured one litre. 100 c.c. of this solution was evaporated nearly to dryness on a water-bath, then the desiccation completed by passing a current of dry air upon the residue by means of an aspirator, the temperature of the substance ranging in the meantime between 90° and 100° C. The residue was then weighed, incinerated, and weight of ash noted.

**Albuminoids.—** 400 c.c. of the aqueous extract were evaporated to a syrup on the water-bath, calcined gypsum added, the whole then dried and the residue ignited with soda lime. 500 c.c. of the aqueous extract were rapidly evaporated nearly to dryness, and the residue exhausted with alcohol of 87 per cent. by repeated boilings with fresh portions of the solvent as long as it was colored. The liquids were filtered, the residue thrown upon the filter and washed with hot alcohol, and the washings added to the filtrate. Water was added to the filtrate, the alcohol expelled by heat, and then the solution diluted to 200 c.c.

**Grape Sugar.—** 100 c.c. of this solution were reserved for the estimation of grape sugar. The remainder was acidulated with dilute sulphuric acid, and boiled to convert the cane into grape sugar.

**Cane Sugar.—** The cane sugar was then estimated with Fehling's solution, as usual.

**Gum and Vegetable Acids.—** The residue insoluble in alcohol was dried at 100° C., weighed and then incinerated. This ash and the soluble albuminoids were subtracted from the total amount of residue, and the remainder estimated as gum and vegetable acids.

The residue left after extracting the ten grams of cane with water was washed with alcohol acidulated with sulphuric acid to dissolve the albuminoids, transferred to a beaker, and diluted to 200 c.c. 5 c.c. of normal sulphuric acid were added, and the whole boiled for an hour on the water-bath, then filtered through Bunsen's filter. The filter was also cut into shreds and boiled with water containing one per cent. of sulphuric acid, to dissolve any starch remaining on it. After filtering, the two filtrates were added, and the starch estimated from an alliquot portion by conversion into glucose.

The method was as follows: The starch solution was diluted to 500 c.c. Three separate portions of 50 c.c. each were transferred to prescription bottles, 10 c.c. normal acid added, the bottles were then stoppered with rubber stoppers firmly tied, and placed in a salt-bath and boiled respectively for three, four, and six hours. The contents of the bottles were then neutralized, diluted, and starch calculated from the amount of grape sugar present. The solution boiled six hours had 0.02 per cent. more starch than that boiled four hours. Three hours' boiling did not convert all of the starch into grape sugar. The residue from which the starch was taken was
boiled with sodium hydroxide, thrown upon a weighed filter, and repeatedly washed with the same solution, then washed with hot water, and finally with alcohol and then with ether. The washed residue was dried at 110° C., and weighed, then incinerated, the weight of ash subtracted from the former weight, and the difference estimated as fiber. The gram reserved for the albuminoids was ignited with soda-lime, and albuminoids determined as usual.

The oil was extracted by ether from five grams of the dried cane. The total water was estimated by adding the per cent. of loss of the air-dried cane and the hygroscopic water.

RESULTS.

Composition of stalks of Orange cane in one hundred parts.

<table>
<thead>
<tr>
<th>Component</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>76.58</td>
</tr>
<tr>
<td>Grape sugar</td>
<td>3.00</td>
</tr>
<tr>
<td>Cane sugar</td>
<td>9.77</td>
</tr>
<tr>
<td>Starch</td>
<td>4.12</td>
</tr>
<tr>
<td>Fiber</td>
<td>4.54</td>
</tr>
<tr>
<td>Oil</td>
<td>0.07</td>
</tr>
<tr>
<td>Gums and vegetable acids</td>
<td>0.24</td>
</tr>
<tr>
<td>Soluble albuminoids</td>
<td>0.23</td>
</tr>
<tr>
<td>Insoluble</td>
<td>0.16</td>
</tr>
<tr>
<td>Soluble ash</td>
<td>0.68</td>
</tr>
<tr>
<td>Insoluble ash</td>
<td>0.06</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>99.45</strong></td>
</tr>
</tbody>
</table>

ASH

The ash from the remaining dried cane was analyzed by the following method: The cane was incinerated at a low heat, pulverized, dried and put in a stoppered bottle.

Chlorine.—Two grams of the ash were exhausted with water, silver-nitrate added to the extract and the whole acidified with nitric acid. The precipitate of the chloride of silver was collected upon a filter, dried, ignited; weighed, and the chlorine collected in the usual manner. The filtrate was treated with excess of hydrochloric acid, silver chloride removed and the solution preserved.

Silica.—The ash insoluble in water was treated with hydrochloric acid, brought to dryness, moistened with hydrochloric acid, water added, and the residue thrown on a weighed filter. The filter and its contents were heated at 160° C. until of constant weight, then ignited, and the silica weighed. The loss found between the two weights was called charcoal.

The solution from which the chlorine had been precipitated and the filtrate from the silica were mixed, and the whole diluted to 200 c.c., and well shaken. 50 c.c. of this solution were reserved for the estimation of sulphuric acid and alkalies, 50 c.c. for phosphoric acid, manganese, lime, and magnesia.

Iron.—The remaining 100 c.c. were treated with sulphuric acid, and heated upon a water-bath until the chlorine was expelled; then transferred to a flask, water and sulphuric acid added, and the iron
reduced with hydrogen, generated by zinc suspended in the liquid, by means of a platinum wire. To facilitate the operation, a strip of platinum was introduced into the flask and allowed to come in contact with the zinc. After the reduction, the iron was estimated by a standard solution of potassium permanganate.

*Phosphoric Acid.*—A solution of ferric chloride was added to the portion reserved for phosphoric acid, etc., in sufficient quantity for the iron to combine with all the phosphoric acid present. Sodium carbonate was added until the last drop caused a precipitate, which did not re-dissolve upon agitation. The mixture was then heated, a hot solution of sodium acetate added, and the whole brought to the boiling temperature, filtered and washed with hot water.

The residue was dissolved in nitric acid and concentrated to about 10 c.c.; a nitric acid solution of molybdate of ammonia was added in excess, and the mixture allowed to stand in a warm place for 24 hours. The precipitate was collected on a filter, the beaker rinsed, and the contents of the filter washed with a mixture of the molybdate solution and water. The precipitate was dissolved in the smallest quantity of ammonia. Any of the phospho-molybdate precipitate remaining in the beaker was dissolved in a mixture containing 3 parts of water and 1 of ammonia and thrown upon the filter; finally, the filter was washed with the ammoniacal water. The filtrate was boiled, and the phosphoric acid precipitated with a mixture of ammonium-chloride, magnesium sulphate and ammonia, made according to Fresenius' formula. After allowing the mixture to stand 12 hours, the precipitate was collected on a filter, washed with ammonia water, and the volume of the filtrate and washings noted.

The precipitate was ignited in a platinum crucible, a little nitric acid added, and again ignited to oxidize the charred matter present, cooled, and weighed. As ammonia-magnesia-phosphate is soluble in about 54,000 parts of ammoniacal water, .003 of a grain was added to this weight, as the filtrate measured a little over 150 c.c. The phosphoric acid was then calculated from this weight of pyrophosphate of magnesium.

*Manganese.*—The solution from which the iron and phosphoric were precipitated was treated with a few drops of bromine, and boiled to precipitate the manganese. The precipitate was collected upon a filter and thoroughly washed, then strongly ignited, and weighed.

*Lime.*—The above filtrate was concentrated, and while hot a little ammonia added, and then an excess of ammonium oxalate, to precipitate the lime. The mixture was allowed to stand 12 hours. The precipitate was then collected upon a filter, dried, and ignited in a platinum crucible. After the filter was reduced to ash, carbonic acid was passed over the ignited lime, to reconvert any oxide formed into carbonate. From the weight of calcium-carbonate thus obtained the per cent. of lime was calculated.

*Magnesia.*—The filtrate from the lime was concentrated, ammonia added in excess, and then a solution of phosphate of soda to precipitate the magnesia present. This precipitate and its filtrate were treated the same as the corresponding one, the estimation of phos-
phoric acid. The magnesia was calculated from the amount of pyrophosphate of magnesia found.

**Sulphuric Acid.**—The 50 c.c. of the solution reserved for this purpose were boiled, and the sulphuric acid precipitated, with a slight excess of barium-chloride. The precipitate was collected upon a filter, washed, ignited, and weighed.

**Potassa.**—The above solution was treated, after concentration on a water-bath, with ammonia and ammonium-carbonate as long as any precipitate was formed, digested on a water-bath, filtered, and the contents of the filter carefully washed. The filtrate and washings were evaporated to dryness on a water-bath, and the residue ignited to expel ammoniacal salts. This residue was then treated with five and one-half times its weight of pure oxalic acid in the form of a concentrated solution, then evaporated to dryness, and again ignited to dull redness. The ignited residue was treated with a small quantity of boiling water, thrown upon a filter, washed with hot water, hydrochloric acid added to the filtrate, the mixture evaporated to dryness, and gently ignited, and the weight of the alkaline chlorides ascertained.

The separation of the alkalies was effected with platinic chloride, as follows:

The residue of alkalies was dissolved in a little water, and enough platinic chloride added to combine with the alkalies estimated as potassium salt. This mixture was evaporated nearly to dryness over a water bath, care being taken not to boil the water. A mixture of six volumes of alcohol and one of ether was poured over the residue, and the whole allowed to stand several hours in a covered vessel, with occasional stirring. The insoluble potassio-platinic chloride was transferred to an equipoised filter, washed with alcohol and ether mixed, and finally dried at 106° C., and weighed.

**Soda.**—From the weight of the double potassium chloride, the amount of the potassium chloride was ascertained. The weight was subtracted from the weight of the combined alkali chlorides, and the remainder called sodium chloride, and calculated as soda.

**Carbonic Acid.**—One gram of the ash was transferred to a Rose carbonic acid apparatus, and the carbonic acid estimated by loss. The following were the results obtained:

**Composition of ash.**—

<table>
<thead>
<tr>
<th>Substance</th>
<th>Weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silica</td>
<td>27.91</td>
</tr>
<tr>
<td>Iron oxide</td>
<td>0.14</td>
</tr>
<tr>
<td>Phosphoric acid</td>
<td>5.37</td>
</tr>
<tr>
<td>Manganese oxide</td>
<td>0.89</td>
</tr>
<tr>
<td>Lime</td>
<td>6.82</td>
</tr>
<tr>
<td>Magnesia</td>
<td>4.64</td>
</tr>
<tr>
<td>Sulphuric acid</td>
<td>6.23</td>
</tr>
<tr>
<td>Potassa</td>
<td>46.48</td>
</tr>
<tr>
<td>Soda</td>
<td>0.98</td>
</tr>
<tr>
<td>Sodium chloride</td>
<td>0.42</td>
</tr>
</tbody>
</table>

**Total** 99.88
ANALYSIS OF SORGHUM SEED.

A sufficient quantity of the seed was ground as fine as possible in an iron mortar, and was preserved in a glass-stoppered bottle. The following portions of the ground seed were taken:

10 grams, for the estimation of sugar, dextrine, starch and fiber.
1 gram, " " water and ash.
1 " " albuminoids.
1 " " oil.
1 " " tannin.

Sugar, etc.—The ten grams reserved for sugar, etc., were rubbed up thoroughly with water in a mortar, then transferred to a filter and washed well with water.

Solution=A. Residue=B.

The solution, A, was concentrated to about 10 c.c. in a porcelain dish on a water bath, then transferred into a strong prescription bottle and washed with about 10 c.c. of water, and the washings added. 5 c.c. of normal sulphuric acid were added, the bottle closed with a rubber stopper securely tied. The bottle and its contents were then transferred to a salt bath and boiled for six hours. After cooling, the contents of the bottle were transferred to a graduated cylinder, neutralized and diluted to 100 c.c., the coloring matter precipitated with acetate of lead, and, after thoroughly mixing, the whole was allowed to stand until the precipitate had settled to the bottom. A portion of the clear liquid was then transferred to a burette and dropped into 10 c.c. of Fehling's solution, diluted four times, and at the boiling temperature, until the whole of the copper had been precipitated as cuprous oxide. This point was determined by filtering a small quantity from time to time, acidifying the filtrate with acetic acid, and testing for copper with ferro-cyanide of potassium. The number of c.c of the sugar solution it took was noted, and the sugar and dextrine determined by the following proportion:

1. The number of c.c it took to precipitate copper solution: total number of c.c. : : .05 (grams of grape sugar required to precipitate 10 c.c. of Fehling's solution) : x.

X multiplied by 0.95 will give the grams of sugar in 10 grams of seed.

The residue, B, was washed on the filter with alcohol acidulated with sulphuric acid and finally with water, to dissolve the gluten. Then the residue was washed off the filter into a beaker diluted to about 400 c.c., 5 c.c. of sulphuric acid added, and the whole boiled on a water bath until the liquid had no milky appearance. It was then filtered through an equipoised filter and washed.

Solution=C. Residue=D.

Solution C was diluted to 500 c.c. 50 c.c. of this solution were transferred to a prescription bottle and then treated as above for sugar and dextrine. From the grape sugar obtained, the amount of starch was calculated.

Residue D was boiled with hot sodium hydroxide, again thrown upon the filter and washed with the same solvent; afterwards, with
hot water, then with alcohol, and finally with ether. The washed residue was dried at 119° C., weighed, ignited, and the amount of ash deducted. The remainder was estimated as fiber.

Water.—For the estimation of water, the ground seed was weighed in a glass-stoppered test tube. After weighing, the glass stopper was replaced by a rubber one, through which passed two glass tubes, bent at right angles. One of these tubes was connected with an aspirator; the other, with a calcium chloride tube and a sulphuric acid drying bottle. The test tube and its contents were then placed in an opening of a drying oven, whose temperature was between 100 and 110° C. During the operation, a current of air, passing through the sulphuric acid and calcium chloride tube, thus drying it, was drawn into the tube and the moisture sucked out by means of the aspirator. When the weight became constant, the loss was estimated as water.

Ash.—The contents of the tube were transferred to a platinum crucible, incinerated, and ash weighed.

Albuminoids.—One gram of the ground seed was ignited with soda lime. The substance was intimately mixed with a portion of soda lime sufficient to fill a 14-inch combustion tube two-thirds full. About two inches of the tube were filled with soda lime, then the mixture of soda-lime and substance added, the mortar rinsed with soda-lime, and finally the rinsings and enough soda-lime added to nearly fill the tube. A plug of asbestos was put in, and the tube gently tapped to insure an air passage throughout its length.

Will's bulbs were charged with a deci-normal solution of oxalic acid. The tube being placed in the combustion furnace, was connected with the bulbs. The fore part of the tube, containing the soda-lime only, was heated to redness, then heat applied, one jet at a time, along the entire length of the tube, care being taken that the combustion was completed in that portion of the tube where heat was applied before other jets were turned on, and also that the combustion was not too rapid. After the combustion was ended, the contents of the bulbs were transferred to a beaker, tincture of litmus added, and the excess of acid titrated with a deci-normal solution of potassa. The amount of ammonia found to be present was calculated as nitrogen. The nitrogen was multiplied by 6.25, and the result called albuminoids.

Oil.—The one gram of ground seed reserved for the estimation of oil was placed in a short test-tube, the bottom of which was drawn out in the shape of a cone, with a small opening at the apex. A small filter placed in the cone kept any of the substance from passing through the opening. The tube was suspended in a small flask, and this stoppered with a cork through which a long glass tube passed. The whole was placed in a water bath, ether (½ oz.) put in the outer tube, and heat applied to the water bath until the temperature of the water boiled the ether. This operation was continued for half an hour, the percolate transferred to a small weighed beaker, ether evaporated, and the beaker and its contents dried at 100° C., and then weighed.

Tannin.—One gram of the pulverized seed was digested with hot water for several hours, and the tannin estimated by a standard solution of gelatine.
Composition of Sorghum Seed—Orange.—

Sugar ........................................... 0.56
Starch ......................................... 63.09
Fiber ........................................... 6.35
Water ........................................... 12.51
Ash ............................................... 0.64
Albuminoids ................................... 7.35
Oil ............................................... 3.08
Tannin .......................................... 5.42

Total ............................................. 99.00

EXPERIMENTS IN SUGAR MAKING—1880.

The grinding of cane and the evaporation of the juice began on the 18th of September. It was the intention to begin working up the Early Amber as soon as possible after it had reached its maximum per cent. of cane sugar, and thus have it finished by the time the Orange was ready to harvest, leaving a small portion for subsequent experiments. Owing to the delay in the arrival of machinery, the work was not begun until the above date.

The Early Amber had been ripe for over two weeks, and was lying prostrate from the effects of a storm. The Orange was ripe. The object of these investigations was to see whether any method of manufacture of the juice into syrup could be depended upon to insure the subsequent crystallization of the sugar.

These investigations were undertaken with a view to the simplicity of machinery used and to the economical manufacturer of the syrup, so that they could be of practical use to the farmer, should any of the experiments prove successful.

The apparatus used for crushing and pressing the cane was a two-horse Victor mill, with three upright rollers. The juice was evaporated in Cook's evaporator, with furnace attached, and of the size recommended for use with a two-horse crusher.

The remaining apparatus consisted of barrels, tubs, pails, etc.

An attempt was made to heat the juice for skimming and clarification after it had been treated by chemicals, in the pan of a steam boiler of the form used by farmers to cook food for cattle. This boiler was found unfit for the purpose, as the temperature of the juice could not be raised in it above 108° C. A small pan was made, similar in construction to a Cook's evaporator, but furnished with a double bottom. The steam space in the bottom was about two inches high, and was connected with one of the boilers in the Chemical Laboratory. The object was to test the feasibility of evaporating the juice by steam under pressure with shallow pans.

In the experiments which follow, the juice was either evaporated directly after it came from the mill, i. e., without the use of reagents, or after it had been submitted to clarifying processes. In the first, the juice is designated in the experiment as not clarified, in the second, as clarified, defecated, or neutralized.
THE EXPERIMENTS.

1. *Early Amber.*—September 18. Cane, very ripe and down; juice, not clarified,—evaporated to a syrup which upon cooling weighed 11 lbs. to the gallon. It was of a light color and had a distinct sorghum taste. Stalks, stripped and topped, yielded 48 per cent. of juice, having a specific gravity of 1.066. The sugar, not crystallized.

2. *Early Amber.*—September 20. Juice defecated. As the juice was brought from the mill, milk of lime was added, little at a time, until a piece of red litmus paper would change to purple when dipped into the juice. Then a solution of tannic acid and finally gelatine was added. The juice was then boiled and well skimmed, and concentrated to syrup. The syrup was scorched and had a taste of extract of licorice. A small portion of the syrup evaporated to almost candy, was readily crystallized.

3. *Early Amber.*—September 21. Juice not clarified. The evaporation was continued until the syrup upon cooling weighed 11 lbs. The sugar did not crystallize.

4. *Early Amber.*—September 22. Juice made alkaline with lime, and then neutralized with sulphate of alumina. Concentrated to a syrup that weighed when cooled between 11 and 11½ lbs.; sugar crystallized.

Before expressing the juice for this experiment the rollers were moved closer together and the cane crushed so much that the bagasse as it came out fell in pieces. 51 per cent. of juice was obtained with a specific gravity of 1.068. One row of cane (0.087 acres) was taken for this experiment, producing 23 gallons juice from which was made 3.17 gallons syrup, weighing 11½ lbs. per gallon. Calculating from this data, an acre of the Early Amber would yield 624.2 gallons of juice, or 86.1 gallons of syrup.

5. *Orange.*—September 13. Juice neutralized with milk of lime; afterwards tannin and gelatine added; evaporated to a syrup of 12 lbs. to the gallon; syrup dark. The sugar commenced crystallizing in a few days. Three weeks afterwards the sugar was separated from the syrup by a centrifugal separator. Sugar, brown.

In this experiment, 360 lbs. of topped and stripped stalks were used; producing 155 lbs. of juice (48 per cent.); 28 lbs. syrup (7.78 per cent. of the stalks and 18.04 per cent. of the juice); 13½ lbs. sugar (3.8 per cent. of stalks, 8.87 per cent. of juice, 49.1 per cent. syrup.)

One row, .0898 acres, yielded 30 lbs. juice. Calculating the yield of an acre from these data, we have 754 gallons juice, 120.6 gallons, or 1,447.2 lbs. syrup, and 710.67 lbs. sugar.

6. *Orange.*—September 24. Juice neutralized with lime, and a few drops of tannin added to every 10 gallons juice; then ¼ oz. gelatine, and afterwards a little sulphate of alumina. Juice evaporated to a syrup of 11 lbs. to the gallon; color, very light. Sugar began crystallizing after standing two days.

7. *Orange.*—September 27. Juice neutralized with lime, and concentrated to a syrup of 11 to 12 lbs. per gallon. Sugar readily crystallized.
8. *Orange.*—September 27. Juice neutralized with milk of lime; *sulphurous* acid was added to combine with any lime remaining uncombined in the juice. The sugar began crystallizing as the syrup was cold.

9. *Orange.*—October 1. Juice defecated with lime and sulphate of alumina. Sugar began crystallizing after three days. In this experiment stripped and topped stalks were used; yielding 54.2 per cent. of juice; specific gravity, 1.076.

10. *Orange*—Oct. 1. Juice evaporated without defecation. The syrup, after standing about five weeks, had but few crystals of sugar. In a subsequent analysis of this syrup (see analysis of syrup, No. 4), there was found to be 38.9 per cent. of cane sugar, and 26.91 per cent. of grape sugar.

11. *Orange.*—Juice not defecated; evaporated to a syrup of 12 pounds to the gallon. The sugar has not crystallized.

12. *Amber.*—Juice defecated with lime and sulphate of alumina. The juice was quite acid as it came from the mill. Syrup black. Sugar crystallized.

Finding that some of the syrup whose juice had not been defecated did not crystallize, it was thought that perhaps a farther concentration would cause the sugar to crystallize. For this purpose the syrup produced in experiment No. 3 was selected. In the early part of November it was further concentrated in the steam evaporator, but this had no effect upon the crystallization of the sugar.

Finding that the concentration of the syrup did not cause the sugar to crystallize, an analysis of several of the syrups was undertaken, in order to investigate this subject more thoroughly. The following syrups were selected to be analyzed:

No. 1. *Early Amber.*—Syrup taken from that made in experiment No. 3.

No. 2. Syrup of No. 1 subjected to further concentration.

No. 3. *Orange.*—Syrup of experiment No. 9, with the crystallized sugar taken out by the centrifugal separator.

No. 4. *Orange.*—Obtained from the syrup of experiment No. 10.—

The following were the results obtained:

<table>
<thead>
<tr>
<th>Number</th>
<th>Cane Sugar</th>
<th>Grape Sugar</th>
<th>Gum</th>
<th>Water</th>
<th>Ash</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 1</td>
<td>47.22</td>
<td>14.70</td>
<td>6.80</td>
<td>29.4</td>
<td>1.97</td>
<td>100.1</td>
</tr>
<tr>
<td>No. 2</td>
<td>45.62</td>
<td>20.00</td>
<td>10.51</td>
<td>29.39</td>
<td>3.78</td>
<td>100.3</td>
</tr>
<tr>
<td>No. 3</td>
<td>35.63</td>
<td>26.82</td>
<td>6.75</td>
<td>28.67</td>
<td>1.49</td>
<td>99.27</td>
</tr>
<tr>
<td>No. 4</td>
<td>38.9</td>
<td>26.91</td>
<td>7.80</td>
<td>24.04</td>
<td>1.75</td>
<td>96.40</td>
</tr>
</tbody>
</table>

The cause of the large per cent. of ash shown by No. 2 was undoubtedly the lime added to neutralize the syrup before the second concentration.

