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About the Institute

The Hunt Institute for Botanical Documentation, a research division of Carnegie Mellon University, specializes in the history of botany and all aspects of plant science and serves the international scientific community through research and documentation. To this end, the Institute acquires and maintains authoritative collections of books, plant images, manuscripts, portraits and data files, and provides publications and other modes of information service. The Institute meets the reference needs of botanists, biologists, historians, conservationists, librarians, bibliographers and the public at large, especially those concerned with any aspect of the North American flora.

Hunt Institute was dedicated in 1961 as the Rachel McMasters Miller Hunt Botanical Library, an international center for bibliographical research and service in the interests of botany and horticulture, as well as a center for the study of all aspects of the history of the plant sciences. By 1971 the Library's activities had so diversified that the name was changed to Hunt Institute for Botanical Documentation. Growth in collections and research projects led to the establishment of four programmatic departments: Archives, Art, Bibliography and the Library.

WASHINGTON UNIVERSITY

Student's Name Rogers

Course Student Seminar

Section _____

Instructor or Assistant _____

Date Presented _____

Sold by
Washington University Quad Shop
The Students' Store

The Morphology of the Female Fructification of the Cordaites and Conifers

- RUDOLF FLORIN

Lectures delivered to the Graduate Seminar Sept. 30 and October 1, 1948.

The origin of the paired appendages (ovuliferous scale and bract) which compose the female cone of the modern conifers has long been an unsolved puzzle as vexing as the origin of the angiosperms. In his book "Gymnosperms..." Chamberlain cites a long series of speculations bearing on the evolution of the ovuliferous scale.

During the past 25 years Dr. Florin has made an intensive study of the late Paleozoic Cordaites and early Mesozoic Conifers. His researches are based largely on compression type fossils, supplemented with petrifications when available as well as cuticular remains. Briefly, his work points very decisively to the origin of the ovuliferous scale as a much reduced and flattened short shoot. Certain of the key fossils in the evolutionary sequence are: Cordaianthus pseudofluitans (Upper Carboniferous) with a strong axis bearing two rows of numerous fertile dwarf shoots, each in the axil of a bract, seeds are borne terminally on some of the slightly flattened appendages composing the shoot; Lebachia piniformis (early Permian) with short shoots aggregated into distinct cones, appendages of short shoots fewer than in Cordaianthus, one seed borne in terminal position on side of shoot away from bract (cone axis side); Walchiostrobus fasciculatus (Lower Permian) and Pseudovoltzia Liebesana (Upper Permian) are forms in which the short shoot is much reduced with regard to number of appendages, the latter are partially fused and flattened bearing two seeds on recurved "megasporephylls" so that the micropyle points to the cone axis; Ulmannia Bronni (Upper Permian) with the appendages of the short shoot reduced to a single "ovuliferous scale" with one seed on the upper surface. The distinctive features of the corresponding organs in the modern conifers such as Pinus were already highly evolved late in the Paleozoic.

Literature by Florin:

Short English summary of his above described work in: Botaniska Notiser, pp. 547-565, 1939.

Detailed complete account in: Die Coniferen des Obercarbons und des unteren Perms, Palaeontographica, 86, Abt. B, pt. 2, Lief I-VIII, 1938-1945.

Other references of interest:

On the structure of the pollen grains in the Cordaitales: Bot. Tidskrift, Bd. 30, 1936.

The Tertiary fossil conifers of south Chile and their phytogeographical significance, K. Svenska vetensk. akad. Handl. III, 19, 1940.

The September, 1948 issue of the Botanical Gazette will contain a paper voicing Florin's views concerning the Taxada.

BIOGRAPHY

1. Accounts of his itineraries on his American travels.
Bot. Gard. Kew, Bull, Misc. Inf. 1934:20-27
In English 1925:295-310
1926:181-190
2. Agassiz, L. "Alexander de Humboldt". Journ. Geneve, 1870
A booklet in French.
3. Bruhns & Lassell, Life of Alexander von Humboldt. 2 volumes.
London 1873----English translation.

WORKS

A. In English

1. An account of the Cinchona forests of South America;
bound with A.B. Lambert, "An illustration of the genus
Cinchona", London 1821. An English article.
2. Thomasina Ross, Personal narrative of travels (Humboldt)
to the equinoctial regions of America during the years
1799-1804. 3 volumes. London 1852-53. An English
translation.
3. Views of nature. A translation from the German into English
by E.C. Otte & Henry G. Bohn. London, 1850.

B. In French

1. Et Bonpland. Essai sur la geographie des plantes, etc.
Paris, 1805. Complete book in French.
2. Et Bonpland. Monographie Melastomacearum. 2 volumes
Paris 1816-23. In French.

C. In German

1. Friedrich Alexander von Humboldt's...Aphorismen aus der
chemischen Physiologie der Pflanzen. Leipzig, 1794. Book.
2. Beobachtungen an Pflanzen, wissenschaftliche Pflanzengeo-
graphie. Ges. naturforsch. Freunde. z. Berlin. Sitzungs-
Ber. 187-203. 1902. An article in German.
3. Collected workd, 12 volumes. Kosmos, Journeys, writings
etc. Stuttgart, 1889 ed. Hermann Hauff. In German.

D. In Latin

1. De distributione geographica plantarum secundum coeli, tem-
periem et altitudinem montium, prolegomena. Paris 1817. Book.
2. Et Bonpland & Kunth...Voyage de Humboldt et Bonpland. Nova
genera et species plantarum. 7 volumes. Paris 1815-25. Book.

Alice Bryan 10/11/57

BOTANY SEMINAR

The Herbalists: Shades of the past, shadows of the future.

Iconographers

- Incunabula: Latin Herbarius. 1484.
German Herbarius. 1485.
Ortus Sanitatis. 1491.

These were among the earliest printed books on plants, crudely illustrated and believed to be based on manuscripts originally done by the Greeks and Romans.

- Otto Brunfels. Herbarium Vivae Eicones. 1530. The first publication of life-like engravings of plants; with descriptions extracted from the ancients.
Leonhard Fuchs. Historia Stirpium. 1542. Contains over 500 engravings and the first botanical vocabulary.
Martinus de la Cruz, Juannes Badianus. Aztec Herbal. 1552. A manuscript done for medical purposes with plants grouped under diseases which they are reported to cure.

Phytographers

- Hieronymus Tragus (Jerome Bock). New Krauterbuch. 1539. The first descriptions of plants independent of the ancients.
Valerius Cordus. Opera Botanica Conradi Gesneri. 1751. Emphasizes plant descriptions rather than illustrations; includes several new genera. Published posthumously.
Mathias de l'Obel. Stirpium Adversaria Nova. 1570. Presents a system of classification based on leaf form, roughly separating monocots from dicots.
Andrea Cesalpino. De Plantis. 1581. One of the first to propose relationships of plants based on fruits, seeds, superior or inferior position of the ovary.
Gaspard Bauhin. Pinax Theatri Botanici. 1623. A systematic synonymy of over 6000 previously known species.
John Gerard. Herball. 1636. Apocryphal treatise of its day however most wholly compiled from the works of others and including considerable ludicrous and erroneous information.
Joseph Pitton de Tournefort. Institutions Rei Herbariae. 1700. Presents a classification of groups higher than genera based to a large extent on the condition of the corolla.
John Ray. Historia Plantarum. 1704. Proposes a classification followed in part by the proponents of the natural system De Jussieu and De Cendolle.

Bibliography

- Arber, Agnes. 1938. Herbs, Their Origin and Evolution. A very readable account of the herbalists and herbaria from 1470 to 1670. Special reference is made to the artists and illustrations of the herbaria and many woodcuts are illustrated.
Greene, Edward Lee. 1909. Landmarks of Botanical History. Smiths. Misc. Coll. No. 1870. A scholarly study of the development of botany from Theophrastus to Cordus, from their original writings, giving a detailed account of the accomplishments of each.
Miall, L. C. 1912. The Early Naturalists. A review of naturalists from Brunfels to Buffon including interesting notes on their lives and writings.
Reed, Howard S. 1942. A Short History of the Plant Sciences. An abbreviated account of botanical history from the Stone Age to the early 19th century; with references for each chapter.

A.F.T. 1950

Jack Gillette
10/25/80

BOTANY SEMINAR

Fruits of Exploration

Economic Plants - Cordón introduces the potato 1533, Heredia brought Cocoa to Spain, Spruce searches for quinine in Ecuador.

Floras - Hooker's Antarctic Flora, The Flora of British India, the Genus Plantarum, and the Index Kewensis.

Rumphius and his "Herbarium Ambolnense".

Martius - "Flora Brasiliensis".

Saint-Hilaire - "Flora Brasiliae Meridionalis" (1825-33).

Contributions to advance of botany: Andanson evolves the idea of mutability of species. Darwin and the "Voyage of the Beagle". Wallace and his observations.

Geographic exploration - Cooke's voyage around the world, accompanied by Sir Joseph Banks. Robert Brown and his voyage to Australia. Humboldt and his explorations in South America.

The Michaux's study forest trees in America, botanize in Carolinas, Florida, Kentucky, Canada.

Nuttall visits Arkansas, Port Vancouver, Sandwich Islands, Cape Horn and back to Boston.

Bibliography

Geiser, Samuel Wood. Naturalists of the Frontier. S. Method. Press. Dallas 1948.

Martius, Carolus Fridericus Phillipus de. Flora Brasiliensis 1906.

Oliver, F. W. Makers of British Botany. Cambridge Univ. Press. 1913.

Thwaites, Reuben Gold. Early Western Travels, 1748-1846. The Arthur Clarke Co. Cleveland. 1904.

Von Hagen, Victor Wolfgang. The Green World of the Naturalists. Greenburg. N. Y. 1948.

Von Hagen, Victor Wolfgang. South America Called Them. Alfred A. Knopf. N. Y. 1945.

Smith, E - The Life of Sir Joseph Banks

News 10/12/50

LINNAEUS--THE FIRST MODERN

Born at Rashult, Sweden, in 1707. Rather a Cleric.
First schooling at Wexio, where he made a rather poor showing in theological subjects.
Saved from entering a trade by Dr. Rotuman, and encouraged to go to University of Lund.
Then went to Upsala to train for medicine, and became adjunct of aging Professor Rudbeck.
Went to Lapland in 1732, found many new species.
Got M. D. in only three weeks in Holland. He then visited noted botanists in England, France, Holland before returning home.
Established medical practice in Stockholm, and married in 1739.
Got chair of Botany at Upsala in 1742, had many famous students.
Died in 1778, at 70, replaced by son, who was a disappointment.

SIGNIFICANCE:

Not an originator, but unsurpassed as an analyst, describer, and organizer. Sachs says Linnaeus had an "Utter incapacity for careful investigation of any object at all difficult to observe."

He made three great contributions:

1. The Sexual System: This work brought him the greatest fame among his contemporaries, but has been said to have held back the science of botany for a century. It was a purely artificial system, based on the number, union, and insertion of the stamens. He did, however, recognize the errors in the system, and proposed a natural system, parts of which are still valid today.
2. The Binomial System of Nomenclature: General use of generic and specific names of one word each, instead of the earlier polynomial.
3. Nomenclature: Linnaeus brought into common usage the terminology of Jung.

In each of these fields he did little original work, but used and coordinated the investigations of others.

Botany received a great impetus from the popularization obtained from his simplification of identifications and nomenclature.

Rather than being called the first modern, he could better be called the last of the school started by Caesalpino.

BIBLIOGRAPHY:

- Caddy, Florence, Through the Fields with Linnaeus, 1887. A "Human Interest" story of Linnaeus' life. Not at all concerned with his scientific work. 2 vols.
Greene, Edward L., Linnaean Memorial Address, Proc. Wash. Acad. Sci., LX, pp. 241-274. Also largely concerned with the story, rather than the science.
Harvey-Gibson, R. J., Outlines of the History of Botany, 1919. A brief evaluation of Linnaeus' work is included.
Jackson, Benjamin Daydon, Linnaeus, 1923. An adaptation from a work in Swedish by Fries.
Lovejoy, Arthur, The Place of Linnaeus in the History of Science. Pop. Sci. Monthly, vol LXXI, Dec. 1907. By a former W. U. professor.
Miall, L. C., The Early Naturalists, Their Lives and Work, 1912.
Sachs, Julius Von, History of Botany (1530-1600) Trans. E. F. Gamsey. 1906. The best and most comprehensive account of his work.
St. John, Harold, Linnaeus, The First Modern Botanist, 1938. A reprint of a N. Y. Public Schools Bulletin.

Hugh Iltis
Nov 15, 1950

TO hope for the new systematics is to imply no disrespect for the old. It has been largely the rapid progress made by the classical taxonomy itself that necessitated the introduction of new methods of analysis, new approaches to synthesis.

....

The rise of other branches of biology has been exerting a profound effect on the outlook of taxonomists. Genetics, cytology, ecology, selection theory, field natural history, paleontology, even developmental physiology,-- they are all proving relevant to this or that aspect of taxonomy.

....

The result has been that the outlook for taxonomy has altogether changed. A quarter of a century ago ... taxonomy ... was ... a narrow, specialized branch of biology. Today, on the other hand, systematics has become one of the focal points of biology

....

Nature of some of the information.

CYTOGENETICAL

Chromosome morphology

Chromosome number

- a. On a higher level (Family, genus) Basic sets and similarity of sets may indicate relationship.
- b. within a species . Diploids- polyploids.

Ecological

Relative importance of environment versus heredity.

Transplant studies

- | | |
|------------------------|-----------|
| Jordan | 1860' |
| Turesson | 1920' |
| Clausen, Keck & Hiesey | 1930-40'. |

Emphasis on population rather than on individual plant.

clone - populations may originate through vegetative propagation from one individual

apomixis - production of seeds through means other than sexual.

Introgressive hybridization

NEW SYSTEMATICS

Bibliography

- Anderson, E. Intregressive Hybridization. New York, Wiley and Sons. 109 pp. 1949.
- Babcock, E.B. 1947. The Genus *Crepis*, I and II. Univ. of Calif. Publ. Bot., vols. 21 and 22. 1,030 pp.
- Cain, S.A. 1944. Foundations of Plant Geography. New York, Harper. 556 pp.
- Clausen, J., D.D. Keck, and W.M. Hiesey. 1940. Experimental studies on the nature of species. I. The effect of varied environments on western North American plants. Carnegie Inst. Washington, Publ. No. 520. 452 pp.
1945. Experimental studies on the nature of species. II. Plant evolution through amphiploidy and autopoloidy, with examples from the Madiinae. Carnegie Inst. Wash. publ. 564. 174 pp.
- Dobzhansky, Th. 1941. Genetics and the origin of species. Revised ed. New York, Columbia University Press. 446 pp.
- Huxley, J.S. (editor). 1940. The new systematics. Oxford, Clarendon Press. 334 pp.
- Mayr, E. 1942. Systematics and the origin of species. New York, Columbia University Press. 334 pp.
- Stebbins, G.L. Jr. 1950. Variation and evolution in plants. New York, Columbia University Press. 643 pp.

Botany Seminar
spring 1951

Cytology, Genetics and Cytogenetics

- Week 1: Survey of the Field
George McCue - 2/7/51
- Week 2: Cytology; the early years
Thomas Graven
- Week 3: Hybridization before Mendel
Robert Gillespie
- Week 4: Techniques of Karyology
Amy Gage
- Week 5: The Union of Karyology and Genetics (= cytogenetics)
John Ayeres
- Week 6: Polyploidy
Reino Alava
- Week 7: Modern Russian Genetics
Donald Duvick

THE BANDWAGONS OF "GENETICS"

Y. McLuc
2/9/51

Pre-Mendelian Heredity and Evolution:

Earliest observation of relation between parents and offspring.
Earliest theories of the relation between various organisms.
The union of early theories of heredity and evolution.

Pre-Greeks, Greeks, Middle Ages, Linnaeus, Buffon, Lamarck,
Darwin, Weismann, Galton.

Early Plant Hybridizers:

The experimental method is applied to heredity and evolution.

Koelreuter, Gärtner, Vilmorin, Nägeli, De Vries, Bateson.

Mendel:

The most important of the early plant hybridizers reduces heredity
to understandable terms.

Cytology:

The discovery of the cell, nucleus, chromosomes and their activities.
The clarification of the phenomena of sexual reproduction.

Hooke, Malpighi, Leeuwenhoek, Grew, Brown, Schleiden, Schwann,
Strasburger, Flemming, Montgomery, Sutton.
Camerarius, Arici, Kölliker.

Cytogenetics:

The facts of Mendelian heredity are explained in terms of cytology.
Variation is made upon the simple thems of Mendel.
Physiology, biochemistry offer explanations for the facts of Mendelism.
Genetics is applied to the problems of evolution.

Bateson, Sutton, Castle, Morgan-Sturtevant-Muller-Bridges,
McClintock, Johannsen, Janssens, Clausen, Goodspeed, Blakeslee,
Sachs, Goldschmidt, Wright, Anderson.

Mendelian Dissenters:

The Lysenko school.

BIBLIOGRAPHY

In addition to such standard histories of biology as Singer and Nordenskiöld there are several other books and pamphlets dealing specifically with the history of genetics and evolution.

1. Haeckel, E. B. "The Development of Fundamental Concepts in the Science of Genetics"; reprinted from Portugalia Acta Biologica; Series A, 1949.
2. Cook, R. A. "A Chronology of Genetics, U. S. D. A. Yearbook, 1937.
3. East, E. M. "As Genetics Comes of Age" Journ. Hered., 13, 207-14.
4. Osborn, H. F. From the Greeks to Darwin, MacMillan, N. Y., 1899.
5. "Twenty-five Years of Genetics", Brooklyn Bot Gard. Mem., 4-29-40.

CYTOLOGY: THE EARLY YEARS

Development of the Microscope

Euclid, 590 B. C.
Pliny the Elder
D'Armato, 1317
Copernicus
Janssen Brothers
Galileo, Leeuwenhoek, Hooke
C. L. Chevalier
Charles A. Spencer, 1847

Development of the Cell Theory

Early observations of cells were made by Hooke, Grew, Malpighi and Leeuwenhoek.

Preformation and Epigenesis

Bonnet
William Harvey, 1578-1667
Caspar Wolff, 1759

Cellular Tissue Theory

Lamarck, 1800
C. F. Mirbel, 1808

Cell Theory

Dutrochet, 1824
Schleiden, 1838
Schwann, 1839

"Every plant developed in any higher degree is an aggregate of fully individualized, independent, separate beings, even the cells themselves. Each cell leads a double life: an independent one, pertaining to its own development alone; and another incidental in so far as it has become an integral part of a plant. It is however easy to perceive that the vital process of the individual cell must form the first, absolutely indispensable fundamental basis, both as regards vegetable physiology and comparative physiology in general."

-----Schleiden, 1838

Development of Protoplasm Theory

Cell division established -- Nageli, 1846
Sarcode and protoplasm -- Payen and Cohn, 1850
Protoplasm theory -- Schultze and De Bary, 1861

Reticular theory -- Fromman, Klein, Van Beneden, Carnoy, Leydig
Fibrillar theory -- Velten
Granular theory -- Altmann
Alveolar theory -- Rutschli, 1892

--- the units of organization are masses of protoplasm, and this substance is in general, similar in all living organisms.
Schultze, 1861

Nuclear Studies

Organismal theory

De Bary, Saachs, Hofmeister, Hertwig

Syngamy and Embrogeny

Amici, Strasburger, Schmitz, Hofmeister, Radlkopfer

Cell Division

Schleicher, Van Beneden, Fleming, Strasburger

Heredity

Weismann

BIBLIOGRAPHY

Hertwig, Oscar, The Cell, trans. Campbell, Macmillan Co., New York, 1909.

Manton, I., "The Spiral Structure of Chromosomes", Biological Reviews of the Cambridge Philosophical Society, Vol 25, #4, October, 1950.

Mumoz, F. J. and H. A. Charipper, The Microscope and its Uses, Chemical Publishing Co., Inc., Brooklyn, 1943.

Robertis, E. D. P. and V. W. Nowinski and F. A. Saez, General Cytology, W. B. Saunders Co., Philadelphia, 1948.

Romanes, G. J., An Examination of Weismannism, The Open Court Publishing Co., Chicago, 1899.

Sharp, Lester W., Fundamentals of Cytology, McGraw Hill Book Co., Inc., New York, 1943.

-----, Introduction to Cytology, McGraw Hill Book Co., Inc., New York, 1934.