From the proximate analysis of the cane, it appears that one acre of sorghum produces 2,559 pounds of cane sugar. Of this amount we obtained 710 pounds in the form of good brown sugar,
and 265 pounds were left in the 737 pounds of molasses drained from the sugar. Hence, sixty-two per cent. of the total amount of sugar was lost or changed during the process of manufacture. This shows that the method of manufacture in general use is very imperfect.

EXPERIMENTS IN SUGAR MAKING, 1881.

Last year a large number of experiments were made in order to determine the means by which the cane sugar could be made to crystallize. This object was much more readily attained than we at first expected, and consequently we selected from those experiments the one which was most simple and most likely to be practicable when operating on a large scale. In perfecting this our attention was given to the production of sugar and syrup which should be free from the objectionable sorghum taste and odor. In this we succeeded perfectly. Sorghum juice in its normal condition is acid. The conversion of cane sugar into grape sugar by boiling a solution of the same with a strong acid, as sulphuric or hydrochloric, has long been known to chemists. All other acids, even the weak organic acids contained in sorghum juice, act in a similar manner. Hence it will readily appear why, in the ordinary manner of making sorghum syrup, so little of the cane sugar originally contained in the juice can be made to crystallize. A great deal of the cane sugar is converted into grape sugar during the process of defecation and evaporation, and what remains unchanged is prevented from granulation by the undue proportion of grape sugar produced. To avoid this loss of cane sugar we neutralize the juice when cold with calcium carbonate or milk of lime or both. This part of the process requires skill and care, as the subsequent defecation of the juice depends upon it. After thus neutralizing the juice it is heated to boiling and thoroughly defecated. It is then passed through bone-back filters and finally evaporated to crystallization. The sugar and molasses obtained by this process are unobjectionable in regard to color and taste.

Exp. 1.—August 22 1881. The cane selected for this experiment was grown on land which had previously been used as a barn-yard, the same as in analyses Nos. 8 and 14. The seed was very ripe and the cane very thrifty.

Wt. of cane crushed ......................... 1.560 lbs.
Wt. of juice obtained ......................... 687.50 lbs.
Per cent. of juice ......................... 43.40

The juice was carefully neutralized with milk of lime, and brought to the boiling point in the defecating pan. A very heavy green scum rose, and this being removed the juice was seen to be full of a green light flocculent precipitate which did not subsequently rise to the top, in any considerable quantity. The juice was now drawn off into tubs, where it was allowed to repose twelve hours. At the end of this time only about one-half of the juice could be drawn off clear, the precipitate being still suspended in the remainder. It was found impossible to filter this portion and it was therefore thrown away. The clear juice after being passed through bone-brake was evaporated in a copper finishing pan to the crys-
tallizing point. The melada had a very unpleasant saltish taste owing to the presence of salts of ammonia. The sugar crystallized very readily, and although it looked well it still retained somewhat of this saltish taste after being separated from the molasses. Unquestionably this excessive amount of albuminoids—the green scum and suspended precipitate—was taken up by the plant from the nitrogenous elements of the manure, and the saltish taste was due to ammonium salts which came from the same source.

Manure therefore not only has a deleterious effect upon the development of sugar in cane, but it also prevents the thorough defecation of the juice which is necessary to the manufacture of sugar.

Experiment 2—Aug. 25. Cane same as that of which analyses Nos. 15 and 16 were made. Size of field 3-16 of an acre.

**CALCULATIONS FOR ONE ACRE.**

<table>
<thead>
<tr>
<th>Description</th>
<th>Pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stripped cane with tops</td>
<td>18,535.3</td>
</tr>
<tr>
<td>Stripped cane without tops</td>
<td>15,765.9</td>
</tr>
<tr>
<td>Weight of juice obtained</td>
<td>6,545.6</td>
</tr>
<tr>
<td>Per cent, of juice of stripped and topped cane</td>
<td>41.52</td>
</tr>
<tr>
<td>Weight of melada from juice</td>
<td>1,298.7</td>
</tr>
<tr>
<td>&quot; bagasse</td>
<td>253.9</td>
</tr>
<tr>
<td>Total weight of melada</td>
<td>1,552.6</td>
</tr>
<tr>
<td>Weight of sugar from juice</td>
<td>504.6</td>
</tr>
<tr>
<td>&quot; bagasse</td>
<td>104.0</td>
</tr>
<tr>
<td>Total weight of sugar</td>
<td>608.7</td>
</tr>
<tr>
<td>Weight of molasses from juice</td>
<td>794.7</td>
</tr>
<tr>
<td>&quot; bagasse</td>
<td>149.2</td>
</tr>
<tr>
<td>Total weight of molasses</td>
<td>943.9</td>
</tr>
</tbody>
</table>

Calculations for one ton of topped and stripped cane:

<table>
<thead>
<tr>
<th>Description</th>
<th>Pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight of juice</td>
<td>830.4</td>
</tr>
<tr>
<td>&quot; sugar</td>
<td>77.2</td>
</tr>
<tr>
<td>&quot; molasses</td>
<td>119.7</td>
</tr>
</tbody>
</table>

To obtain the sugar from the bagasse it was packed in large barrels as it left the mill and was exhausted with water. The percolate thus obtained was treated like juice.

Experiment No. 3—Sept. 17. Early Amber. Obtained from the University farm. Volunteer growth among the corn. Seed ripe. Cane mostly blown down:

<table>
<thead>
<tr>
<th>Description</th>
<th>Pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight of stripped and topped cane</td>
<td>1,440</td>
</tr>
<tr>
<td>Weight of juice</td>
<td>637</td>
</tr>
<tr>
<td>Per cent, of juice</td>
<td>44.2</td>
</tr>
<tr>
<td>Weight of melada obtained</td>
<td>145.8</td>
</tr>
</tbody>
</table>

Experiment No. 4. Early Amber, grown upon University farm:

<table>
<thead>
<tr>
<th>Description</th>
<th>Pounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight of stripped and topped cane</td>
<td>1,661.0</td>
</tr>
<tr>
<td>&quot; juice obtained</td>
<td>603.5</td>
</tr>
<tr>
<td>Per cent, of juice</td>
<td>36.33</td>
</tr>
</tbody>
</table>
Weight of melada from juice .......................... 95.5
" " bagasse ............................................. 13.5
Sugar from juice ........................................ 41.5
" " bagasse ............................................. 6.0
Molasses from juice .................................... 54.0
" " bagasse ............................................. 7.5
In the last two experiments the cane was poorly developed, and
full of suckers, and consequently poorly adapted for the production
of sugar.

GLUCOSE FROM SORGHUM SEED.

Our experiments have shown that as good glucose can be made
from the seed of sorghum as from any other starchy substance.
The yield of glucose or grape sugar is three-fourths or more of the
weight of seed employed. The tannin does not interfere, as it is
converted into glucose by the same means which are used to con­
vert the starch, namely, boiling with dilute acids.

RECEIPTS AND EXPENSES OF ONE ACRE OF SORGHUM.

On the basis of the results actually obtained as described in the
foregoing pages, we have calculated the receipts, and from the best
data at hand the expenses for one acre of sorghum.

BALANCE SHEET.

RECEIPTS FROM SUGAR AND MOLASSES.

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>600 pounds sugar at 7 cents</td>
<td>$42.00</td>
</tr>
<tr>
<td>30 gallons molasses</td>
<td>$34.00</td>
</tr>
<tr>
<td><strong>Total Receipts</strong></td>
<td><strong>$76.00</strong></td>
</tr>
</tbody>
</table>

EXPENSES.

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultivating one acre</td>
<td>$10.00</td>
</tr>
<tr>
<td>Stripping and cutting</td>
<td>$2.50</td>
</tr>
<tr>
<td>Hauling</td>
<td>$6.00</td>
</tr>
<tr>
<td>Four days' labor</td>
<td>$1.00</td>
</tr>
<tr>
<td>Barrels</td>
<td>$4.00</td>
</tr>
<tr>
<td>Freight and drayage</td>
<td>$8.00</td>
</tr>
<tr>
<td><strong>Total Expenses</strong></td>
<td><strong>$37.50</strong></td>
</tr>
</tbody>
</table>

Net profit on sugar and molasses .................................. $38.50

RECEIPTS FROM GLUCOSE.

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,250 pounds glucose at 2 cents</td>
<td>$25.00</td>
</tr>
</tbody>
</table>

EXPENSES.

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gathering seed</td>
<td>$2.00</td>
</tr>
<tr>
<td>Fuel</td>
<td>$1.50</td>
</tr>
<tr>
<td>Labor</td>
<td>$2.00</td>
</tr>
<tr>
<td>Barrels</td>
<td>$4.00</td>
</tr>
<tr>
<td><strong>Total Expenses</strong></td>
<td><strong>$9.50</strong></td>
</tr>
</tbody>
</table>

Net profit on glucose .................................................. $15.50

Total net profit on one acre of sorghum .................................. $54.00
GENERAL CONCLUSIONS.

1. Seed should be planted as early as possible.
2. The proper time to begin cutting the cane for making sugar is when the seed is in the hardening dough.
3. The cane should be worked up as soon as possible after cutting. Cane which is cut in the afternoon or evening may safely be worked up the following morning.
4. The manufacture of sugar can be conducted properly only with improved apparatus and on a scale which would justify the erection of steam sugar works, with vacuum pans, steam defecators and evaporators, and the employment of a competent chemist to superintend the business. The same is true for the manufacture of glucose from the seed. Our experiments were made with the ordinary apparatus used in manufacturing sorghum syrup, and any person, who desired to work on a small scale, could use the methods with good results, provided he had acquired the necessary skill in neutralizing and defecating the juice and in the treatment of bone-black filters. The manufacture of glucose on a small scale is entirely out of the question. Five hundred to a thousand acres of sorghum would be sufficient to justify the erection of steam sugar works, and this amount could easily be raised in almost any community within a radius of one or two miles from the works.
THE BACTERIA:

AN ACCOUNT OF THEIR NATURE AND EFFECTS, TOGETHER WITH A SYSTEMATIC DESCRIPTION OF THE SPECIES.

By T. J. Burrill, Ph. D., Professor of Botany and Horticulture.

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3. Movements.
4. Structure.
5. Reproduction and Development.
6. Vitality and Endurance.
8. Origin.

PART II.—EFFECTS OF BACTERIA.

1. Fermentation and Putrefaction.
2. Diseases of Plants and Animals.

PART III.—CLASSIFICATION OF BACTERIA.

1. Sphaerobacteria.
2. Microbacteria.
3. Desmobacteria.
4. Spirobacteria.
INTRODUCTION.

Biology—the science of life—has no more interesting and important problems than those concerning the smallest and simplest of animate objects, the Bacteria. These exceedingly common living things, visible to us only by the aid of powerful magnifiers, have latterly received much attention on account of the endeavor to find out by scientific research, the origin of life on our globe; but more for the undreamed of power and influence which they have been found to possess and exercise in the operations of the organic world. Since the discovery of their existence and modes of action, many questions previously unanswerable have become easy, and the knowledge obtained has passed into science to serve, not only as an intellectual stimulus to man, but as sure standing-ground from which he may reach other heights and gain at last his rightful dominion over the forces and objects of earth.

It is not too much to say that mankind could not continue to exist, could never have existed, on the earth as at present constituted, but for these minute though effective agents; the truth of this does not depend on any mere figure of speech, or even on any delicate adjustment of nature, but on the actual and essential work accomplished. Without them, and with other things as they are, there could have been no fertile soil, no luxuriant pastures, no bountiful harvests, no possibility for man. On the other hand we should not suffer many of the ills that flesh is heir to, if we could escape their restless activities in certain forms and ways.

It is the object of this paper to present, in language freed as far as possible from technical terms, the principle and most interesting facts now known about these silent-working denizens of the earth, the air, and the water. Should any one wish to inquire further, he may soon find an abundant literature on the subject; but the whole matter is still so new that a great proportion of it is only to be found in the scientific periodicals of the last two decades, and unfortunately for many, mostly in foreign tongues. The best general work of American publication is The Bacteria, a translation from the French of Dr. Magnin, by Dr. G. M. Sternberg: Little, Brown & Co., Boston, Mass. There are several excellent general articles in numbers of the Popular Science Monthly, and very instructive reports by Drs. Detmers, Law and Salmon, on infectious diseases of animals, in the annual reports of the United States Commissioner of Agriculture, for 1878, 1879, and 1880. For “blight” in pear trees, etc., see report for 1880, of the Illinois Industrial University.

Charles S. Dolley, of Rochester, N. Y., has issued in pamphlet form a translation from the German of an interesting general article by Ferdinand Cohn.
For the practical study of these minute organisms, a good compound microscope is required and the ability to use it; but any one possessing ordinary capacity for scientific study, with plenty of patience, may gain a large amount of information by the aid of an instrument costing not more than fifty to one hundred dollars.

The organisms may be readily obtained by putting a few bits of flesh or of any soft animal or vegetable matter in water kept at the ordinary temperature of a comfortable living-room and allowed to stand one to several days. Characteristic species often occur in given infusions. Others may be sought for in decaying fruits and vegetables, on the surfaces of cooked articles of food, as of boiled potatoes, rice, beans, &c., while some are commonly present in the mouth, especially in the collections on the teeth and the fur of the tongue. The pus from external wounds, and very often the discharges from pimples, boils, ulcers, etc., contain myriads of the organisms.

Bacteria may be mounted for preservation on the usual thin cover glasses used by microscopists, and the covers inverted and fastened to the ordinary microscopical slides. First smear the cover glass with the material containing the bacteria, and after drying a few minutes immerse in strong alcohol to fix the specimens by coagulation of the imbedding substance. Then stain by immersing in common violet ink (aniline) at least five minutes, wash in water and mount in a weak, aqueous solution of carbolic acid. There are many other processes and materials used to advantage in certain cases, but this is the simplest and most generally successful of any now known.

I have not considered it wise to encumber these pages with references, yet make no claims to anything original except as indicated in the proper places. I have, however, verified by experimental studies much of the information presented, gained in the first place from others.

PART I. NATURE AND ORGANIZATION.

1. EXISTENCE AND HABITAT.

The minute organisms, to which the term Bacteria is now commonly applied, cannot be individually recognized without a magnifying glass of high power; so, to those not accustomed to work with the compound microscope, the existence of the little creatures as common objects may not be suspected, or at least rationally realized. To be sure much is said of the life of a drop of water or other fluid; but a large amount of this sort of retailed information is purely imaginary, having nothing or little of truth about it. The fact is, pure water, such as is taken from a good well or spring, has absolutely no life in itself, nor are there in it any living things whatever, no matter what magnifying power one examines it with. On the other hand, there are no other living things in nature, from the highest to the lowest, so widely distributed in the earth, the air and the water, throughout the world, so commonly and multi-
tudinously present, near us, and on us and in us, as the various kinds of the microscopic organisms of which we now write. If pure well water does not contain these or any other living things, all foul waters do. Bacteria or their allies exist in countless myriads in all filth, in all decomposing vegetable or animal matter, whether ill-scented or not, in all organic substances undergoing apparently spontaneous change, as heating in the mass, becoming sour, rancid, or putrid, and, generally, those changes known as fermentation or decay.

The water from ill-scented cisterns, and indeed from many in which odor is imperceptible, contains varying numbers of these minute living creatures. The water of foul ditches, stagnant ponds, marshes and sloughs teems with them, in numbers surpassing those of the leaves of the forests; a drop under the microscope often presents a maze of living forms, more wonderful than imagination ever pictured, or of which fiction ever dreamed. The waters of running streams are more or less inhabited by them, and the ocean itself is the special home of peculiar kinds.

The air may, like water, be absolutely pure or clouded by innumerable numbers of the almost imponderable, but living, multiplying things. Wherever there is floating dust of organic origin, they may be said to be certainly present. The stifled atmosphere of close apartments, and of thickly built streets, especially over decomposing filth, is laden with various forms of Bacteria and allied organisms; and these are unavoidably inhaled by ourselves with every breath inspired. But in the dry, open country, few of them can be found in the pure, fresh, invigorating air, and over wide desert regions and the tops of high mountains none whatever exist. With us the air in winter, especially when the earth is long covered with snow, becomes almost free, while in midsummer and autumn, especially after damp and close weather, their myriad numbers are wafted to and fro by every movement of the freighted atmosphere.

The shine on vessels of standing water, on the surface of vegetable or animal substances, like cold articles of food set away for some time, eg. boiled potatoes, cooked meats, etc., is composed of these organisms and their products. Brewers' yeast, used in bread making, is not a Bacterium, but it is a related growth, and the so-called salt-rising, not unfrequently used in making bread, owes its energy to living Bacteria. Sour milk always contains swarms of the microscopic, moving things, and during the formation vinegar from the juice of fruits, from solutions of whisky and sugar, etc., they may always be found in similar numbers.

They are invariably present in pus from open, suppurating wounds, in the discharge from boils and tumors on and in our own bodies, and in the ill-scented accumulations of the bodily excretions, as from the arm-pits and unwashed feet. If they have any connection with bad odor, no one will wonder why the breath sometimes smells bad if the material collecting on the teeth or the fur on the tongue can be seen under a good microscope. The cleanest human mouth can hardly be said to be ever perfectly free from these active organisms; while, those to which the tooth brush or its equivalent is a stranger, are veritable culture boxes, or hot houses, richly supplied with rapidly growing and prodigiously multiplying forms and
kinds. We swallow them with our food, and at least some kinds sometimes retain their activity in the stomach and intestinal tube. It now seems certain that the latter is always inhabited by special kinds which have to do with the activities there in operation. In health the blood is usually quite free from them, but in certain diseases this too, as it rapidly courses through the arteries and veins, sweeps along in the current myriads of the minute but living and developing, ever active things, inappropriately called "germs." We may well say in such cases that "the blood is out of order."

What perhaps more than all else gives vivid interest to our microscopical studies of this sort, is the fact that special kinds of these tiny living beings are found uniformly in connection with the severest diseases known to man, either of himself or of the plants and animals about him. We may name as examples "blight" in pear, apple and many plants, hog and chicken cholera, pleuro-pneumonia and splenic fever in cattle; malaria, typhoid fever, diphtheria, small-pox in man. What the connection is between organisms and the diseases, we leave for another part of this paper. Very recently it has been fully demonstrated that consumption, the most terrible scourge of the human race, invariably has its accompanying specific form in the diseased tissues and the exudations from them.

It will thus be seen that these microscopic organisms are by no means unusually or uncommonly present about, upon and within us. Taken as a classified group they are more widely dispersed and dwell more numerously everywhere, in everything, than all other living things put together. For the truth of this statement I need only to appeal to the observation of any one who, having a good compound microscope, will take the trouble to state the facts as seen. Still it would be unfair to leave the impression that any one specific kind is thus invariably near us, or that the most common, taken as a simple species, is as widely and thoroughly disseminated as might be inferred from the foregoing. The statements made have reference to the numerous species comprised in the entire group, not to certain ones. It is one thing to say that birds are very widely dispersed over the earth; it is quite another thing to state the facts as they are concerning the common domestic fowl or the snowy owl.

2. Color, Shape, Size.

As a rule Bacteria are white, so that when numerous in water the fluid is opalescent or milky. They very frequently settle down, when the proper food supply is exhausted, to the bottom of the containing vessel, and in this case form a white shiny or flocculent mass. But of numerous species each has its peculiar color, as red, blue, yellow or green. On the moist surfaces of prepared articles of food, as of cooked potatoes, bread, cheese, rice, etc., spots of a red color much resembling drops or splashes of blood are not uncommon. Formerly these reputed blood-stains were regarded with superstitious wonder, and have been held to indicate guilt, and the anger of God. These, as well as other colored spots and pigments, are now traced to their true cause, and are found due to the dis-
tinct color of the organisms themselves or to the chemical combina-
tion which they produce.

The different kinds of *Bacteria* vary in shape from spherical to
oval, cylindrical and thread-like; and the latter are straight, or
crooked, or spiral, flexible or rigid. The spherical ones are often
connected in two's or more, and sometimes form bead-like strings
or chains. The main classifications in use are based on the form
and size of the organisms.

It was impossible to know anything about *Bacteria* until after the
invention of the microscope, because none of them can be indi-
vidually seen with the unaided eye. In transverse diameter, one
twenty-five thousandth of an inch is a very common measurement,
while some, including spherical ones, are even less than half this
size. Now, a dot one two-hundredth of an inch across is barely
visible to the eye of most persons, hence a magnifying power of
more than one hundred times across (ten thousand in area) is
required to barely see a common sized *Bacterium*. To make out its
real shape and any details of structure, ten times the enlargement
mentioned is necessary, and not unfrequently as much more as can
be secured by the highest possible powers of the microscope. In-
crease the heighth of an ordinary man one thousand times and his
head would be over a mile above the earth, yet under the same
magnification one of these organisms would have plenty of room to
swim freely, to stand on end and dance up and down, in the film
of water included between two pieces of flat glass pressed so close
together as to strongly adhere by capillary attraction. From one
hundred to two hundred and fifty of them placed side by side would
be required to stretch across the ordinary thickness of book paper.
They are the smallest living organisms known to man, yet, as we
shall see, by no means the least important in the economy of nature.

3. Movements.

*Bacteria* have sometimes been divided into groups upon their ap-
parent ability to move or not; but further study has demonstrated
that many, if not most, species have states in which they remain
at rest, and others in which they are freely motile. These states
depend partially on their stage of development, partly on the sur-
rounding conditions. For the latter the degree of moisture and
temperature, and the food supply, are especially effective.

Some species at most only oscillate and quiver in the fluid
medium in which they grow, never making progress in any given
direction; others slowly and smoothly glide along in a straight but
more often undulating path, while still others whirl and dance and
roll, turning over and on end, now spinning round and round, now
swaying gently back and forth, now darting like a flash across the
microscopic field. Sometimes they move as though perfectly free
and had abundant muscular force, at other times they appear to
be struggling to overcome obstructions, or to free themselves from
some impediment. Not unfrequently they may be seen to carry
along little adhering extraneous particles, well showing their vital
power, or two, in some way attached, pull in opposite directions
with varying advantage for the one or the other.
No one, having once seen these motions, can doubt the inherent power the little things possess, or can question their right to be classed as living objects; whether as animals or plants will depend on his previous information and experience, as well as upon what he sees. How they move, that is by what sort of organs or mechanism, is not easy to make out; but they have this power only when immersed in a fluid medium. When dry they are motionless except as carried by external agents, as air currents.

It is now well known that different species have different methods and facilities for dissemination. Many kinds are externally viscid, or, are always when moist imbedded in a mucilaginous exudation, and hence in either case adhere to any solid substance they may touch. These therefore are rarely found floating in the air. So long as the material containing them does not become dry and then pulverized, such species are not distributed by the currents of the atmosphere. It is quite possible that a foul drain or a filth-filled cesspool may contain myriads of disease-producing Bacteria which are only taken into the human body by swallowing them in contaminated water, the vitiated air though laden with fetid gases being harmless, yet this can by no means be said of all species known to be injurious to man. Their great numbers, their exceedingly minute size and their powdery character in mass, together in many cases with their long contained vitality, pre-eminently fit them for aerial distribution. The dust made evident by a sunbeam is often in considerable portion composed of these specks of living matter, which only await suitable conditions for growth and development. What intellectual light the careful study of such a sunbeam may throw upon knotty questions of vital importance to man.

4. Structure.

Small as these organisms are, they possess well differentiated parts, which are each, presumably, absolutely necessary for their existence as living things. We do not infer that structure is life, but there is every reason to believe that life is just as dependent on structure in these simple and low forms as it is in the highest plants or animals. Solution, separation of parts, can no more take place in the one than in the other, without destruction of life. Liquids, separated from solids, never possess, nor are possessed by, the life principle, whatever that is. Think of dissolving the body of a mouse in acids, and then, by proper chemical manipulation, collecting every atom of the original substance and reforming by this means a living mouse! There is, however, just as much ground for the supposition that this can be done with the mouse, as there is in the case of the minute things of which we now write. To be sure, there is not so much complexity of organization, but there is quite as constant a certain and characteristic structure on which life depends.

Bacteria, like other living things, are composed of cells; or, perhaps, it is better to say, each Bacterium is an organic cell. There is an outer wall or membrane closed on every side like the skin of a raisin, and within this envelope there is a plastic substance forming the entire contents of the cavity. Chemical reagents show that the outer membrane is made up of cellulose, the substance of
which wood consists, everywhere forming the framework of all plant structures. This, at first, is uniformly white, but becomes variously stained, as in the heart-wood of trees of different kinds. It is, except in peculiar states, insoluble in water, but swells and shrinks from its power of absorbing and again giving up this liquid. Fire destroys it, forming, with the oxygen of the air, carbonic acid and water.

The inner soft substance of the cell is protoplasm, which is even more common in higher organisms than cellulose; for while the latter is almost without exception confined to plants, the former is present in all living things, plants and animals alike. Taken by itself, it probably has a uniform composition in all organic nature; but it is variously mixed with other substances, rendering it difficult to determine the exact chemical components. Besides the carbon, oxygen and hydrogen of cellulose, it invariably has nitrogen, which cellulose does not have. Though usually semi-fluid, it also is insoluble in water. Heat coagulates, and thus destroys its functional activity—kills the organisms. Not the least instructive is the power of motion possessed by protoplasm. Its mass is often agitated by internal currents, made evident by little granules carried along by the stream. Sometimes these granules remain for a time at rest, then start off in an irregular line across the cell, rolling and tumbling on the way. These motions are not easy to see within most Bacteria, but are readily enough made out in some of the larger kinds.

This is the simple structure of Bacteria—a minute cell with an outer cellulose wall inclosing the protoplasmic contents. There are no organs or appendages, save in some, and perhaps all motile forms, there is at one, or at most two points, an exceedingly fine, hair-like appendage, to the vibrations of which the movement of the organism is attributed. This fine cilium or flagellum, as it is called, is a difficult thing to see, even with the best microscopic equipment and the most expert manipulation, partly on account of its exceeding fineness or thinness, partly from its rapid vibrations. Sometimes by introducing a weak solution of iodine, so as to gradually subdue the movement, the cilium can be made out when not practicable otherwise.

5. Reproduction and Development.

Bacteria increase by one dividing itself into two. There is no such thing as sexual differentiation, nor is there in the development anything comparable to the germination of a seed. Division is affected by the formation of a transverse partition or septum of cellulose across the middle of an adult cell, thus making two compartments, after which separation gradually takes place by the parting of the outer wall and the middle of the new partition with a rounding off of the contiguous ends; while, during the same time, each half grows to the size of the original whole. Thus one becomes two, each of the latter being in every way similar to the first. Under favorable circumstances this process may in some species take place within one hour, then in the course of another hour be repeated, and so indefinitely. Shorter periods for the
process have often been reported. If we pause to rationally comprehend this rate of increase, we shall soon be lost in the amazing numbers which in a little time spring from one. It may seem incredible, but any one may readily verify the fact that according to the rate of one division each hour the number from one after twenty-four hours will be more than sixteen millions, and after forty-eight hours nearly three hundred billions. Cohn has computed that *Bacterium termo*, (a very common species in putrifying organic matter) would at the end of twenty-four hours, at the above rate of increase, fill a little cube one-thousandth of an inch across each side; after forty-eight hours the solid mass would amount to about a pint; then of course at the end of another hour—since each would become two in this time—there would be two pints, in two hours four, in three eight, in four sixteen, etc., and such is the astonishing increase by this geometrical progression, that at the end of five days from the beginning the mass arising from one of these exceedingly minute creatures would be sufficient to fill completely full, or to equal in weight the water of the oceans of the world.

Incredible as this seems it is a simple calculation which any one can make on the supposition that the organism is one twenty-five thousandth of an inch in transverse diameter and twice as long, and that the number is double every hour. That nothing like this ever really occurs in nature for any consecutive number of hours, we need not be told; but this only shows the harmonious interaction of causes and effects among the sum total of forces and activities on our earth; it is not because this *Bacterium* under the assumed conditions does not increase at the marvellous rate stated, but because such conditions do not continuously exist. The limitations are fixed by the given supply of proper nutriment, the absence of harmful chemical compounds, temperature, electrical and mechanical agitations, the effects of other living organisms, etc.; nevertheless the computations prepare us for the acceptance of facts, which would otherwise be deemed incredible, and they aid us in the explanations of observed phenomena otherwise inexplicable. When it is known that a certain species may reproduce itself with anything like this rapidity, we need not wonder that individuals are found, after a short exposure of the nutrient substance, in innumerable great numbers; and, if there is any chance for one or more of such individuals to gain entrance in the first place, we need not resort to speculations concerning spontaneous generation, or transformation, to account for the multitudes subsequently found.

But some species seem never to grow or multiply rapidly, even under the most favorable conditions. They differ among themselves as do the species of the higher plants. Some varieties, for instance, of the cultivated radish may have two or even three generations in a season; while others require two years to perfect seed. Some weeds come to maturity in a few weeks and produce thousands of seeds, while an oak lives through the centuries.

In the process of self-division, complete separation may or may not take place. There is indeed considerable variation in this respect, even in the same species according to external and perhaps internal conditions. If, after the transverse dividing septum has been formed, further separation does not take place, the result is in a little time
a filament, made up of cells placed end to end, and either quite smooth and of uniform diameter, or more or less constricted at the joints, so as to be bead or chain-like. In this case, however, each link is really a distinct individual so far as its physiological functions are concerned, and life is in no way interfered with if they are mechanically or otherwise separated. In one genus (Sarcina) division appears to take place in two directions, transverse and longitudinal, so that little regular squares of cells are produced, four or sixteen being frequently seen associated together in order.

The individuals of certain species cohere together without order in a somewhat compact mass called zoöglæa, bound by the glairy substance in which they are imbedded. But this is the case only in special conditions or states, for it is easy to see single ones free themselves from the immovable mass, and swim away in the liquid in which the whole are submerged. The zoöglæa mass may be the result of the multiplication of a single cell or those originally separate may become thus united.

Besides the method by division, several species are known to reproduce themselves under certain conditions by what are termed spores. The protoplasm of a cell becomes consolidated into a spherule occupying only a small part of the cavity. This afterward becomes free by the dissolution of the old cell wall, and, at the proper time, under the proper conditions, the spherule develops into a full sized cell like its parent form. The formation of such, so-called spores, usually takes place when the nutriment is nearly exhausted, or when not suited, either in kind or in the required state as to temperature, etc., to the regular growth of the organism. It is a method of self-perpetuation rather than multiplication. Still, in a few cases of which record has been made, more than one spore is produced by each cell. Touissant, of France, has seen within the cavity the formation of spore sacks (sporangia), each of which produced from three to six spores. It is often in the form of these all but infinitesimal spores that Bacteria are carried in the atmosphere. When produced in liquid they fall to the bottom after the dissolution of the old cell wall, and form, when numerous enough, a plainly visible, white sediment. In case the water is then evaporated, the sedimentary material becomes a fine powder, the particles of which readily float in moving air.

6. Vitality and Endurance.

Moisture is essential to the growth of Bacteria, but prolonged drying does not necessarily kill them. In the case of the species causing the blight of pear and other plants, they certainly lose little or none of their vitality by preservation during two years in the dry state on the point of a quill. Among those kinds producing spores, the adult organisms often do not live more than a few days or weeks, while the spores seem to absolutely defy time. Pasteur thinks he has shown that the latter retain their vitality in the earth out of doors for at least twelve years. After keeping in a sealed tube four years, some virus of splenic fever was sent from England to this country, where it was opened and used with fatal effect in inoculating animals. It has even been argued by some investigators that Bacteria never die, except as destroyed by fire or injurious
chemical compounds; and whatever may be the case otherwise, so far as age is concerned, this is true, for on account of their manner of propagation an individual does not grow old.

Each species is adapted to a certain best temperature from which variation may take place, within only very narrow limits in some kinds, or a wider range with others, (75° to 105° F.) None appear to be killed by cold, but their vital activities cease at given limits, never reaching below the freezing point of water. An artificial temperature of 123° F. has been tried without killing them. On the other hand not only is the limit of activity reached by increase of temperature, but death always ensues by exposure to a given but greatly varying degree of heat for different species. Spores immersed in the fluid resist for a time the heat of boiling water, but all adult forms are killed in this way. When the medium is alkaline a higher degree of heat is required to destroy life than when neutral or acid, and if the organisms are dry a still higher temperature may be withstood; 140° F. in water, fruit juices, vinegar, sour milk, etc., is absolutely fatal to such as ordinarily occur in these fluids. The highest temperature yet known at which any Bacteria are able to live and develop is 133° F.; this has been observed in an infusion of beans. But some spores are not killed, especially in alkaline fluids, by prolonged boiling, just as some seeds withstand a similar test. If either are softened by germination, they quickly succumb.

We make use of these facts in the operations of every day life, especially in the process of canning articles of animal and vegetable foods, scalding cooking utensils, etc. The heat kills the Bacteria present.

Various substances destroy Bacteria, or at least prevent their propagation in nutritious solutions. Of these, the best known and most widely used are carbolic acid and quinine. Several others are more deadly to the organisms than these; but they either have some objectionable properties, or have not been so generally introduced. Grace Calvert asserts that some Bacteria can live in pure carbolic acid, but there seems to be some mistake in this, at least for ordinary species, for hundreds of experiments prove that none are developed in a liquid containing one-half per cent. of this antiseptic.

The following table, from experiments by M. Jalan de la Croix (Revue Scientifique, Feb. 4, 1882), shows the number of parts of water to one of the substance named which barely permits the development of Bacteria in infusions of meat. For instance, if thirty parts of water are mixed with one of alcohol, organisms may infest the mixture; but if twenty-nine parts of water are used to one of alcohol, Bacteria do not develop, and the mixture does not ferment:

<table>
<thead>
<tr>
<th>Substance</th>
<th>Parts of Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol</td>
<td>80</td>
</tr>
<tr>
<td>Chloroform</td>
<td>134</td>
</tr>
<tr>
<td>Soda biborate</td>
<td>107</td>
</tr>
<tr>
<td>Eucalyptol</td>
<td>308</td>
</tr>
<tr>
<td>Phenol (carbolic acid)</td>
<td>1002</td>
</tr>
<tr>
<td>Thymol</td>
<td>2229</td>
</tr>
<tr>
<td>Potash permanganate</td>
<td>3041</td>
</tr>
<tr>
<td>Picric acid</td>
<td>3041</td>
</tr>
<tr>
<td>Borated soda salycilate</td>
<td>3377</td>
</tr>
</tbody>
</table>
From my observations these results seem to be trustworthy, though others very dissimilar have been published. It is not a sufficient test to observe through the microscope the effect that any substance has upon the motions of Bacteria. Sometimes the addition of pure water causes their motions to cease, and sometimes molecular oscillations, not always easy to distinguish from those of life, continues after the organisms are dead. This has no doubt been a source of error in some of the accounts given to the press. The above figures were arrived at, by trying more and more water to one gramme of the substance until at last Bacteria developed and putrefaction set in.

It should be said that it is well nigh impossible to kill Bacteria in the air, by any kind of fumigation, except in a very thoroughly closed space, like an air tight vessel or box. A mistaken sense of security often exists when the atmosphere of living rooms, sick chambers, etc., are pervaded by the odors of some supposed antiseptic material. These floating “germs” can at least withstand as much fumigating as any human being, and usually very much more. On the other hand, much can be done towards destroying noxious Bacteria, or preventing their growth and propagation, by impregnating liquids and solids by proper amounts of such destructive agents as are enumerated above. Experiments are now in progress of treating the carcases of slaughtered animals with antiseptics not poisonous to man, for the purpose of sending fresh meat without ice across the ocean or other similar distances, and the results give much promise of success. A white powder is offered for sale to keep fruit without canning, and it appears to have virtue enough to really accomplish the result claimed without detrimentally affecting the food. (Compounds of boracic acid). There is, no doubt, much to be gained of practical utility in this direction.


Bacteria absorb their food by endosmosis through the cellulose coating of their minute bodies. The nutrient material must therefore be in a liquid state as well as of the kind and strength suited to the specific organism. Like more highly organized living things, each species has its own peculiar kind of food, without which development does not take place. As a cat would starve on hay, and an ox on meat, so similar differences are found among these inhabitants of the microscopic world. But all require organic food derived from the bodies of higher plants or animals, though it has been sufficiently proved that at least some kinds can take the required
nitrogen from inorganic sources. *Bacteria* could not live alone on the earth; they are destroyers, not up-builders; they pull down and decompose material prepared by the assimilation of other vitalized workers.

Some kinds are rigidly confined to dead matter, others develop and grow at the expense of living plants or animals, causing little or no inconvenience or even conferring real benefit to the latter; or instituting varying degrees of discomfort, injury and disease.

The waste products of their physiological processes are as varied, after their kinds, as their food, acids, alkalies, gases, liquids, fragrant, ill-scented, &c., but always of simpler chemical composition than the original, until at last, through perhaps the consecutive action of several species, the elemental state is reached. Thus in the fermentations of solutions of sugar, alcohol is given off as a waste product by the "yeast plant" (sacharomycetes) and the diluted alcohol ferments through the effects of the "vinegar plant" (mycoderma), and in this case vinegar is the substance thrown off, while this in turn decomposes in a similar manner by other agents, into carbonic acid and water.

8. ORIGIN.

The question, "Where do *Bacteria* come from?" that is, what is their original source, is sure to press itself for answer. This answer is by no means an easy one to give with positive assurance of correctness. We have already seen how they are reproduced and the rapidity with which they may multiply, as well as something of the modes by which they are disseminated; but all thinking persons wish to know how or whence the first ones came into existence.

Upon this question there have been many experimental inquiries by the ablest investigators, and many theories have been propounded by those most competent to formulate them, as well as the crudest of unsupported hypotheses by untrained minds. Among all these opinions we may select three as worthy of special notice:

1st. Spontaneous formation under proper conditions form inorganic chemical elements or compounds. 2d. Transformation from other living organisms or their parts, and 3d. Direct creation by the great Author of all things.

It would require too much space to even sketch in this place the arguments which have been advanced in support of each of these theories by thorough scientists. The voluminous literature on the subject shows the interest that has been felt and the real warfare of words that has been waged by contending supporters of their own or others ideas.

But no one without personal bias can carefully review this literature to-day, with the results of experiments clearly in mind, without concluding that the first and second have not been proved. From a philosophical stand-point the first is highly plausible, since these organisms are admittedly among the lowest living things. If spontaneous generation takes place anywhere in nature, we should look for the phenomenon here; but, while certain experimentors have supposed their results showed the theory true, others still more expert have uniformly pointed out the fallacies of such experiment or deduction, so that up to the present time we are bound to
say the facts known disprove rather than prove the hypothesis. The second has not been so fully and conclusively studied, yet the most searching investigators have not been wanting, with, upon the whole, negative results. No untrammeled scientist conversant with the entire subject as now known, admits the proof of the origin of *Bacteria* by transformation of the parts of other plants or animals, however close and constant may be the accompaniment of the one with the other. In this statement we exclude the idea of evolution during centuries of time, the change taking place by numerous unrecognizable differences; for, to our mind this belongs under the third hypothesis. We have, therefore, just the same scientific information about the origin of *Bacteria* as we have about that of other living things, man included. Whether we hold that the Creator fashioned each species in the beginning by a direct act, or accomplished the same by instrumentalities, working through the ages, makes no difference in the question before us. We are forced to refer the origin of *Bacteria* to the same Power to which we attribute the origin of man. It is certain that these minute organisms have existed in very closely similar, if not identical, forms as at present, from remote antiquity, as is proved by the discovery of fossil remains, as well as the evident effects produced in the past ages of the world, according perfectly with those now known to be the results of their action.

It must be admitted, however, that in the progress of individual development some kinds pass through different forms, which have been supposed to be characteristic of species, and that, retaining the same form, the physiological effects may vary through the prolonged influence of certain external conditions. Thus an individual cell may be spherical, then oblong, cylindrical, and filamentous in regular sequence of growth, though each of these forms in other species may be characteristic and unchanging. And a species ordinarily living in an infusion of dead vegetation may, by a slow and gradual change, become capable of surviving and multiplying in the blood of living animals, whereas a sudden transfer from the one to the other medium would have permitted no such results. But man himself is capable of becoming adapted to as remarkable changes. We say we become habituated or acclimatized to things and conditions, as of eating arsenic and of dwelling in the malarial regions of tropical countries. No greater changes than these are known in the life history of *Bacteria*, only that it requires less time for the modifications to take place; and this should be anticipated from their rapid succession of generations.

9. **Place in Nature.**

*Bacteria* are certainly living things, hence, according to the ordinary thought and classification of objects, must be either plants or animals. Formerly spontaneous or self-caused motion was held to be characteristic of animals as distinguished from plants; and, as many *Bacteria* are seen under the microscope to move freely and in some cases very rapidly to and fro, hither and yon, they were at one time unhesitatingly classed as animals, as indeed most unscientific observers would at once pronounce them now when viewing them for the first time by the aid of a powerful magnifier. But
the fact is, self-caused motion is not confined to animals. Really all plants more or less possess this power. A seedling causes its stem to turn upward and rootlet downward through internal forces, and afterward the growing parts bend to or from the light, as every one has observed. Leaves quite generally assume different positions day and night; flowers open and close, twining plants revolve in such manner that the free end sometimes sweeps a circle of four feet in diameter about the supporting object, tendrils twine in some instances fast enough to be plainly observed by any one possessing good eyes and a fair share of patience. It is true that all the higher plants are fastened to their supporting substance, and are incapable of roaming from place to place; but the lowest members of the vegetable kingdom are not thus limited. In some conditions at least the latter move as freely as any animals, not simply through the controlling influence of external agents, but from forces wholly within themselves. Such motile plants are all microscopic in size, but no botanist or zoologist hesitates to pronounce them true plants, having all the fundamental characteristics of members of the vegetable kingdom.

So, freedom of motion itself, however striking it may be, is not sufficient cause for classing Bacteria with animals. But it has been before stated that the outer coat or wall of the organisms is composed of cellulose, and this is peculiarly a substance belonging to all plants, and, with very rare exceptions, to any animals. It has also been mentioned that Bacteria are capable of taking the nitrogen required for their nutrition from inorganic salts, and this is alone characteristic of plants. There are no exceptions on the animal side.

These and other reasons have in recent times caused all naturalists who have made these objects a special study to pronounce them plants. There is no difference of opinion among proper authorities, if the choice is limited to one or the other of the two great kingdoms of animated nature; but Haeckel, a German scientist, has proposed to take the lowest forms of both these kingdoms and constitute therewith a third, called Protista; in this case the Bacteria would be called neither plants nor animals.

As plants, the Bacteria certainly occupy a position at or very near the bottom of the scale. They are among the simplest in structure of living things, and include among them the smallest objects in nature, animated with a spark of that vitality whose nature and essence is as unknowable in them as it is in the being created in the image and likeness of God.

There is a further and undecided question as to whether the Bacteria belong to the Fungi or to the Algae, two great divisions of the vegetable kingdom; but this depends solely on the definitions given to these groups. If greater prominence is given to form and habitat, they more nearly resemble the Algae, or sea-weeds; if physiological functions are decisive, then the Bacteria are unquestionable Fungi. This is now less important, since in a strictly natural classification it is undecided whether or not the great groups known as Algae and Fungi are entitled to remain as such. Probably not; in which case the term Prototypes will almost surely be
uniformly adopted to designate the lowest division of the vegetable kingdom, and in this the *Bacteria* will presumably occupy the lowest place under the ordinal name of *Schizophytes*, a word now in use, and meaning dividing or splitting plants.

**PART II. EFFECTS OF BACTERIA.**

1. **Fermentation and Putrefaction.**

Until within recent times it has been supposed that organic matter, dispossessed of the vitality to which it owed its existence, was naturally very unstable in its chemical constitution, and that its tendency was to go back to the elementary inorganic state, through the operations of simple chemical affinities. The soft parts of animal bodies have been considered especially liable to change after death; indeed this is now so common and constant a phenomenon that it is looked for as a matter of course, unless express provision is made to prevent it. We are surprised, when told that during the summer season the fresh flesh of buffalo on the western plains remains sweet and perfectly good until dry in the warm open air. The astonishing story is repeated again and again that the bodies of the woolly elephant of ancient Siberia have been taken out of the ice, in which they perished long ages ago, yet with flesh still so fresh that dogs feed upon the carcases.

The scrupulous care which we are obliged to take to avoid ill consequences to butchers' meats, makes these exceptional instances of preservation in nature really wonderful to us. We say the law is for such material to putrify and decompose, for milk and cider to sour, for the expressed juices of fruits to ferment, and the fruits themselves to decay. A pile of green herbage heats and rots, and wood exposed to moisture gradually loses its strength and disappears to help form vegetable mould.

These various changes, to which all dead organic matter is subject, going on about us so abundantly and so constantly make up a large part of the physical phenomena of the world; we expect them to occur and recur with the same certainty if not the same regularity of time or rate as the fall of unsupported bodies to the earth, the planetary changes and the succession of the seasons. We just as much expect fresh meat to spoil in warm summer weather as we do enkindled wood to burn. The wine maker counts just as certainly upon the fermentation of the juice of the grape as the engineer upon the pressure of superheated steam, though neither the one nor the other may stop to consider the philosophy of the phenomena with which they are respectively confronted. They have ascertained by experiment the governing conditions, and proceed with the confident assurance of what has been, will be.

Now, to those who herein read for the first time that dead organic matter has in itself no such tendency to spontaneous change, that, subject, as in nature generally, to all the activities of pure air, and
pure water and to these alone whatever the temperature, dead fish and flesh will not become ill scented or putrid, that milk and blood will not change from the condition they have when drawn from the living animal, that a heap of green or wet grass will not heat and rot, that moist wood will remain as durable as granite, and that the substances of their own bodies after life has departed are as incorruptible as gold,—these words may seem foolishness and upon the face of them absurd; yet this is the teaching of science and is the unavoidable conclusion from many instructive experiments. When the whole facts are known, the wonder is rather that the flesh of slaughtered animals so surely putrifies with us, not that as a rule fresh meat exposed to the pure air of the western plains should remain forever good. These facts could never have been known without the aid of the microscope, and since this wonderful instrument is of modern invention the knowledge set forth in the following pages has been gained alone by modern investigation. If there is still doubt about the matter as a general phenomenon, it is only because new ideas are slowly accepted; if there is dispute among the informed as to details of the process, it is mostly because so few really competent experimenters have yet undertaken the delicate but fruitful work.