BOTANY SEMINAR

Plant Breeding Before Mendel

THE PERIOD OF DISCOVERING AND PROVING SEX IN PLANTS

- 2000 BC The Ancients: Men 2000 years BC hand pollinated date palm.
1660 Robert Sharrock: Discussed hybridization in *Brossica*.
1694 Rudolph Camerarius: Suggested that plants had sex.
1716 Cotton Mather: Attributed xenia in maize to cross pollination.
1717 Thomas Fairchild: Crossed the Carnation with the Sweet William.
1719 Jean Marchant: Recorded mendelian segregation in *Mercurialis*.
1721 Phillip Miller: Described insect pollination.
1724 Paul Dudley: Described wind pollination in *Zea* maize.
1728 Henri Louis Du Hamel Du Monceau: Discussed hybridization as a means of forming new species.
1729 Thomas Henschman: Commented on different colored peas in the same pod.
1738 John Mitchell: Attempted to show botanists that generic relationships could be discovered by breeding experiments.
1739 John Bartram: Describes species crosses he had made and results obtained.
1739 James Logan: Found pollen necessary for fertilization in *Zea* maize.
1744 Daniel Rudberg: Described *Peloria* as a hybrid descended from *Linaria*.
1745 Johann Gmelin: Reported on several new varieties of *Delphinium* which he believed were hybrids.
1745 Benjamin Cook: Described variety crosses in *Zea* maize.
1746 Johannes Wahlborn: Stated that the pollen parent contributed to the progeny.
1750 Pehr Kalm: Described variety crosses in *Zea* maize.
1751 Johannes Paartman: Assumed that many horticultural varieties were hybrids.
1751 Johann Gleditsch: Hand pollinated date palm at Berlin Botanical Garden.
1751 Christlob Mylius: Reported variety crossing in *Brassica*.
1752 Edme Guyot: Published on breeding for flower color in garden flowers.
1752 James Parsons: Described sterility in hybrids.
1752 Johannes Gessner: Discussed the artificial production of hybrids.
1755 Nicol Dalberg: Discussed the possibility of man producing "monster" plants.
1759 Christian Ramstrom: Discussed the relative importance of the male and female in plant hybridization.
1760 Carolus Linnaeus: Described hybrids he had produced as proof for sex in plants.
1761 Rudolph J. Kolreuter: Proved conclusively that plants had sex, and applied the scientific method to plant breeding.

THE ERA OF EXPERIMENTATION

- 1793 Christian Sprengel: Described insect pollination.
1795 Thomas Knight: Reported on dominance in peas.
1816 Louis and Henry Vilmorin: Understood the principle of "pure lined"
1819 William Herbert: Presented evidence to show that hybrid pollination was slower and many times not as effective.
1822 John Goss: Recorded dominance and segregation in peas

- 1822 Alexander Seton: Reported dominance in peas.
 1826 Augustin Sageret: Found that many characters were inherited independently.
 1828 A. F. Wiegmann: Confirmed the work of Kolreuter.
 1835 Von Gartner: Classified hybrids according to closeness to parental types.
 1859 C. Darwin: Came close to Mendel's principles and discredited many false beliefs.
 1863 D. A. Godron: Believed that if two species were fertile, they were the same species.
 1863 C. Naudin: Stated that the F_1 of a cross and the F_1 of its reciprocal were alike.
 1865 M. E. Wichura: First to use the term "factor".
 1865 B. Verlot: Explained how man developed pure lines.
 1872 Thoma Laxton: Reported that "pure lines" of peas seldom segregated.
 1873 Patrick Shirreff: Used "pure line" methods in breeding wheat.
 1881 W. O Focke: Compiled all known plant hybrids in his "Pflanzenmischlinge".
 1882 Sir Francis Galton: Stated in his book "Natural Inheritance" that all living things were "individual" in one respect and "composite" in another.

BIBLIOGRAPHY

1. Babcock, E. B. Review: "The Early History of the Idea of the Inheritance of Acquired Characters and of Pangenesis", (C. Zirkle), Journal of the History of Medicine and Allied Sciences, Vol. 1, No. 3.
2. Ford, W. C. "The Diary of Cotton Mather", Boston, 1911.
3. Kittredge, G. L. "Cotton Mather's Scientific Communications to the Royal Society", Proceedings of the American Antiquarian Society, Vol. 26, 1916.
4. Roberts, H. F. "Plant Hybridization Before Mendel", Princeton University Press, 1929.
5. Zirkle, C. "The Beginnings of Plant Hybridization", University of Pennsylvania Press, 1935.

Amey Hage 2/28/51

THE TECHNIQUES OF KARYOLOGY

- I. The early microscopists employed methods and instruments often ancestral to those in use at the present time, but very crude, and too often the technique was pursued as an end in itself.
- II. The development of modern histological and cytological methods.
 - A. Staining methods.
 1. Early use of dyes in histology: Hartig (1854), Gerlach (1858), Maschke (1859).
 2. Anilin dyes, introduced in 1862, have wide usage within next several decades. Flemming outstanding among early users.
 3. Hematoxylin methods are developed in the works of Waldeyer (1848), Bohmer (1865), Delafield (1885), Mayer (1891), Benda (1886), and Heidenhain (1892).
 - B. Cytological fixatives.
 1. Osmic type fixatives, such as those of Benda, Taylor, and La Cour, founded upon Flemming's chrom-osmo-acetic fluids (1881-1884).
 2. Navashin type fluids - derived from osmic fluids. Include Karpechenko's and Randolph's variants.
 3. Acetic alcohols - Carnoy.
 - C. Miscellaneous developments.
 1. Canada balsam first employed with a solvent by Griffith (1843).
 2. Clearing methods employing essential oils introduced in 1860's.
 3. Embedding by infiltration first successfully employed by Flemming in 1873. Chloroform method published in 1881 by Griesbrecht and by Butschli, but not generally established in botany until after 1887.
 - D. The question of artifacts: Fischer and Hardy.
- III. Techniques of cytogenetics.
 - A. Further developments in section methods.
 - B. The Biological Stain Commission (1922).
 - C. Smears and squashes.
 1. John Belling's contribution.
 2. Tricks of the trade.
 3. Smears versus sections.
 - D. The Feulgen technique (= the "nuclear reaction" - Feulgen and Rossenbach, 1924).
 - E. Special methods relating to chromosome structure or the division cycle.
 1. Demonstration of heterochromatin: methods of Darlington and La Cour, Levan, and others.
 2. Spiralization of chromosomes: Baranetzky (1888), Sakamura (1927), Kuwada and Nakamura (1934), La Cour (1935), Hillary (1940).
 3. Structure of the centromere: Lima-de-Faria (1949) and Tjio and Levan (1950).

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1. Conn, H. J. et al. 1933. The History of Staining. Biological Stain Commission, Geneva, N. Y. Fairly good general reference, as far as it goes.
2. Smith G. M. 1915. The development of botanical microtechnique. Trans. Am. Mic. Soc., 34:71-130. Gives good coverage of early developments and has good bibliography.
3. Lumb, Ethel Sue. 1950. Cytochemical reactions of nucleic acids. Quart. Rev. Biol. 25:278-291. Up-to-date review of nuclear staining methods, with good bibliography.
4. Nucleic Acids and Nucleoproteins. 1947. Cold Spring Harbor Symposium in Quantitative Biology, vol. XII. Cold Spring Harbor, N. Y.
5. Darlington and La Cour. 1947. The Handling of Chromosomes. Allen and Unwin, London (?). 180 pages packed with useful information (which is more than I can say for some of their more lengthy works).
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The Union of Karyology and Genetics (Cytogenetics)

- 1883 van Beneden showed the haploid chromosome number in Acanthamoeba gametes.
- 1888 Strasburger found that reduction division in number of chromosomes took place in the microspores of plants. In 1890 he postulated that there was a reduction in the number of chromosomes at sporogenesis in all organisms which exhibited sexuality. Not till the year 1907 that he proposed the terms haploid and diploid.
- 1900 Rediscovery and verification of Mendel's principles. De Vries, Correns, von Tschermak.
- 1901 H. Henking and Paulnier reported an "accessory chromosome" in spermatozoa. Montgomery emphasized the presence of paternal and maternal homologous chromosomes in diploid groups and accepted their conjugation and disjunction in pairs at meiosis.
- 1902 Guenot and Bateson showed the application of these principles to animals. E. C. McClung related an accessory chromosome found in some insects to sex determination -- this was the first attempt to connect a specific character with a particular chromosome.
- Bateson coined a number of terms as: homozygote, heterozygote, etc. Later he observed interaction, coupling, repulsion, etc. Coined term "genetics" in 1906. He published book, "Mendel's Principles of Heredity", in 1913.
- 1903 Sutton showed that the formulas of Mendelian heredity could be applied without alteration alike to the factors and to the chromosomes. Thus was closed the gap between cytology and genetics.
- 1904 T. H. Morgan became professor of Zoology at Columbia University, beginning the famous "Columbia group".
- 1905-06 E. B. Wilson identified the X chromosome previously referred as the one which determines the sex in animals. Female 2X Male X.
- C. W. Woodworth and W. E. Castle "discover" Drosophila.
- 1909 F. A. Janssens advanced the crossing over hypothesis. Johannsen coins the term "gene" to signify the unit in inheritance.
- 1910 T. H. Morgan proposed the explanation of sex-linked inheritance; published first gene mutation in Drosophila (white eye). Gene theory was announced by Morgan, which also included the principle of linkage of genes resident on the same chromosomes. Also the beginning of chromosome maps compiled by linkage and crossing over data.

- 1913 Carothers and others showed by cytological means that the segregation of a heteromorphic pair of autosomes and the unpaired X was independent. This gave the necessary evidence to establish the correlation of independent assortment of factors with the independent assortment of chromosomes.
- 1925 E. G. Anderson demonstrated the attachment of two X chromosomes in *Drosophila* and the fact that here crossing over takes place in the four strand condition.
- 1931 Creighton and McClintock found that chromosome 9 in certain strains of maize could be heteromorphic at both ends. This ninth pair of homologous chromosomes could also be heterozygous. Using the heteromorphic and heterozygous condition in the same plant it was possible to show that when cytological crossing over took place genetic crossing over also occurred.

Stern working with *Drosophila* found by similar methods proof for the same conclusion.

* * * * *

Morgan, Thomas Hunt, The Theory of the Gene, Yale University Press, New Haven, 1926, p. 25.

"The theory states that the characters of the individual are referable to paired elements (genes) in the germinal material that are held together in a definite number of linkage groups; it states that the members of each pair of genes separate when the germ-cells mature in accordance with Mendel's first law, and in consequence each germ-cell comes to contain one set only; it states that the members belonging to different linkage groups assort independently in accordance with Mendel's second law; it states that an orderly interchange—crossing-over—also takes place, at times, between the elements in corresponding linkage groups; and it states that the frequency of crossing-over furnishes evidence of the linear order of the elements in each linkage group and of the relative position of the elements with respect to each other."

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Don Deusch

May 23, 1951

GENETICS IN THE SOVIET UNION

MENDELIAN GENETICS IN THE USSR

Was developed with government support after the revolution; along the same lines as in the other parts of the world. Muller, during the period 1922 - 1937, did much to aid this development; brought the first genetical stocks of *Drosophila* to USSR. Bridges was also in the USSR for a few years.

Prominent Russian Mendelian geneticists:

- Navaashin - cytology
- Dubinin - cytogenetics
- Timofeev-Ressovski - cytogenetics (went to Germany until after World War II)
- Botzhansky - cytogenetics (came to U.S.).
- Vavilov - plant breeding, genetics, evolutionary theories.

MICHURINIST GENETICS (LYSENKO SCHOOL)

Development:

Men whose ideas contributed to the present theories.

USSR

- Michurin (1855 - 1933) - horticulturist, plant breeder and importer
- Timirjazev (1843 - 1920) - plant physiologist and plant breeder
- Lysenko (1898 -) - agronomist, plant breeder
- Prezent - philosopher

France

- Naudin (late nineteenth century) - plant breeder
- Millardet(" " ") - plant breeder

Great Britain

- Darwin (1809 - 1882) - naturalist, evolutionary theories

United States

- Burbank (1849 - 1926) - plant breeder, horticulturist

Events and Ideas

Late 1800's. Naudin

- 1) Hybrid is an individual in which are united two different natures, which are constantly striving to dissociate themselves from each other.
- 2) Thus, a hybrid is a living mosaic of more or less finely dispersed particles of paternal and maternal tissue.

Millardet

- 1) Non-segregating F_2 's (Millardetism) explained by saying that elements of one parent were sometimes annihilated in the hybrid (after combining a la Naudin). They also were sometimes merely latent in the hybrid.

Darwin

- 1) Natural selection from variable types (species, etc.) was postulated.
- 2) Thought environment may cause heritable variations.
- 3) Atavism, its appearance supposedly affected by environment and hybridization, used to explain some of the variation of types.
- 4) Espoused the theory of Use and Disuse (from Lamarck).
- 5) Relieved inbreeding was necessarily deleterious; outcrossing beneficial, especially when two strains have been growing in different environments prior to crossing.
- 6) Though graft hybrids occasionally occurred.

Early 1900's

Timirjazev

- 1) Classification of types of inheritance.
- 2) Insists genetics should be studied as the physiology of development.
- 3) Criticizes the idea of isolation of the germ plasma advanced by Weissman, and the concept of the unchanging gene, as given by Bateson.
- 4) Emphasizes Darwin's idea of the necessarily deleterious effects of selfing, also Darwin's concept of graft hybrids.

Burbank

- 1) Says environment may modify the genetical constitution.
- 2) "Heredity is nothing but stored environment".
- 3) "Graft [graft] hybrids" postulated.

1915-1930 (approximately)

Michurin

- 1) Says Mendelian genetics valid only when parents and hybrids grown under same environmental conditions.
- 2) Claims that vigor of each parent, as affected by the environment, affects its prepotency in crosses.
- 3) Says entirely new characters may arise as result of crossing, or characters may be lost entirely during crossing.
- 4) Dominance is said to depend on local environment at the moment each character is developed. (Reversal of dominance).
- 5) Mentor theory advanced (effect of stock on scion, and vice versa).
- 6) Claims maternal parent is more likely to transmit its characters to progeny than is the paternal parent.

1929

Lysenko

- 1) Theory of phasic development.
- 2) Practical application of wheat vernalization

1932

All Union Conference on Planning of Genetics and Selection

- 1) Need of improving varieties and raising standard of seed production emphasized; practical results stressed as most important.
- 2) Genetics and plant breeding are to conform with dialectical materialism.

1934

Lysenko

- 1) Presentation of theories on interaction of environment and heredity.
- 2) Claims formal genetics has too rigid concept of stability of genetical characters.

1935

Lysenko and Present: Plant Breeding and Phasic Development

- 1) Amplification of theory of phasic development.
- 2) Claim is possible to predict dominance or recessiveness.
- 3) Limiting factor hypothesis, operates in crosses.
- 4) Denial of transgressive segregation in F_2 (for instance, no F_2 is supposed to be earlier than the F_1).
- 5) Michurin's idea of dominance reversal under appropriate environments is adopted.

Lysenko and Present (in Jarovizacija, a periodical)

- 1) Claim the non-existence of pure lines.
- 2) Adopt Darwin's views on the deleterious effects of selfing; advance recombination theory (intra-pure line crossing) on the strength of this hypothesis.
- 3) Selective fertilization claimed; only pollen which will give the best progeny can fertilize the ovum, as a result of natural selection.

1936

Soviet Genetics Congress

Lysenko

- 1) Denounces chromosome theory of heredity; denies importance of chromosomes and genes in determining hereditary behaviour.
- 2) Says Mendelian laws of heredity are false; cites instances on F_2 segregation in other than 3:1 ratios and instances of Millaudetism (non-segregation of F_2).
- 3) States has changed, with proper vernalization techniques, a winter wheat into a spring wheat; claims this is proof for environmental effect on heredity.

Present

- 1) Denounces (as did Lysenko) Mendelian genetics as impractical, inconsistent with dialectical materialism, and as associated with Nazi race concepts.

Vaviloff, Muller, Dubinin, Serebrovski, others

- 1) Oppose Lysenko, defend Mendelian genetics.
- 2) Serebrovski says Lysenko resurrects Lamarckism; Muller agrees.

1937

Zhebrak

Criticizes Vavilov's theories of Centers of Origin and Law of Homologous Variation.

1938

Lysenko

Becomes President of Union Society of Agricultural Sciences.

1939

Soviet Genetics Congress

Lysenko

- 1) Claims environmental induction of heritable changes.
- 2) Again denounces Mendelian genetics.

Vavilov

- 1) Says achievements of Russian plant breeders are based on Mendelian genetics.
- 2) Claims the distinction between genotype and phenotype is legitimate.
- 3) Says Mendelism is best guide to inheritance studies.
- 4) Chromosome theory is stated to have too much evidence to be shaken.
- 5) Criticizes Lysenko's ignorance of genetic literature, says he is scheming to repress genetics.

1940

Lysenko

- 1) Attacks use of mathematics (especially statistics) in biology.
- 2) Urges his system of genetics replace teaching of Mendelian genetics in universities.
- 3) Cites graft hybrids to show environmental induction of hereditary changes.
- 4) Advances nutrient theory of heredity.
- 5) Becomes director of Institute of Genetics of the Academy of Sciences, after Vavilov's removal.

Vavilov

- 1) Loses the last of his important positions.
- 2) Transferred to Siberia, dies in 1942.

Present Status of Michurinist Genetics (the Lysenko school):

The System:

"The facts reported by Lysenko in support of his system are as follows:

- 1) An F_1 hybrid cannot be later than its earlier parent.
- 2) Biologically advantageous characters are dominant.
- 3) F_2 transgressive segregation for earliness is impossible.
- 4) Pure lines necessarily degenerate on selfing.
- 5) Intravarietal crossing gives rise to increased vegetative vigour.
- 6) Genetic variation is induced by environmental factors.
- 7) Segregation ratios are determined by the environment.
- 8) F_2 hybrid progenies may fail to segregate.
- 9) The F_2 generation of homozygous parents may be heterogeneous.
- 10) Reciprocal hybrids may differ inter se.
- 11) Different parts of the same individual may differ genetically.
- 12) F_1 hybrids may exhibit a mosaic of tissues derived from either parent respectively.
- 13) Grafting may bring about genetic interaction between stock and scion.

The hypothesis advanced by Lysenko to cover these presumed facts is the nutrient theory. Organisms are regarded, not as enduring entities, but as streams of stages, each stage arising from the preceding through absorption (assimilation), by the preceding stage, of environmental elements (nutrients) to give a new compound, the next stage in development. Each generation is regarded as a cycle of developmental stages. The similarity between parents and offspring is attributed to conservatism, a property of all living matter. Assimilation of nutrients is not at random, but selective, organisms having the power to select nutrients which will combine with the organism to produce a biologically advantageous course of development. Selective fertilization, the selection by the ovum of biologically advantageous pollen grains, here acting as nutrients, is a special manifestation of the organism's general capacity for selective assimilation. If the nutrients are not of like nature to the selecting organism its conservatism is overcome and new cycles of development are initiated. In this way the environment can modify the nature of organisms. Local differences between nutrients within an individual plant result in internal genetic variation. When this occurs in the sporogenous tissue, differentiation of gametes and subsequent segregation occur. Hybridization is regarded as an additive process, leading to the combination in one plant of two developmental potentialities, while segregation is conceived as a subtractive process dispersing developmental potentialities. Crossing is supposed to result in hybrid vigour through the combination of dialectically opposite gametes; selfing is believed to be deleterious through the absence of dialectically opposite gametes. Biologically advantageous characters are believed to be dominant, the organism selecting those nutrients which will combine with it to initiate the most favourable cycle of development." (from Hudson and Richens, "The New Genetics in the Soviet Union")

Michurinist Refutations and Criticisms of Mendelian Genetics:

- 1) The stable genotype does not fit with the idea of perpetual conflict and change of all material things which, according to dialectical materialism, must always be occurring.
- 2) Genetics is anti-Darwinian.
- 3) Genetics leads to racial theories.
- 4) Genetics depends on mathematics; mathematics cannot be applied to biological phenomena.
- 5) Genetics has no practical value (for plant and animal improvement, etc.)
- 6) The chromosome theory of heredity and the gene concept are false; the gene concept is an "ekatic hypothesis" (may be altered to explain any ratios of progeny, etc.)