The marvellous progress of modern science is based on the well-grounded idea that every effect has an adequate cause, and that these causes, in the material world at least, are subject to undeviating law. If a body moves, the force is sought, and usually not in vain, which produced the motion. If change occurs, a competent agent is at once supposed to be instrumental in its accomplishment. Students of nature are not content with passing anything as mysterious which can be brought within the domain of knowledge, nor with accepting as a fact anything which does not fall within the reign of natural cause. Possessed of this spirit, and provided with the necessary instruments and means, the subject before us could not escape investigation by the quickened intellects of recent times. The result is, after much conflict of opinion and difference of interpretation, the established fact, that the natural changes taking place in non-living organic matter, are all due to the vital activity of living things. Some of the usual results of life-forces may be accomplished in the chemist’s laboratory, but the processes and conditions there and in nature are entirely different. What life is, and to what its particular powers are due, we do not know; but we do know its effects, and these are as pronounced and unique in the natural destruction as they are in the original upbuilding of organic matter. Life manufactures, and life in turn pulls to pieces and destroys. An organic body is not a watch, which, having been wound up, runs down of itself; but it is a splendid temple, the rich material of which, accumulated from all lands, would require the same as its original freighting for its redistribution. But the low, microscopic organisms are by no means alone, if they act in any sense different from other vitalized beings, in the work of destruction. Every living creature is continually destroying itself, reducing, through its physiological and normal processes, the solid parts to liquids and gases, from the organic to the inorganic. This is the waste which all plants and animals suffer as long as life continues.
After death waste goes on in a different way, through the physiological and normal activities of other living beings, and the more noticeably because there is no repair.

Among these latter destroyers there are very many kinds of animals and plants. Indeed all animals are included in the list, and the digestion of food with them is always a work of destruction, as is readily understood. There are among flowering plants certain kinds which are also purely destroyers—the dodder or golden thread (*cuscuta*), found sometimes in tangled profusion on weeds, flax, clover, etc., is common with us. But it is to the *Fungi* that we must look for the principal agents, of the plant kind, which act as pure destroyers of organic matter. These degraded plants live solely on the accumulated and organized products of other plants and animals, assimilating a portion for the architecture of their own bodily structure, and exhaling another very considerable part as waste, in one shape or another, but ultimately as carbonic acid and water, two prominent ingredients in the original nutrition of green-leaved plants. Nitrogenous compounds, as ammonia, nitric and butyric acids, are also given off in the destruction of most organic matter. An old log in the woods having no tendency to decay, and resisting much better than iron the slow corrosion of the oxygen of the air, tumbles to powder under the digestive power of insects, toadstools and *Bacteria*, each kind working differently, but accomplishing nearly the same result.

It has already been said that in their physiological effects at least the *Bacteria* are *Fungi*. Their food is organic, elaborated in the first instance, if not direct, by green-leaved plants. Their function is to destroy, like that of other colorless plants and all animals. In this process of destruction peculiar and characteristic effects are usually produced by each species, and in very many cases each species is limited to some special kind of food material. In this there is nothing new or strange, for the law holds good throughout all nature, among all animals and all plants.

If, now, we remember the facility of distribution which these minute organisms enjoy, their vital endurance and their wonderful powers of reproduction, we need not after all be surprised that milk, wherever left exposed under the proper conditions of temperature, etc., becomes sour through the agency of a living organism developing in, and feeding on, some element or elements of its substance; or that fresh meat becomes ill-scented through the respiration of similar living things, acting in a similar way. Keep these destroyers out, and no such results would occur. In wide arid regions where there is but little material on which they may develop, their uniform presence in the air or on the surfaces of solids, cannot be expected, and this is the secret (now a secret no longer) of the fact that meat keeps in such places without putrefying. Since the white man has made his habitation in the West where the old hunter used to expose his jerked buffalo with impunity to the warm sun and air, this can no longer be done with butchered flesh. But it is still found possible on these wind-swept plains to keep meat fresh for a considerable time by sticking it on poles high above the earth, above the usual dissemination in these places of living organisms. The same thing is true
on high mountains, though the warmth of the sun may be fully sufficient during mid-summer for the manifestation of all kinds of life and of rapid changes in putrefactive substances.

Among the destructive alterations of organic matter, those known as fermentation and putrefaction are peculiarly the effects of certain species of the low plants of which we write. Because the latter are so minute, they are not commonly known to be present, hence the popular idea that the processes are spontaneous, due to the nature of the material in which they occur. The French Count, Appert, early in the present century, working under the idea that the oxygen of the air is the active agent in these destructive changes, devised the method now so largely adopted of hermetically sealing fruits and meats. He fortunately hit upon the plan of expelling the air by heat, and of closing the vessel while the contents are hot. The result is what he hoped for, the indefinite preservation of the material. This explanation, though the only one known to many to-day, is absolutely false, as has been clearly shown in several ways. It is by no means necessary to exclude the air; it is only essential that living things adhering to the surfaces of the fruits, etc., and often contained in the air, be prevented from developing and multiplying in the substances. The heat destroys such as are in the vessel either on its own interior surface or on the fruit, and the closing while hot prevents the entrance of fresh germs. A can of such preserved material opened in summer on the house top in the country might not spoil for many days or weeks. In such an experiment care should be taken to keep the article to windward of the person for obvious reasons. In a warm time during winter success would be much more certain. Two years ago I found that milk taken direct from a cow in a heated glass fruit jar, with the simple precaution of previously washing the udder and adjacent parts and closing the jar as soon as possible, often kept sweet and fresh many times as long as that left open in a clean milk room.

I now proceed to rehearse the results of some more careful and conclusive experiments which, it must be admitted, fully substantiate what has been said about fermentation and putrefaction being due to living organisms instead of to the air or any quality of the experimental material.
Figure 1 represents a little glass flask, invented by Pasteur, of France, for the purpose of making pure cultures of certain kinds of these minute organisms. The drawing was made from one of several in actual use by the writer, and made at the chemical laboratory of the Industrial University. It will be seen to consist of a little bowl of the capacity of about one fluid ounce, and from this arise two tubes, one of which is surmounted by a short piece of rubber pipe, containing a glass stopper, the other long drawn out and bent downward, the descending portion being very fine, with an internal continuous cavity about the diameter of a medium sized horse-hair. The end is left open.

For our purpose we may take any fermentable or putrefactive infusion, as of hay or chicken broth. Filter to remove the solid particles, that we may better observe what does or does not take place, and fill the bowl of the flask through the stoppered tube.

We now hold the flask over a flame until the fluid boils, and the steam passes out of the larger tube, which we then close, having previously passed the stopper through the flame. The steam is permitted to rush out of the fine tube for a little time, after which we hold the fine open end in or just above the flame until the steam within the flask is condensed by cooling and the inrush of air ceases. We have now only to set the flask aside and watch results. If any change takes place, as a skum forming on the surface, a mouldy growth on the glass, or a sediment settling on the bottom, it can readily be observed; if not, we may see that the clear liquid continues limped and pure. Let us examine closely the conditions, supposing the temperature to be that of warm summer weather. We use a fluid which, freely exposed to the air or enclosed in a bottle without subsequent heating, would rapidly ferment or putrefy, becoming turbid and milky, with (if soup) a slimy scum forming on the surface, and withal an odor so characteristic that we shall know well enough what it means. By boiling in the flask, any living organisms in the liquid or attached to the interior of the vessel are killed. And by holding the minute opening in the flame—taking care that the glass is not melted—until after the condensation of the steam by cooling, there is afterward no strong inrush of air through the open tube. Now, all living things, no matter how large or how small, have solid parts, and are really heavier than the air, so that however minute, they cannot float in the latter, except as
swept along by currents; hence, though by every alteration in temperature, without or within, there will be slow interchange of air, the minute solid particles of the external atmosphere are not likely to be carried up the fine tube and over into the liquid, which is therefore exposed to pure germless air. I have now such a flask, filled nearly two years ago with filtered chicken broth which is as clear and sweet as when first made, and this has been kept on a shelf in the laboratory, where the temperature has been very favorable to putrefactive changes, and where, from the use of the room, the air is unusually laden with organic dust. On the same shelf are other flasks of similar kind, some of which, after keeping for some months in the condition of the one described, have been unstopped for a few minutes, and then closed again, with sure putrefaction as the result. Sometimes simply shaking is sufficient to start this process, showing well enough the preservation was not due to any want of susceptibility of the liquid to such change. If, however, we take the precaution to hold the larger tube over a flame, we may open and close it without such results, and in this way we may from time to time microscopically examine the liquid by taking a drop upon a previously heated glass rod. While the liquid remains limped and sweet, no organisms are found, but they always swarm in profusion when visible changes take place.

A successful experiment of this kind seems to prove two things: 1st, that the potential factor in fermentation resides neither in the substance itself nor in the pure air; 2d, that organisms do not spontaneously develope from germless material.
Tyndale, of England, has taught us another mode of experimenting to gain answers to the same questions. He constructs a wooden box with a back door, glass front and side windows, and passes through the bottom several test tubes, air tight. Through a hole in the top fitted with a sheet of India rubber and a stuffing box of cotton wool wetted with glycerine, a long glass rod with a funnel above may be thrust to fill the test tubes, and two sinuously bent glass tubes pierce the top for the admission of air without dust, as explained in the account just given of Pasteur's flask. The interior surfaces are moistened with glycerine and the box closed. By passing a beam of sun, or brilliant artificial light, through the windows it can be readily ascertained when the floating matter has settled and the air is pure, after which the test tubes are filled with putrescible liquid, which is now boiled by heat applied externally. We notice that the boiled infusion is freely exposed to the air of the box as well as to the outer atmosphere through the bent tubes, and that the only precaution taken is to allow time for all minute solid particles to settle in the still air of the chamber to whose moistened surfaces they adhere. Hundreds of tests have been made in this way by Professor Tyndale with the most satisfactory and positive results, with very many kinds of putrescible substances, as natural animal liquids, infusions of flesh, the viscera of animals, of fish and of vegetables. The perfectly sweet and limpid filtered infusions remained in this condition for months, while outside of the moteless box in the same room they became putrid and offensive in some hours. It was sufficient at any time to open the back door of a box, if but for a moment, to secure these latter results in the experimental test tubes. In the clear, unchanged liquid living organisms were never found; in the ill-scented turbid ones, these always existed in countless numbers. What can be more instructive? What better demonstration could we wish of the non-occurrence under usual circumstances of spontaneous generation of living organisms, or of the stability without these of organic substances?

2. Diseases of Plants and Animals.

From the earliest times many of the diseases of man and of the domesticated animals have been known to be contagious, i.e. capable of being transmitted from a diseased to a healthy subject, while some that are now known to be propagated in this way were
looked upon as peculiar visitations of Providence for supposed sin—the fact of the contagion not having been observed. There have also been from earliest history many speculations as well as careful studies, upon the nature of the poisonous or contaminating principle, and physicians, ever since their art has been practiced, have endeavored to find out remedies by experiment. Among the diseases of the human skin that is happily much less prevalent now than formerly, the itch was the subject of extended and warm controversy from the twelfth to the eighteenth century among Arabian, Italian, French and German physicians and scientists. Some held that want of personal cleanliness was the sole cause and that the disease might spontaneously appear at any time and place, given only the proper conditions. Others found a minute, living, crawling, egg-laying inhabitant of the diseased skin, and attributed the ill effects directly to its work. Then came learned disputes as to whether this living thing did or did not originate from the filth, and whether it came as a consequence simply, or was verily the exciting cause of the disgusting malady. The literature upon the subject is very full, and if in those days they had possessed our aptitude for putting things in type, it would have required a library of books to contain the discussions.

Practicing the experimental method, some investigators at last put the living creature, separated from the débris of the diseased skin, on their own bodies, and watching its operations, established its true parasitic nature.

The agent, a mite, popularly called an insect, is propagated only from eggs laid by parent individuals, and thus maintains its specific identity. Its life-history having been satisfactorily made out, and its mode of operation fully made known, it is no longer a subject of dispute; but the history of the controversy is a valuable one in our present studies. Knowing the facts, we now smile at the absurdities of the opinions held, and the foolishness of the supposed proofs upon which these opinions were founded; yet these were not cruder nor farther from the truth than are many of the speculations and incredulities of our times concerning “diseased germs.”

While an illustration of this kind cannot be taken as evidence in the case of bacteria, the same questions are now asked about, and the same objections made against, these latter organisms as the cause of disease. Yet careful investigators are to-day as able to handle bacteria, to see their shape, observe their manner of increase, ascertain their proper food material, and find out the substances inimical to their lives, as were Abenzoar and Bonomo in their time to similarly study the itch mite,—thanks to the improvement of the microscope, more than anything else, except the general acceptance of the experimental and inductive method of study.

The fact is, those competent to judge, now agree in holding that some severe contagious diseases of man and animals are directly due to bacteria, while many scientific investigators, whose abilities cannot be questioned, and who have abundant facilities and opportunities to learn and to know, claim that all diseases, readily communicable from the infected to the healthy, have their origin in the activities of these living organisms, and this opinion is certainly growing into wide, if not universal, acceptance. Other diseases, as
fever and ague, not understood to be infectious or contagious, are also believed to be due to certain kinds of the same things.

Herein lies the greatest interest and highest importance attributed to these wonderful but excessively minute denizens of the, to common eyes, invisible world; and herein, more than anywhere else, rests the hope of attaining a scientific basis for medical practice, as well as a rational adoption of preventive measures against the ravages of disease. It will not do for the hobbyist to assume that all the ills that flesh is heir to can be traced to the corrupting work of “disease germs,” for, as has been before pointed out, these minute things have no life functions which strictly separate them from other plants and animals. Their physiology is our physiology; they assimilate food material as we do, and, by virtue of this power, live as we live. The delicate and complicated machinery of the higher animal bodies may be put out of order in many ways, and by want of nature’s harmony the normal, vital forces themselves may be the agents of disease.

But while there is no toleration for the hobbyist, those who have not investigated and cannot investigate for themselves should not hesitate to accept the testimony of capable specialists, when the latter find reason to assert that such and such a disease is due to the microscopic mischief-makers. Their bacteria minuteness no longer prevents the demonstration of their presence, the tracing of their development, the detection of the actual effects and the experimental testing of results. There is now in certain cases just as good evidence that bacteria cause disease as there is that hawks destroy chickens, and the evidence is as inductively rigid in the one case as in the other. Even without microscopic examination, there is good reason to assert that the contagious principle, whatever it is, grows. Any chemical poison decreases in virulence by diffusion in a mass of inert matter, and soon loses its effectiveness; but it is the special characteristic of the poisons of which we write that a minute quantity soon infects the whole system of a large animal, and then the smallest drop of fluids from its body is sufficient to give origin to the disease in another animal and so on perpetually. Increase has taken place; there must have been growth; only living things grow; the microscope aids us to see what this living thing is; why should we doubt!

It is true that Dr. Lionel Beale proposed a theory of disease germs, which accounts for increase by assuming that degraded, yet not dead, parts of the animal body itself constitute the true contagion, and that every such living but degraded portion has the power in some way of over mastering the healthy—a speculation which, though brilliantly conceived and sustained at the time, has not been definitely supported by later investigations, nor held with assurance by any other authority, known to the writer; though, from what has just been said, the process is neither inconceivable nor a priori impossible, perhaps not even improbable. The only question is, “Do facts prove it?” There are indeed some experimental facts which seem to favor the idea, viz: the transmissibility of inflammation produced by chemical or physical means upon inoculations with the exuding serum. It may be said however that even in this there is the possibility of independent organisms being the real virus.
The first septic disease well worked out was that of *pebrine*, an infectious malady of silk worms in France. In 1853 the production of cocoons was 57,000,000 pounds avoirdupois, and had doubled during the preceding twenty years with every prospect of continued increase; but during the next twelve years, owing to the ravages of the disease mentioned, the production fell to 9,000,000 pounds, a loss in 1865 alone of twenty million dollars. During those twelve years of national disaster, the disease had been sedulously studied by all the scientific and professional skill of the times so far as the light of pathological knowledge then attained permitted, without practically beneficial results. In this state of things Pasteur was besought by the Minister of Agriculture to undertake the investigation, though this scientist had no special qualification for the work, except his natural talents and his acquirements through studies on the origin and effects of the micro-organisms in fermentations and putrefactions. Great numbers of minute corpuscles had been seen some years before in the bodily tissues of the diseased caterpillars, but no one attached any importance to them. Pasteur at once turned his attention to these microscopic bodies, proved them to be living organisms, studied their propagation and mode of development, became able to distinguish infected from healthy eggs, and in September 1865 communicated his results to the French Academy of Science. His labors met with inattention or derision, so novel were they, and contrary to the learning of the time. To convince the skeptical and arouse the heedless, he selected fourteen lots of eggs in 1866 and wrote out what would be the fate of the moths hatched from them in 1867. These predictions, placed in the hands of a public officer in a sealed envelope, were exactly fulfilled in twelve of the fourteen cases, and produced the expected effect. His instructions were obeyed and France rapidly regained her great silk industry—one of the great triumphs of practical science in our triumphant century, and the foundation of an entirely new system of research in preventive and curative medicine.

Guided and profiting by Pasteur’s former studies, Lister, then of Edinburgh, since of London, began in 1865 to perfect a system of anti-septic surgery, which, as introduced by himself and others, has been the means of inestimable progress in this difficult art, saving life and limb, as well as untold suffering to mankind. Unfortunately, either from the want of sufficient information or from placing too much stress on certain details, doubts are entertained by some fair-minded professional surgeons as to the correctness of the theory, though not upon the real progress that has been made. There seems good reason to believe such doubts will rapidly pass away, and that still further profit will be secured in the practical application of scientific knowledge. It is well known to veterinary surgeons that animals may be castrated by a sub-cutaneous rupture of the spermatic cords, followed by the death and absorption of the testicles, without mischief to the animal, provided the epidermis remains unbroken, but this provision is imperative. Gangrene is sure to follow if the exterior is punctured. Flesh bruises on our own bodies do not suppurate under similar conditions, and wounds made with a truly clean instrument heal by “first intention,” if immediately closed and bandaged in such manner that living organisms
are excluded. This result is more certainly assured by the proper application of an antiseptic dressing, as of glycerine, in which a small amount of carbolic acid has been stirred.

The etiology of no infectious disease is now so well understood as that known as "splenic fever," "anthrax" or "charbon" of the domestic animals and "malignant pustule" in man. It is said, between 1867 and 1870 over 56,000 horses, cattle and sheep, and 528 human beings perished from this alone in a single district of Russia, while the annual loss of live stock in France has been millions of francs. This is now practically subdued by prevention of infection and by vaccination, the history of which reads like a romance. The contributions thus made to medical practice opens up boundless visions of future welfare to man. Jennerian vaccination against (for ?) small-pox was the result of an acute but fortunate observation, one almost might say a lucky coincident; but Pastorian vaccination, as we may properly term it, is the outcome of methodical and precise scientific research, gaining knowledge step by step and reaching new facts by logical induction from the known. To this progress there have been many contributors, but among them it is not unjust to mention Koch, of Germany, and Pasteur, of France; the former for his splendid studies on the cause, the latter for the introduction of a practicable remedy, now adopted on a commercial scale in France and Austria.

The terrible disease is thoroughly known to be due to the inimical activities of a specific organism, *Bacillus anthracis*, described in another part of this paper. Within the last few years certain researches have been published which seemed to demonstrate that this was a physiologically varied form of a species of the same genus common in infusions of vegetable substances, as of hay; but very recent investigations make any such transformation questionable.

Pasteur's vaccination material is obtained by prolonged cultivation of the deadly Bacillus in a decoction of animal flesh kept at a certain temperature, in which the organism multiplies rapidly, but progressively loses its virulence. At the proper stage, the liquid swarming with this particular microphyte is used for the inoculation of animals which scarcely, or not at all, suffer in consequence, but are thereby protected from the virulence of the dreaded parasite in its usual condition, bringing almost certain death within twenty-four to thirty hours.

As an experimental illustration, Pasteur and his co-workers made a public test, at the request of a provincial agricultural society, and before a large assembly of interested persons and experts. Fifty sheep were taken from a flock, and from these twenty-five were earmarked and vaccinated, May 3, 1881. This was repeated on the 17th of the same month. In the meantime the fifty sheep were kept together in the same flock, under the same conditions and influences. May 31 the whole fifty were inoculated with strong virus, and the sheep again turned loose together. Pasteur's predictions as to the result were fully verified the following day—twenty-three unvaccinated sheep being dead at two o'clock, and the two other during the afternoon, while the twenty-five vaccinated animals remained in perfect health, save that one purposely receiving an extra dose of the strong virus was sick for a few hours, then recovered.
Such satisfactory experiments having been often made, thousands upon thousands of domesticated animals have been vaccinated during the spring and summer of 1882, with material furnished by the renowned investigator, and again the financial interests of France owes to her illustrious son and to science a splendid recompense of reward.

Nor is the end reached here. The successful study of this disease and the production of a safe vaccination virus, will no doubt lead to similar results for other diseases, and not improbably furnish a scientific basis for that already practiced upon human beings as a preventive of small-pox. The fact is, a study of the disease of fowls commonly called cholera, helped in working out that of splenic fever, and especially led the way to the preparation of the vaccination material as now used. This disease of the domestic fowl occurring on both sides of the ocean is really of like nature, but want of space precludes further notice of it. Suffice it to say that it is readily transmissible, either through external puncture or wounds, or by taking the parasite with the food. This fact alone should soon lead to measures for its extermination.

In our own country, among other studies of this kind, much has been learned about yellow fever, undoubtedly due to a specific organism not yet satisfactorily determined; about diphtheria, in which the minute but dangerous enemy has been well recognized and carefully studied; about several forms of septicæmia or blood poisoning; and especially about a prevailing disease of swine ordinarily known as "hog cholera." Though "a prophet is not without honor save in his own country," let us hastily review the facts ascertained by Drs. Detmers and Law in regard to this last-named malady.

Hogs were entirely exempt in the United States from the disease until quite recent times, and though the original infection and the spreading from the first locality was not observed, many facts are known concerning its introduction in given areas and its subsequent mischief, where swine kept under the same conditions were robust and healthy before. Numerous speculations were made and theories advanced to account for the plague. By some it was attributed to the diet (too exclusively corn), by others to filth and unhygienic surroundings, and by others again to degeneration from improper breeding, etc.

The gentlemen named above, with others, were appointed by the Commissioner of Agriculture of the United States to investigate the disease, and, provided with the requisite means and apparatus, working separately, they satisfactorily proved the infectious character of the devastating malady. A fraction of a drop of the fluids from a diseased animal, placed beneath the skin of one in health by an inoculating needle, produced in a few days the characteristic affection, as did the diseased parts given in the food. They found by hundreds of post mortem examinations the lesions produced, and the course and progress of the injuries. They also found constantly present a specific organism, and thoroughly studied its morphological and physiological characteristics. They cultivated it outside the living body, in harmless fluids, and by further inoculations and examinations proved its direct agency in the production of the observed results. They showed how this organism was liable to be
transported by infested animals, sometimes other than hogs, by water-currents, and, under certain limitations, through the air; they found under what circumstances it was naturally destroyed, and how preserved, and they succeeded in showing what preventive measures could be used through general management, medicinal treatment and vaccination. It was my good fortune to witness many of the experiments of Dr. Detmers, and can personally vouch for most of the above results, making, for myself, conviction irresistible, that the immediate cause of the disease is none other than the living organism always found in the blood and excretions of the diseased animals.

Whether through the information thus derived, or from other causes, the loss from this dreaded scourge has been conspicuously less during the last few years. Certain it is, men are on the alert to prevent, through intelligent endeavors, the infection of herds, even though they do not, in words, admit the truthfulness of the "germ theory."

The investigations of the author on "blight" of the pear tree and other plants—the only facts yet made public of injuries to living vegetation by bacteria,—have a scientific interest in consequence of the readiness with which studies may be made. It is not possible to cut pieces from the flesh of live animals and examine them under the microscope in their living state; but this can be done with plants. In the latter there are no sympathetic inflammatory processes, by which a healthy part suffers in consequence of injury to some other part of the body; neither are there facilities for the distribution of microscopic parasites through the structure, as there is in the blood currents of animals. We often say the sap "circulates;" but no such thing really takes place. All the movements of fluids in plants are processes of imbibition, or soaking through the cell-walls, never in streams in tubular vessels. Hence disease infection is local, and the effects are comparatively very easy to make out.

In animals it is hard to determine whether the injury comes from the destructive action of bacteria or from their mechanical obstructions, or the poisons they give rise to, etc.; in the pear tree such queries are quickly answered, and one soon sees that death comes from the fermentation of the cell contents. It is highly probable that much can in this way be learned to help in the study of similar maladies of man and the domestic animals.

The studies on blight have also a practical interest in the well proved fact that the progress of the disease is slow, instead of the rapidly spreading plague formerly thought. Careful examination, once or twice a month, will usually suffice for the efficient excision of all infected parts, and this, if properly done, is perfect protection to the tree. The wounds must be quickly covered with paint or other dressing.

The attested fact that the poisonous principle of certain plants, as of poison ivy or oak (Rhus), is a living organism (T. J. Burrill, Proceedings American Association for the Advancement of Science, 1882,) instead of a volatile chemical compound as heretofore supposed, is also a fruitful beginning in the study of the origin of infectious diseases. Of a similar nature is the ascertained fact that a micro-organism found in the saliva of healthy human beings,
causes death when inoculated into a healthy rabbit, (Sternberg, National Board of Health, 1880).

Such facts offer no contradiction to the disease-producing agency of the observed living organisms; but only show that they may be harmless to one host and deadly to another, at least when first introduced. Many facts go to show that the physiological system may become inured to those poisons as well as to those of a chemical nature. As a man becomes habituated to the use of deadly doses of opium and arsenic, so in like manner he may resist after a time the pernicious effects of bacteria, though the latter continue to live and multiply in certain parts of his body. This probably explains the peculiar characteristics and effects of "Texas cattle fever." In this very characteristic disease of neat cattle the native animals of Texas do not suffer, while those recently introduced from abroad are almost certainly affected. Still more curiously, the healthiest Texan animals carry the contagion with them when transferred to the Northern States, where for a time the alarming death of cattle which have in anyway come in contact with those from the South excites the liveliest inquiry and most earnest investigation as to the cause. Until bacteria became known as true disease producers no satisfactory explanation could be made of the strange phenomenon.

What inscrutable mystery has been connected with that terrible scourge to human beings, leprosy! How it baffled the skill of the physician, and doomed the unfortunate to helpless and hopeless misery, making them loathsome though pitiable objects; life a wearisome burden to themselves, and their very being a menace to their friends! But the puzzle is solved. Through the microscope, the cause is visible as a self-perpetuating, parasitic plant, growing, propagating, destroying; yet subject to the same general surrounding conditions as other life-possessing things. Its terror is half gone from being known, and scientific medical treatment will banish the other half. Though by no means a disease of the ancient times alone, its uninterrupted career need no longer darken the lives of innocent sufferers superstitiously supposed to be under the curse of God's anger. The diseased need no longer be driven to the deserts or isolated in asylums for life in order to protect the community from the dreadful plague.

Without attempting to give a résumé of what is known of the disease-producing effects of bacteria, but simply illustrations of this knowledge, mention is here made of only one more case,—the most dreaded and destructive of all the ills of the human body, consumption, (tuberculosis). Since 1865 this has been positively known to be transmissible from the diseased to the healthy, though not formerly so recognized. Up to the present year able investigators have sought in vain for the parasitic organism which all analogical facts strongly indicated must be the cause of the terrible disease. But skill and patient research have at last triumphed. By certain processes of staining, the first of which rewarded the labors of Dr. R. Koch of Berlin, the destroyer has been detected, and has now been seen by hundreds of expectant eyes. It inhabits diseased parts of the body, which may be in almost any organ as well as the lungs; it lives and grows and reproduces, slowly for its kind, but surely working its dreadful results. The disease is common to
human beings and the domesticated animals, and is transmissible from one to another in either order. With such knowledge and the possibility, now of definite and sure grounded study, the misery and suffering heretofore so calamitously common, must soon be beneficiently controlled, and the world made brighter and happier to unnumbered thousands of its inhabitants. We cannot anticipate the results in regard to cure, but may comprehend means of prevention. There need be no more discussion about hereditary taint except as in direct conditions. Let it be well understood that the terrible disease is liable to be contracted from an animal or man suffering from it by any one predisposed to its attack, and let the modes of infection be made known, and instead of one-seventh of the human family perishing, as they now do after months and years of misery, the statistician, of the future may write one-seventy-seventh. Whatever alleviation there may be for those already diseased, the above is not too much to reasonably expect as to prevention.


The foregoing might lead one to the conclusion that bacteria were injurious and only injurious in their effects, but a little thought will soon convince us that this is far from the truth. They are primarily the agents of decay, yet in this very sense untold good comes from their activities. It is indeed no more startling than true to say that as at present constituted the organic world is indebted to them for its existence; without them man could not live upon the earth. The processes of nature run in a circle, the possibility and perfection of which depend upon the proper filling of every part. Green plants, the architects of the world, build solid structures out of gaseous and liquid materials, but must have these materials furnished. They create nothing. The supply being limited, this would soon be exhausted were there not some provision to prevent it. We have seen that organic materials, though dead, have no inherent tendency to decompose; kept free from the working of living things they endure forever, except when consumed by fire. How different the world would be without putrefaction and decomposition! Eliminate these processes now, and we should see the fallen trunks of trees accumulating in the forests as obstructions, instead of helping to form a rich vegetable mould for future growths and generations of forests; the mummied bodies of animals would remain for all time, like the grotesque cadavers of the old Egyptians, teaching history, but teaching only the sad one of the reign of death. It is well known that fertile soils have as an indispensable part of their composition a certain amount of partially decomposed vegetable matter; this is in truth the special characteristic of the surface soil as distinguished from the subsoil. Our field and garden plants are dependent on this rich upper stratum, and our valuable animals and ourselves are dependent on the plants; hence, following the circle round, we reach the knowledge of our indebtedness to the bacteria as agents of decomposition.

There is another way in which the fertility of soil has recently been shown to depend on bacteria. Green leaved plants require nitrogen as an essential part of their food, and they are only able
to make use of this when in the shape of nitrates, or as combined with earthy or mineral substances. It has long been known that saltpeter (nitrate of potash) collects in caves. In times of need, it has been artificially obtained by washing earth in which there existed considerable amounts of organic matter undergoing decomposition, and to the surprise of the workmen such soil, after certain intervals of time, may be washed and re-washed without apparent exhaustion. So it came to be understood in time that in suitable caves the compound actually formed where it was found, not simply collected there through the percolation of water, etc. Upon heating a portion of such nitro-collecting earth, or treating it with chloroform, this peculiar power was observed to be lost, and by further investigation it was demonstrated that a microscopic living organism is the real agent in the work. Thinking no doubt in part of this, a well-known scientist has announced as the topic of a paper, "The soil a factory, not a mine."

We more directly make use of bacteria in many ways. The fermentations in which alcohol is the chief product, are commonly due to the yeast plants, closely allied to the bacteria; but the latter are rarely absent from brewers' yeast, used in bread-making. The so-called "salt-rising" is wholly dependent on the work of bacteria. Similar agents make for us vinegar and saur kraut; for the chemist, litmus; they "rot" flax; they "bleach" linen and cotton spread out on the dewy grass; they clean bones macerated in water by the anatomist; they purify the waters of rivers, cisterns and tanks, causing it in close reservoirs to "work," after which it is sweet and bright. It is said bacteria play an important part in the manufacture of cheese, and in the production of certain perfumes and flavoring extracts. They are found in germinating seeds and in the digestive organs of animals; but whether or not of real use in these cases, cannot be confidently stated. It is even probable that the wonder-working little creatures are used in medicine under cover of some other name and idea, the physician as well as the patient being ignorant of the real action of the dose. It is pretty certain that epidemics among noxious insects sometimes occur through the influence of bacteria. Considerable interest was recently taken in the apparent destruction, under certain conditions, of insects by yeast artificially applied to their bodies or given them to eat. But the results of experiments seemed to show that the yeast itself was not capable of injuriously affecting any insects, and it was left to conjecture whether or not there might be something else in some specimens of yeast cake or powder which, by its action, would explain the few known instances of the death of insects presumably from the effects the yeast tried. It has now been demonstrated by Prof. S. A. Forbes (American Naturalist, Oct., 1882,) that living chinch bugs are sometimes filled with enormous numbers of bacteria, and the observations so far made go to show that such bugs are decidedly unhealthy, and perish in great numbers before completing their full development. Certain it is that these pests of the grain fields do die off at times by some epidemic among them, as the writer can testify from his own observations. Hundreds of them, of all ages, have been found about harvest-time in little heaps, at the base of wheat plants, dead and dying, while the
weather and other conditions were favorable for their life and development. The disastrous scourge to "silk-worms," before mentioned, shows that such diseases of insects are not only possible, but they really do exist. Pasteur suggests investigations to find out some such destroyer of the Phylloxera now so injurious to the grape vines in Southern Europe, and he is quite confident that success would crown proper efforts in this direction. There does seem to be in this a line of study of most excellent promise, not for one species of injurious insects only, but for the mastery by man over many of his minute but most dreaded enemies.

PART III. CLASSIFICATION OF BACTERIA,
AND A SYSTEMATIC DESCRIPTION OF THE SPECIES.

No one pretends to have made out a complete, natural classification of the Schizophytæ or bacteria; although several naturalists have embodied in systematic form, their ideas of the kinds and their relations, based on shape, development, motion, physiological effects, etc.; but all such classifications are acknowledged to be preliminary and more or less artificial. That, however, which proves to be most useful and apparently as nearly natural as any, is founded on the form of the cells and their organic association. It has been best worked out by Dr. Ferdinand Cohn, substantially as follows:

TRIBE I. SPHÆROBACTERIA.

Cells globular, or oval; size, very small, often less in diameter than .00004 in.; isolated, in pairs, or in chains of many articles, or when young and actively increasing in number, imbedded in gelatinous masses, called zoogloea, or when forming a pellicle on the surface of liquids, mycoderma; without true spontaneous motion, but oscillating in liquids by molecular trepidation.

But one genus, viz.: Micrococcus.

TRIBE II. MICROBACTERIA.

Cells elongated-oval or short-cylindrical; isolated, in pairs, or in chains of four, more rarely of many rather loosely attached, or sometimes in zoogloea; with active, spontaneous motions, when in nutritious liquids supplied with free oxygen.

One genus, viz.: Bacterium.

TRIBE III. DESMOBACTERIA.

Cells cylindrical, usually several times as long as wide, straight; isolated, or usually united in chains; often with spontaneous movements, but in the case of some species always without motion.

Genera: Bacillus, and with some doubt, Leptothrix, Beggiatoa, Crenothrix. The question about these three genera is whether they should be included among the Schizophytæ or referred to the filamentous Algae.
TRIBE IV. SPIROBACTERIA.

Cells cylindrical, usually several times as long as wide; curved or spirally wound; isolated, or united in chains of less or greater length; with active, spontaneous movements.

Genera: Vibrio, Spirillum, Spirochaeta.

Besides the above, other species, multiplying by self-division, are referred to the following genera: Sarcina, Asccoccus, Streptococcus, Myxconostoc, Cladothrix and Streptothrix. The old genus Monas, formerly including many species of low animals and plants, has been so modified that it now contains only a few forms of doubtful affinities.

It must be remembered that these genera are principally based on the shape and association of the cells, and that the latter are supposed to be in their adult condition. It may be that very arbitrary separations are made. It is quite possible, indeed, that the same specific organism assumes, under certain conditions, several of the proposed generic forms; but, it is at least probable that each genus named includes some species which do not change beyond the limits of the description. For instance, the spores of Bacillus would, from appearances alone, be classed as Micrococcus at first, and as Bacterium after a certain period of growth; but Bacterium termo never changes so much that the genus can be mistaken. Billroth goes so far as to claim that all the subjects of Cohn’s classification, except, perhaps, those constituting the genera Spirillum, and Spirochaeta, belong to a single species, which he names Cocco-bacteria septica, while Nägeli supposes there exists a small number of true species, each of which takes several forms.

With such differences of opinion among those most competent to judge, we cannot pronounce with any confidence upon the number or the actual characteristics of the species in existence; but that true species do exist we may feel well assured. When sufficient knowledge has been gained of their life histories, a natural classification can be arranged. In the meantime, such as we have already outlined must continue to be of much service, as it has been in the past.

Dr. Luerssen has arranged the following key to the genera:

I. Cells not in cylindrical filaments, separating immediately after division, or in couples (or chaplets) free or united in colonies (Zoogloea) by a gelatinous substance.
   A. Cells dividing in one direction only.
      a. Cells globular .......................................................... Micrococcus.
      b. Cells elliptical or shortly cylindrical ................................ Bacterium.
   B. Cells dividing regularly in three directions, thus forming cubical families, having the form of little bags attached side by side, and consisting of 4, 8, 16, or more cells ................................ Sarcina.

II. Cells united into cylindrical filaments.
   A. Filaments straight imperfectly segmented.
      a. Filaments very fine and short, forming rods ................................ Bacillus.
      b. Filaments very fine and very long .................................. Leptothrix.
      c. Filaments thick and long ............................................ Beggiatoa.
   B. Filaments wavy or spiral.
      a. Filaments short and stiff.
         a. Filaments slightly wavy, often forming woody flocks .......... Vibrio.
         b. Filaments spiral, stiff, moving only forward and backward .... Spirillum.
      b. Filaments long, flexible, with rapid undulations, spiral through their whole length, and endowed with great mobility ........ Spirochaeta.
What follows is chiefly from Dr. Rabenhorst's *Kryptogamic Flora of Germany, Austria and Switzerland*, of which this part has been recently (1881) re-edited by Dr. G. Winter, of the University of Zürich, and which is translated from the German by the present writer. The original source of the most of the matter is Cohn's *Beiträge zur Biologie der Pflanzen*. As the work now stands the systematic description of species, herein given, is believed to be the fullest and most nearly complete of any in existence. In the English language the only similar publication is Dr. Sternberg's translation of Magnin's treatise.

Winter unhesitatingly classes the bacteria among the Fungi and includes in the latter all cellular Cryptogams (flowerless plants) devoid of chlorophyll. It is true that this rigid classification unnaturally separates some species certainly very closely allied; but, since the physiological effects are of prime importance in the practical study of these plants, this separation is less to be regretted. It must certainly serve a useful purpose to present together those which, through the want of chlorophyll, are dependent on the assimilated products of other plants and animals for nutriment, and which thus agree in being agents of destruction in organic matter.

I have added to those in Winter's work such further species as seem to be well established, as well as some doubtful but often quoted names—the latter mostly by Hallier, and are copied from Magnin. The following are herein described as new species:

*Micrococcus amylovorus*, the "blight" of pear trees, etc.

*Micrococcus toxicatus*, the "poison" in species of *Rhus* (Poison Ivy, etc.)

*Micrococcus insectorum*, in diseased chinch bugs and supposed to be the cause of an epidemic destruction of these insects.

I have also felt obliged to name anew the organism found by Dr. Detmers and others in diseased pigs, for though there is a general agreement that the species belongs to *Micrococcus*, no one has published a name for it thus classified. It may now be known as *Micrococcus suis*. For the organisms causing the disease of the common fowl usually known as "chicken cholera" I have proposed the name of *Micrococcus gallicidus*. Several species have been recorded without specific names, because properly published names for them are not known by me. Thus, while some write *Bacillus tuberculosis* for the recently discovered species in this disease, I am not informed that the name as such has been published by Koch or any one else according to established usage. Still this may be the case and a new name should not be given. I have therefore simply written *Bacillus of tuberculosis*.

All notes and additions by myself to the German text are inclosed in brackets. In the translation I have endeavored to express the evidently intended meaning of the author rather than to make a literal rendering of the wording.
DESCRIPTION OF PLATE I.

(Fig. 1.—Microcococcus prodigiosus (Monas prodigiosa, Ehr.) Spherical bacteria of the red pigment, aggregated in pairs and in fours, the other pigment bacteria are not distinguishable with the microscope from this one.

Fig. 2.—Microcococcus vaccinae. Spherical bacteria, from poek-lymph in a state of growth aggregated in short four to eight-jointed straight or bent chains, and forming also irregular cell-masses.

Fig. 3.—Zoögliese-form of Micrococcus, pellicles or mucous strata characterized by granule-like closely set spherules.

Fig. 4.—Rosary chain (Torula form) of Micrococcus ureae, from the urine.

Fig. 5.—Rosary chain and yeast-like cell-masses from the white deposit of a solution of sugar of milk which had become sour.

Fig. 6.—Sacharomyces glutinis (Cryptococcus glutinis, Fersen), a pullulating yeast which forms beautiful rose-colored patches on cooked potatoes.

Fig. 7.—Sarcina spec, * from the blood of a healthy man. * * from the surface of a hen’s egg grown over with Micrococcus luteus, forming yellow patches.

Fig. 8.—Bacterium termo, free motile form.

Fig. 9.—Zoögliese-form of Bacterium termo.

Fig. 10.—Bacterium, pellicle, formed by rod-shaped bacteria arranged one against the other in a linear fashion, from the surface of sour beer.

Fig. 11.—Bacterium lineola, free motile form.

Fig. 12.—Zoögliese-form of B. lineola.

Fig. 13.—Motile filamentous Bacteria, with a spherical, or elliptical highly refringent “head,” perhaps developed from gonidia.

Fig. 14.—Bacillus subtilis, short cylinders, and longer, very flexible motile filaments, some of which are in process of division.

Fig. 15.—Bacillus ulna, single segments and longer threads, some breaking up into segments.

Fig. 16.—Vibrio rugula, single or in process of division.

Fig. 17.—Vibrio serpens, longer or shorter threads, some dividing into bits, at * two threads entwined.

Fig. 18.—“Swarm” of V. serpens, the threads felted.

Fig. 19.—Spirillum tenue, single and felted into “swarms.”

Fig. 20.—Spirillum undula.

Fig. 21.—Spirillum volutans, * two spirals twisted around one another.

Fig. 22.—Spirochetæ plicatilis.

All the figures were drawn by Dr. Ferdinand Cohn with the immersion lens No. ix, of Hartnack Ocular III. representing a magnifying power of 650 diameters.)
**KEY TO THE GENERA OF SCHIZOMYCETES.***

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1</td>
<td>Cells globular or oval</td>
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<td></td>
<td>— Cells short or long cylindrical</td>
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<tr>
<td></td>
<td>— Cells lancet like, flat, spirally wound</td>
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<td>2</td>
<td>Cells isolated or united in chains, or in formless masses imbedded in mucus</td>
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<td></td>
<td>— Cells united in very great number in regular colonies</td>
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<td></td>
<td>— Cells short cylindrical, single, in pairs, or a few more loosely joined</td>
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<tr>
<td></td>
<td>— Cells longer cylindrical joined in filaments</td>
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<tr>
<td>3</td>
<td>Colonies hollow, with a single peripheral layer of cells</td>
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<td></td>
<td>— Colonies solid, filled with cells throughout</td>
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<tr>
<td></td>
<td>— Cells united in small but fixed number in regular families</td>
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<td></td>
<td>— Cells united in unlimited number in irregular colonies</td>
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<td></td>
<td>— Cells short cylindrical, single, in pairs, or a few more loosely joined</td>
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<td>— Cells longer cylindrical joined in filaments</td>
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<tr>
<td>4</td>
<td>Filaments isolated or felted</td>
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<tr>
<td></td>
<td>— Filaments imbedded in globular jelly-masses</td>
<td>8</td>
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<tr>
<td></td>
<td>— Filaments with apparent branches</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>— Filaments spirally wound or curved</td>
<td>11</td>
</tr>
<tr>
<td>5</td>
<td>Filaments distinctly articulated, short</td>
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<td></td>
<td>— Filaments mostly indistinctly articulated, long</td>
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<tr>
<td></td>
<td>— Filaments very slender</td>
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<td></td>
<td>— Filaments thicker</td>
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<td></td>
<td>— Filaments short with few spirals or a single curve, rigid</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>— Filaments longer with numerous spirals, flexible</td>
<td>148</td>
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The Genera *Spharotilus* and *Crenothrix* may be found in the appendix. The *Sacharomycetes* have also been added.

**SYNOPSIS OF THE GENERA.**

**Micrococcus.**—Cells globular or oval-elliptical, motionless,† dividing only in one direction, isolated or united in chains or in zoogloea.

**Ascococcus.**—Cells globular, united in irregular families, which are often lobed and surrounded by a capsule of firm, cartilage-like jelly.

**Cohnia.**—Cells globular, imbedded in a single peripheral layer of jelly, which is spherical and hollow, or at a later stage irregularly bladder-form; the forms like nets are broken through.

**Sarcina.**—Cells globular, dividing in two or three directions; daughter cells small, united in solid or tabular families, mostly in fours, or some multiple of four.

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*Dr. Winter adheres to the opinion that the Fungi and Algæ are distinct classes of plants, and includes the bacteria among the former. For this reason the term *Schizomycetes* is chosen rather than *Schizophytes.*]

†i.e., having only “Brownian” movement—not swimming freely from place to place.]
Bacterium.—Cells short cylindrical, or long elliptical, or fusiform, with rapid movements; otherwise as in Micrococcus.

Bacillus.—Cells elongated cylindrical, mostly united in filaments dividing transversely; forming spores.

Leptothrix.—This doubtful genus is characterized by the very long, slender, unbranched and apparently unarticulated filaments.

Beggiatoa.—Filaments very long, rather thick, mostly indistinctly articulated, actively vibrating, containing highly refractive granules.

Cladothrix.—Filaments very slender, indistinctly articulated, pseudo-branched.

Myconostoc.—Filaments very slender, bent and twisted through each other, imbedded in globular, jelly-like masses.

Spirocheta.—Filaments long and very slender, with numerous close spirals; movements lively.

Spiromonas.—Cells flattened, spirally twisted.

Spirillum.—Cells cylindrical, with a single curve or spirally wound, mostly with a cilium at each end.

APPENDIX.

To the Schizomyces are appended the following allied genera whose systematic position is still doubtful:

Sphcerotilus.—Cells arranged end to end in a colorless, gelatinous sheath, forming long threads and flocks.

Crenothrix.—Cells united in filaments surrounded with a sheath.

SCHIZOMYCETES.

The Schizomyces or cleft-fungi are one-celled plants, which multiply by repeated division in one, two or all three directions of planes, and which also abundantly reproduce themselves by spores formed within the cells.

They live isolated or united in various ways, in fluids and in living and dead organisms, in which they induce decompositions and various—but not alcoholic—fermentations.

MICROCOCCUS, Cohn.

(Beiträge z. Biol. d. Pflanzen, I Bd. 2 Heft, p. 151.)

Cells colorless or slightly tinted, globular or oval-elliptical, motionless, dividing only in one direction. The daughter cells either soon separate from each other or remain in pairs or are united in chains or form zoogloea. Not certainly known to produce spores. [The molecular oscillations of these minute bodies must not be mistaken for spontaneous movements.]

The species of Micrococcus are not readily discriminated. The supposed distinct kinds show in form and size little or no differences and there remains only their chemical activities as the means of distinguishing them, which may be managed with considerable completeness.

A.—Pigment forming Micrococci.

M. Prodigiousus, Cohn.

Cells globular or oval, colorless, .00002 to .00004 in. in diameter; at first rose-red, then blood-red, finally growing pale; forming a slimy substance.