Sample Criticisms of Lysenko and his School:

"As to the question of evidence, it would be as foolish to deny categorically all the Russian reports as to accept them as they are. If any of Lysenko's admirers in this country would care to do his cause the greatest service, they might be recommended to set up and repeat in any scientific research institute in this country any of Lysenko's basic experiments. But till this is done, the only mental attitude that can be reasonably advocated with respect to Lysenko's claims is a state of chronic and slightly suspended judgment."

E. H. Richens, in Lysenko: the Scientific Issue.

"These theories, although exhibiting a certain degree of internal coherence, contain various inconsistencies and receive only slight support from the facts. Lysenko's rejection of the data accumulated by Mendelian genetics during the past thirty years is obscurantist and reduces the value of his speculations."

P. S. Hudson and E. H. Richens, in the The New Genetics in the Soviet Union.

"I am disappointed with this book. The Situation in Biological Science, a verbatim report of the session of the Lenin Academy of Agricultural Sciences of the U.S.S.R. I had hoped to find an account of controlled experiments and results; especially of those concerned with the alleged inheritance of acquired characters and vegetative hybridisation. But as usual, essential details are not given and statements are presented in a vague and elusive way. Consequently they fail to carry conviction."

M. B. Crane, in a review in Heredity.

"The bulk of Lysenko's opinions on genetics may be dismissed as the products of a medieval mind using what is almost a medieval technique".

E. Ashby, in Scientist in Russia.

"Michurinism, even though it rejects some of the ideas of classical Lamarckism, is thus entirely Lamarckian in its general theoretical basis."

J. Huxley, in Heredity East and West.

"... much of the evidence Lysenko produces can already be understood in normal genetical terms; some is unconvincing as it stands, but if confirmed would demand additions to present theory; none of it demands the abandonment of the degree of understanding we have yet reached."

C. H. Waddington, in Lysenko and the Scientists -- II.

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Physiology Seminar 1951
Milton Zooker, et al.

NATURE OF AIR

Philo of Byzantium:
(2 B. C.)

QUESTION: Nature of air
INVESTIGATION: Burned candle under inverted vessel of water; level rose
CONCLUSIONS: Flame of candle converts some of corpuscles of air into the finer particles of fire which escapes through pores of glass vessels.
Partial vacuum causes water to ascend neck of the vessel.
MATERIALS AND METHODS: Observation

Heron of Alexandria: "Pneumatics"
(1st or 2nd century A. D.)

QUESTION: Nature of air
INVESTIGATION: Plunged inverted vessel into water, no water flows in even if completely submerged.
CONCLUSIONS: Air is a body.
Wind is air in motion.
GENERAL CONSEQUENCES: Air is a body, rather than an essence.

Jabir Ibn Hayyan: Arabian alchemist
(720-813 A. D.)

QUESTION: Transmutation of base metals
INVESTIGATION: Conversion of ores by combustion
CONCLUSIONS: Combustible bodies lost something when they burned.
GENERAL CONSEQUENCES: Origin of phlogiston theory
(See Pecher and Stahl)

Robert Boyle: Minister, Irish, member of "Invisible College"
(1627-1691)

QUESTION: Nature of air
INVESTIGATION: When suction of piston removes air from confined space rest of air expands to fill space. Mercury barometer fell.
CONCLUSION: Air is resilient.
MATERIALS AND METHODS: Air pump, mercury barometer, quantitative measurements
GENERAL CONSEQUENCES: Boyle's Law--volume of given mass of air varies inversely as pressure upon it. Makes possible quantitative determination of gases: basis of eudiometer.

John Mayow: Lawyer, doctor, died at age of 35
(1643-1679)

QUESTION: Relation between air and respiration and combustion
INVESTIGATION: Candle went out when 1/14 of air ^{in an enclosed vessel was} used.

CONCLUSION: Only part of the atmosphere (called "spiritus nitro-aereus") is active in both combustion and respiration.

MATERIALS AND METHODS: Eudiometer

GENERAL CONSEQUENCES: Blow to elemental nature of air. Not all the air is necessary for respiration or combustion.

Johann Joschim Becher:
(1635-1682)

QUESTION: Nature of combustion

INVESTIGATION: No investigations, rewrote Jabir

CONCLUSIONS: Combustible portion of air terra pinguis. Three formative principles—terra pinguis (fatty earth), terra mercurialis (mercurial earth), and terra lapida (stony earth).

GENERAL CONSEQUENCE: Forerunner of phlogiston theory

George Ernest Stahl: Doctor, pupil of Becher
(1660-1734)

QUESTION: Nature of combustion

INVESTIGATION: Burned sulfur and phosphorus, weighed reactants and products

CONCLUSIONS: Plants and animals made of earth, water, and "phlogiston" - Calx + phlogiston = metal. Charcoal burned yields "phlogiston" to the air accompanied by fire. Metal heated in air = calx + phlogiston (to the air).

MATERIALS AND METHODS: Weighing

GENERAL CONSEQUENCES: Established phlogiston theory; acted as damper on the understanding the true nature of combustion until 177. (Lavoisier)

Stephan Hales: clergyman
(1677-1761)

1. QUESTION: Relation between air and chemical reactions

INVESTIGATION: Subjected miscellaneous substances; animal, vegetable, and mineral to chemical action and collected gas evolved.

CONCLUSION: Plants give rise to air; therefore contains it. (Note: the terms "air" and "gas" used interchangeably by Hales.)

2. QUESTION: Relation between plants and air

INVESTIGATION: Observed continuous series of bubbles in exudate at top of "bleeding" vine so as to make a large froth at the top of sap. Sealed stem in and showed that air is drawn in as water transpired through leaves.

CONCLUSION: Air ascends with the sap

3. QUESTION: Relation between plants and air

INVESTIGATION: Peppermint in glass cistern absorbed 1/7 of air

CONCLUSION: Plants actively "fixed" air in course of growth

MATERIALS AND METHODS: Weighing, eudiometry, distillation, fermentation, pneumatic trough, measurement of area of leaves, thermometer, water manometer, peppermint

GENERAL CONSEQUENCES: Determined through chemical analysis that air is a component of plants; also suggested the influence of light and importance of leaves.

Charles Bonnet: Swiss, lawyer, wealthy
(1720-1793)

QUESTION: Relation between air and plants

INVESTIGATION: Leaves plunged under water in light give off air bubbles.

Same action by pure water in light

CONCLUSION: Evolution of bubbles by leaves not due to vital action.

MATERIALS AND METHODS: Observation, grape vine

GENERAL CONSEQUENCES: Confusion between actual evolution of oxygen by photosynthetic leaves and formation of bubbles by dissolved gases.

Joseph Priestley: Nonconformist minister, born of low parentage, librarian for Lord Shelburne who later gave him an annuity; met Lavoisier in 1774
(1733-1804)

1. QUESTION: Relation between air and plants (1771)

INVESTIGATION: Sprig of mint placed in air in which candle had burned out *and which would not sustain a mouse.*

Air was purified because mouse survives.

CONCLUSION: Green plants purify foul air.

2. QUESTION: Composition of air (1774)

INVESTIGATION: Heated mercuric oxide. Air expelled. Mouse lives three times longer, candle burns brighter *when enclosed in evolved gas.*

CONCLUSION: "Dephlogisticated" air (later called oxygen by Lavoisier) discovered.

3. QUESTION: Relation between plants and light (1778)

INVESTIGATION: Green *Conferva* in light and dark. In water impregnated with carbon dioxide, there was abundant growth; not so in unimpregnated water. Gas evolved free of carbon dioxide, rich in "dephlogisticated" air (oxygen).

CONCLUSION: Sunlight necessary for growth of *Conferva* and evolution of "dephlogisticated" air.

MATERIALS AND METHODS: Eudiometer, balance, lens (12 inches in diameter), mint, *Conferva*

GENERAL CONSEQUENCES: The discovery of "dephlogisticated" air and the necessity of sunlight for its production laid further basis for study of relation between air and plants.

Jan Ingenhousz: Dutch, M. D., annuity from Empress Maria Theresa and Lord Shelburne, interest in function of plants aroused by speech of J. Pringle at presentation of Copley medal to Priestley in 1773, interested in influence of foul and pure air on the health of man.
(1730-1799)

1. QUESTION: Relation of air and plants (1779)

INVESTIGATION: Two dozen small French beans in two pint jar left overnight, chick killed in less than twenty seconds. Flowers, roots, fruits yield poisonous air.

CONCLUSION: All plants in darkness; especially flowers, roots, fruits, render air impure.

2. QUESTION: Relation of light to evolution of "dephlogisticated" air
 INVESTIGATION: Plant in transparent glass vessel inverted into tub of water.
 In light "dephlogisticated" air bubble to top. In dark yields bad air.
 CONCLUSION: Green plants give off "dephlogisticated" air in sun, plants exhale foul air in dark. (Later accepted Lavoisier's views as regards phlogiston.)
3. QUESTION: Relation of light and heat to the evolution of oxygen
 INVESTIGATION: Plants in jars of pump water. One placed near fire, other in sunlight. The first produced foul air, the latter produced dephlogisticated air.
 CONCLUSION: Light, not heat from sun induced emission of "dephlogisticated" air.
4. QUESTION: Relation of maturity of leaves to evolution of "dephlogisticated" air
 INVESTIGATION: Vine placed in jar of pump water. Air bubbles appear in old leaved first and then up the vine to the young; size of bubbles same also, *graded*.
 CONCLUSION: Mature leaves give off more "dephlogisticated" air than young leaves.
- MATERIALS AND METHODS: Eudiometer, bubble counts, candles
 GENERAL CONSEQUENCE: The work on relation of light and heat on the evolution of "dephlogisticated" air by green plants served as impetus to more investigations.

Jean Senebier: Swiss, clergyman, son of wealthy merchant, student of Bonnet
 (1742-1809)

1. QUESTION: Relation of air and plants (1783)
 INVESTIGATION: Exposed to sun green leaves of different plants in vessel of recently boiled distilled water, variously charged with carbon dioxide. The volume of oxygen evolved measured.
 CONCLUSION: Oxygen evolved by green plants proportional to amount of carbon dioxide present up to point where an excess of carbon dioxide began to injure the vitality of the leaves.
2. QUESTION: Relation of plants and light
 INVESTIGATION: Used large, double walled bell-bottles and tested with blue (litmus sol) and yellow (curcuma extract) light the effect of colored light on the formation of oxygen.
 CONCLUSION: Red light most effective. No basis for conclusion in view of state of knowledge in related fields.
3. QUESTION: Validity of Ingenhousz's experiments
 INVESTIGATION: Repetition of Ingenhousz's experiments
 CONCLUSION: Reconfirmed Ingenhousz's conclusion that green parts of plants produce "dephlogisticated" air.
- MATERIALS AND METHODS: Phyllometer, Volta's eudiometer, chlorophyll extraction, colored solutions
 GENERAL CONSEQUENCES: Relation between plants and air known and expressed in terms of gases utilized and evolved.

Henry Cavendish: Wealthy, physicist, chemist
(1731-1810)

1. QUESTION: Nature of gases (1784)

INVESTIGATION: Dilute hydrochloric or sulfuric acid plus metals yields "inflammable air". Performed specific gravity determinations and showed "inflammable air", "fixed air" and other gases to be distinct entities. Sparked inflammable air (423 cc) in common air (1,000 cc) and produced water and had $\frac{4}{5}$ of common air left.

CONCLUSION: Prepared "inflammable air". Supposed gas produced came from metal and to be composed of phlogiston. Proved inflammable air, fixed air and other gases are distinct entities.

2. QUESTION: Relation of light and plants

INVESTIGATION: No experiments. Examined Priestley's work on evolution of "dephlogisticated air" from green leaves of plant when exposed to sunlight.

CONCLUSION: Plants assisted by light deprive part of water of its phlogiston and turn it into "dephlogisticated" air while phlogiston unites to form part of substance of green plants.

MATERIALS AND METHODS: Cavendish Eudiometer, quantitative measurement of gases, electricity

GENERAL CONSEQUENCES: Air is not an element. Adherence to phlogiston theory brought confusion in attempt to explain Priestley's results. Not convinced that water is not an element.

Antoine Laurent Lavoisier: French nobleman, chemist, beheaded during French Revolution
(1743-1794)

QUESTION: Nature of combustion (1777)

INVESTIGATION: Phosphorus and sulfur burned in sealed vessel with air. Sulfur and phosphorus increased in weight by exactly the same amount which air had lost.

CONCLUSION: Sulfur and phosphorus combined with air, not phlogiston. Priestley's "dephlogisticated" air was absorbed; this was named oxygen.

MATERIALS AND METHODS: Exact quantitative weighing with a balance

GENERAL CONSEQUENCES: Death blow to phlogiston theory. Explained Cavendish's doubts on non-elemental nature of water. Laid down basis for modern chemistry because of his quantitative studies.

Thales of Miletus: Merchant, learned Egyptian geometry, improved navigation instruments
(c.640-546 B. C.)

QUESTION: Nature of matter

INVESTIGATION: None; Speculations based on Babylonian legends of creation.

These legends apparently derived from Babylonian experience with swamp-draining and observation of delta-formation by rivers. Held that the earth (and all other matter) was ultimately derived from water.

CONCLUSION: All things are water.

GENERAL CONSEQUENCE: Water thought to be the source of everything. Apparent origin of idea that water is one of the four elements.

Anaximenes of Miletus:
(contemporary of Thales)

QUESTION: Nature of matter

INVESTIGATION: Speculation based on analogies with observed phenomena (evaporation and condensation of liquids). Mist is the fundamental form of things; it becomes harder and heavier on being packed more closely. Rarefied mist is fire; condensed mist is first water, then earth. Rarefaction accompanied by heat, condensation by cold. ("Proof": Breath blown on hand through open mouth is rarefied and warm; blown through pursed lips is condensed and cold.)

CONCLUSION: Mist is the original element from which the universe is derived.

Heraclitus of Ephesus:
(540-475 B. C.)

QUESTION: Nature of matter, especially of changes in form of matter

INVESTIGATION: Speculation based on observation that fire is the most common agent which produces changes in technical and natural processes.

CONCLUSION: Fire held to be fundamental element. All matter in a state of tension between upward force leading to Fire and downward force leading to Earth. This idea came from analogy with the tension of strings in bow and lyre.

Empedocles of Agrigento:
(c.495-435 B. C.)

QUESTION: Nature of matter

INVESTIGATION: Analogies based on observations of technical processes and implements: Mixing of points, bread making, the sling. Experimented with the Clepsydra (cylindrical water-clock) If one end of the cylinder is closed and the other thrust under water, the latter is unable to enter the cylinder space.

CONCLUSION: Air is a material body.

GENERAL CONSEQUENCE: First demonstration that air, though invisible, is material in nature. Encouraged development of idea that human senses do not always detect presence of matter unless aided by experiment.

Anaxagoras of Clazomenae:
(c.500-430 B. C.)

QUESTION: Source of plant matter

INVESTIGATION: None, reason and logic

CONCLUSION: Rocks, plants, animals preformed, present since beginning as miniatures

Democritus of Abden:
(c.400-360 B. C.)

QUESTION: Nature of matter

INVESTIGATION: None, reason and logic

CONCLUSION: Matter composed of individual atoms of different form, weight, size.

Basic materials of atoms same; variation in form, size and arrangement caused differences in properties. Variation in density because atoms fill given space with greater or lesser degree of compactness. Matter indestructible. Denied convertibility of one atom into another. Evaporation of water due to separation of invisible atoms of water by wider intervals.

Aristotle:
(384-322 B. C.)

Note: Aristotle's work exemplifies the contradictory development of the two chief trends in Greek Science: 1. The earlier trend in which science was closely linked to technology, and employed concepts based on techniques. 2. The later trend exemplified by Plato, which scorned practical control of nature and emphasized an abstract system of thought (logic). Of Aristotle's works, three (Physics, Logic and Metaphysics, and Politics) are based wholly on reason and logic, while the last (on biology) is based on practical observations and dissections. By and large, the metaphysical trend dominates Aristotle's writings.

CONCLUSION: Matter composed of individual atoms of different form, weight, size. Basic materials of atoms same; variation in form, size and arrangement caused differences in properties. Variation in density because atoms fill given space with greater or lesser degree of compactness. Matter indestructible. Denied convertibility of one atom into another. Evaporation of water due to separation of invisible atoms of water by wider intervals.

Aristotle:

(384-322 B. C.)

1. QUESTION: Nature of matter

INVESTIGATION: None, reason and logic

CONCLUSION: Material of world formed from mixtures of four elements. Fire and water united by intermediation of air to give multitude of substances-- mineral, vegetable, animal.

2. QUESTION: Source of plant matter

INVESTIGATION: None, reason and logic

CONCLUSION: Nutritive organic matter of plants generated in form of exceedingly minute particles (homoiomera) which being assimilated through roots were deposited unchanged in the tissues and organs of similar homoiomeric character.

MATERIALS AND METHODS: Observation of natural phenomena

GENERAL CONSEQUENCE: The origin of the "humus" theory which persisted for a long time in "explaining plant nutrition". firmly established the concept of four basic elements which led to much confusion up to the end of the 18th century.

Philippus Theophrastus Paracelsus: Swiss, M. D., famous alchemist

(1493-1541)

1. QUESTION: Nature of plant matter

INVESTIGATION: Chemical analyses

CONCLUSION: Plants consist of water, oil, resin, gum, tar, electuaries, powder, ashes, mercury, sulfur, salt.

2. QUESTION: Sources of plant matter

INVESTIGATION: Experience

CONCLUSION: Vegetables receive from the soil and rain for their nutriment, organic constituents (sulfur), water (mercury), and mineral matter (salt).

MATERIALS AND METHODS: "Distilling, resolving, putrifying, calcining, reverberating, subliming, reducing, coagulation, pulverizing, decanting."

GENERAL CONSEQUENCE: Initiated series of experiments on the nature of plant matter, using techniques of alchemy.

Joseph Duchesne: French, M. D., alchemist

(1521?-1609)

QUESTION: Nature of plant matter

INVESTIGATION: None

CONCLUSION: Postulated possibility by chemical means to regenerate an entire plant from its ashes.

Angelo Sala: Italian, M. D., ridiculed idea of philosopher's stone and avoided all
(1575-1640)pretentious theorizing and confined his attention to fact and observation

QUESTION: Nature of plant matter
 INVESTIGATION: Chemical analysis--ash, oil, salt and earth found by destructive distillation of plants.
 CONCLUSION: Compounds existed in different form in original plant material
 MATERIALS AND METHODS: Destructive distillation, chemical techniques used in alchemy

Jan Baptista van Helmont: Belgian, M. D.
(1577-1644)

QUESTION: Source of plant matter
 INVESTIGATION: 200 lbs. of soil thoroughly dried placed in pot with willow twig of 5 lbs. Five years later willow showed increase of 164 lbs, soil lost only two ounces
 CONCLUSION: Plants absorb only water
 MATERIALS AND METHODS: Weighing
 GENERAL CONSEQUENCE: First to place investigation of plant nutrition on experimental basis and questioned Aristotle's humus theory which was based only on reason and logic

E. Mariotte:
(1621-1684)

QUESTION: Source of plant nutrition
 INVESTIGATION: Ash analysis
 CONCLUSION: Mineral constituents of a plant which are found in the ash thereof are taken from the soil by the plant
 MATERIALS AND METHODS: Ashing
 GENERAL CONSEQUENCE: Introduced the ashing technique used as basis of analysis by successors

Robert Boyle:
(1621-1691)

1. QUESTION: Source of plant matter
 INVESTIGATION: Repeated van Helmont's experiment
 CONCLUSION: Water is parent material from which minerals, plants, animals derived
2. QUESTION: Nature of matter
 INVESTIGATION: Ripening of fruits after picking, changes color
 CONCLUSION: Ultimate corpuscles of substances were of various shapes; particles could be changed by attrition and other agencies.
3. QUESTION: Nature of matter
 INVESTIGATION: Observed coagulation of milk; experimented with metals such as lead and copper dissolved in acids and found that their properties were disguised in the compound.
 CONCLUSION: Ultimate corpuscles of different substances could combine by cohesion to form a new compound of higher complexity and of different nature

MATERIALS AND METHODS: Weighing, observation, chemical reactions
 GENERAL CONSEQUENCE: Refuted Democritus in showing the convertability of one particle into another. Reaffirmed van Helmont's concept that water is an element.