*Micrococcus prodigiosus* is the organism which, as known for some time, produces the singular phenomenon called in earlier times the blood of bread, the blood of the Host, etc. It forms at first minute rose-red points, and little heaps, which, becoming larger, form circumscribed, roundish, deep-red spots; afterward these spots run together and spread out, at the same time become dripping with a blood-red semi-fluid material. This consists of a red, gelatinous mass in which millions of cells of the *Micrococcus* are imbedded. The latter are colorless; they give out the pigment to the jelly. The coloring matter, in its chemical and physical characteristics, very much resembles fuchsia. It is insoluble in water, but completely soluble in alcohol, and this solution evaporated to dryness and again dissolved is orange-red. On the addition of acids it becomes bright-red; with alkalies yellow. In the spectroscope it shows with others a characteristic broad absorption band in the green. *Palmella mirifica*, Rabh., can scarcely be different.

**M. lutens**, Cohn.
Synonym: *Bacteridium luteum*, Schroeter (l. c. p. 119 und 120).
Exsiccatum: Thümen, Mycotheca Universalis, 1400.

Cells elliptical, a little larger than those of *M. prodigiosus*, with highly refractive contents; forming light-yellow drops on a solid substratum, at first the size of a poppy seed, later the half of a grain of pepper, and finally drying up into flat, shield-form, little bodies. This species forms, on the nourishing fluid, a thick yellow skin which becomes wrinkled if the development is luxuriant.

On boiled potatoes, etc.

The coloring matter is insoluble in water; it is not changed by sulphuric acid or alkalies.

**M. aurantiacus**, Cohn.
Synonym: *Bacteridium aurantiacum*, Schroeter (l. c. p. 119 und 120.)
Exsiccatum: Thümen, Mycotheca Universalis, 1700.

Cells oval, .00006 in. long; forming, on a solid substratum, orange-yellow drops and spots, which finally spread into a uniform coating; on nutritive fluid it forms a golden-yellow layer.

On boiled potatoes and eggs.

Coloring matter soluble in water.

**M. ulyus**, Cohn.
Exsiccatum: Rabenhorst, Algae Europææ, 2501.

Cells globular, .00006 in. in diameter; at first forming rust-red conical little drops .02 in. in diameter, these enlarge and finally appear as a broad mass of slime.

On horse-dung.

**M. chlorinus**, Cohn.

Cells globular (?); forming golden or verdigris-green slime masses, or a verdigris-green layer on fluids which gradually becomes colored throughout.

On boiled eggs.

The coloring matter is soluble in water; it does not turn red with acids.
**M. cyaneus**, Cohn.

Synonym: *Bacteridium cyaneum*, Schroeter (l. c. 122, und, 126).

Cells elliptical, producing on slices of potato an intense blue coloration which also penetrates the substance and even shows on the opposite side of the slice. On nutritive fluids zooglaea are formed which are at first colorless, then bluish-green and finally an intense blue.

On boiled potatoes.

The coloring matter is soluble in water; the solution is at first verdigris-green, afterwards as a rule pure blue. It is made by acids an intense carmine-red and changed again by alkalies to blue or gall-green. In the spectroscope it shows no absorption-line but only a darkening of the less refractive parts.

**M. violaceus**, Cohn.


Cells elliptical, larger than those of *M. prodigiosus*, in little bright violet-blue drops of slime which enlarge (to one-fourth of an inch in diameter) and run together into spots.

On boiled potatoes.

**B. — Micrococci producing fermentations.**

**M. urese**, Cohn.

Cells globular or oval, .00005 to .00008 in. in diameter, isolated or united in chains, or forming zooglaea on the surface of liquids. In urine.

*Micrococcus ureæ* is the ammoniacal ferment. When fresh urine is allowed to stand at a proper temperature 30° C., it loses in a few days its acid reaction, becomes neutral and finally alkaline, showing signs of fermentation. The urea is changed into ammonium carbonate, while at the same time ammonio-magnesium phosphate is precipitated. This fermentation follows only when the Micrococcus is developed in the liquid.

**M. crepuscum**, Cohn.

Synonym: *Monus crepusculum*, Ehrb. (Infus, p. 6, t. I, Fig. 1). Exsiccat: Babenhorst, Algen Europa's, 2502.

Cells globular or short-oval, very small, scarcely .00008 in. in diameter, isolated or forming zooglaea.

In and on various infusions and foul liquids.

This common Micrococcus appears with *Bacterium termo* in all foul substances and infusions.

**M. candidus**, Cohn.

Forms on slices of boiled potato snow-white points and spots.

**[M. of nitrates.]**

Schloesing and Muntz have communicated to the French Academy of Science the results of studies on the formation of nitrates in ordinary soil, and they prove that a minute, globular, or slightly elongated organism, is the cause of the phenomenon so common in nature, and of such vital importance in the fertility of the soil. (Comp. Rendus, T. 89, pp. 891 and 1104). More recently, Gayon and Dupetit have shown that these same nitrates are decomposed by another *Micrococcus*, possibly *M. ureæ*. (l. c. T. 96, p. 544.)

**C. — Disease producing Micrococci.**

**M. Vaccinae**, Cohn.

Synonym: *Microsphaera vaccinae*, Cohn (Virchow's Archiv. IV.)

Cells globular .00002 to .00003 in. in diameter, isolated or in pairs or united in chains or masses, or forming zooglaea.
In fresh lymph of vaccine vesicles of the cow, and of man, as well as in the pock-postules of variola (small pox.)

Micrococcus vaccinae must be accepted, after the many reliable investigations, as the effective element in vaccine virus. It is the carrier of the contagion of small pox. By filtering the lymph the solid constituent can be separated from the fluid. When the latter is used for inoculation no effect is produced, while the former induces the formation of the pock-vesicles. But that the micrococci and not the lymph cells are the active constituent of the solid residue appears from the fact that when vaccine virus is exposed to the air for a time it becomes less and less effective. Such virus finally putrefies, and with the increase of putrefaction the micrococci correspondingly disappear, displaced by rot-producing Bacteria.

M. diphtheriticus, Cohn.

Cells oval .000013 to .000004 in. long, single or united in chains or forming variously-shaped masses and colonies.

In the so-called diphtheritic membrane found especially on the mucus surfaces of the throat, pharynx, windpipe, etc., but also of those of the sexual and digestive organs, as well as in wounds, etc.

This organism is of very great pathological importance: for the infection spreads from its place of origin through the lymph vessels and their enclosing tissue, later into the connective tissue, the kidneys, the muscles, and finally the organisms gain entrance to the blood vessels, where they cause the greatest disturbances. They plug the capillaries and cause them to burst. The thinner bones and cartilage are destroyed through this same process. The contagious properties of the fungus is also very great.

M. septicus, Cohn.

Synonym: Microsporon septicum, Klebs. (zur. patholog. Anat. der Schusswunden, 1872.)

Cells globular .00002 in. in diameter, united in chains or masses or forming zoogloea.

In wounds; generally with all the kinds of disease known as Pyämia and Septicemia.

In the various states of suppurating and putrefying in the living body, in blood-fermentation and blood-poison, this micrococci plays an active part. Whether all the manifold phenomena are called forth by micrococcus septicus or more kinds take part, is questionable. In wounds we find the micrococci in the fresh pus, in which they multiply rapidly and bring on inflammation and fever, destroying the tissues and penetrating deeper and deeper. They gain entrance to the blood vessels and cause obstructions and festering; similar phenomena occur in the lungs and liver.

[M. bombycis, Cohn.

Synonym: Microzyma bombycis, Bechamp (Comptes Rendus, tome 64, 1867, p. 1945.) Exsiccata, Umlant w.; Thumen Mycotheca Universalis 1799.

Cells oval .00002 in. in diameter, single or in chains.

In the gastric juice and intestines of silk-worms, producing in them the so-called "Schlaufsucht" [pébrine], an infectious disease from which the animal after a short time dies.

There are probably many other infectious diseases, as cholera, measles, scarlattina, typhus fever, etc., which are due to Bacteria. Reliable observations are wanting upon them.

[M. of traumatic erysipelas.

This disease has been abundantly proved to be contagious and in many cases very virulently so. There have also been very numerous observations upon the existence of globular organisms in the excretions, but it has not been known until recently whether these living things were active agents in, or merely accompaniments of, the disease. The investigations of Orth, Becklinghausen and Lukomsky, corroborated by Koch and others, seem to demonstrate the fact that a Micrococcus is the real cause of the occurring pathological changes and the active element in the contagion. Puerperal fever is probably due to the same organism.

This Micrococcus is described as globular, isolated or in chains, without motion.]
M. of croupous pneumonia.

Many investigators agree in finding minute organisms in the excretions of inflamed tissues affected with this disease. Friedlander of Berlin has recently (1882) made careful researches, which seem to establish the fact that the living organisms exist and multiply within the tissues and blood vessels and not simply in the exudations. The description is as follows: Cells ellipsoidal, .000024 in. wide, .00004 in. long, usually in pairs, sometimes in chains or spread out in a film, aggregated in colonies in the lymphatic vessels. Lancet (London) March 4, 1882.

[M. amylovorus, Burrill.]

Cells oval, single or united in pairs, rarely in fours, never in elongated chains, imbedded in an abundant mucilage which is very soluble in water; movements oscillatory; length of a separate cell .00034 to .00056 in.; width, .000028 in.; length of a pair .00008 in.; of four united about .000012 in.

The cause of "blight" in plants, especially of the pear tree (fire blight) and of the apple tree (twig blight and sun scald.) The organism gains entrance to the living tissues through wounds or punctures and produces butyric fermentation of the starch stored in the cells. The disease is transmissible by artificial inoculation. (Tenth Report Illinois Industrial University. Transactions American Association for the Advancement of Science, 1880.)

[M. suis, (Detmers) Burrill.]

Cells globular, or elongated and more or less contracted in the middle, single or in pairs or chains of many articles; .000028 to .000032 in. in diameter (Detmers).

Found in the blood and other fluids of pigs suffering with swine plague or "hog cholera." Dr. Detmers at first classed this organism with the Bacilli and named it Bacillus suis. But Detmers, Meguin and Salmon essentially agree in giving the characteristics of Micrococcus, and with this some observations of the author accord. Detmers describes a peculiar contraction of the middle portion of elongated forms rendering the sides concave, and in this condition he finds them in zoogloea and in chains. Others, according to the same authority, as well as Meguin and Salmon, are spherical. It seems well established that the Micrococcus is the real contagious element in the disease. (Annual Reports United States Department Agriculture 1870-80.)

[M. toxicus, Burrill.]

Cells globular, single and in pairs, rarely in chains of several articles; .00002 in. in diameter; movement oscillatory only.

Apparently parasitic on species of Rhus, and constituting the poisonous principle in these plants. Reaching the human skin, the organisms penetrate in some way its tissues, and multiplying there induce the peculiar inflammation which takes place. (Some Vegetable Poisons. Trans. American Association for Advancing Science, 1882. Am. Mic. Journal, October 1882, p. 192.)

[M. isectorum, Burrill.]

Cell obtusely oval, isolated or in pairs, rarely in chains of several articles; .000022 in. wide and .000027 to .00004 in. long, usually about .000032 long; movements oscillatory only; forming zoogloea (?). In the digestive organs of chinch bugs (Blissus leucopterus).

Professor S. A. Forbes discovered this minute organism, in 1882, infesting the intestines of chinch-bugs, which evidently suffered thereby (S. A. Forbes, American Naturalist, Oct. 1882.) Very many of the insects, especially the older ones, were found to harbor the parasite in great numbers, and at certain times very many of the bugs were found dead and dying before reaching maturity. It is well known that these pests of the grain fields do perish at certain periods by some epidemic disease, from which few individuals escape, and there is every reason to believe that the organism found by Professor Forbes causes the destruction. He finds it can be successfully cultivated in beef-broth, and the possibility is thus apparently within reach of artificially introducing and spreading the disease. If so, a most important step has been made in economical entomology and scientific agriculture.

The organism is somewhat similar to, but not identical with, Micrococcus bombycis, the "disease germ" of the silk worm, which was so fatally destructive to the silk industries of France, and which became the subject of the successful studies of Pasteur.
On the stems and leaf-sheaths of maize injured by the bugs a *Micrococcus*, supposed to be the same, was found imbedded in firm zoogloea masses.

The form of the organism approaches the typical shape of *Bacterium*, being between oval and short cylindrical, with rounded ends; otherwise the characteristics are those of a true *Micrococcus*.

(M. of fowl cholera.)

While all who have carefully studied this disease agree that the contagious element consists of minute globular granules, capable of self-multiplication, it appears that no one has either named the organism or given a scientific description of it. Toussaint (Compt. Rend. xxi. 1889, p. 301) supposed he had sufficient proof of the identity of this disease of the domestic fowl and septicaemia, or blood-poisoning, and that in both cases the living organism believed to be the active agent, is the same. But Pasteur (L. c. p. 457) pronounces them similar in appearance but quite distinct in effect. Salmon (Report Dept. Agriculture U. S.) 1888, p. 401) confirms the infectious nature of the disease, and the virulence of the multiplying granules, but is inclined to attribute their origin to the transformations of the animal protoplasma (p. 439.) There can scarcely be a doubt but that the so-called granules constitute a true species of the present genus. It may be called *Micrococcus gallicidus*.

Doubtful Species.

**M. griseus**, Winter.

*Synonym: Bacterium griseum*, Warming.

Cells nearly globular or oval, colorless; 0.0010 to 0.0016 in. long, with those dividing 0.00024 to 0.00028 in. long, 0.000072 to 0.0010 inches wide.

In infusions of fresh and salt water.

Since according to Warming this form appears only in the motionless state, (and then forms no zoogloea) and since the shape of its cells corresponds better to the genus *Micrococcus* than to *Bacterium*, I have placed the fungus in the former genus.

**M. ovatus**, Winter.

*Synonyms: Panhistophyton ovatum*, Lebert. (Ueber die gegenwartig herrschenden Krankheit des Insect der Seide in; Jahresbericht ueber die Wirksamkeit des Vereins zur Beforderung des Seidenbaues fur die Provinz Brandenburg im Jahre 1856-57, p. 28 und folgde.)


Cells oval, twice as long as wide, rounded at the ends; 0.0016 to 0.0002 in. seldom 0.0024 in. long, 0.00008 to 0.00012 in. (mostly 0.00010 in.) thick, isolated in pairs or united in little masses.

In various organs of the silk-worms, their pupae, and winged forms.

It is questionable whether the described cells belong to the *Schizomycetes*. They were first discovered by Cornalia in Mailand and designated corpuscles; according to him they are also found, though very scarce and more incidentally, in the blood of healthy caterpillars. Later these small bodies have been recognized as the cause of the epidemic disease of the silk-worm known as "gattine."

As the cells in shape and want of motion agree very well with *Micrococcus*, I have introduced them here.

[The eight following, by Hallier, are given without much confidence in the correctness of his observations and interpretations. These are taken from Magnin's "Bacteria."]

**M. of animal variola**, Hallier.

Small, endowed with lively movement, furnished with a very delicate appendage, sometimes united in the form of little elongated rods; found in spontaneous or inoculated pustules, in the lymphatic canals and the ganglia of animals attacked with variola.

**M. of rugeola**, Hallier.

Very small, without color, often with a caudal prolongment; in the sputa and blood of the sick.
M. of scarlatina, Hallier.

Free or in colonies, either on the surface or in the interior of blood corpuscles, or in chains.

M. of epidemic diarrhoea, Hallier.

In intestinal matters with vibrios, cells and monads.

M. of exanthematous typhus, Hallier.

Relatively large brown, endowed with rapid movement, sometimes in chains, in the blood.

M. of intestinal typhus, Hallier.

Very small, without movement in the blood; larger forms with quick movements, furnished with contractile appendages; in dejections. Similar Micrococci are found in cholera diarrhoea, but in less number.

M. of glanders, Zürn.

Cells free or adhering to the blood corpuscles, or even penetrating in their interior; sometimes in chains; in the blood. Very numerous, endowed with rapid movement; in the lymphatic ganglia, in the mucus of the frontal sinus and in chancroid ulcers.

M. of syphilis, Hallier.

Numerous, colorless, free or in globules; in gonorrhoea, the primitive ulcer, and in the blood of subjects with constitutional syphilis.

ASCOCOCUS, COHN.

(Beitr. z. Biol. I, Bd. 3, Heft, p. 154.)

Cells colorless, very small, globular, united in larger or smaller globular or irregular families in shapeless masses. Families often lobed, the lobes again incised, inclosed in a firm cartilage-like gelatinous capsule of rounded form.

The value of Cohn's genus Ascococcus is to me as questionable as that of Billroth's genus of that name; it is also doubtful whether the two are identical. Possibly Ascococcus is only a stage of development of Micrococcus.

A. Billrothii, Cohn.

Families lump-like, .00080 to .00640 in. in diameter, inclosed in a capsule from .00004 to .00060 in. thick; covering the surface of the liquid in a thick, flaky layer.

On a solution of acid ammonium tartrate, forming a pellicle.

The colonies consist of a sharply defined cartilage-like gelatinous envelope, in which either one or more families are inclosed. The families are of very different size and shape, solid, composed of numerous, exceedingly minute, globular cells. This fungus induces in its nourishing fluid singular fermentations. It produces of ammonium tartrate, butyric acid and butyric ether, and changes the originally acid solution to alkaline while free ammonia is given off.
COHNIA, WINTER.

Synonym: Clathrocystis (Henfry), Cohn (Rabenhorst's Algen Europas, No. 2318).

Cells globular; inclosed in a single, peripheral layer of jelly, forming a spherical, or later an irregularly shaped bladder or sack, the walls of which finally break up in a net-form manner. Increase takes place by repeated separation of the cells in twos; of the families through the folding in and lobing of the daughter families.

The genus Clathrocystis, Cohn, is removed according to my idea of the distinction between the Algae and Fungi. Since this generic name was primarily adopted for an alga (Cl. aeruginosa, Henfry) it is advisable to retain the name for it and to make this species belonging to the Fungi the representative of a new genus, to which I have given the name Cohnia, in honor of Dr. F. Cohn, of Breslaw, highly merited for his investigations upon the Schizomycetes.

C. roseo-persicina, Winter.


Exsiccate: Rabh. Algen Sachsens, etc., 986 und 2318; Wartmann und Schenk, Schweiz Kryptog, 343.

Cells globular, oval, or through mutual pressure, polygonal; from rose to purple-red; .00010 in. in diameter. They form at the beginning little solid families in which the single cells are joined by gelatine, while the whole family is inclosed in a gelatinous envelope. Later, there forms a larger, globular or oval, finally irregular, hollow body, attaining a diameter .02640 in., and filled with a watery liquid. In this the cells are arranged in a single peripheral layer. These bladders are often torn or perforated, becoming elegant nets, which finally break up into irregular patches and shreds.

In swamps, swimming on the surface or among algae and duckweeds; often also in aquaria, in which algae, etc., are decomposing.

The only species of this genus, so far known, is remarkable for its red coloring matter which is essentially different from that of Micrococcus prodigiosus, and is known as "bacterio-purpurin." This is insoluble in water, alcohol, etc., is changed by hot alcohol into a brown substance, and is otherwise characteristic by its optical deportment. It shows through the spectroscope the same strong absorption band in the yellow; weaker ones in the green and blue, as well as the darkening of the more refrangible half of the spectrum. The single cell is surrounded by a firm, almost cartilaginous membrane; their contents are, when young, homogeneous, but when older there appears within, one or more opaque granules, which are none other than metallic sulphur.

SARCINA, Goodsir, (Extended).

Cells globular, dividing in two or three planes; daughter cells a long time united, forming little solid or tabular families, which are often again united into larger colonies. As a rule, the families consist of four, or some multiple of four cells.

S. ventriculi, Goodsir.

Synonyms: Merismopedia Goodsirii, Husem (de anim. et veg., p. 13). M. ventriculi, Robin (Hist. des Veget. paras., p. 331, T. I, Fig. 8, et T. XII, Fig. 1).

Cells globular, four, eight, sixteen or a few more united into little cubes with rounded corners—the parts in contact flattened; cells of the colony attaining a diameter of .00016 in.; colonies strung together by the partition walls of the cells; again united into larger masses. Cell contents greenish, yellowish or reddish-brown, somewhat polished.

In the stomach of healthy and diseased man and higher animals; also sometime occurring in other parts of the body.

**S. urinæ**, Weleker.

**Synonym:** Merismopedia urinæ, Rabh. (Flora Europ. Alg. II, p. 59).

Cells very small, .00004 to .00008 in. in diameter, eight to sixty-four united in a family; eight united cells .00008 to .00012 in., sixty-four cells .00016 to .00020 in. in diameter.

In the bladder.

**S. littoralis**, Winter.

**Synonyms:** Erythroconis litoralis, Oersted; Merismopedia litoralis, Rabh. (Flora Europ. Alg. II, p. 57).

Cells globular or, when ready to divide, oval; .000042 in., seldom .00006 in. or more in diameter; united in families of four, six, eight, etc., which are again grouped in larger colonies (as many as sixty-four 4-parted cells). Cell contents colorless, but there is in each cell one to four red granules of sulphur.

In putrid sea-water.

**S. Reitenbachii**, Winter.

**Synonym:** Merismopedia Reitenbachii, Caspary (Schriften der physikal, ökon, Gefellschaft zu Königsberg, XV, 1874, p. 184, T. II, Fig. 7 to 15).

Cells globular, or when ready to divide, oval or elliptical, .00006 to .00010 in diameter, dividing ones attaining .00016 in. long; rarely single or in twos or threes, usually four or eight, or more often sixteen or more united. Cell wall colorless, with the forming wall-borders rose-red.

On the submerged parts of aquatic plants and dead sticks, and swimming free in fresh water.

The families consist at most of thirty-two cells; those of eight globular cells measure .00040 in. long, .000175 in. wide; tabular families of eight cells .00026 in. long, and .000175 in. wide, while those of sixteen cells are .00066 long and .00043 wide.

Probably also *Merismopedia vialacea* (Breb.) Kützing. (Spec. Alg. p. 472, und Tabul. phyc. v. T. 38, Fig. 7; Rabenhorst Flora Europ. Alg. II, p. 57) belongs to the Fungi. This agrees in its large size nearly with *Sarcina Reitenbachii*, yet differs on account of the color, especially as not rarely one hundred and twenty-eight cells are united in a family. Very similar, but hitherto perhaps only found in Sweden, is *Merismopedia chondroidesium*, Wittr. (Wittr et Nordstedt, Algæ Exsiccata, 200).

**S. hyalina**, Winter.

**Synonym:** Merismopedia hyalina, Kütz.

Cells globular, almost colorless, .00006 in. in diameter; families mostly of four to twenty-four (rarely more) united cells, attaining .00060 in. in diameter.

In swamps.
Sarcina renis. Henworth (Mic. Jour., v. 1857, p. 1, pl. 1, Fig. 2), is bright-green; it shows little connection with the species of this genus, therefore I shall only mention it.

Besides the foregoing species of Sarcina there are those hitherto classed as fungi on various substrata; on boiled potatoes (in little chrome yellow masses,) on cooked white of egg (bright yellow spots), also in solutions, and even in the blood of healthy and diseased human beings. Compare Cohn’s Beitr. zur Biologie I, Bd. 2, p. 139.

BACTERIUM, Cohn.

Cells short-cylindrical, long-elliptical or fusiform; increasing by transverse division; having the power of moving spontaneously. The daughter cells separate soon after the division or remain attached in pairs or in a greater number forming a chain; frequently forming zoogloeae; formation of spores similar to that of Bacillus.

[Aside from their shape the species of this genus mainly differ from those of Micrococcus in their power of movement. While the latter oscillate and tip and turn in the suspending fluid, but make no advance, the former freely move from place to place. Of these the motion is of every kind; rolling, spinning, turning end over end, swaying as if attacked at one end by an invisible thread, quivering without change of place, sailing steadily and stately, darting like a flash, whirling, bobbing, dancing—a maze and labyrinth of movement. But these active motions are observed only when the organisms are in a rich nutritive fluid and are supplied with free oxygen. The zoogloeae differ from those of Micrococcus in having a firmer and more abundant intercellular substance.]

B. termo, Dujard.

Synonyms: Monas termo, Muller (Infus. T. I, Fig. 1—non Ehrb.; (? ) Palmella infusionum, Ehrb. (Inf. p. 526). Zoogloea termo, Cohn (Nova Acta Acad. Caes. Leop. Carol. XXIV, Bd. 1, p. 125, T. 13, Fig. 9).

Exsicciata: Thümen Mycotheca Universalis, 1000.

Cells short-cylindrical, oblong; .00006 to .00008 in. long [.00008 to .00012 in. long, .000025 to .00012 in. wide, Magnin]; furnished at each end with a cilium.

In all putrescible substances, especially water in which meat is macerated.

Bacterium termo is the ferment of putrefaction; it produces putrefaction of organic substances, and rapidly multiplies itself as long as the substances capable of putrefaction are present, while it disappears as soon as the decomposition is ended. It is certainly obtained when a piece of meat is put into water in a vessel left open and allowed to stand in a warm place. The reproductive power is so enormous that the bacteria cells reaching the liquid through the air, or as attached to the meat, have, in a short time, so great a progeny that in twenty-four hours the water has a conspicuous milky appearance, caused by the swimming fungi. That the Bacterium is the cause, and not simply an accompaniment of the putrefaction, is made apparent by a simple experiment. Putrefaction begins as soon as air is allowed to freely pass to a putrescible substance, because the air always contains a number of the bacterium cells. But when the putrescible substance is heated over 90° Cent., and the air excluded, it does not ferment. It can be objected that the air, or the oxygen of the same, causes the putrefaction, but this can be readily refuted. Air filtered through cotton-wool, and thus freed from the bacterium cells, can easily be passed to a putrescible liquid which has been highly heated; in this case no putrefaction takes place.

B. lineola, Cohn.


Cells similar to those of Bacterium termo, but larger; .00012 to .00015 in. long by .00006 in. wide; with two cilia at one end.

In various infusions without producing a special fermentation.
Takes the form of zoogloea in which the rods are motionless. Its protoplasm is often studded with dark granules. This is the only statement known to the translator concerning the two cilia, and his own observations have failed to confirm it.

**B. litoreum**, Warming.

Cells ellipsoidal or elongated, usually rounded at the ends, .00008 to .00024 in. long, .00005 to .00010 in. wide; colorless; motile or still, but never united in chains or zoogloea, nor in large masses.

**B. fusiforme**, Warming.

Cells fusiform with sharpened ends .00008 to .00020 in. long, .00302 to .00003 in. wide.

In a loose layer on the surface of sea water.

**B. navicula**, Reinke and Berthold. (Die zetsetzung der Kartoffel durch Pilze, p. 21, T. VII., Fig. 10.)

Cells fusiform or elliptic, diminished at each end; rather large; motile or at rest; having within one or more opaque granules which are colored blue with iodine.

In moist-rotting potato.

**B. synxanthum**, Schroeter.


Not different in form from *Bacterium termo*; .00003 to .00004 in. long; motions lively; single or as many as five united in a chain.

Causing the so-called yellow milk.

Boiled milk becoming after a time coagulated often suddenly turns citron-yellow; the casein gradually disappears until very little remains. The milk, at first neutral becomes sour, then intensely alkaline. The filtered citron-yellow liquid becomes by evaporation amber-yellow; the resulting yellow-brown crust is insoluble in alcohol and ether, but entirely soluble in water. Alkalies do not change its color, while acids cause instant decolorization.

**B. syneycyanum**, Schroeter.


Like the preceding in form.

Producing "blue milk."

The coloring matter is changed by alkalies to peach or blood red, while acids restore the original color. Ammonia, in turn, only changes the blue to a violet tint.

**B. azyruginosum**, Schroeter.

In the so-called green (or blue) pus sometimes found in wounds, etc.

The cells themselves are also colorless in this case; they impart the verdigris-green often changing into blue) coloring matter to the surrounding medium.

**B. punctum**, Ehrb.

Cells elongated, ovoid, colorless, often in pairs; movements slow and oscillating; length .00021 in., thickness .00007 in.

In infusions of animal substances.
**B. catenula**, Duj.

Cells cylindrical filiform, often three, four or five united; length .00012 to .00016 in., thickness .00002 in.

In fetid infusions and in typhoid fever (Coze and Feltz.)

This and the preceding are taken (translated from the French) from Magnin’s work on *Bacteria*; but they are put down as doubtful species. They seem from the shape of the cells to belong rather to *Bacillus*.

The four following, also copied from Magnin, are said by him to require further study, though apparently species of *Bacterium*:

**Vibrio lactic**, Pasteur.

Cells almost globular, very short, a little swollen at the extremities; length .000064 in. in a series; .00200 in. long.

Develops, according to Pasteur, in sweet liquids, in which it causes the formation of acetic acid and in milk the coagulation of the casein. According to other researches the coagulation of the casein is influenced by a soluble (zymase), and not an organized, ferment.

**Mycoderma aceti**, Pasteur.

Synonym: *Ulina aceti*, Ktg.

Exsiccatum: Thümen Mycotheca Universalis 1599.

Cells short, narrowed in the middle, often united in long chains, forming a pellicle on the surface of liquids; length of a cell .00008 in., which is two or three times the width.

This species is thus very near the preceding; it should not be confounded with *Mycoderma vini*, which may develop in the same liquids, but which belongs to the *Saccharomyces*.

**Vibrio tartaric right**, Pasteur.

Cells globular, short, .00004 in., united in chains about .00200 in. long; similar to the preceding.

Decomposes racemic acid, causing right tartaric acid to disappear, and liberating left tartaric acid.

The acid fermentation of beer.

Cohn thinks this is due to a *Bacterium* similar to *B. termo*, but a little larger. He has found it with oval *Saccharomyces* in acid beer—elliptical *Bacteria* endowed with motion, often united in pairs, rarely in fours.

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**BACILLUS**, Cohn.


Cells elongated cylindrical, almost always attached together in straight rod-like (stielrunden) rows or threads (not or little interlaced); multiplying by transverse division. They form zoogloea, but often also occur united in thick swarms without gelatinous secretion. Propagation by spores.

The genus *Bacillus* is closely related to *Bacterium*; especially is *Bacterium lineola* with united cells very similar to *Bacillus* rods. Yet there is this difference, that in the longer *Bacterium* cells the appearance of dividing is perceptible, while in the *Bacillus* cells of equal length it is not.

Some of the species are always motionless, some are spontaneously motile, but go into a resting condition. The rod-like cells elongate by intercalary growth to about double the typical length, and then divide by a transverse partition into two daughter cells, which often separate from each other, but often also remain attached. When the products of repeated division continue joined together filaments are produced, which are zigzag or...
straight, apparently jointless, but the cells become apparent by the use of coloring matters. In the formation of spores the greater part of the cell-contents collects in one place of the rod, which often swells at the point, and the protoplasmic contents becomes sharply defined from that of the rest of the cell. Later, this highly refractive, dark-appearing body (the spore) separates from the sterile part of the cell, and falls to the ground; the ripened spore continues to remain apart. These spores possess the ability to endure unfavourable influences of various kinds, without detriment to their vitality. They can remain a long time in the soil, often many years, before beginning to grow, but also have the power to germinate at once. In germination, the spore first loses its polished appearance and swells a little; the cell-wall then splits around the middle of the spore. Through the opening thus made the spore protrudes by the arching of its substance, and grows into a new rod, to the base of which the old cell wall of the spore adheres, and is often thrown off only at a late period.

The determination of the different species is also here very difficult.

**B. subtilis**, Cohn.

Synonym: *Vibrio subtilis*, Ehrlb. (Inf. p. 89, No. 91. T. V., Fig. 6).
Exsiccata: Thümen Mycotheca Universalis, 1200.

Cells cylindrical, about twice as long as thick, attaining .00024 in. long; bearing a cilium at each end. Mostly several cells, joined into apparent filaments which are motile, flexible and are furnished at each end with a cilium. The spore-forming cells are three to four times as long as thick, isolated or united in filaments. The spores are usually somewhat greater in diameter than the rods.

In different infusions and substances—very probably in the rennet stomach of living ruminants. According to Cohn, the producer of butyric fermentation, and also the active principle in the ripening of cheese.

The extraordinarily great power of resistance of the spores of *Bacillus subtilis* and the other species is a peculiar property. They are not killed by boiling, but made to germinate very quickly, though the duration of the boiling must of course be considered. Fifteen minutes boiling does them absolutely no harm, while most are killed after one hour and all after two hours' boiling. They are insensible to poisons and weak acids.

**B. tremulus**, Koch.

Very similar to the preceding but more slender and mostly shorter, always with a cilium at each end. Spores plainly thicker than the cells, often arranged in lines.

On the surface of foul vegetable infusions, forming a thick slimy layer.

**B. amylobacter**, Van Tieghem.

Synonym: *Closteridium butyricum*, Praz.
Exsiccata: Thümen Mycotheca Universalis, 1800.

Morphologically similar to *Bacillus subtilis*, but distinguished by the fact that at certain times it contains starch in its cell-contents as can be easily proved by the addition of iodine.

In the cells of plants having milk-sap, in foul vegetable infusions, etc.

According to Van Tieghem's first communication this species is the producer of cellulose fermentation. Later *Bacillus amylobacter* (not *B. subtilis*) was pointed out by him and Prazmowski. (Botan. Zeitung, 1879, No. 36) as the cause of butyric acid fermentation (*Vibrio butyricus*, Pasteur). According to Prazmowski, *B. amylobacter* is distinguished especially and essentially from *B. subtilis* in the manner of the germination of the spores. In the first species the germinal tube does not appear at the equator, but at one end of the spore. But to found a new genus upon this, as proposed by Prazmowski, does not seem to me advisable.

[Trecul has held that this organism originates within the closed cells of plants by a direct transformation of the protoplasm, an idea combatted by Van Tieghem. (Comptes Rendus, t. 88, p. 238; t. 64, pp. 136 and 436; t. 65, p. 513)].
B. ulna, Cohn.

Filaments thicker than in Bacillus subtilis, somewhat flexible, with dense, finely granular protoplasm. A single cell attaining .00040 in. length, .00098 in. wide. Spores oblong cylindrical.

In various infusions, for example in the white of egg.

Appears to be scarcely different from Bacillus subtilis; intermediate forms between them have been observed.

B. anthracis, Cohn.

Exsiccate: Thümen Universalis, 1499.

Very similar to Bacillus subtilis, but motionless and without cilia; cells .00016 in. long and longer, very slender, mostly extended; often united in crooked filaments. Spores not, or but little thicker than the threads.

In the blood of animals which have died with splenic fever (Anthrax, Miltzbrand); the cause of splenic fever in cattle, sheep, etc., and malignant pustule in man.

Bacillus anthracis and the disease symptoms caused by the organisms are, among all pathological processes induced by Schizomycetes, the most accurately investigated. The Bacilli are found without exception in the blood of animals dead from splenic fever and the proof has now been sought and found that they are the cause of the disease. So long as only the vegetative rods were known it was difficult to gain this evidence; for these retain their vitality only a comparatively short time and blood containing only these soon loses its power of infection. The remarkable thing about splenic fever is that it often occurs very suddenly in a region, then disappears for a long time to reappear just as unexpectedly, without any transmission having been allowed. From this fact it is to be inferred that the contagion can retain its virulence a long time. The discovery of the spores of Bacillus anthracis, which form only in the blood of dead animals or when the blood of animals sick with splenic fever has been a long time dried, explains this power of long duration. For as the spores of Bacillus anthracis possess a great power of resistance to outside influences, especially dryness, they are capable of developing after many years. They are often produced within the buried bodies of animals dying with the disease, and from these they may be diffused in various ways. Then if in any manner they reach the bodies and gain entrance to the blood of cattle, etc., they germinate, reproducing the rods which multiply richly and soon begin their destructive activity.

Recent investigations (1881-1882) have added further information upon and new interest to this species. It seems well established that Bacillus subtilis may, by graded cultivation, be physiologically changed, so that it is capable of developing in the blood of living animals and thus become the cause of disease; but such changes do not take place suddenly and seldom occur in nature, though the possibility of the latter may explain what has hitherto been mysterious and perplexing. But by far greater scientific and practical interest is attached to the results of modifications through artificial cultivation of Bacillus anthracis itself. By cultivating the deadly organism in well aerated chicken or other broth at a certain temperature, the virulence of its physiological effects is gradually lost, but may be restored after several generations by equally feasible methods. The practical importance of this is at once seen to be very great when it is further made known that the organism modified by habit to a harmless condition constitutes a protective virus which, after inoculation, relieves the animal from danger however exposed to the Bacillus in its malignant state. Some account of this has been given on a preceding page, and the matter has been widely published in recent periodical literature. No greater contribution has ever been made to pathological and medicinal knowledge, and the good results already attained open boundless anticipations of mastery over other ills that flesh is heir to. Pasteur supposed he had conclusive proof that the spores buried with dead animals retained their vitality during ten or more years, but the changes now known possible in other species renders the evidence less valuable.

B. ruber, Frank and Cohn.

Exsiccate: Rabenhorst, Algen 2441.

Rods .00024 to .00032 in. long, scarcely .00004 in. thick, actively moving, isolated or united in twos or fours. Rods (cells) just divided sometimes shorter, only .00012 to .00016 in. long. Imparting a brick-red pigment, different from that of Micrococcus prodigiosus. On boiled rice.
**B. erythrosporus, Cohn.**

Motile, short, slender rods, forming sometimes longer filaments in which originate numerous, oblong-oval, highly polished, dirty-red spores.

On solutions of beef extract, putrid infusions of white of egg and of meat.

This species forms in part little swimming scales, in part a continuous pellicle; the filaments at length decompose into a gelatinous mass whereby the spores are liberated, which now united in little gelatinous masses sink to the bottom. The species is easily recognized by the dirty-red color of the spores.

**B. of tuberculosis.**

Cells very slender, cylindrical, about .00002 in. wide, .00010 to .00012 in. long, isolated or in chains of a few articles; motionless; sometimes containing spores which, from their size, cause slight fusiform swellings of the containing cell.

That this dreaded scourge of the human family as well as of the higher animals is infectious has of late been repeatedly shown, and the most careful search has been made for the organism which, from analogy, was supposed to constitute the *materies morbi*. After many failures on the part of numerous investigators, Dr. R. Koch, of Berlin, succeeded, by a special method of preparation, in discovering the minute species characterized above. In order to see the Bacillus it is first stained as follows: Smear a cover glass with the tuberculous matter (spuTa or a small portion of tubercle), dry over a lamp; float the smeared cover several hours (24) on a concentrated alcoholic solution of methylene-blue 1 part, a ten per cent. solution of potash 2 parts, distilled water 200 parts; wash, and treat with a few drops of aqueous solution of vesuvin. The Bacilli retain the blue, while the rest of the material does not. Now that we know what to look for, the organisms can be seen without staining, but they are very indistinct. The common violet stain of the accompanying material somewhat aids—the Bacilli showing white.

Abundant experiments by Koch and others, have shown that these Bacilli are the true agents in the wasteful processes of the disease—the real cause of consumption in man and animals. It is also demonstrated that they do not develop in nature outside of the living body, hence that the disease is only communicated from the diseased: and, further, that the supposed hereditary peculiarities consist simply and only in the organic inability to resist infection. The children of consumptive parents may remain healthy if kept away from diseased individuals and their excretions.

**B. lepra, Hansen.**

Cells slender, elongated, .00016 in. long, .00004 in. wide; isolated or united in chains of a few articles, often arranged side by side; motionless.

In any or all tissues of the body of those afflicted with leprosy.

The investigations of Hansen, Neisser and others, have fully established the cause of this scourge of the human family in various parts of the world. The contagious character of the disease was among the earliest recognized, and has long been fully understood; but in what the contagion consists, has been entirely unknown until our own time. It is now added to the increasing list of known affectionsthe disease due to the injurious activities of minute parasites which we are just beginning to know and understand. *Bacillus lepra*, like the preceding, is nearly invisible without staining, but is readily seen after treatment with aniline dyes in the manner just given.

**B. of foot-rot in sheep.**

Cells cylindrical .00012 to .00016 in. long, isolated or more generally united in pairs, of which one cell is larger than the other; actively motile.

In pustules in tissues of animals affected with above named disease.
The course of the disease occupies about thirty-five days. In the vegetative stage the organisms are very active, but in liquids (broth of rabbit or mutton) from which the nutrient is nearly exhausted the larger cell of a pair produces a spore at each end and sometimes one in the middle, the smaller cell produces one spore of larger size, about .00004 in. in diameter. The spores, as in other cases, sink to the bottom as a white sediment. Upon inoculations with this material pustules are formed which reach their greatest size in about eighteen days. They never suppurate and appear to be local in effect, though the temperature of the animal rises somewhat by the fifteenth day. (Comptes Rendus, xcii, 1881, pp. 362-4.)

LEPTOTHRIX, KÜTZING (Emend).

Filaments very long and slender, unbranched, apparently not jointed, colorless, motionless, without granules, free or felted.

The fungi referred to the genus *Leptothrix* are, with reference to their specific value, very questionable; I place here the following kinds only provisionally. *Leptothrix* species very commonly occur with those of *Bacillus*. Since the genus will probably have a place among the fungi only a short time, I will not give it a new name. The greater number of the species are typical phycochromous algae.

[Treatment with iodine renders the articulations very distinct],

*L. buccalis*, Robin.

Filaments very long and slender .000028 to .00004 in. (seldom something more) in diameter; jointless, colorless; felted into dense white masses.

Mixed with *Micrococci* (usually also *Vibrio*, etc.,) in the white slime on the teeth, on the epithelium of the mouth and in hollow teeth. Probably the cause of caries (rotting) of the teeth.

The seat of the fungus is especially in the canals of the tooth-bone (the dentine pipe); but it seizes also upon the substance of the enamel which it gradually destroys. In the canals the fungus produces marked enlargement, later the walls themselves become penetrated by fissures and chinks and broken in pieces.

*L. parasitica*, Kütz.

Filaments very slender, mostly curled and crisped, obscurely jointed; loosely felted, nearly colorless; .004 to .0056 in. long, .00004 in. thick.

Parasitic on *Scytonemaceae* and other related *Algae*.

*Leptothrix pusilla*, Rabb, and *L. lanugo*, Kütz, are, perhaps, also to be accounted Fungi.

BEGGIATOA, TREVISAN.

Filaments very long but thicker than those of *Leptothrix*, usually obscurely jointed, quite rigid but actively oscillating, imbedded in jelly, colorless, with numerous highly refractive granules in the protoplasm which consists of sulphur.

The genus *Beggiatoa* is easily recognized by the chalk-white slime-forming, actively moving filaments, whose joints cannot as a rule be distinguished without special processes. In order to see them it is necessary to let the filaments dry on the microscopic slide and then apply bisulphide of carbon, which gradually dissolves the granules of sulphur which in the living plant obscures the joints. The species of *Beggiatoa* live for the most part in thermal
sulphur springs where they decompose, the dissolved sulphur compounds in the water and give off free sulphureted hydrogen. For this reason such water with Beggiatoa put into a stoppered bottle, develops an extremely intense odor of sulphureted hydrogen.

The supposed species of Beggiatoa are of very uncertain value; they are distinguished by very little else than the diameter of the threads.

**B. alba**, Trev.

*Synonyms:* Beggiatoa punctata, Trev. (Flora Enganea, p. 56); Oscillaria alba, Vauch (Confer, p. 198, T. XV, Fig. 11); Hygrocrinis Vandelli, Menegh, (Kützing's Algae exsc. No. 16—Tab. phycol. I, T. XXXVIII, Fig. 3).


Filaments without evident joints, forming dirty or chalky-white slimy masses; .00012 to .00014 in. thick.

In sulphur springs and swamps.

**Var. marina**, Cohn.

Filaments densely filled with blackish granules, only .00008 thick.

In a salt-water aquarium, forming a snow-white, then slimy membrane on dead animals and algae.

**B. nivea**, Rabh.


Filaments very slender, obscurely jointed; .00004 to .00006 in. thick (according to Rabenhorst) forming flocks of snow-white color.

In sulphur springs.

In Wartmann and Schenk's Swiss Cryptogams, 639, this species is given under the name of Symphyothrix nivea, Brugger. Both the above names are cited, pari passu, as synonyms. I take the following from their description: "Filaments not polished, without joints, also without movement, only .00002 to .000032 thick, parallel and variously entwined, united in pencil-like tufts, strings and bundles of very unequal thickness, which are enveloped in a common, homogeneous slime-mass."

**B. leptomitiformis**, Trev.

*Synonym:* Oscillaria leptomitiformis, Menegh. (Ragazz. Nuovo ricerch. fisico-chim. p. 121.—Kützing, Tab. phycol. I, T. XXXVIII, Fig. 1.)

*Exsiccate:* Rabenhorst's Algen, 1813.

Filaments very slender, obscurely jointed, .00007 to .00010 in. thick; forming a thin chalk-white slimy layer.

In sulphur springs.

**B. archnoidea**, Rabh.


Filaments rather thick, evidently jointed, with rounded, slightly curved ends; movements active. Joints as long, or half as long as thick. Filaments .00020 to .00026 in. thick, forming a very thin, cob-webby, chalk-white, slimy pellicle.

In sulphur springs and swamps.
B. pellucida, Cohn, (Hedwigia 1865, p. 82, T. I, Fig. 2.)
Filaments .00020 in. thick, motile, evidently articulated, with rounded ends; joints scarcely as long as thick; pellucid, containing but few granules.
In a salt-water aquarium.

B. mirabilis, Cohn, (l. c. p. 81, T. I, Fig. 1.)
Filaments thick, variously crooked and curled, with rounded ends, evidently articulated; attaining .00064 in. thick; joints half as long as thick, filled with numerous rather large granules. Threads twisted and woven through each other, forming a snow-white, slimy web.
With the preceding.

DOUBTFUL SPECIES.

B. tigrina, Babh. (Flora Europ. Alg. II, p. 95.)
Synonym: Oscillatoria tigrina, Röm. (Die Algen, Deutschlands p. 58.)
Filaments rather thick, oscillating, evidently jointed, with slight and obtuse curves, now and then suddenly reduced in size, with rounded ends; pellucid, .00014 to .00018 in. thick; forming a thin white layer.
In swamps and on wood under water.

B. minima, Warm.
Very small, flexible and actively moving; the longest .0016 in., .00007 to .00008 thick; jointed; distinguished by the order of the delicate stripes. Each joint about half as long as wide. Without granules.
In sea-water.

CLADOTHRIX, COHN.
(Streptothrix, Cohn, Beitr. z. Biol. Bd. I, Heft 3, p. 204.)
Filaments leptothrix-like, very slender, colorless, without joints, straight or slightly undulating, or irregularly spirally wound, with apparent branches.
I am unable to find a satisfactory difference between the genera Cladothrix and Streptothrix. Both are very doubtful genera. Compare Cienkowski’s “Zur Morphologie der Bacterien” (Memoires de l’ Acad. imp. d. Sciences de St. Petersbourg. VII Sér. Tome XXV, No. 2, p. 11.)

C. dichotoma, Cohn.
Filaments repeatedly dichotomously branched, straight or slightly bent, .000012 thick, forming little webs (Rächen) .02 in. and more in diameter.
In foul water, sometimes floating on the surface, sometimes attached to algae.