Robert Hooke:
 (1635-1703)

QUESTION: Nature of plant matter
 INVESTIGATION: Vegetable fibers, sections of leaves, seeds, other plant organs observed. Also observed the "cellular" nature of cork.
 MATERIALS AND METHODS: Microscope

Nehemiah Grew: M. D.
 (1641-1712)

QUESTION: Source of plant matter
 INVESTIGATION: Observed consistency of soil, grew plants in water, observed stomata.
 CONCLUSION: Watery solution of nutriment and air pass through roots from soil. Four external factors contribute to growth of plant - earth, water, air, sun.
 MATERIALS AND METHODS: Observation, distillation, calcination, etc., microscope

John Woodward: M. D.
 (1665-1778)

QUESTION: Source of plant matter
 INVESTIGATION: Green mint placed in distilled water, rain water, and water with soil. Gain in weight of plant not proportional to the amount of water transpired but to the amount of mineral matter dissolved in water.
 CONCLUSION: Earth is the matter which constitutes vegetables.
 MATERIALS AND METHODS: Weighing, mint

Jethro Tull: Lawyer
 (1674-1740)

QUESTION: Source of plant matter
 INVESTIGATION: Pressure of soil upon roots of plants forces fine particles of earth into pores
 CONCLUSION: Earth taken up through roots

Herman Boerhaave:
 (1668-1738)

QUESTION: Source of plant matter
 INVESTIGATION: Examined vegetable products
 CONCLUSION: Materials absorbed by roots; agitated and form vegetable juice. Leaves expose juice to air like lungs.

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PROGRESS IN PHOTOSYNTHESIS 1800-1850

Theodore de Saussure (Swiss)

Moderately wealthy, and from a scientific family, de Saussure devoted the bulk of his time to research in plant physiology. He was successful in local politics and apparently uninterested in university teaching. His great work "Recherches Chimiques sur la Végétation" was published in 1804. There is a copy here at the Garden.

QUESTION: (de Saussure did hundreds of experiments in a score of areas in plant physiology. He wanted to know how the plant grew, how it obtained nourishment, how it used that nourishment available to it, and so forth. An outstanding example of this experiment from the standpoint of photosynthesis is the one listed below).

Do plants fix water?

INVESTIGATION: *Vinca minor* placed in water in an enclosed vessel with a measured quantity of air of known composition. At the conclusion of the experiment the plant was weighed and the remaining gas analyzed. 217 mg. of C from CO₂ had been taken from the air, yet the plant increased in dry weight by 532 mg. Gases exchanged in respiration cancelled out, therefore 315 mg. of water must have been fixed by the plant to account for the increase in weight. Experiment repeated with the same and other plants with similar results.

CONCLUSION: In light the green parts of plants absorb CO₂ and fix water in the same process. Other experiments showed that oxygen was liberated in a 1:1 ratio with the CO₂ absorbed. Therefore, in light, green plants take

CO₂ + H₂O and make (more plant) + O₂

From other experiments he suggested limiting factors --- increasing the CO₂ available to the plant did not result in an increase in rate or quantity in the reaction, and de Saussure speculated that "unless the light be very bright" no increase would result. In still other experiments he suggested that nitrogen was available to the plant in the form of water soluble salts in the soil. This speculation was reversed 40 years later by de Saussure in his famous controversy with Liebig.

MATERIALS AND METHODS: Eudiometer, balance, vacuum pump, flasks. Many living plant materials used, including *Quercus* sp., *Quercus robur*, *Corylus avellana*, *Morus nigra*, *Carpinus betulus*, *Aesculus hippocastanum*, *Ficus sativa*, *Vicia faba*, *Solidago vulgaris*, *Helianthus annuus*, *Rhododendron ferrugineum*, *Pinus avies*, *Vaccinium myrtillus*, *Triticum sativum*, *Zea mays*, *Hordeum vulgare*, *Ilex aquifolium*, *Dryas ssp. viridis*, *Prunus laurocerasus*, *Viburnum tinus*, *Hedera helix*, *Vinca minor*, *Empetrum fruticosum*, *Juniperus sabina*, *J. communis*, *Fagus sylvatica*, *Populus alba*, *Prunus armeniaca*, *Amygdalus persica*, *Juglans regia*, *Platanus occidentalis*, *Robinia pseudo-acacia*, *Syringia vulgaris*, *Fraxinus excelsior*, *Pyrus*, *Rosa centifolia*, *Fagus castanea*, *Solanum tuberosum*, *Brassica oleracea*, *Urtica urens*, *Mercurialis annua*, *Daucus carota*, *Linum catharticum*, and about 30 more.

GENERAL CONSEQUENCES: Photosynthesis "solved", gas exchange and plant product investigations cease for several decades.

1833 Brewster (England)

QUESTION: What is the green pigment?

INVESTIGATION: Alcoholic extraction of green leaves.

CONCLUSION: Nature of green pigment a mystery. In reflected light it fluoresces red.

1838 Berzelius (Sweden)

QUESTION: What is the chemical formula and weight of the green pigment?

INVESTIGATION: Alcoholic extraction of the green pigment treated with concentrated acids and alkalis.

CONCLUSION: Experiments failed, green matter destroyed in treatment. It is, however, neither a resin, fat nor a wax but a dye with a coloring power comparable to indigo.

1843 Liebig (Germany)

QUESTION: What are the first products of photosynthesis?

INVESTIGATION: Analogy and speculation based upon experience and knowledge in the fields of chemistry and plant physiology.

CONCLUSION: Carbohydrate is formed by a series of steps showing successive decrease in the amounts of oxygen formed concomitant with increasing hydrogen. His suggestion: Carbonic acid passes through changes into oxalic acid, to tartaric acid, to malic acid to "other fatty acids" and eventually carbohydrate.

1844 Mulder (Germany)

QUESTION: Chemical formula, structure and weight of Chlorophyll.

INVESTIGATION: Same as Berzelius.

METHODS AND MATERIALS: Same as Berzelius.

CONCLUSIONS: Experiment failed.

1845 Von Meyer (Germany) Discoverer of the Law of Conservation of Energy.

QUESTION: How is energy conserved in nature?

INVESTIGATION: No experiments, investigated literature.

CONCLUSION: The fundamental physical function of photosynthesis is the conversion of light energy into chemical energy.

GENERAL CONSEQUENCES: The question of energy relationships, pointed out by Von Meyer, stimulated later specific work in photosynthesis.

1849 Morot (France)

QUESTION: Chemical formula, structure and weight of chlorophyll

INVESTIGATION: Same as Berzelius

METHODS AND MATERIALS: Same as Berzelius

CONCLUSION: Experiment failed.

SUMMARY OF KNOWLEDGE OF PHOTOSYNTHESIS IN 1849

Green parts of plants in the presence of light take up carbon dioxide and water and yield (a) carbon compound (b) oxygen. The carbon dioxide of the air is the sole source of carbon utilized by the plant. Respiration and photosynthesis are distinct. The fundamental function of this process is the conversion of light (solar) energy to chemical energy. The chemical structure of the green agent is unknown.

SUPPLEMENTARY OUTLINE 1800-1850

The first half of the last century was a period of rapid advances in science. Modern chemistry and physics have developed from seeds germinated by early 19th century scientists. In order to understand better the progress of related fields in connection with the examination of photosynthesis, this supplementary outline has been constructed.

General History

- 1804 Bonapart crowns himself Emperor Napoleon I of France in Notre Dame de Paris.
1805 The battle of Trafalgar
1806 Lamarck Defines a "species"
1807 England abolished slavery
1810 By marrying an Austrian archduchess, Napoleon "neutralized" Austria. Russia is the sole remaining land power opposing the French in Europe.
1812 Retreat from Moscow
1814 Napoleon exiled to Elba
1815 The "Hundred Days", Waterloo, exile to St. Helena. The Congress of Vienna.
1824 Coronation of Charles X in France
1826 Nicholas I assumes throne of Russia
1830 "July Revolution" in Paris. Charles X exiled, Louis-Philippe crowned
1830-33 Lyell establishes the antiquity of the earth
1831-35 Voyage of the Beagle
1832 First Parliamentary Reform Bill--England
1837 Ascension of Victoria
1839 Penny Post established--first regular cheap postal service
1842 Child mine labor laws--England
1847 Factory Labor Act--England
1848 Revolutions of 1848; French monarchy collapses, 2nd Republic formed.

Plant Physiology

- 1804 Knight shows the barberry-wheat rust relationship
1806 Vauquelin and Robiquet isolate asparagine and demonstrate that it contains N_2
1807 Prévost demonstrated the life history of wheat bunt fungus
1819 Griseb described respiration in fungi, no CO_2 fixed
1822 de Saussure shows relationship of oxygen and flower heat
1825 Raspail conducts chemical tests on starch grains under a microscope
1826-28 Dutrochet's tests on osmosis in plants
1831 Brown discovers the cell nucleus
1832 de Candolle publishes treatise on plant physiology. Medieval in outlook.
1837-38 Schleiden and Schwann develop the cell theory
1838 Boussingault shows that legumes, but not other plants, fix atmospheric N_2
1842 Schleiden shows that certain plant roots always associated with fungi
1843 Trinchinette: Differential absorption of soil minerals by plants
1843-44 Bris states that lack of iron causes leaf chlorosis
1844 Piria shows that asparagine is not unique to asparagus
1845 Von Mohl overthrows the Free Cell Theory

Materials and Instruments Available

Prior to 1800 workers had very accurate balances; microscopes; prisms; glassware (blown to order); a limited selection of poorly understood chemical compounds; good pumps, thermometers and clocks; steam engines; slide rules; electroscopes; custom made calculating machines.

- 1801 (About) Solar spectroscope
1819 Stethoscope (Laennec)
1820 Galvanometer (Schweigger)
1825 Actinometer for solar radiation (Herschel)
1825 Powerful electromagnets in commercial production
1826 Osmometer (Dutrochet)

- 1830 Achromatic microscope objective (Lister, father of physician)
1832-38 Telescopes now powerful enough to measure stellar parallax based on diameter of the earth
1834 Wheatstone rotating mirror to measure the duration of an electric spark, and the speed of light.
1837 Tangent and sine galvanometer (Pouillet)
1844 Grease spot photometer (Russon) (Burner invented after 1850)

Most of the above instruments were to be used later in the study of photosynthesis, but by and large were not used for this purpose during this time.

The Study of Light

- 1800-50 Revival and acceptance of the wave theory over the corpuscular theory of light
1800 Herschel discovers infra-red radiation
1801 Ritter discovers ultra-violet radiation
1802 Dollond discovers dark lines in sun's spectrum
1808 Malus discovers polarized reflected light
1809-21 Arago, Biot, Young and Fresnel experiment with polarized light
1814 Fraunhofer studies lines in the sun's spectrum
1817 Grotthuss formulates the first law of photochemistry. Only light which is absorbed can produce chemical change.
1821 Mechanics of polarized light explained
1835 Cauchy's law of light dispersion (refractive index in terms of wave length)
1849 Speed of light measured using the wheatstone mirror

Most of the above discoveries were to be used later in the study of photosynthesis, but by and large were not used for this purpose during this time.

Chemistry

- 1800 Nicholson and Carlisle accomplish electrolysis of water into H_2 and O_2
1802 Charles' law
1808 Dalton proposes the atomic theory
1811 Avogadro's Hypothesis
1811 Davy identifies electricity with chemical affinity
1815 Kirchoff derives sugar from starch and cellulose
1820 (About) Berzelius introduces modern symbols and notation
1828 First organic synthesis (Urea). Death blow to vitalists. Era of synthetic organic chemistry begins.
1835 Magendie differentiates foodstuffs into proteins, carbohydrates and fats.
1840 Hess' Law. Beginnings of thermochemistry
1843 Hoffman derives aniline and benzene from coal tar
1849 Pasteur's work on tartaric acid shows the optical activities of asymmetric molecules. Isomerism.

Most of the above discoveries were to be used later in the study of photosynthesis, but by and large they were not used for this purpose during this time.

Physics (Exclusive of Light)

- 1804 Carnot "founds" modern thermodynamics
1814 DuLong and Petit's Law of Atomic Heats
1820 Orsted and Ampere demonstrate the relationship between electricity and magnetism
1820 Ohm's Law. The discovery of thermoelectricity

- 1834 Faraday's Law. "Electrochemical equivalents
1838 Daguerre--beginnings of photography.

Most of the above discoveries were to be used later in the study of photosynthesis, but by and large they were not used for this purpose during this period.

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QUESTION: What are the true volume relations between carbon dioxide absorbed and oxygen evolved in photosynthesis?

INVESTIGATION: Boussingault (1864) performed more exact experiments than those done by de Saussure in 1804, but used similar apparatus.

CONCLUSION: The volume of oxygen evolved is very nearly equal to the volume of carbon dioxide absorbed.

QUESTION: What effects do other gases have on photosynthesis?

INVESTIGATION: Boussingault (1865-1866) investigated the action of hydrogen, nitrogen and methane on an assimilating plant in an oxygen-free atmosphere.

CONCLUSION: In the dark, plants so treated became asphyxiated, and in the light no longer had the ability to decompose carbon dioxide.

QUESTION: How do gases enter and leave the plant?

INVESTIGATION: Boussingault (1866), using oleander leaves, blocked the stomata of one leaf with lard and put this leaf and a normal one in an atmosphere containing 30% carbon dioxide.

CONCLUSION: Since the blocked leaf absorbed 70% more carbon dioxide than the unblocked one, gas enters and leaves by the cuticle and not by the stomata.

QUESTION: If plants continue to respire in the light, how does this affect the net gas exchange -- i.e., what is the "true" photosynthesis?

INVESTIGATION: Pomier and Lancel (1886) used 4 methods for this problem: (1) assuming that respiration in the light was the same as in the dark, they determined "dark" respiration; (2) they used narcotics which inhibited photosynthesis but not respiration; (3) prevented photosynthesis by omitting carbon dioxide; (4) compared gas exchange in leaves of high and low chlorophyll content.

RESULT: By all methods they obtained Q_p values above unity.

QUESTION: What effect does carbon dioxide concentration have on photosynthesis?

INVESTIGATION: (1878) Codlawski used Pfoffer's audimeter method with five species of plants.

RESULTS: With an increase of carbon dioxide concentration, the photosynthesis increased to a certain optimum, depending on the species; when the concentration was increased beyond this optimum, the photosynthetic rate diminished.

QUESTION: Where did Roussineault go wrong?

INVESTIGATION: Stahl (1894) illuminated leaves which had been deprived of starch and which had their stomatal surfaces smeared by cocoa butter and beeswax.

CONCLUSION: Since the iodine test on such illuminated leaves showed that only those parts which had not been coated with the wax mixture had any starch formed in them, the inference was that blocking the stomata prevented carbon dioxide from entering the leaf.

INVESTIGATION: Blackman (1895) repeated Roussineault's experiments, using a series of concentrations of carbon dioxide from 6% to 97%, and blocked some leaves with vasoline, left others unblocked.

RESULTS: With low concentrations of carbon dioxide, leaves of oleander with blocked stomata absorbed less gas than leaves whose stomata were not stopped up, but as the concentration of carbon dioxide increased, the difference became less until at high concentrations, the vaselined leaf absorbed more than the unvaselined control.

INVESTIGATION: Blackman (1895) using the continuous gas stream method, by which the concentration of carbon dioxide could be determined before and after it entered the test chamber, found that the carbon dioxide intake by the two surfaces of the same leaf under the same conditions was very much in proportion to the number of stomata on the surfaces.

CONCLUSION: The stomata are the principal gateways for exchange of gases.

* * *

QUESTION: What effect do high concentrations of carbon dioxide have on photosynthesis?

INVESTIGATION: Ewart (1896) found that high concentrations had a narcotic effect, that in 100% carbon dioxide photosynthesis ceases.

CONCLUSION: Too much carbon dioxide is not appreciated by most plants.

* * *

QUESTION: How is photosynthesis influenced by light intensity?

INVESTIGATION: (1886) von Helmholtz exposed plants at various distances from an illuminated sheet of ground glass, determined the rate of photosynthesis by the bubble-counting method; he made use of only low light intensities over a small range.

CONCLUSION: Photosynthesis is directly proportional to the intensity of light.

QUESTION: What color of light is most effective in photosynthesis?

INVESTIGATION: Loisel (1871) proposed the idea that the rays which are most effective were those which were most strongly absorbed by chlorophyll, i.e., the rays in the red end of the spectrum.

QUESTION: What is the relation between the absorption spectrum of chlorophyll and the efficiency of photosynthesis?

INVESTIGATIONS: (ca 1872) Timiriazev, Pfeffer, Müller and Loisel independently worked on the problem, used prisms, filters, sunlight, bubble-counting method and eudiometer, etc.

SUGGESTION: Timiriazev suggested that chlorophyll acts as a sensitizer which absorbs radiation and makes it then institute chemical changes in the carbon dioxide.

QUESTION: How is the energy distributed in the solar spectrum?

INVESTIGATION: (1890) Lanley, finding existing instruments too poor for his purposes, invented the bolometer, a device of almost incredible sensitivity, meticulously measured the spectrum of the sun.

CONCLUSION: There is more energy associated with the red end of the spectrum of the sun than with the blue end.

QUESTION: What wavelengths are most effective in photosynthesis?

INVESTIGATION: Engelmann (1882-1884) used oxygen-sensitive, motile bacteria and algal filaments; the bacteria won't move or develop without oxygen, the alga won't evolve oxygen without light; Engelmann sealed filament and bacteria under a coverglass and put the chamber in the dark. The bacteria depleted the oxygen in the system. The filament was then illuminated by a micro-spectrum.

RESULTS: The bacteria moved to, and congregated around, the parts of the filament which were evolving oxygen in greatest amount; the larger number of bacteria collected about the part of the filament lying in the red end of the tiny spectrum, next largest swarm were found near the blue end.

CONCLUSIONS: Red rays were of primary importance, blue rays of secondary effectiveness, in photosynthesis.

QUESTION: How is photosynthesis affected by light intensity?

INVESTIGATION: Reinke (1883) used Lodea, the bubble-counting method, sunlight and lenses, and was able to get light intensities varying from 1/16 of and 60 times sunlight.

CONCLUSION: In moderate light intensities, an approximate proportionality existed between intensity and photosynthesis, but with greater intensities a progressively smaller increase in photosynthesis occurred; in very high intensities, a falling off in the bubble count took place.

CONCLUSION: Too much light is not appreciated by Lodea.

* * *

QUESTION: What rays of the spectrum are most efficient in photosynthesis?

INVESTIGATION: In 1874 Reinke used a "spectrophore" and the gas-bubble method.

CONCLUSION: The absolute maximum of oxygen evolution is caused by rays of wavelength 6800 to 6900 Angstrom units; i.e., between Fraunhofer lines B and 7 (red end). The intensity curve for oxygen production fell off quickly toward line A (infrared) and also, but less steeply, toward H (green) and then slowly to V (violet). So Reinke denied that there was a second maximum in the violet part of the spectrum, as Engelmann had said.

* * *

QUESTION: How leaves absorb light.

INVESTIGATION: (1870) Betlelsen used a thermopile to measure the absorption of light by a leaf, placed the leaf first in air containing 10% carbon dioxide, then in air free of that gas.

RESULTS: In the former case, in which carbon assimilation went on, he found that more light was absorbed than when there was no assimilation of carbon.

* * *

QUESTION: What is the first product of photosynthesis?

INVESTIGATION: (1857) Cris observed chloroplasts in the daytime and at night.

RESULTS: The starch grains seemed to enlarge during the day, dissolve during the night.

INVESTIGATION: (1862-1864) Sachs, in one of many experiments, showed that of two halves of a leaf (one half being covered) only the half exposed to sunlight gave the starch-iodine reaction.

CONCLUSION: Starch is the first visible product of photosynthesis and the chloroplasts are the site of the process of carbon assimilation.

INVESTIGATION: (1870) Naeyer, on the basis of Butlerow's discovery in 1861 that formaldehyde can condense into a sugary substance, suggested that carbon dioxide is reduced to formaldehyde during photosynthesis, then condenses to form sugar.

QUESTION: What happens when plants are "fed" formaldehyde?

INVESTIGATION: Dokorny & Leew (1897), knowing that they must guard against the poisonous quality of formaldehyde, used compounds of this substance which, in solution, would yield only a small amount of formaldehyde to the plant being "fed."

RESULTS: For algae exposed to light, positive results were obtained, but for algae in the dark, results were negative.

QUESTION: What is the first product of photosynthesis?

INVESTIGATION: Edlin & Meyer (1903-1905) floated leaves on solutions of various organic substances, including glucose and fructose; they then followed the rate of starch formation in the leaves in the dark.

RESULTS: Glucose and fructose were best for starch formation.

CONCLUSION: Since starch when hydrolyzed gives only glucose, and the feeding experiments showed that starch formed in the leaves which were supplied with that sugar, glucose must be the first product of photosynthesis.

QUESTION: Once more, what is the first product?

INVESTIGATION: Brown & Morris (1898) analyzed Tropaeolum leaves after various periods of illumination; sugar analysis by the polariscope (identification by optical properties).

RESULTS: A decided increase in the amount of sucrose and of fructose, but no appreciable increase in glucose.

CONCLUSION: Sucrose is the first product of photosynthesis; it is hydrolyzed in the plant cells which use the glucose for respiration and reject the fructose which thus accumulates.

QUESTION: Cause and cure of chlorosis.

INVESTIGATION: (1857) Griseb. studied plants growing in an iron-free medium, found that their chlorosis could be alleviated by adding a small amount of an iron salt.

CONCLUSION: Iron is an essential constituent of chlorophyll.

* * *

QUESTION: Nature of the green pigment.

INVESTIGATION: In 1860 Engelm. extracted leaves with alcohol, treated residue with strong acid and ether.

RESULTS: The ether became yellow-colored, the acid bluish.

CONCLUSION: Chlorophyll consists of a blue pigment and a yellow one.

* * *

QUESTION: Nature of the green and yellow pigments.

INVESTIGATION: Stokes in 1864 tried to separate the pigments by means of carbon disulfide and alcohol.

RESULTS: Stokes claimed to have separated 2 yellow pigments and 2 green ones; spectroscopically observed that chlorophyll was a mixture of two components which he called a and b.

* * *

QUESTION: The nature of the bleaching of chlorophyll by light.

INVESTIGATION: In 1869 Timiriazov exposed alcoholic chlorophyll solutions to light, with and without oxygen.

RESULTS: Even when oxygen was absent, chlorophyll was bleached, and the solutions after illumination smelt of alcohol.

CONCLUSION: The bleaching was caused by a reduction of the pigment.

* * *

QUESTION: What protects chlorophyll from being bleached in vivo?

INVESTIGATION: Hiesner (1874) illuminated solutions of chlorophyll in alcohol, benzene, ether and olive oil.

RESULTS: 3 1/2 hours of illumination were needed to give the olive oil solution the same degree of bleaching that occurred in the alcohol solution within 3 minutes.

CONCLUSION: Some oils or oil solvents protected from bleaching.

* * *

QUESTION: Is chlorophyll related to the blood pigment, hemoglobin?

INVESTIGATION (1) Hoppe-Seyler (1879) extracted fresh leaves with boiling alcohol, finally crystallized a greenish pigment which contained 1.4% phosphorus.

CONCLUSION: Chlorophyll belonged to the lecithins.

INVESTIGATION (2) In 1880 Hoppe-Seyler compared a derivative of chlorophyll, which he called phylloporphyrin, with the hemoglobin derivative, hemetoporphyrin.

RESULTS: These derivatives had the same absorption spectrum.

CONCLUSION: Hemoglobin and chlorophyll are definitely related.

* * *

1850--1900

Progress in Related Fields

- 1850 WILHELMY investigated for the first time the rate of a chemical reaction: the inversion of cane sugar in the presence of an acid by means of the polariscope (invented 1840).
- WILLIAMSON first clearly formulated the concept of dynamic equilibrium in bimolecular reactions.
- 1851 KELVIN placed the new science of thermodynamics on a secure foundation (The Dynamical Theory of Heat).
- 1852 FRANKLAND brought forward the concept of chemical valency.
- 1853 BUNSEN developed the gas burner named for him.
- 1855 BUNSEN and ROSCOE began a series of investigations on the chemical action of light.
- 1856 BUNSEN and RESCOE invented the actinometer.
- 1857 CLAUSIUS published the first adequate kinetic theory of matter.
- BERNARD proved that the liver forms a starch-like substance which he called glycogen. Explained poisonous nature of carbon monoxide.
- KEKULÉ first mentioned the quadrivalency of carbon.
- 1858 The first cable communication between England and the United States.
- KEKULÉ showed that the structures of many organic compounds can be explained by assuming (a) carbon is tetravalent, (b) carbon atoms can link together.
- 1859 BUNSEN and KIRCHHOFF devised the first exact methods of spectrum analysis.
- DARWIN published The Origin of Species.
- 1864 GULDBERG and WAAGE gave a full statement of the Mass Law of chemical action.
- 1865 KEKULÉ discovered the "ring" structure of benzene; gave impetus to the theory of structural formulas in organic chemistry.
- 1866 MENDEL published Experiments in Plant Hybridization (obscure until 1900).
- NOBEL invented dynamite.
- 1867 HOFFMAN discovered formaldehyde.
- 1869 MENDELÉEFF developed the Periodic Law; Periodic Table of the chemical elements; predicted several elements then unknown on the basis of gaps in the Table.
- 1870 MAXWELL published his theory of electromagnetic waves.
- ca 1870 The centimeter-gram-second system for scientific work agreed on.

- 1873 van der WAALS developed the equation of state for imperfect gases.
- 1874 LeBEL and van't HOFF developed their theory of optical isomerism and the concept of the "tetrahedral" carbon atom; the isomerism of maleic and fumaric acids explained.

VOGEL discovered the sensitization of the photographic plate.
- 1875 FISCHER discovered the phenylhydrazine, of immense value in sugar chemistry.
- 1876 BELL invented the telephone.
- 1877 GIBBS proposed a theory of phase equilibrium ("Gibbs' Phase Rule").

PFEFFER was the first to make measurements of osmotic pressures, used a membrane of copper ferrocyanide in unglazed porcelain.
- 1878 KUHN proposed the name "enzymes" for those peculiar organic catalysts that are responsible for the wide variety of biochemicals formed in vivo from common starting materials.
- 1881 PASTEUR Devised a treatment for anthrax.
- 1883 The era of synthetic drugs began with the discovery of antipyrine.
- 1884 FISCHER published his first paper on sugar chemistry.
- 1887 ARRHENIUS showed that osmotic pressures of solutions were related to their electrical properties.

MICHELSON and MORLEY performed a futile experiment on the velocity of light to determine "ether drift" past the earth.

HERTZ produced and detected electric (radio) waves in space, found them to have properties similar to those of light as MAXWELL had earlier predicted.
- 1889 ARRHENIUS first showed that the specific reaction rate for many chemical reactions varies with the temperature.
- 1892 IVANOVSKI first demonstrated the filtrability of a virus.
- 1895 RONTGEN discovered x-rays.
- 1896 BECQUEREL discovered radioactivity (of uranium).
- 1897 THOMSON et al discovered and made first measurements of electrons.
- 1898 CURIE'S discovered radium.

PHOTOSYNTHESIS
1850--1900

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Oxygen Production

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I. The early period of study and description of fossil plants previous to 1800.

A. Early ideas regarding fossils.

B. Theories concerning the origin of fossils.

1. The "Accidental Theory".

2. The "Flood Theory" and the Diluvialists.

John Woodward

Johann Scheuchzer

Johan Berenger

II. The Period of Transition, 1800-1828.

A. Early attempts at paleobotanical classification and the first use of binomial nomenclature in fossil plants.

Ernest von Schlotheim

Rev. Henry Steinhauer

Kaspar von Sternberg

III. The Modern Period of Paleobotany.

A. Adolphe Brongniart, the father of paleobotany.

1. New classification and the development of new methods for the study of fossil plants.

B. The two great trends of paleobotanical study after Brongniart.

1. Systematic and floristic study of fossil plants.

Heinrich Goëppert

Baron von Ettingshausen

Oswald Heer

Leo Lesquereux

William Schimper

Sir. J.W. Dawson

2. Anatomy and comparative morphology of fossil plants.

Bernhard Cotta

W.C. Williamson

H.T. Witham

Bernard Renault

August Corda

D.H. Scott

Sir Albert Seward

IV. Paleobotany in America.

A. The geologists and paleontologists as the pioneers of American paleobotany.

F.V. Hayden

E.D. Cope

Lester Ward

O.C. Marsh

B. The turning point in American paleobotany, 1920.

1. Present day paleobotanical activity in the United States.

H.N. Andrews

E. Barghoorn

C.A. Arnold

H. Hoskins

J.M. Schopf

R. Brown

R.W. Chaney

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BOTANY SEMINAR

Rise and Development of Microbiology

(Four discussions to be presented beginning Nov. 29, 1950, through Dec. 20, 1950.)

- I. The Development of Microbiology with Emphasis on the Life and Work of Louis Pasteur. Dan McClary, Nov. 29. !.!!
- II. The Work and Influence of Robert Koch and his School. Sid Rodenberg, Dec. 6.
- III. The Development of Industrial Microbiology. Mas Yamada, Dec. 13.
- IV. Modern Developments in Microbiology. Harrison Hoffmann, Dec. 20.

I. The Development of Microbiology with Emphasis on the Life and Works of Louis Pasteur

A. Four fundamental questions of microbiology of interest to early workers.

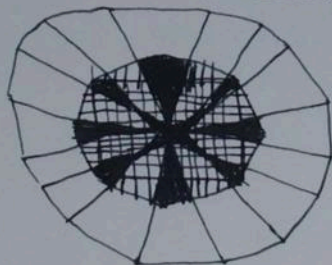
1. Classification of microorganisms and their relation to the larger and more familiar forms of life.
 - a. Antony van Leeuwenhoek (1672); animalcules.
 - b. Mueller (1773); described arranged and named with considerable accuracy a number of microscopic plants and animals.
 - c. Ehrenberg (1838); classed bacteria and protozoa as Infusoria.
 - d. Dujardin (1841); placed bacteria in the family Vibrioniens.
 - e. Cohn (1854); bacteria should be placed in plant kingdom.
 - f. Nageli (1857); term Schizomycetes for all organisms classified as bacteria.
 - g. Cohn (1872); physiological as well as morphological differences necessary for classification.
 - h. Zopf (1885); classification based on morphology alone.
 - i. Migula (1897); combined classifications of others into a system used by bacteriologists until fairly recently.
2. The origin of microbes and the truth or falsity of the theory of spontaneous generation.
 - a. Anaximander (610-547 B.C.) and Aristotle (384-322 B.C.); animals derived from moisture, soil, water, and other plants and animals.
 - b. Van Helmont (1577-1644); directions for making mice.
 - c. Francesco Redi (1668); maggots do not arise spontaneously from meat.
 - d. Louis Joblot (1718); microorganisms do not develop in hay infusion sterilized by heat and protected from air.
 - e. Needham (1749); vegetative force in organic matter caused the medium to be converted into living forms. Used inefficient sterilization.
 - f. Spallanzani (1776); no organisms develop in heated and sealed infusions.
 - g. Schultz (1836); air filtered through sulfuric acid.
 - h. Schwann (1837); air heated.
 - i. Schroeder and Dusch (1854); air filtered through cotton.
 - j. Louis Pasteur and Tyndall vs. Pouquet and Bastian (1861-1876).
3. The relation of microorganisms to fermentation and putrefaction.
 - a. Gay-Lussac (1810); crushed grapes require oxygen to start fermentation but once started the gas is no longer necessary.
 - b. Cagniard-Latour (1836); fermentation probably the result of the growth and multiplication of a microscopic plant (yeast) in sugar solutions.
 - c. Schwann (1837); nitrogen as well as carbon necessary for growth of yeast.
 - d. Berzelius, and pupils Wohler, and Liebig (1779-1873); fermentations and putrefactions purely chemical reactions.
 - e. Mitscherlich (1841); fermentation occurs only in presence of yeast but not convinced by his own experiments.
 - f. Pasteur (1822-1895).
 - 1) 1848. Discovery of stereo-isomeric forms of tartrate crystals.
 - 2) 1857. Lactic acid fermentation then alcoholic fermentation.
 - 3) 1868. Heating of wines (Pasteurization).
4. The relation of microorganisms to disease.
 - a. Aristotle (384 B.C.) and Rhazes (860-932 A.D.) invisible living creatures responsible for disease and its spread.
 - b. Varro (116-26 B.C.); fevers in swamps due to invisible organisms.
 - c. Benedetti (1493); disease spread by contact.
 - d. Fracastoro (1484-1553); existence of seeds of disease.

- e. Kircher (1602-1682) and Lange (1619-1662); infections produced by living organisms.
- f. Marten (1720); views concerning the etiological agent of tuberculosis.
- g. Anton van Plenciz (1705-1786); a specific germ for each different disease.
- h. Jacob Henle (1809-1885); modern concept of germ theory.
- i. Louis Pasteur (1882-1895); work and influence.
 - 1) 1865-1870. Silkworm disease: solved.
 - 2) 1865. Lister applies antiseptic surgery.
 - 3) 1873. Election into the Academy of Medicine.
 - 4) 1887-1882. Work on surgery, puerperal fever, chicken cholera, and anthrax. Attenuated virus.
 - 5) 1884-1884. Work on rabies and anti-rabies vaccine developed on dogs.
 - 6) 1885-1888. Rabies treatment on man.
 - 7) 1889-1895. Influence of Pasteur and his students.

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*T. Huxley - Lay Sermons, etc. N.Y. 1903 Appleton Co.
S. Generation.*



*Our house is being painted -
Do you mind the smell?
Don't have to come if
you don't want to"*

ROBERT KOCH

Biographical Notice

Born 1843, in Clausthal, Hanover, the son of a mining engineer. Studied in Univ. of Göttingen under Wöhler, G. Meissner, and J. Henle. Graduated as doctor of medicine 1866. Practised in Niesmegk and Rakowitz. Served as surgeon in Franco-Prussian war, and in 1872 became Kreisphysikus in Wollstein.

Published his classical research on anthrax in 1876, on the technical methods of bacterial examination in 1877, and on the etiology of traumatic infective diseases 1878. Became associated with the Gesundheitsamt in Berlin and founded famous school of bacteriology there. In 1881 he solved the problem of pure bacterial cultures and his methods were universally employed. Discovered tubercle bacillus 1882, and cholera vibrio in 1883. In 1890 made known his discovery of tuberculin, and in 1900 his views on the non-identity of human and bovine tuberculosis. From 1891 to 1904 Koch was Director of the Institut für Infektionskrankheiten in Berlin. In 1896 he investigated rinderpest in South Africa and sleeping-sickness in Uganda. Travelled extensively studying protozoal diseases in the East. Received Nobel Prize 1905 and was ennobled with the title of Excellenz. Foreign member of the Royal Society 1897. Died 1910, aged 67.--Bullock, The Hist. of Bacteriology.

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Koch's Postulates

1. A particular organism must always be associated with a particular disease and must be present in tissue infected with such disease.
2. The organism must be isolated in pure culture and grown on artificial media.
3. It must produce symptoms of the same disease in experimental animals.
4. Organisms in lesions of experimental animals must be the same as those found in the original infected tissue.

Associates and Students of Robert Koch

- Abbe, Ernst-Contributed condenser and oil immersion lenses.
- Abel, Rudolph Existence of antitoxin in normal persons.
- Babes, Victor, Numerous bacteriological writings.
- von Behring, Emil Discovery of antitoxin.
- Buchanan, Robert Investigation of Plague.
- Cohn, Ferdinand Discoverer of Koch, editor of Beiträge zur Biol. der Pflanzen.
- Cohnheim, Julius Classical work in pathology, staunch supporter of Koch.
- Cornet, George Contracted tuberculosis and studied it as pupil of Koch.
- Crookshank, Edgar Student, founded 1st bacteriological laboratory in England.
- Dñitz, Wilhelm Standardization of diphtheria antitoxin and tuberculin.
- Dunbar, W.P., Investigations on hay fever and Asiatic cholera.
- Dunham, Edward K. Early bacteriological diagnosis of cholera.
- Shrlich, Paul Differential Stains, Immunity studies, founder of Hematology & Chemotherapy. Introduction of methods and discovery of 605.
- von Ermengen, S. Discovered Bacillus botulinus.
- von Smarck, Ervin Student, wrote many bacteriological papers.
- Fischer, Bernhard Studied marine bacteria.
- Flügge, Carl Noted hygienist, edited with Koch the Zeitschrift für Hygiene.
- Fraenkel, Carl Immunological investigations.
- Frosch, Paul Foot and Mouth disease investigations.
- Gaffky, Georg Aupil, assistant and successor of Koch in Berlin. Worked on cholera and was first to cultivate bacillus of typhoid.
- Goppert, August J. Effects of Disinfectants on Bacteria.
- Hata, Schachiro Work on treatment of Syphilis.
- Hair, Ludwig Hygienist and bacteriologist, wrote Text-book of Bacteriology.
- Henle, Jacob Koch's teacher, anticipated the germ theory of disease.
- Hesse, Walther Investigations of air-borne bacteria in relation to hygiene.
- Hesse, Frau W. Aided husband and suggested use of agar-agar for culturing.
- Jensen, Carl World-famed for mouse cancer research and work in veterinary bact..
- Kitasato, Shibasaburo Discovered plague bacillus, first cultivated B. tetani, discovered with Behring, tetanus antitoxin 1890.
- Kolle, Wilhelm Successful worker in bacteriology, immunology, and chemotherapy.
- Kossel, Hermann Important work on bovine and human tubercle.
- Loeffler, Friedrich Succeeded Gaffky in Berlin, discovered diphtheria and glanders bacilli, worked successfully on virus attenuation, disinfection, water bact., typhoid, etc.. Presented many new methods and founded the Centralblatt für Bakteriologie.
- Morgenroth, Julius Classical work in chemotherapy and immunology.
- Meisser, Albert Discovered gonococcus, extended work on leprosy, aided Wassermann.
- Moufoid, Fred Important work on pneumococcus infections.
- Petri, Richard Inventor of plates bearing his name. tuberculosis patient
- Pfeiffer, August Observations on typhoid bacilli in stools, discovered P. pseudo-
- Pfeiffer, Richard Discovered influenza bacillus and N. catarrhalis etc.
- Proskauer, Bernhard Excellent work in bacteriology and hygiene.
- Römer, Paul Published much on bovine and human tuberculosis and work on polio.
- Schätz, Wilhelm Glanders, tuberculosis and veterinary bacteriology.
- Shiga, Kiyoshi Discovered dysentery bacillus, did excellent work on chemotherapy.
- von Wassermann, August Famed for syphilitic reaction bearing his name.
- Weigert, Carl Introduced staining methods used by Koch and Ehrlich (still in use).
- Welch, William Developed bacteriology in U.S.A..
- Zettnow, Hugh Export technic and photographer of bacteria, developed cilia stain.
- Zieth, Franz Developed stain for tubercle bacillus

Industrial Microbiology

1. Historical Introduction

The problem of alcoholic fermentation, of the origin and the nature of that mysterious and apparently spontaneous change which converted the insipid grape juice into a stimulating wine, seems to have exerted a fascination over the scientists from the earliest times. Alcoholic beverages preceded the earliest writings. Many observers claim yeast to be one of the earliest cultivated plants. The process of making wine, vinegar, beer, cheese, and bread were processes developed from family arts.

In 1810 N. Appert investigated food preservation and published the book "The Book For All Households or The Art of Preserving Animal and Vegetable Substances For Many Years".

Also in 1810 Gay Lussac investigated Appert's work and proved that fermentation and spoilage of foods occurred in the presence of air.

1837 Cagniard Latour claimed that fermentation was caused by a yeast.

1857 Pasteur published the classical paper on lactic acid fermentation.

1858 Traube proposed the existence of enzymes.

1897 Buchner isolated the enzyme zymase from crushed yeast cells.

2. Scope of Industrial Microbiology

Microbiology includes in its scope the study of:

- a) Fermentation processes in which production of alcohol, glycerol, organic acids, acetone, and other substances are the end products.
- b) Food manufacturing processes such as baking, cheese making, butter making, sauerkraut, and pickle making.
- c) Food conservation methods such as canning, quick freezing, and drying.
- d) Microbiological processes concerned with textiles and commercial fibers.
- e) Production of antibiotics and its application to the drug industries.

3. Fermentation Processes

a) Yeast and their application to industry.