The branching in this case, as with Cladothrix Forsteri, is only apparent. The filament split themselves into two halves, which independently elongate and so grow side by side; in this way the separated pieces are crowded to one side and appear as branches.
C. Forsteri, Winter.
Synonym: Streptothrix Forsteri, Cohn. (Beitr. z. Biol. I, 3 Heft., p. 186 und 204.
Filaments straight or curved, irregularly spirally twisted, sparsely and irregularly branched, occurring in pieces of various lengths.
In the lachrymal ducts of human eyes, forming greasy or crumbling yellowish-white or blackish concretions, .125 to .25 in. long, .083 in. thick.

MYCONOSTOC, Cohn.
(l. c. p. 183 und 204.)
Filaments very slender, colorless, not jointed, but upon drying separating into short cylindrical articulations, variously curved and entwined, imbedded in jelly, forming globules from .00040 to .00068 in. in diameter.
Multiplying by the infolding and the division of the globules of jelly in two parts.

M. gregarium, Cohn.
Gelatinous globules, floating on the surface of foul waters, single or aggregated in little slimy drops, with the circumference sharply defined.
On water in which there are decomposing algæ.

SPIROCHÆTA, Ehrb.
Cells united in long slender threads, mostly showing narrow spiral windings. The filaments have the liveliest movements, and clearly propel themselves forward and backward, but are also able to bend in various ways. Forming no zoogloe, but often felted in dense clusters.
Differs from Spirillum by the long, narrowly-wound, flexible threads.

S. plicatilis, Ehrb.
Synonym: Spirillum plicatile, Duj. (Infs. p. 225, T. I, Fig. 10).
Spirulina plicatilis, Cohn. (Nova Acta Acad. Caes. Leopold; Carroll, XXIV, I, p. 125, T. XV, Fig. 10, 11).
Filaments very short and slender, with numerous narrow spiral turns; jointed, obtuse at the ends, .00440 to .00900 in. long (according to Rabenhorst); diameter, .00009 in. (according to Ehrenberg).
In swamp water, among algæ.
This species differs, according to Koch, from the others, by the double spiral formed by the filaments. Yet threads wound in a continuous spiral are very common.

S. Obermeieri, Cohn.
Very similar to Spirochæta plicatilis in form, only differing by the filaments being sharply pointed at both ends.
In the blood of the sick with recurrent fever, and apparently the cause of the sickness.
The filaments of *Spirochaeta Obermeieri* are either extended and regularly spirally wound, or they are bent, so that the spirals appear irregular, especially in the parts most crooked, rapidly moving in various ways. This species is found in the blood of persons having recurrent fever, and fairly only during the returning access (onset) of the fever or a short time thereafter. They disappear in the periods between the paroxysms of the fever. (The former investigations have been confirmed by extensive observations in India, where relapsing fever is now very common. See volume on 'Spirillum Fever,' by Dr. Vandyke Carter, London, 1882.)

**S. Cohnii**, Winter.

Very similar to both the foregoing species, but always shorter and usually also more slender, like *Spirochaeta Obermeieri* sharply pointed at both ends.

In mucus on the teeth; discovered by Cohn, figured by Koch (Beitr. z. Biol. II, Bd. 3, Heft., T. XIV, Fig. 8).

**S. gigantea**, Warming.

Filaments cylinrical, obtuse at both ends, about .00012 in. thick, with numerous spiral turns of a diameter of .00028 to .00036 in. and length of each .001 in.; flexible; the articulations are not apparent, but the threads sometimes separate into joints. The longest have sixteen spiral turns; cilia have not been found.

In sea water.

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**SPIROMONAS, PERTY.**

*(Zur Kenntniss der Kleinsten Lebensformen, p. 171.)*

Cells leaf-like (flat), compressed, twisted around an ideal longitudinal axis; multiplying by transverse division.

**S. volubilis**, Perty.

Colorless, pellucid, polished, without in any part special differentiation; movements quite rapid, turning upon the axis upon which the leaf-like body is wound. Body often very little twisted, never forming more than one spiral turn; length .00060 to .00070 in.

In stagnant swamp water and foul infusions.

**S. Cohnii**, Warming.

Cells flattened, but sometimes scarcely angular, sharply pointed at both ends and always furnished with a cilium, having one and a fourth (rarely more) spiral turns; these six to nine times as high as their diameter; height .00036 to .00080 in., diameter .00005 to .00014 in. Thickness of the cells .00005 to .00016 in.; colorless, often with one or two longitudinal stripes.

In ill-scented, very strongly fermenting water.
SPIRILLUM, EHRB.


Vibrio, Cohn. (Beitr. z Biol. I, Bd. 2, Heft, p. 178.)
Ophidomonas, Ehrb. (Inf. p. 43.)

Cells cylindrical or somewhat compressed, with a single arch-form curve or spirally wound; rigid; furnished at each end with a cilium (not certainly observed in all the species); multiplying by transverse division, the parts soon separating from each other. The formation of zoöglæa and of spores as in the species of Bacillus sometimes occurs.

I unite with Spirillum the genera Vibrio, Cohn, Ophidomonas, Ehrb. The genus Vibrio does not indeed permit of sharp definition since their cilia have been found. Cohn himself has united Ophidomonas with Spirillum. Warming also shows that all three genera are the same. Although the name Vibrio has the priority, I have chosen Spirillum because with the first, aside from its being non-botanical, misuse has been practiced, so that it is better to drop it altogether.

S. rugula, Winter.

Synonyms: Vibrio rugula, Muller (Inf. p. 44, T. VI, Fig. 2.) Melanella flexuosa, Bory (Encycl. method, 1824.)

Cells 0.0024 to 0.0064 in. long, 0.0002 to 0.0010 in. thick; either only one curve or one flattened spiral turn, bearing a cilium at each end, actively rotating around their long axis; the cells often felted into dense swarms; height of a spiral mostly 0.0024 to 0.0040 in., diameter 0.0004 to 0.0008 in.; globular spores always formed at the ends of the cells.

In swamp water and various infusions; also in the slimy material on the teeth, &c.

According to Warming some specimens attain a height of single spiral of 0.0050 to 0.0080 in., and diameter of 0.0010 to 0.0020 in.

S. serpens, Winter.

Synonym: Vibrio serpens, Muller (Inf. T. VI, Fig. 7 and 8.)

Cells half as thick as the preceding species, 0.0045 to 0.0012 in. long (according to Rabenhorst) 0.0003 to 0.00045 in. thick, with more usually three to four spiral turns; often joined in long chains; furnished with a cilium at each end; also often collected in swarms; height of a single spiral 0.0030 to 0.0050 in.; diameter, 0.0005 to 0.0012 in.

In various infusions.

Rabenhorst's measurement of the length, 0.0092 to 0.0012 in., probably applies to the whole filament consisting of several cells. According to Warming the height of a single spiral sometimes attains 0.0088 in.

S. tenue, Ehrb. (Inf. p. 84, T. V, Fig. 11.)

Cells very slender, 0.0016 to 0.0060 in. long, 0.00010 in. thick (according to Ehrenberg), with at least one and a half, usually two,
three, four or five spiral turns; height of a single turn of the spiral, .00006 to .00016 in.; diameter, from one-half to the same; movements very active, but also without motion; collected in dense swarms or masses, or forming zoogloea.

In various infusions.

According to Warming only .00004 in. thick, and the distance of the turns of the spiral sometimes .00032 to .00040 in.; their diameter only one-eighth to one-tenth this measurement. A confusion appears to prevail in respect to *Spirillum tenue* and *Sp. undula*.

**S. undula**, Ehrb.

Synonyms: *Vibrio undula*, Müller (Vermium historia, p. 43). *Vibrio prolifer*, Ehrb. (Infs. p. 81, T. V. Fig. 8.)

Cells .00032 to .00018 in. long, .000044 to .000056 in. thick (Rabenhorst; spiral wider than the preceding; turns .00016 to .00020 in. distant; each cell usually having only one-half or one, rarely two or three spiral turns; furnished at each end with a cilium; motions very active; sometimes also forming zoogloea.

In swamp water and in various infusions.

Ehrenberg gave for *Spirillum tenue* a thickness of 1-1000 of a Prussian line, and for *Sp. undula* only 1-1680 of a line; he also said in the description: "Sp. fibris valde tortuosis brevibus, validioribus."

According to Warming, *Spirillum tenue* is more variable than has been hitherto supposed. The turns of the spiral are often very long, so that the cell appears almost straight, therefore the distance between them varies from .00012 to .00042 in., with a diameter from one-tenth to three-fourths of this measurement; the thickness of the cell is from .000024 to .00006.

**Var. litorale**, Warming.

Attains .00012 in. thick, length of one turn of the spiral form .00020 to .00040 in., and diameter from one-sixth to one-fourth as much.

On the coast of the Baltic sea.

**S. volutans**, Ehrb.

Synonyms: *Vibrio spirillum*, Müller (Infs. p. 49, T. VI. Fig. 9). *Melanella spirillum*, Bory (Encycol. method.)

Cells somewhat tapering at the ends, gradually rounded, .00100 to .00120 in. long, .00006 to .00008 in. thick; each cell with two and a half to three and a half spiral turns, each of which is .00036 to .00050 in. high, .00026 in. in diameter; furnished with a cilium at each end.

In various infusions as well as in swamp water among algae.

According to Warming, the spiral is often elongated so that the cell appears almost straight, the diameter then becoming only .00006 to .00016 in.

**Var. robustum**, Warming.

Thickness .00008 to .00018 in.; height of spiral .00040 to .00080 in.; diameter .00004 to .00012 in.; mostly one and a half turns; sometimes two cilia at one end.

In sea water.

**S. sanguineum**, Cohn.

Cells cylindrical, only rarely tapering at the end, .00012 in. and more thick, of various lengths, with mostly two, seldom only one-half or two and a half spiral turns; distance of the latter .00036 to .00048 in.; diameter two-thirds as great; furnished at each end with a cilium. Cell-contents colored by numerous reddish granules with many granules of sulphur.

In foul brackish water.

According to Warming the longest specimens reach a length of .00260 in., the distance of the turns of the spiral .00060 to .00150 in., diameter one-half to two-thirds, or with the smallest one-fourteenth to one-seventh as much.

**S. violaceum**, Warming.

Cells either crescent-form (without a complete spiral winding) or with one or one and a fourth spiral turns; abruptly rounded at the ends and furnished with a cilium. Cell-contents violet, containing little granules of sulphur. Distance of the turns of the spiral .00030 to .00040 in., diameter .00034 to .00006 in., thickness of the cell .00012 to .00016 in.

In brackish water.

**S. Rosenbergii**, Warming.

With one or one and a half turns of the spiral, cells .00016 to .00050 long, .00006 to .00010 in. thick; colorless, but with numerous, highly refractive, sulphur granules. Distance of a turn of the spiral .00024 to .00050 in., diameter very different, highest half as much. Active and moving in various ways, but without cilia as it appears.

In brackish water.

**S. attenuatum**, Warming.

Cells tapering to the ends, usually with three spiral turns, the middle one is .00044 in. high and .00024 in. in diameter, the end ones .00040 in. high, and .00080 in. in diameter; thickness of the cell .00005 to .00008 in.

In sea water.

**S. jenense**, Winter.

**Synonym:** *Ophidomonas jenensis*, Ehrb (Infs. p. 44).

Cells obtuse at both ends, furnished with a cilium, olive-brown, .00160 in. long, .000132 in. thick, with one-half to two and a half spiral turns.

Whether this is really a distinct species is hard to say so long as it is not again found in the original locality. Possibly it is identical with *Spirillum volutans*.

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**APPENDIX.**

We connect with the *Schizomyctes* some genera which are united with them on the part of others without question; but which show so many peculiarities that I may provisionally separate them.
SPHÆROTILUS, KUTZING.

(Linnea VIII, 1833, p. 385, T. IX.)

Cells roundish, angular, or oblong, rounded on the angles, in the greater number united end to end in a colorless, slimy sheath, into long filaments which form cue-like, interlaced and entangled floating flocks. Multiplying by isolating vegetative cells which produce, through continued division, new filaments; propagation by spores, which form within the vegetative cells.

S. natans, Kützing, (l.c.; also 54 Jahresb. d. Schles. Ges. f. vaterl. Cultur. 1876, p. 133.)

Flocks in the vegetative stage, in the old parts yellowish-brown, in the younger colorless, much branched, very slippery. In those producing spores, a part milk-white and a part colored red. Cells .00016 to .00036 in. long, .00012 in. thick.

The flocks consist of an enormous mass of long, variously collected threads, which are formed of cells in rows, surrounded by a slimy, refractive sheath. These threads often form shaggy, branchy structures, which become attached to aquatic plants, or float in a thin stratum on the water. In the thread-cells forming spores the protoplasm separates in numerous small, highly refractive portions, which become the globular spores colored; when ripe, red; later, brown. These become free when the membrane of the mother cell dissolves. They germinate very soon and grow into threads, which are either isolated or attached to the mother or other threads. These daughter threads, formed from the germinating spore, are at first undivided, and only later become the typical row of cells. Sometimes the spores develop into threads inside the mother cell.

CENNOTHEIX, COHN.

(Beitr z. Biol. I. Bd. 12, Heft, p. 130).

Filaments cylindrical, slightly club-form, thickened above, jointed, furnished with a sheath; multiplying by the escape of the joint-like cells from the sheath and their growth into filaments. Propagation by spores, which are formed within the sheath by the further division of the cells. The spores either grow directly into threads, or form, by continued division, gelatinous colonies of round cells, which afterward produce threads.

C. Kuhniana, Zopf.


Filaments in whitish or brownish webs (Räschens), .00003 to .00020 in. thick, widened near the ends to .00024 to .00036 in.; joints of very different lengths. Spores .00004 to .00024 in. in diameter.

In springs and drainage tile, etc.

Often a very troublesome fungus since it pollutes the water and stops up small pipes. The cylindrical filaments slightly thickened towards the end are evidently articulated; the joints after a while separate from each other, but are then enclosed by a sheath, which, originally colorless, becomes yellow or yellowish-brown by imbibing iron. The sheath, at first closed, is finally burst by the continued division of the joints and these escape. Each joint can develop into a new filament. But in other cases the thread remains enclosed in the sheath; its joints are divided by numerous close cross-partitions into thin disks, which then by vertical divisions separate into little globular cells; these may be considered as the spores of the fungus. They often develop inside the sheath
into new filaments which grow through the swelling gelatinous sheath; or they leave the sheath in order to further develop outside. They either grow in filaments or form by repeated bi-partition little colonies of rounded cells, which are held together by the membranes, now become gelatinous. These colonies are assigned to the *Palmellae* (perhaps *Palmellina flocculosa*, Bad.); each of their cells can again form a filament.

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**SACCHAROMYCETES.**

*Saccharomyces*, or yeast fungi, are one-celled plants which multiply by budding and propagate themselves by spores produced within the cells. They live isolated or joined in sprouting chains (sprossverbänden), chiefly in liquids containing sugar in which they induce alcoholic fermentation.

In most *Saccharomyces* the cells are globular, oval or elliptical, only rarely do they elongate into cylindrical tubes, which become jointed by transverse partitions, and may then be considered the earliest imitation of hyphæ or mycelium formation. For the purpose of multiplication the cell pushes out a little rounded protuberance (Austülpung) which becomes filled with a part of the contents of the mother cell, whose form and size it gradually acquires, and is cut off by a partition wall. Both cells can, in like manner, produce daughter cells, which frequently remain attached for a time and after their separation continue to vegetate independently.

A damp solid substance is especially favorable for the formation of spores. Typically the whole cell contents divides into two to four rounded portions, or contracts into a single globular body. Each of these surrounds itself with a cell-wall, and thus becomes a spore which can bud like the vegetative cells.

To the yeast fungi (in the narrower sense) belongs the ability to decompose the sugar of a solution, for example of wine must, into alcohol and carbonic acid, that is, to set up alcoholic fermentation. The carbonic acid escapes in rapid streams, while the alcohol, as well as some subordinate elements of sugar, e. g. succinic acid, remains behind. The fermentation proceeds with special energy with a small supply of air; but by long continued exclusion of air the yeast cells perish.

The validity of the *Saccharomyces* species from a botanical standpoint, is similar to that of the *Schizomycetes*. As with the latter, it is also necessary here to make a limitation to the leading species, and to leave out of consideration only those species established by reliable investigators. Even then there remains much doubt, for the majority of accepted species at present are probably only different forms of one and the same kind, which have become differentiated under changed conditions of growth.

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**SACCHAROMYCES, MEYEN.**

One-celled fungi with vegetative multiplication by budding; propagation by spores which (usually) form by the division of the contents of the mother cell.
[This is the only genus, hence has the general characteristics of the group. The relation to the *Schizomycetes* is certainly quite close and apparently nearer than usually supposed by excellent authorities. The so-called budding is, after all, only a peculiar mode of self-division by elongation and the formation of transverse partitions, and the production of spores is entirely similar in the one to the other, while the physiological processes and effects are not more distinct than the existing difference in these respects between true species of *Schizomycetes*. For these reasons, as well as the fact that the two kinds of organisms are very commonly associated in nature, I have appended this account of the *Saccharomyces* without intending to imply that the species belong among the *bacteria*.

**S. cerevisiae**, Meyen.

*Synonyms:* *Torula cerevisiae*, Turpin (Compt. Rend. VIII, 1838, p. 379); *Cryptococcus fermentum*, Ktz. (Species Algarum, p. 140); *Hormiscium cerevisiae*, Bail. (Flora. 1857, p. 417).

*Exsiccatae:* Rabenhorst's Algen, 121; Fungi Europ., 1999; Thümen Mycotheca Universaliis, 800; Kryptogamen Baden., 141.

Cells mostly globular or oval, .00032 to .00036 in. long; isolated or joined in little colonies; spore-forming cells isolated, .00044 to .00058 in. long; spores usually three or four in a mother cell, .00016 to .00020 in. in diameter.

In beer, in both the surface and bottom fermentation.

This peculiar beer yeast is found in the various kinds of beer, in both kinds of fermentation. It is cultivated in quantity and furnishes then the so-called compressed yeast—a mass consisting of yeast cells and water.


Cells elliptical, usually .00024 in. long; isolated, or united in little branched colonies. Spore-forming cells mostly isolated; spores in the mother cell two to four, .00012 to .00014 in. in diameter.

In wine must, spontaneously fermenting.

**S. conglomeratus**, Reess, (l. c. p. 82).

Cells almost globular, .00020 to .00024 in. in diameter, united in skeins which consist of numerous budding cells from one or a few mother cells; spore-forming cells often to one or two vegetative cells united; spores two to four in a mother cell.

In wine must at the beginning of the fermentation and on decaying grapes.

**S. exiguus**, Reess, (l. c. p. 83).

Cells conical or top-form .00020 in. long, .00010 in. wide, united in little branched colonies; spore forming cells isolated with always two to three spores in a row.

Among the yeast of the secondary fermentation of beer.
S. Pastorianus, Reess. (l. c. p. 83.)


Cells roundish-oval or elongate-clavate, of various dimensions; colonies branched, consisting of primarily club-shaped joints .00072 to .00088 in. long, which form secondary roundish or oval, angular cells .00020 to .00024 in. long. Spore-forming cells roundish or oval; spores two to four .00008 in. in diameter.

In the yeast of the secondary fermentation of wine, ciders and self-fermenting beer.

S. apiculatus, Reess, (l. c. p. 84.)

Exsiccata: Thümen Fungi Austriaca, 263.

Cells lemon-shaped, with a little short point at each end; .00024 to .00026 in. long, .00008 to .000012 in. wide, sometimes a little longer; daughter cells only from the ends of the mother cell, usually soon isolated, rarely joined in little scarcely branched colonies. Spores not known.

In the principal fermentation of wine and other spontaneous fermentations.


Exsiccata: Thümen Mycotheca Universalis, 900.

Cells of different forms; the basal one (of a colony) oblong or cylindrical, .00040 to .00060 in. long, .000060 in. wide; the rest globular, .00020 to .00024 in. in diameter, united in crooked, branched, often skein-like families; spore formation not known.

In the fermenting juice of Lycopersicum esculentum (Tomato.)

S. glutinus, Cohn (l. c. p. 187.)

Synonym: Cryptococcus glutinus, Fresenius, (Beitr. z. Mycol. 2 Heft, p 77.)

Cells globular, oval, oblong, elliptical or short cylindrical, .00020 to .00044 in. long, .000010 wide, isolated, or two, rarely more, united; cell wall and contents in a fresh condition, colorless, after drying and again moistened a slightly reddish nucleus in the middle; spore formation unknown.

On starch paste, slices of potato, etc., forming rose-red slimy spots which at the beginning have a diameter of .02 to .04 in., but gradually spreading and uniting they cover a surface of more than .4 in. square. The coloring matter is not changed by acids or alkalies.

S. Mycoderma, Reess (l. c. p. 83).


Exsiccata: Thümen Fungi Austri. 1299, 1300.

Cells oval, elliptical or cylindrical, .00024 to .00028 in. long, .00008 to .00012 in. wide, united in richly branched colonies. Frequently the cells are elongated, mycelium-like; spore-forming cells reaching a length of .00030 in.; spores one to four in each mother cell.

On fermented liquids, sauer-kraut, juices of fruits, etc. On wine and beer, forming the so-called mold.
This and the following species reach in their development the highest rank in the Saccharomycetes. The cells often form especially in aqueous solutions elongated tubes, which become articulated by the growth of cross partitions and from these separate into single cells. The latter bud on their part in a similar manner.

While the proper yeast fungus vegetates submerged, in the upper strata of liquids and here sets up very active alcoholic fermentation, the mold fungus grows on the surface without exciting fermentation. Artificially forced to grow submerged there is a small quantity of alcohol formed, but the fungus soon perishes.

Although the growth of the mold-layer goes hand in hand with the souring of wine and beer, yet this Saccharomyces is not the cause of the latter phenomenon. Several other fungi whose systematic position is not certain, produce this vinegar out of the alcohol of wine, etc. According to some it is a Vibrio (spirillum) species which excites this decomposition.


*Synonym:* Oidium albicans, Robin (Hist. Nat. d. Veget, Paras, p. 488, Pl. I, Fig. 3 to 7).

Cells in part globular, in part oval, or elongated to cylindrical, .00014 to .00020 in. wide, the globular ones .00016 in. in diameter, the cylindrical ones ten to twenty times as long as thick. Budding colonies usually consisting of rows of cylindrical cells, from the ends of which rows of oval or globular cells are produced by budding. Spores single, formed in roundish joints.

On the mucous membrane of the mouth, especially of nursing infants, producing the disease known as Thrush ("Soor"). Also in animals.

This fungus appears in the form of less or greater grayish-white masses which, however, do not consist entirely of Saccharomyces, but also contain Schizomycetes and the mycelium of mold fungi. When cultivated the fungus forms abundant long-jointed, richly branched threads; at the upper end of each joint is usually found a crown or tuft of short cells which have an oval or globular form and these bud again in their turn. In other cases all the cells of a colony remain short and take the globular form. The fungus excites alcoholic fermentation only in a slight degree. According to Grawitz (Virchow's Archiv. f. pathol. Anat. und Physiol. 70 Bd. p. 557), *Saccharomyces albicans* is identical with *S. mycoderma*.

**S. guttulatus**, Winter. (Doubtful species.)

*Synonym:* Cryptococcus guttulatus, Robin (l. c. p. 337, Pl. IV, Fig. 2.)

Cells elliptical or elongated oval, .00060 to .00096 in. long, .00020 to .00082 in. wide; brown, opaque, with two to four colorless vacuoles, isolated or two to five united. Spore-formation unknown.

In the æsophagus and intestines of mammals, birds and reptiles.