1. Brewing - Saccharomyces cerevisiae
2. Wines - Saccharomyces ellipsoideus
3. Food yeast and vitamins - S. cerevisiae
4. Industrial alcohol - S. cerevisiae
5. Glycerol - S. ellipsoideus

a. Uses; nitroglycerine, solvents, sweetening agents, and constituents of ointments.

6. Fat production - Cospora lactis and Endomyces vernalis.

b) Bacteria and their application to industry.

1. Acetone - Butanol Clostridium acetobutylicum

a. Uses; lacquers, photographic film, cement, airplane dope, artificial silk and leather.

2. Acetic acid - Acetobacter aceti

a. Uses; condiments.

3. Lactic acid - Lactobacillus casei and Lactobacillus bulgaricus.

a. Uses; preservative, acidulant, and baking.

4. Sauerkraut making - requires three organisms Leuconostoc mesenteroides, Lactobacillus plantarum, and Lactobacillus pentoceticus.

5. Pickles, olives etc.

6. Propionic acid - Propionibacterium thoenii.

a. Uses; perfumes.

- c) Molds and their application to industry.
 - 1. Citric acid- Aspergillus niger.
 - a. Uses; flavoring, medicinal.
 - 2. Gluconic acid - Penicillium chrysogenum.
 - a. Uses; pharmaceutical uses.
 - 3. Itaconic acid - Aspergillus terreus.
 - a. Uses; starting material for plastics.
 - 4. Mold enzyme preparation - Aspergillus oryzae and A. flavus.
 - a. Uses; industrial.
 - 5. Fat production - Penicillium sp.
- d) Production of antibiotics.
 - 1. Penicillin - P. chrysogenum.
 - 2. Streptomycin - Streptomyces griseus.
 - 3. Chloromycetin - S. venezuelae.
 - 4. Aureomycin - S. aureofaciens.
 - 5. Neomycin - S. fradiae.
 - 6. Terramycin - S. rimosus.
- d) Other microorganisms adaptable for industrial use.
 - 1. Food yeast - Torulopsis utilis.
 - 2. Fat production - Rhodotorula ~~mitis~~ gracilis.
 - 3. Production of algae as cheap protein source. Chlorella vulgaris.
 - 4. Production of Agaricus campestris in submerged fermentation and mycelia extracted and used for flavoring of soups etc.

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Chemicals From Conn and Thin Uses

Acetone

Conn Oil

Conn
Gram Meal

Butanol

Ethyl Alcohol

CO₂

Methanol

Antyline
Solvent

Photographic
Film

Lacquers

Photographic
Films

Metal
Cleansers

Formaldehyde

Methyl
Selenate

Cellulose
Acetate Silk

Pyrex Lin
Plastic

Spinit
Varnishes

Artificial
Leather

Alcohol
Denaturant

Synthetic
Resins

Paint
Removers

Liniments

Cellulose
Acetate

Dye
Solvent

Drug
Extraction

Dehydrates

Embalming
Fluid

Dye
Solvent

Airplane
Dopes

Nitrocellulose
Cements

Penetrating
Oils

Soldering
Flux

Di-Fruth

Antifreeze

Alcohol
Denaturant

Varnish
Removers

De-waxing
oils

Rust
Removers

Synthetic
Resins

Day
Cleaning

Spinit
Varnishes

De-waxing
Gums

Alcohol
Denaturant

Artificial
Leather

Butyl
Propionates

Butyl
Xanthates

Butyl
Cellulose

Essential-
oil Solvent

Day
Cleaning

Synthetic
Resins

Smokeless
Powder

Butyl
Aldehyde

Butyl
Acetate

Dibutyl
Phthalate

Lithograph
Work

Pyrex Lin
Plastics

Extraction

Drugs

Rubber
Accelerator

Lacquers

Plasticizer

Methyl
Anthranilate

Methyl
Chloride

Chloroform

Iodoform

Butyl
Chloride

Butyl
Stearate

Butyl
Lactate

Dimethyl
Aniline

Dimethyl
Amine

Diacetone
Alcohol

Alcohol
Denaturant

Water proof
Compound

Bronzing
Lacquer

Monomethyl
Amine

Antifreeze

Compression
Fluids

Cellulose
Acetate
Lacquers

Emulsification
Agent

De-waxing
Hides

Dye
Intermediates

Harry Hoffmann 12/16/50

SOME RECENT DEVELOPMENTS IN MICROBIOLOGY
1920-1950

- I. During the last thirty years there has been a general trend toward increased research on the basic nutritional requirements of microorganisms and cell metabolism.
- A. The necessity for improved culture media both for the culture of pathogens and for industrial fermentations stimulated the study of growth factors.
 - B. By 1941, five growth factors; pantothenic acid, nicotinic acid, biotin, inositol, and p-aminobenzoic acid were shown to have vitamin characteristics for microorganisms before their role in animal nutrition was recognized.
 - C. Growth factor studies were a major contribution to the concept that nutritional requirements and metabolic pathways were generally similar in all forms of life.
- II. " . . . the history of science is the history of the development and application of techniques . . . ".
- A. The microbiological assay, which is a natural development in studies of nutritional deficiencies, has been an important tool to research in all fields of biology and biochemistry.
 - 1. Roger J. Williams and his students, as a group, have contributed most to nutritional studies and assay methods in microbiology.
 - 2. Snell and Strong in 1939 published the first satisfactory quantitative microbiological assay employing Lactobacillus casei for the determination of riboflavin.
 - B. Paper-partition chromatography, since the work of Consden, Gordon, and Martin in 1944 has been widely employed in the separation, purification and isolation of many metabolites and is contributing to progress in microbiology and allied fields.
 - C. Inhibition analysis, although employed much earlier in cellular physiology, was established as a research tool for bacterial metabolism by the observations of Fildes, Woods and Wyss (1940) that p-aminobenzoic acid antagonized the growth inhibition by sulfonamides.
 - D. The use of radioactive isotopes for tracing the fate of metabolites in bacterial and yeast cultures has resulted in a number of successful studies and may become a laboratory fashion in the near future.
- III. The intensive study of antibiotics today is perhaps comparable to the "bandwagon" of the microbe hunters a half-century ago.

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July 13, 1949

Dear Fellow Traveler:

From suggestions received from several sources the following plan of action for the student seminar seems to meet with more or less general approval.

The seminar should follow some schedule. A tentative schedule is included. It is hoped that you will find time to annotate it and return it to me.

The procedure to be followed might be some modification of the plan that was outlined in the first letter with some specific refinements. Briefly, for each seminar each participant would prepare an outline of the major figures contributing to the phase of science under examination. This would include a super brief biographic sentence or two as well as the person's specific contributions to the phase of science being studied. Besides this outline of persons and deeds a number of references from which further information could be obtained should be included. Key reference works and pertinent works should be compiled. The easiest way to do this would be for everyone to bring to each seminar bibliography cards on the works of which he is aware that apply to the phase of science under consideration. The "secretary" may then compile the cards and have the complete bibliography for distribution at the beginning of the next seminar. It is estimated that at the conclusion of the seminar there should result a general reference on the history of botany and general bibliography of the field of botany and plant sociology of about 230 pp.

The following arbitrary and tentative schedule is submitted in the hope that everyone concerned will feel motivated to present further suggestions. The schedule was prepared by a quorum of three summer residents in consultation with as many other graduate students as could be contacted.

DHM

Proposed schedule for the student seminar 1949-1950.

Sept. 30.	Organizational meeting.	
Oct. 7.	Biology up to 1850.	Morey
Oct. 14.	Taxonomy- Phanerogama.	Hols
Oct. 21.	Taxonomy- Vasc. Crypto.	Mitchell
Oct. 28.	Taxonomy- Remainder.	Praytag
Nov. 4.	Morphology.	Ilitis and Lay
Nov. 11.	Physiology.	Zucker
Nov. 18.	Horticulture.	Gage
Dec. 2.	Bacteriology.	McClary
Dec. 9.	Plant Pathology	?
Dec. 16.	Microbiology.	Yamada and Hoffman
Jan. 6.	Anatomy.	Tryon, A.
Jan. 13.	Palaeobotany.	Mamay
Jan. 20.	Ecology.	Etter and Dietz
Feb. 10.	Phytogeography.	Ilitis and Rogers
Feb. 17.	Climatology	Sauer
Feb. 24.	Cytogenetics.	Duvick
March 4.	Ecology.	Rodenberg
March 11.	Pharmacology.	Mercer
March 18.	Mathematics.	Van Schaak
March 25.	Evolution.	Hall
April 1.	Open	
April 8.	Open	
April 15.	Open	

It is proposed that meetings in April, if any, in deference to those preparing theses, should entail no outside preparation. These meetings might well be dedicated to a general discussion of oral exams and their ways and means.

The dates above are based on a Thursday night meeting. The time will naturally have to be adjusted to the satisfaction of a great number as possible.

New students can be worked in on the more difficult topics.

EEL
DEM
DJR

DRogers

Denny Macey
10/11/49

BOTANY UP TO 1550

It must be realized that botany did not exist as a separate science until very recent times. As a rule, in the past it has been the province of court recorders, poets, and physicians. Earliest botanical observations were those of the agriculturalist in the dawn nations of China, Assyria, and Egypt. Records of agricultural materials are to be found throughout Assyrian, Chinese and Egyptian court records, religious writings, and burial artifacts. Associated with these earliest botanical writings there are few known authors. The earliest author is probably Chinese.

Shen Nung, emperor of China, c. 2700 B.C. Legend establishes him as the father of agriculture; wrote 20 chapters on the Materia Medica of China at that time. Shen Nung pen Tsao ching - name of herbal

Democritus (c. 450 B.C.) Earliest great propounder of the atomic theory. Believed all matter was made up of particles of various size and shape. Plant morphology resulted from this various shape of atoms. Believed that matter had consciousness.

Aristotle (c. 384-323) Observed... 1. The fundamental color of plants is green. 2. The parts of a plant represent an integrated whole, and 3. Tried to analogize plant and animal parts and function.

Theophrastus (c. 371-285) The father of botany. Divided plants into trees, shrubs, and herbs. Noted the difference between monocotyledonous plants and dicots. Noted that plants had certain habitats that they seemed to prefer. Was very interested in climatic and edaphic responses of plants, in the propagation of plants, their culture, growth and periodicity in plants and the effects of heat and cold.

He thought that the roots were concerned with nutrition and realized that the stem was involved in food transfer. he did not understand the function of the leaf but went to great lengths to describe the diversities that leaves assume. Two main writings: De Causis Plantarum and Historia Plantarum.

Hippocrates (c. 460) Lists 240 plants. Interested in the cause and effect relationships of drugs and disease.

Ptolemy I (c. 367- 283) Founded the Alexandrian school. The ^{most} important aspects of this school were the museum, the library, the medical school where the first dissection of the human body took place for research, the cynicism which led to open antagonism to Aristotle and the broadminded patronage of the Ptolemaic dynasty.

The Roman agricultural writers: Cato (234- 149 B.C.) De Re Rustica; Columella, Varro, and Vergil all wrote advice to the farmer, listed crops and care. All circa 100 B.C.

Pliny the Elder (23-79 A.D.) Wrote 37 books on natural science. Of those 16 are on botany. Compiled all available material much of it uncritically, and added some personal observations of his own. His systematics a device of convenience, e.g. trees are divided into forest trees, exotic trees, and fruit trees. His descriptions are carefully done and quite complete.

Dioscorides (c. 100 A.D.) The most important botanist after Theophrastus. The first complete herbal. Contained 600 plants of which he described the entire plant. Usually only the medicinal uses were given. Gave the vernacular name and all the synonyms with which he was acquainted. Systematics based on use but he recognized such natural groups as the Labiatae, Leguminosae, and

the Umbelliferae. His work became the standard reference for all future works until early modern times. His work was saved for the western world through the Byzantine and Arabian cultures.

Anicia Juliana (c. 500 A.D.) Princess of the Byzantines. Had an herbal compiled. Very much a retake of Dioscorides. This ^{manuscript} MS was brought into the west in 1562 at the instigation of Matthioli.

Spanish Moor
Ibn Sina (Avicenna) 980-1037 A.D. Assembled in critical form all medical botany to date that was available to the widely disseminated Moslem culture.

Spanish Moor
Ibn Baither (c. 1200) The best of the Arabian botanists. Described 1400 plants and described only what he saw. Removed much superstition from the published material.

Constantine the African (c. 1050) A Dominican monk. Translated many Arabian works into Latin. The first great plagiarist but he brought much of the Arabian knowledge into the hands of western scholars.

Albertus Magnus (Albert von Bollstadt) The Aristotle of the middle ages. Encyclopedist of plant knowledge. Was interested in botany rather than medicine. His descriptions are critical and useful. Speculated on the nature of tendrils, thorns, etc. Felt that trees, shrubs and herbs represented natural divisions. Separated the thallophytes from leafy forms. Recognized the difference between Monocots and Dicots and the distinction between herbaceous and woody habit. A big churchman whose deviations from the dogma were not detected because of his high position and discretion in publication.

Frederick II of Hohenstaufen (1194-1250) King of Naples and Sicily, Holy Roman Emperor. Highly enlightened monarch. He founded the medical school at Palermo where dissections of the human body were permitted for the first time

*. *Michael Scott (Scottish) did the work.*
since Alexandria. Financed translations of Aristotle from the Hebrew and Arabian.

An event of much importance to botany was the invention of the printing press. This resulted in a new form of herbal. An herbal of wide distribution and with profuse illustrations. The few herbals with the exception of Otto Brunfels's that appeared before 1550 were compilations of earlier works of many authors done by the publishers and one or several scholars. The competition soon became however and haphazard illustrations and descriptions would no longer suffice. The consequence was an enormous impetus for botanical research; in the field of systematics in particular and in assembling of botanical materials both in herbaria and botanical gardens.

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GENERA OF PALMS IMPORTANT IN NATIVE DOMESTIC ECONOMIES

SUBFAMILY

TRIBE

Subtribe

Genus

(Systematic arrangement according to O. Drude, in Engler & Prantl, Natürlichen Pflanzenfamilien 2 (3) 28-90. 1889.)

CORYPHINAE

PHOENICEAE

Phoenix (Date)

N. Africa, Near East, S. Asia

SABALEAE

Chamaerops (Dwarf Fan)

Mediterranean Fiber - Swigs, cloth for tents

Trachycarpus (Chusan)

China - only temperate Asian palm

Corypha (Talipot)

S. Asia - used for writing in ancient Burma

Nannorhops (Mazari)

SW. Asia

Livistona (Serdung)

SE. Asia, Indonesia

Pritchardia

W. Pacific Islands

Washingtonia (Desert)

SW. United States

Sabal

West Indies

Copernicia (Carnauba)

Brazil

BORASSINAE

BORASSEAE

Hyphaene (Doom)

Africa

Borassus (Palmyra)

Africa, S. Asia - sugar "jaggery"

Lodoicea (Sea Coconut)

Seychelles

LEPIDOCARYINAE

MAURITIEAE

Mauritia (Muriti, Caraná)

Tropical America

METROXYLEAE

Raphia

Raphia (Raffia, Jupatí)

Africa, Madagascar, S. America

Oncocalamus

Nigeria

Ancistrophyllum

Tropical Africa

Eremospatha

Tropical Africa

Calameae

Metroxylon (Sago)

S. Asia, Indonesia

Coelococcus (Tahiti Nut)

Pacific Islands

Daemonorops (Dragon's Blood)

Indonesia

Calamus (Rattan) 200 sp.

Africa, S. Asia, Indonesia

CEROXYLINAE

ARECINEAE

Caryoteae

Caryota (Fishtail)

S. Asia, Indonesia

Arenga (Sago)

S. Asia, Indonesia

Geonomeae

Podococcus

Tropical Africa

Manicaria (Bussú)

Tropical America

Leopoldinia (Jará, Piassaba)

Brazil

Geonoma

Tropical America

Calyptrogyne (Coligallo)

Central America

Iriarteae

Iriartea (Pachuba, Maquenque)

Tropical America

Ceroxylon (Wax)

Andes

Moreniaceae

Chamsedorea (Pacaya)

Central America

CEROXYLLINAE (cont'd)

ARECINAE (cont'd)

Areceae

Oreodoxa (Cabbage)	West Indies
Jessenia (Bataú)	S. America
Oncosperma (Nibong)	S. Asia, Indonesia
Euterpe (Assaf)	Tropical America
Oenocarpus (Bacaba)	Brazil
Rhopalostylis (Nikau)	New Zealand
Ptychosperma	Australia
Areca (Betel)	S. Asia, Indonesia, Pacific Islands

COCOINAE

Elaeideae

Elaeis (Oil) sp. guineensis	Tropical W. Africa, Tropical America
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Attaleae

Orbignya (Babassú)	Brazil
Attalea	Tropical America
Maximiliana (Inajá)	Brazil, Guiana
Cocos (Coconut, Licuri)	Tropics
Diplothemium	Brazil
Jubaea	Chile

Bactrideae

Acrocomia (Coyól, Mucajá)	Tropical America
Astrocaryum (Tucúm, Murumurá)	Brazil
Bactris (Iá, Uizcoyól)	Tropical America
Desmoncus (Matamba)	Tropical America
Guilielma (Peach, Pejibaye)	Tropical America

PHYTELEPHANTINAE

Phytelephas (Tagua)	South America
Nipa	S. Asia, Indonesia

Phoenix - Fruit, "Butter", wine
Wood-
Fiber (at base of leaf [coir]) - baskets.
Nut - crushed, cattle feed.

Revised schedule for the student seminar 1949-1950:

Sept. 30.	Organizational meeting.	
Oct. 7.	Biology up to 1550.	Morey
Oct. 14.	Taxonomy-up to vaso. crypt.	Freitag
Oct. 21.	Taxonomy-Vasc. Crypt.	Mitchell
Oct. 28.	Taxonomy-Phaneros.	Holm
Nov. 4.	Morphology.	Iltis and Lay
Nov. 11.	Physiology.	Zucker
Nov. 18.	Horticulture and Agronomy.	Gage and Duvick
Dec. 2.	Bacteriology.	Hoffman
Dec. 9.	Plant Pathology.	McClary
Dec. 16.	Microbiology.	Yamada
Jan. 6.	Anatomy.	Tryon, A.
Jan. 13.	Palaeobotany.	Mamey
Jan. 20.	Ecology.	Etter and Dietz
Feb. 10.	Phytogeography.	Iltis and Rogers
Feb. 17.	Climatology.	Sauer
Feb. 24.	Cytogenetics.	Alava
March 4.	Zoology.	Rodenberg
Mar. 11.	Pharmacology.	Mercer
Mar. 18.	Mathematics.	Van Schaak
Mar. 25.	Evolution.	Hall
April 1.	Open	
April 8.	Open	
April 15.	Open	

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Bot. 205A, Fall 1948

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October 5, 1949

Revised schedule for the student seminar 1949-1950:

✓Sept. 30.	Organizational Meeting.	Meroy
✓Oct. 11.	Biology up to 1550.	Umanzio
✓Oct. 18.	Taxonony up to vasc. crypt.	Tryon & Mitchell
✓Oct. 25.	Taxonony-Vasc. Crypt.	Helm
✓Nov. 1.	Taxonony-Phanerog.	Ilitio - Lay
✓Nov. 8.	Herbology.	Zucker
✓Nov. 15.	Physiology.	Gage, Duvalick & James
✓Nov. 22.	Horticulture and Agronomy.	Hoffman
✓Nov. 29.	Bacteriology.	Neclary
✓Dec. 6.	Plant Pathology.	Yamada
✓Dec. 13.	Microbiology.	Freitag & Gillette
✓Jan. 3.	Anatomy.	Harvey
✓Jan. 10.	Palaeobotany/.	Utter & Dietz
✓Jan. 17.	Zoology.	Ilitio & Rogers
✓Feb. 7.	Phytogeography.	Lauer
✓Feb. 14.	Climatology.	Alava
✓Feb. 21.	Cytogenetics.	Lodensborg
✓Feb. 28.	Zoology.	Merceur
✓Mar. 6.	Pharmacology.	Van Schaak
✓Mar. 13.	Mathematics.	Wall
✓Mar. 20.	Evolution.	
✓Mar. 27.	Open	
✓April 4.	Open	
✓April 11.	Open	
✓April 18.	Open	

Jean Mitchell 10/12/49

HISTORY OF PTERIDOLOGY

Before 1900.

- Linnaeus. Species Plantarum, 1753. Genera Plantarum, 1754. Recognized 14 genera of ferns, 132 species. Genera were mostly artificial. Also 4 genera of the fern allies: Equisetum, Filularia, Isoetes, Marsilia. Lycopodium put in the Musci. Genera based upon the characters of the sori: superficial or marginal, round, linear or confluent. This type of division went on for a century and one half. Sori were felt to be analogous to the flowers in higher plants.
- J. E. Smith. Purchaser of the Linnaean herbarium. Discovered the indusium and separated Linnaeus's classification into those with annulus and those without. This followed the trend in the 18th century when the indusium was discovered. Indusiata and Exindusiata.
- Olof Swartz. A Swede, Synopsis Filicum, pub. 1806, traveller in Jamaica. Used Gyrateae, Agyrateae, and Spurio Gyrateae. 38 genera. 710 species.
- C. F. Willdenow. Professor of botany in Berlin. In the fifth volume of the Species Plantarum, 1810, 41 genera, 1,000 species. No new system.
- Brown, Kaulfuss, etc. Began to use venation as a character as the number of ferns increased.
- C. B. Presl. Tentamen Pteridographiae, 1836. Professor of botany at Prague. Described ferns collected by the traveller Haenke, 1825. Used venation and the number of vascular bundles in the stem. 165 genera.
- John Smith. Head curator of the Kew greenhouses. Historia Filicum, 1875. Followed Presl and advised use of sterile fronds and articulation of the frond to the rhizome. 217 genera.
- A. L. A. Fee. Professor of botany at Strasbourg. Also followed Presl. Used number of cells in the annulus and relied on natural relationships. Genera Filicum, 1830-32.
- W. J. Hooker. Director of Kew in 1830's. Genera Filicum with Bauer in 1842. Followed Presl. Synopsis Filicum in 1865 retreated to Swartz with 75 genera. Set pteridology back ten years, a very popular work.
- Georg Mettenius. Professor of botany at Leipzig. Used external morphology and microscopical research bearing chiefly on the development of the sori. Died in 1866.
- H. Christ. Farnkrauter der Erde, 1893. Swiss. Used the characters of the whole plant, returning partially to the theory of evolution. 140 genera.
- Ludwig Diels. Head of the Berlin Botanical Garden. Died in 1945. Broke Hooker's stigma. 141 genera in 4th volume of Engler and Prantl. Did not quite come up to Smith and Fee but followed phylogeny more than the others.

After 1900.

Carl Christensen. Index Filicum, 1906. Listed Diels's genera. Three supplements up to 1934. Later studied on his own and in Verdoorn lists 247 genera. Unnatural sequence, misconception of some genera. Danish.

K. Goebel and F. O. Bower. Found that the soral characters may be different stages in evolution arrived at in groups based on entirely different features such as hairs, stelar structure, and other organs. They did not make their own classification. Archegoniatenstudien and The Ferns, respectively.

E. B. Copeland. Philippine Bureau of Science, was to Malay-Oceania what Christensen was to the rest of the world. Arranged the oriental genera of the Polypodiaceae into a phyletic sequence in 1929 omitting the African and American sps. Uses genus to mean a group of related species instead of similar species. Uses geography, fossils to settle ancestry. 303 genera. Now at Berkeley.

Current workers by countries:

United States: Maxon.. curator of the U. S. Herbarium. Specialized in Am. tropical ferns, succeeded by Morton.

China: R.C. Ching..33 families in the Polypodiaceae, 257 genera, Fan Memorial Inst

Japan: Hayata and Tagawa

Germany: Brause and Rosenstock. (Heironymus, Lycopods and Selaginella)

France: Bonaparte and Madame Tardieu-Blot

Australia: Mrs. Gay-Smith and Wakefield

Netherlands: Van Alderweireldt van, Rosenburgh and Posthumus, a morphologist.

Britain: Holttum, monographer of the Malayan ferns, and Walton and Alston, students of the Lycopodiaceae.

Workers on North American Ferns:

D. H. Campbell. Indiana U. and Stanford. Mosses and Ferns.

D. C. Eaton. Died 1870. Japan, Cuba, U.S., North American Ferns.

Davenport. Boston.

A.A. Eaton. Isoetes and Equisetum. Isoetes herbarium at MSG.

C. A. Weatherby. Cheilanthes and Notholaena.

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C. F. Martius, Brazilian Ferns, 1820.

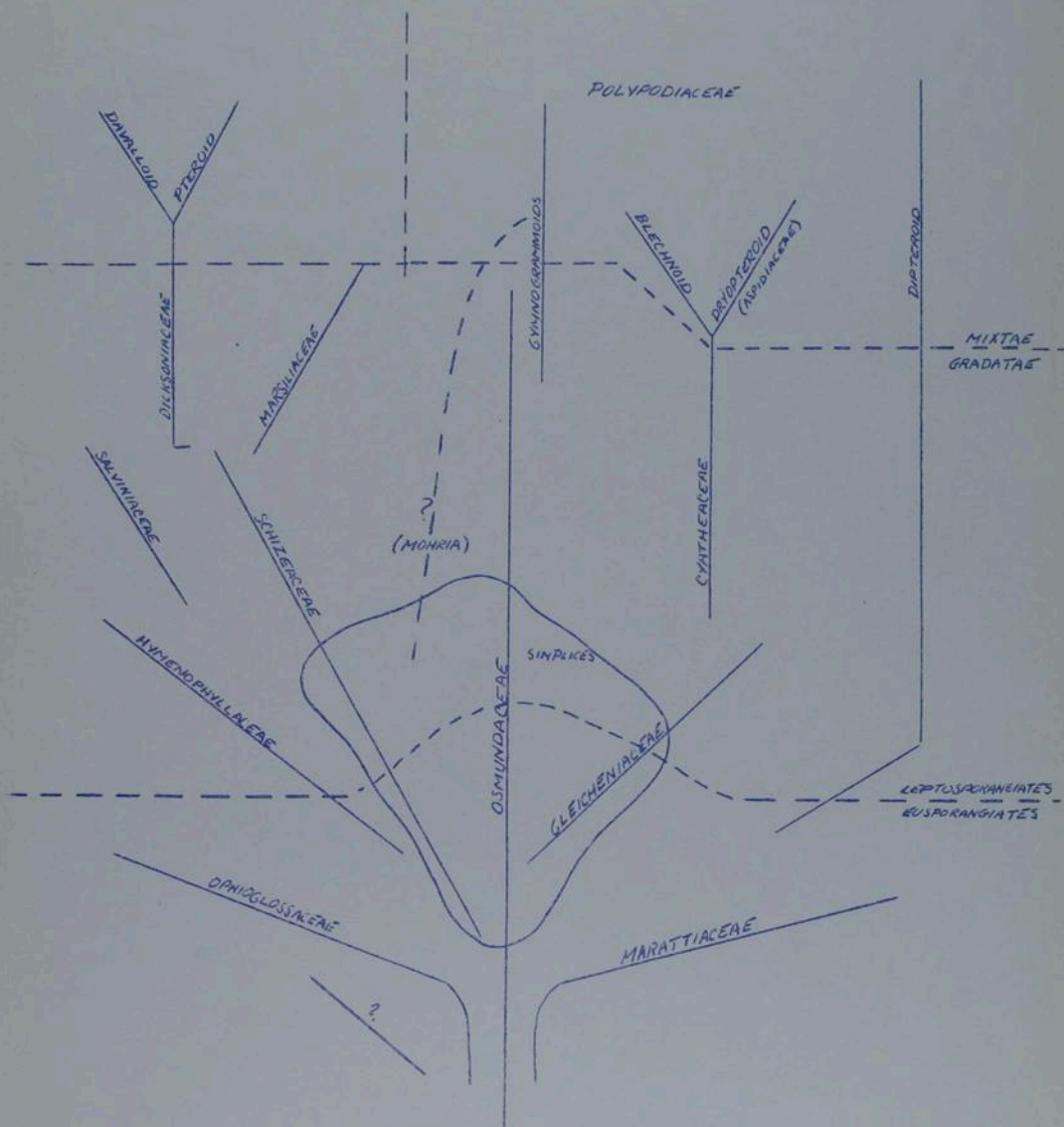
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42:103, 44:156, 46:197.

PHYLETIC BUSH OF THE FERNS



K. Koloy Nov 1, 1949

Linnaeus (1751) "Philosophia Botanica" - derived parts of flowers from parts of stems.

Wolf, Caspar Friedrich (1759) studied the development of organs from the growing point.

Goethe (1749-1832) "Doctrine of Metamorphosis" (1790) - founder of a school of idealistic philosophy in botany; formulated the concepts of normal (ascending) and abnormal (descending) metamorphosis. A foliage leaf might expand into a sepal in normal or contract into a stamen in abnormal metamorphosis.

Schimper, K.F. (1803-1867) - made a serious attempt at studying leaf arrangement and expressed the series in simple fractions $1/2$; $1/3$; $3/8$; $5/8$ etc. Phyllotaxy though in itself a fruitless exercise, demonstrated that organs had a definite distribution in space.

Braun, Alexander (1805-1877) - believed that in the development of a shoot (or bud) there is a succession of leaf metamorphosis viz. "cataphyllary", "euphyllary", "hypophyllary", "sepals", "petals", "stamens" and "pistils".

Schleiden (1804-1881) - Iconoclastic to an extreme, he insisted that Botany is an inductive science and criticized with asperity the idea of all his contemporaries. "Books have been written when plants should have been examined, conjectures have been made, when investigations should have been pursued". (Grundzüge der wissenschaftlichen Botanik, 1843).

De Candolle, A.P. (1778-1841) - thought that the most diverse genera of each family, as well as families could be referred to a definitely regular and systematic "type". He speaks of every part as an "organ", designating cells as "elemental organs" and roots, stems and leaves as "fundamental organs".

ALTERNATION OF GENERATION:

Endlicher (1805-1849) designated the Thallophyta, due to absence of leaves, stems and roots.

Vaucher, Tulsane, Oersted, Pringsheim & De Bary - demonstrated the sexual and asexual reproductive cycles in the thyllophytes.

Hofmeister "Lehre von der Pflanzenzelle" (1867) & "Allgemeine morphologie" (1868) - first to demonstrate that the ~~prothallium~~ ^{prothallium} of the moss plant corresponds the prothallium of the vascular cryptogams and to the endosperm of the gymnosperms. His greatest achievement was the establishment of alternation of generation in the plant kingdom.

Farlow (1844-1919) - discovered apogamy in ferns (1874).

Pringsheim (1824-1894) - discovered the corresponding phenomenon (apospory) in mosses in 1877, and formulated "the homologous theory". *Sporophyte & gametophyte were independent in the algae*

Celakowsky (1834-1902) - introduced the concept that the sporophyte of the moss is antithetic to the gametophyte in the completion of life cycle.

Bower, F.O. - champion of "antithetic view" and proposed it biological basis.

Scott (1854-1934) - supporter of "homologous theory".

THE STELE:

De Candolle, A.P. - classification of angiosperms as exogens (Dicotyledones) and endogens (Monocotyledones), but had no insight into the problem of histology.

Sanio, Carl (1832-1891) - discovered the origin of secondary meristem and secondary tissue. *Cambium (cork + inner vascular) + annual rings*

De Bary (1877) - in his own words describes his book as "an epitome of the present knowledge of the anatomy of the vegetative organs of vascular plants". A scholarly compilation describing anatomy of matured tissues and minimising juvenile stages and ontogeny.

Van Tieghem (1839-1914). Proposed the theory of the stele, and defined pericycle, endodermis and epidermis in terms of stele and cortex.

Jeffrey (1866-) - modified Van Tieghem's concepts of the stele, and introduced the terms siphonostele & protosteles, and concluded that the former had arisen from the latter in ontogeny; and pith is of cortical origin.
(Growth theory)

Bower (1930) "Size and Form in Plants"

Thompson, D'Arcy (1942) "Growth and form in Plants".

SYSTEMATIC ORGANOGRAPHY:

Van Tieghem (1872) - distinguished between roots by their axial symmetry and centripetal differentiation of primary woody bundle; the stem by axial symmetry, but the differentiation of its first woody bundles is centrifugal; the leaves by bilateral symmetry.

Goebel, Karl (1855-1932) - maintained that morphology should no longer be kept separate from physiology. A student of Sachs, he believed in the dependance of form on function. "Study of ontogenetic development is more important, because it permits of experimental study and can only be accepted when they rest upon experimental proof".

MERISTEM:

Nageli (1817-1891) - who coined the word, defined meristem as a group of cells capable of division. Having been greatly impressed by the sequence of cell divisions in the apical cell of thallophytes, he assumed that the heart of meristem of all plants was an apical cell (Scheitelsell) and maintained no fundamental differences in the mode of origin of apical tissues in vascular cryptogams & phanerogams.

Schwendener (1829-1919) - announced that the single, 3-sided apical cell is the exception in shoot apex of gymnosperms, and suggested that the apex is frequently crowned with four equivalent juxtaposed initials.

Hanstein (1868) - "Histogenic theory" - "apical meristem of angiosperms consists of dermatogen (producing epidermis), periblem (the cortex) and plerome (the stele), and reported their presence in the embryos of phanerogams and the absence of an apical cell - that a differentiation already existed in the youngest stages of shoot apex.

The Histogenic theory persisted for quite some times, although its validity could not be proved in all plants.

Kooh, L. (1891) - proposed a new classification, in which there were 2 zones, the outer mantle of cells, containing dense cytoplasm, and an inner core of cells containing vacuolated cytoplasm, which absorbed dyes less than the outer. The outer producing the epidermis, cortex, procambial tissues and leaves, the inner producing the pith.

Schmidt, A. (1924) - "Tunica-carpus theory". The "tunica" consists of the outer meristematic layer of 2 or 3 cells wide, which generally divide anticlinally, while the "carpus" is the central meristematic aggregation of cells in which divisions occur in many planes. The growth of "carpus" is by increase in mass, where the planes of division and arrangements of cells are highly 'irregular'. The maintenance of proper balance between surface and volume growth leads to constant adjustments, which find their expressions in the rhythmical growth of shoot apex into "maximal" and "minimal" areas with resultant production of surface folds or leaf primordia.

Kerody, E. (1927) - showed that *Abies concolor*, *Picea excelsa* & *Pinus montana* have growth apices similar to those described by Kooh.

Foster, A.S. (1939) - Unique type of growth meristems in Ginkgo, Cycas & Zamia; also in angiosperms there is great variations in the number of cells in the 'tunica' layer.

DETERMINATION OF LEAVES:

Snow, R.M. & R. (1948) - Explanation of phyllotaxis and 'available space theory'. *Difference theory that phyllotaxy is not a constant cannot be changed.*

Wardlaw, C.W. (1948) - Experimental work on apices of fern.

Richards, F.J. (1948) - Phyllotaxis and field(repulsion) theory.

MORPHOLOGY OF THE FLOWER:

Goethe (1790) - derivation of floral parts from leaves.

Saunders, E.R. (1922) - "Carpel Polymorphism theory" - recognizes 2 types of carpels:
(a) the valve or hollow type which is more or less extended laterally and, if fertile, bears the ovules either singly or in a single row on either margin;
(b) the consolidated type which, if fertile produces ovules on either singly or in from one to several rows on each flank of the midrib. She claims that carpel polymorphism is almost universal in the angiosperms and believes that they have arisen by reduction in carpel number (Ranunculaceae, Rosaceae, Phytolacaceae). The supply of trace per carpel is usually one, utmost 2.

Arber, Agnes (1937) - elaborated the foliar origin of carpel theory and has interpreted the flower in holæstic sense, suggesting that it is comparable to a vegetative shoot in a condition of permanent infantilism. Believes that carpel is not homologous with foliar leaves, but that carpel and leaf are parallel developments in the same plant body.

Thomas, H.H. (1934) - does not believe the angiospermic flower as the homologous of vegetative bud. He derives flowers from structures similar to those possessed by Caytoniales, with cupules. He points out that sterilization of structures originally fertile is much more likely to have taken place than the metamorphosis of leaf-like structures into reproductive organs.

Hunt, K.W. (1937) - believes that carpel was derived from 3-lobed palmately veined structure by either (1) the formation of a carpel in which the central lobe becomes the stigma and is supplied by the dorsal bundle; or (2) a carpel in

which all 3 lobes enter into the composition of the style, each lobe supplied by a bundle from one of the original lobes of the appendages.

Thompson, J. McLean, (1937) - visualizes the basis of the modern flower in a "sporogenous axis, devoid of obligate appendages". The lower part of the axis is sterile and produces bracts, bracteoles & sepals. The base of sporogenous tip is potentially microsporangial, from it emergences arise, which ultimately become stamens; sterilization of the lowermost microsporangial emergences results in petals or staminodes. When toral growth becomes dominant over apical growth at an early stage and extends beneath the bracteoles and sepals, the maturing axis is cup-shaped and the "condition of flower with inferior or semi-inferior ovary is initiated and is later attained if the dominance of toral growth is continued". An inferior ovary thus is acarpous. In formation of superior ovary the apical growth is maintained throughout.

Troll, Wilhelm (1932-38) - foliar theory, carpels being formed from peltate leaves, and recognizes 3 types of carpels with (a) manifest, (b) latent peltation and (c) epeltate.

Gregoire, V. (1938) - floral receptacle with two main zones throughout its entire development: (1) the outer zone "Manchon meristematique" has the form of a cloak or "muff" and consists of small densely cytoplasmic cells in which mitosis are relatively frequent; (2) the inner zone "massif parenchymateux" consists of a core of extremely large, thin-walled highly vacuolated cells, with infrequent mitosis.

"In a word, the constitutional tendency of the vegetative cone, its morphological orientation, is to produce growth, theoretically without limit, of an axis of which it is the extreme meristematic portion, whereas the constitutional tendency of the floral receptacle, its morphological orientation is to produce, on the surface of a parenchymatous support, a meristematic cover destined to form exclusively the floral organs. & These two tendencies and these two orientations are radically exclusive one from the other; they define - in sense of typology - two irreducible types".

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SOME PHASES OF HORTICULTURE. I.

Horticulture (courtesy of Bailey) is the growing of flowers, fruits,

and vegetables, and of plants for ornament and pleasure. In origin it was primarily an art, but in development it has been intimately connected with science: questions of plant breeding, propagation, introduction of new plants, nutrition, and hormone effects, as well as many others are all properly in the province of horticulture.

The ancient beginnings of gardens have already been covered; it is enough to say here that the cultivation of plants for religious and medical reasons was as important to early gardeners as was the production of food; and that by the time of the Roman writers, especially Cato, Varro, Virgil, and Pliny, husbandry was well developed - irrigation, grafting, budding, layering, and topiary work were all practiced, and there were even greenhouse-like structures (specularia).

LITERATURE OF MEDIEVAL TIMES AND RENAISSANCE

Walafrid Strabo of Suebia (807-849) - first gardening book of medieval period: Hortulus.

Piero Crescenzi - lawyer of Bologna: Opus Ruralium Commodorum - based on Roman writings, but contained many new observations.

BOTANICAL GARDENS: The earliest of these were physic gardens, founded for the protection of doctors and apothecaries; later ones were more of the type of such extensive gardens as that of John Gerard (1545- 1612), whose Catalogus arborum fruticum ac plantarum tam indigenarum quam exoticarum (1596) listed 1039 plants then in his garden.

1533- Padua

1542- Leipzig. Clusius one of early heads.

1543- Pisa. Casalpino second director.

1547- Bologna

1560- Zurich

1635- Paris (Museum d'Histoire Naturelle): founded by Guy de la Brosse, physician to the king. Early directors included Bernard, Antoine L., and Adrien de Jussieu.

1673- Chelsea Physic Garden. Established by the Society of Apothecaries as a physic garden, but owing to the influence of Sir Hans Sloane, developed along experimental horticultural and systematic lines. Directors have included: Philip Miller (1691-1771), an outstanding horticulturalist in his time and author of the classical Gardener's Dictionary (first edition 1724); William Curtis, author of Flora Londonensis and founder in 1787 of the Botanical Magazine (at Kew); and John Lindley, author of The Theory of Horticulture (1840), and founder of the Gardener's Chronicle.

1728- John Bartram's Garden, near Philadelphia, and America's first botanical garden. Bartram traveled widely in America, introduced 150-200 plants into European gardens.

1759- Royal Botanic Garden, Kew - William Aiton first head: systematic arrangement of the plants, sent out first collectors, and published first edition of Hortus Kewensis (1789). Early development influenced greatly by Sir Joseph Banks, royal adviser from 1772 to 1820. Later directors have included W.J. and J. D. Hooker. Publications include Curtis's Botanical Magazine; Hooker's Icones Plantarum (discontinued).

Gardens of the Royal Horticultural Society -

1822- John Wedgewood and Thomas A. Knight found garden at Chiswick.

Present garden, at Wisley, offers popular courses in horticulture.

Tropical gardens: those at Calcutta (1787) and Buitenzorg, Java (1817) outstanding.

PLANT INTRODUCTION AND EXPLORATION

Earliest introduction of plants in quantity into Europe during crusades; till until discovery of new world, when Raleigh and the East India Co. brought quantities of plants and animals to Europe. Other plant explorers include:

- John Tradescant- first Englishman to study Russian flora; brought back seeds and plants (3 generations of the family maintained extensive gardens at Lambeth).
Francis Masson (1741-1806) - professional plant hunter from Kew who visited South Africa, West Indies, Spain, Portugal, and South America.
David Nelson- collected with Cook on 3rd voyage; with Bounty, 1787.
Andre Michaux (1746-1802) - collected in America; nurseries in N.Y. and Charleston for plants which he later shipped to France.
David Douglas (1798-1834) - collected in western N. America for the Horticultural Society of London.
Robert Fortune (1812-1880) - travels in China, especially; many important introductions, including that of tea from Shanghai to the Himalayas.
Reginald Farrer - 20th century; introduced a number of Primulas and rhododendrons from southwest Asia.
David Fairchild - American, with Office of Plant Introduction of Bureau of Plant Industries (U.S.D.A.)

Practical Gardening

- Thomas Hyll (1563) - early English work: A Most Briefe and Pleasaunt Treatise.
Parkinson: Paradisus in Sole, Paradisus Terrestris (1629) - describes plants in his garden, as well as gardening methods.
John Evelyn - gentleman gardener and traveller: diary, letters, translations of popular French works on gardening (particularly Jean de la Quintinie's Traite des Jardins Fruitiers et Potagers), author of Kalendarium Hortense (1664)
Andre Le Notre (1613- 1700) - French garden designer who landscaped Versailles, many other estates, exerted strong and lasting influence at home and abroad.
Thomas Fairchild - author of The City Gardener (1722). Many experiments in grafting, cross-fertilizing.
Jethro Tull - early 18th century: invented a seed drill and a horse hoe.
Steven Switzer - modified inclined fruit walls by adding glass sash and flues.
Loudon - author of numerous works on horticulture; Treatise on several improvements recently made in Hot-houses (1805); An Encyclopedia of Gardening (1822); edited Gardener's Magazine, 1826-1843.

HORTICULTURAL SOCIETIES

- Royal Horticultural Society of London (1804). Transactions began appearing in 1810.
Deutschen Gartenbau Gesellschaft (1822). Publication: Gartenflora.
Societe d' Horticulture de France (1827)
Penns. Horticultural Society (1828) - first in this country.
Russian Horticultural Society - founded by Edward Regel in 1858.

PLANT BREEDING

Though Camerarius, Kolreuter, and Grew had discovered and worked out sex in plants in the late 17th century, Thomas Fairchild in 1719 was probably the first to do any breeding of garden plants for commerce. By the early 19th century a good bit of breeding was being done: Thomas Knight and von Mons were early leaders. Important impetus was given to such work by Darwin's papers, especially Animals and Plants under Domestigation (1868). Methods of selection developed at about this time: the nursery method was first used by Hallsell about 1860, and the field method by Rimpau in 1867. Since 1900 genetics has been an important influence on progressive plant breeding, though many varieties are still the result of haphazard crosses.

NURSERIES AND SEEDSMEN - the influence of these establishments upon horticultural progress has been considerable: plant introduction, breeding, and testing of varieties are systematically carried out by the more prominent houses. Some establishments of

historical significant have been:

Spath (Germany)- since 1720

Vilmorin-Andrieux - since early 18th century; great influence on French and continental horticulture.

Veitch (English)

Backhouse (English)

David Landreth - first commercial seed-house in U.S.

William Prince - founded first independent general nursery (Flushing, ca.1750).

Maintained by 4 generations of his family.

Luther Burbank - introduced many novelties, exotics, etc.

Don Plurich
11/2/49

I. Defined - study of crops and soils as they relate to agriculture.

A. Crop science

Fields of study:

Breeding

Selection and testing of adapted or new varieties (includes collecting)

Physiology - of nutrition, as means of diagnosing abnormalities in growth, etc.

Biochemical and chemical - analysis of food products, as an adjunct to physiology and breeding, etc.

Cultural techniques - largely accumulation of common sense observations, but makes large use of physiological and soil science information.

Pathology

Plant - insect relationships

Purpose: to improve the yield and quality of farm crops.

B. Soil science

Fields of study:

Classification

Morphology and structure

Genesis

Physics of the soil

Chemistry

Organisms - macro and micro; botanical and zoological

Erosion control - conservation, regeneration

Purpose - to conserve and/or increase productive value of soils.

II. The United States Department of Agriculture - its connection with agronomy.

A. Early agricultural societies and individuals

James Oglethorpe - 1733 - started experimental garden in the new colony of Georgia to find adapted plants and best means of growing them.

James Logan - c. 1700 - Secretary of William Penn, observed pollination necessary for maize fertilization.

Jefferson, Washington and many farmers of less text-book import did common-sense experimentation.

South Carolina Society for Promoting and Improving Agriculture - 1784. Recommended farmers use small portion of land for experimental purposes.

Several other states and/or communities formed like associations; most of them were neither long-lived nor operated along the lines of systematic research.

B. State provisions for agricultural research - before 1880.

1. State geological surveys

Albany county, New York, surveyed in 1821. Report contained soil analyses and accounts of cultural methods of agricultural crops.

Geological surveys were made in about 30 states before the first agricultural experiment station was organized in U.S. (1875). These were very influential on further soil science; soil analyses were made by trained geologists who knew rocks and minerals, but generally were not formally trained in biology.

2. State agricultural colleges - established by Land Grant Act of 1862. Several outstanding men developed in these colleges prior to advent of Federal Aid (1887).
Eugene Hilgard - c.1875- prophetic soil scientist in California.
William J. Beal - 1870 - Michigan - plant breeder - noted and made practical use of heterosis in maize. Student of Gray and Agassiz.
T.S. Burrell - 1870 - Illinois - first to show bacterial origin of any disease (fire blight of pears).
C.F. Bessey - 1871 - Iowa and Nebraska - horticulture and botany - selection in apple trees, and a little taxonomy

3. State Experiment stations.

- 1843 - Rothamsted, England experiment station, under Lawes and Gilbert.
1851 - Moeckorn, Saxony experiment station
1875 - Middlebury, Connecticut. First U.S. Experiment station.
Early U.S. experiment stations were much influenced by those already established in Europe, especially in Germany. Although generally established in connection with ag colleges, state stations were sometimes independently maintained.
independent E. L. Sturtevant - c.1885 - New York - one of the outstanding workers in the type of station. Known especially for work in corn classification.

- G. U.S. Patent Office to 1862 - besides patent work, it made compilations of agricultural statistics, distributed seeds, did some agricultural research. Its annual reports contain much agricultural (and botanical) information that is unavailable elsewhere for this period in U.S. history.

D. U.S.D.A. - 1862 - 1887.

Organized in 1862, it was at first little more than a branch of the census bureau, compiling agricultural statistics. It gradually broadened its activities, including developing limited research on agricultural problems.

E. Hatch Act - 1887.

Granted Federal money to states for use in agricultural experiment stations; nearly all experiment stations were departments of land grant colleges.

Stations were thus under Federal supervision, actually, for they reported to USDA and received appropriations from USDA.

F. Adams Act - 1907.

Provided funds from federal government for specific research problems at experiment stations.

Simultaneous Thus encouraged and tied down research even more.

III. Agronomical research elsewhere than USDA-land grant colleges.

Certain amount done in larger seed and fertilizer companies, but it is necessarily of mostly short term type.

Thus, nearly all agronomical research in U.S. is done by men who depend on U.S. government for funds.

IV. Agronomy - crops

- A. Most crop scientists doing outstanding work are well known in the various botanical fields of their specialty; examples:
Randolph - cytogenetics - Cornell
Sears - cytogenetics - Missouri
Bonnett - developmental morphology - Illinois
- B. Their work appears in the usual botanical journals, plus agronomy and U.S.D.A. journals (see bibliography).

V. Agronomy - soils

- A. Agriculture's unique contribution to the sciences. Just emerging as a science, a synthesis of geology, chemistry, biology, and more than a smattering of horse-sense farming knowledge. It is at the point where masses of disconnected observations are being correlated by various men - in various ways.

B. History

1. German school

Justus von Liebig - 1844 - "The crops on a field diminish or increase in exact proportion to the diminution or increase of the mineral substances conveyed to it in manure."

His work was a great advance in agricultural thinking - one of the first scientific approaches, but it also retarded further development for half a century. Was not until development of Russian school that workers realized soil is not a cash register of minerals.

Because of the relatively uniform climate and vegetation of western Europe, and because of small scale of the observations, soil genesis in this school was attributed to only parent material, slope and drainage. The dynamic nature of soil was hardly noted.

U.S. soil science was greatly influenced by this school of thought - and much thinking in this country still is.

C. Hopkins - Illinois - 1900 - advocate of addition of limestone and rock phosphate ~~to soils~~.

F. King - Wisconsin - 1900 - worked on soil physics, structure and properties.

2. Russian school

Dokuchaev - Russia - c. 1870 - founded Russian school of soil science.

Konstantin Glinka - c. 1900 - proponent of Russian school - his book, The Great Soil Groups of the World and Their Development, when translated into English, did much to spread the gospel to the west.

When surveying Russian soils in the vast Eurasian land mass, encompassing many types of climate and vegetation, Russian observers realized the major influences of climate, vegetation and time in soil genesis. The essentially dynamic nature of soils was appreciated by them.

3. U.S. school

Eugene Hilgard - c. 1880 - California. Was an unnoticed prophet of the Russian concepts. Today his book Soils is classic.

G. F. Marbut - c. 1910 - 1935. Influential in introducing Russian soil concepts in to German-patterned American soil science. Today soil science in the U.S. is a synthesis of German and Russian concepts, modified in many ways to adapt them to U.S. conditions. The intricate and ever-changing interaction between organisms (as influenced by climate) and the soil is recognized, and tempers studies of morphology, chemistry, physics, etc., of the soil.

C. Current problems - a few examples:

1. Humus -

Protein and protein breakdown constituents - their relationship to colloidal properties of humus, to nutritive properties of humus, their actual composition and structure in the soil humus.

2. Soil-plant relationships

Though is detailed information on soil preferences of most crop plants, and a few economically important "wild" plants, is little or no information on fundamental reasons for known preferences. Is also wide-open field in soil type influences on plant structure.

3. Microorganisms

To date work has been mostly descriptive. Determination of microbial activity needs of various crops, relationships thereof; relationships of microorganisms and humus, especially in a dynamic sense, etc., are all yet to be worked on.

CROPS

1. Agricultural Index.
Lists articles on agricultural subjects appearing in about 100 scientific journals, in USDA and state experiment station literature.
2. Bailey, L. H. Manual of Cultivated Plants. Macmillan. 1941.
"The purpose of this Revised Manual of Cultivated Plants, as of the original work, is to provide a ready means for the identification of the species in the usual domestic flora of the continental United States and Canada."
3. De Condolle, Alfonse. Origin of Cultivated Plants. 1885.
In French, though there is an English translation. Besides being still a good authority, it is invaluable because of numerous references to ancient literature on the subject.
4. Georgia, Ada. Manual of Weeds. Macmillan, 1927.
5. Hayes, H. K. and Immer, F. R. Methods of Plant Breeding. McGraw-Hill. 1942.
Discusses inheritance in several important agricultural plants, with breeding techniques used for each kind of plant. Also has section on statistics and their application to study of inheritance. Most valuable feature is the compilation of information and references on inheritance of the various plants. Includes wheat, oats, barley, flax, and maize.
6. Hitchcock, A.S. Manual of Grasses in the United States. USDA Misc. Pub. 200, Washington, D. C. 1935.
7. Journal of Agricultural Research. USDA Publication.
Contains the bulk of the work done by USDA researchers. Though has some inconsequential papers, is generally of high calibre.
8. Journal of the American Society of Agronomy.
Contains the papers on agronomical research that are not printed in orthodox botanical journals.
9. Nelson, Alexander. Principles of Agricultural Botany. Nelson and Sons, Edinburgh. 1946.
Good on morphology and physiology, with especial reference to farm crops. Covers pathology and plant breeding competently.
10. Piper, C. E. Forage plants and Their Culture. Macmillan, 1937.
Though out of date, it is the only book in the United States with such a complete coverage of forage crops valuable to America. Gives botanical and cultural information on each variety.
11. Robbins, W. W. The Edays of Crop Plants. Blakiston's, 1931.
A good compilation of agriculturally important plants with adequate, though simple, descriptions and botanical relationships, economic and agricultural information.

12. Robbins, W.W., Crafts, A.A., and Raynor, R. N. Weed Control. McGraw-Hill. 1942.
Treats means of dissemination, reproduction, ecology of weeds, competition between crops and weeds, biological and chemical controls.
13. State Experiment Station Bulletins. in
Valuable basic information is hidden with/a mass of information on how to can peas and whether to feed hogs slop or dry feed. An index of the state publications is necessary to find anything.
14. USDA bulletins.
Are of the same type as the EXXX state bulletins.
15. USDA Publications Index.
Lists by authors and by subjects all USDA publications. There is one at the MBG.
16. USDA Bibliography of Agriculture.
Lists articles on agricultural subjects appearing in most scientific and pseudo-scientific journals in the United States and several foreign countries.

SOILS

1. Soils and Man. Yearbook of USDA. 1939.
Most extensive symposium to date on United States soil science. Covers all fields, has bibliography of nearly 500 references. Includes map and descriptions of main soil associations in the United States.
2. Glinka, Knostantin. The Great Soil Groups of the World and their Development. Translation by Marbut.
3. Hilgard, Eugene. Soils.
4. Jenny, Hans. Factors of soil formation. McGraw-Hill. 1941.
Attempts to derive quantitative laws of relationships between the five main factors of soil formation - climate, organisms, parent material, time, and topography.
5. Lyon, T. L. and Buckman, H. O. The nature and properties of soils. Macmillan Co. 1947. 3d Ed.
An outstanding elementary text covering the complete field of soil science, although mainly from an agricultural point of view. Covers soil genesis, plant nutrient supply and availability, physical properties of soils, soil organisms, soil colloids, (mineral and organic), soil moisture movements and plant relationships, and soil classification. Each section has an extensive bibliography.
6. Journ. Assoc. Off. Agr. Chem. Office of Agricultural Chemistry.
7. Soil Science.
8. Soil Science Society of America Proceedings.
This journal and Soil Science are the two most important collections of important soils work.

HISTORY OF AGRONOMY

1. Bidwell, P. W., and Falconer, J. I. History of Agriculture in the Northern United States. Peter Smith, 1941.

The "classified and critical bibliography" is an excellent listing of old agricultural journals and books not usually found in one compilations.

2. Edwards, Everett, E. Selected References on the History of Agriculture in the United States. USDA Library Biographical Contrib. #26 Ed.2. 1939.

"for those who need citations of books and articles that afford convenient summaries of the main facts concerning the history of agriculture in the United States or of some major period of this subject."

3. Edwards, Everett E. Selected References on the History of English Agriculture. USDA Library Biblio. Contribs. #24, Ed. 2.

In two parts: a short group of bibliographies, and histories devoted exclusively or in part to English agricultural history.

4. True, Alfred C. A History of Agricultural Experimentation and Research in the United States, 1607 - 1925. USDA Misc Pub 251. 1937.

Is actually a history of the USDA, its department chiefs, and lesser bureaucrats, but still has a wealth of information on the development of agronomy as a science in the United States. Bibliography of over 300 references.

SOME IMPORTANT DATES AND NAMES IN MODERN HORTICULTURE

- 1909 -- FITTING. First induced parthenocarp by using extracts of orchid pollen. Fitting caused fruit development in some kinds of orchids by applying extracts to pistil.
- 1913 -- KLEBS. Noticed that flowering time of Sempervivum funkii was determined by day length.
- 1915 -- MAZÉ. Challenged classical idea of "ten essential elements" being necessary for plant growth; suggested that others might be required, if only in minute amounts.
- 1920 -- GARNER & ALLARD. Showed a direct relationship between length of daylight period and initiation of flowering cycle in many plants.
- 1922 -- KNUDSON. Proved that orchid seeds could be germinated successfully without symbiotic fungi; revolutionized private and commercial orchid growing by developing a reliable nonsymbiotic culture method.
- 1929 -- Sand culture suggested for commercial use by N. J. Agricultural Experiment Station.
- 1933 -- ZIMMERMAN, CROCKER, HITCHCOCK. First to report a chemical (carbon monoxide) that had a specific and marked capacity to initiate rooting of cuttings.
- ca. 1934 -- DUSTIN, LITS, LUDFORD. Working with animals, noticed that colchicine interfered with tumor cell division, gave first clue to the probable later importance of colchicine in plant research.
- 1935 -- Importance of plant hormones definitely established after a series of intensive investigations beginning around 1925.
- 1935 -- AUCHTER & ROBERTS. Hormone-sprayed apples to prevent fruit set; eliminated laborious method of hand thinning; cresylic acid and its derivatives; naphthaleneacetic acid and derivatives.
- 1936 -- Gravel culture methods developed by N. J. Agricultural Experiment Station and by Purdue University Agricultural Experiment Station were proposed for commercial consideration.
- 1937, 1938 -- BLAKESLEE, BRUES, DERMEN, KOSTOFF, et al. Applied colchicine and acenaphthene to many species of plants to produce polyploid varieties.

Some Important Dates and Names in Modern Horticulture (2)

- 1939 -- GARDNER, MARTH & RATJER. Delayed abscission of fruits by hormone sprays; preharvest drop of apples prevented by use of indoleacetic acid, naphthaleneacetic acid, etc.
- 1942 -- ZITLERMAN & HITCHCOCK. Produced flower clusters in lieu of leafy branches by the use of triiodobenzoic acid.
- 1943 -- RALEIGH. Broke dormancy in (lettuce) seed and secured uniform germination by the application of thiourea.
- ca. 1946, etc. -- ALLARD, DE ROSE, ENNIS, et al. Investigated certain herbicidal compounds such as 2,4-Dichlorophenoxyacetic acid ("2,4-D") and iso-Propylphenylcarbamate ("IPPC"); most grasses are immune, but most broad-leaved plants are affected by "2,4-D," whereas the reverse is true with respect to "IPPC."

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Hormones

- Avery, G. S., Jr., et al. Hormones and Horticulture.
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New York: Prentice-Hall, Inc., 1940.

Light

- Murneck, A. E., R. O. Whyte, et al. Vernalization and Photoperiodism.
Waltham, Mass.: Chronica Botanica Co., 1948.

Pathology

- Chester, K. S. Nature and Prevention of Plant Diseases.
Phila.: The Blakiston Co., 1947.

According to F.E. Fritsch, "unless artificial limits are drawn, the algae must include all holophytic organisms and their colorless derivatives which fail to reach the archegoniata level." If this definition is accepted, the group encompasses organisms showing tremendous range in structure, reproduction, and life history, but the growing tendency is to accept this concept, realizing at the same time that the group is quite heterogeneous and comprises a number of Divisions rather than one natural group.

HISTORY OF SYSTEMATICA OF ALGAE

Systems previous to mid-nineteenth century - generally quite inadequate, because of lack of knowledge of life cycles.

Linnaeus (1754) - order Algae contained lichens and thallose liverworts as well.

Jussieu (1789) - Algae better defined, in the Acotyledones.

→ Agardh, Carol A. (1824) - Systema Algarum.

Endlicher - Gen. Pl. Secundum Ordines Naturales Disposita (1836-40); included Algae and lichens in his section Protophyta.

→ Agardh, Jacob G. - Species genera et Ordines Algarum (1848).

→ Thuret - made a number of fundamental discoveries, especially in regards to the reproduction of algae; divided them into 2 groups, one propagated by zoospores and other lacking them. Recherches sur les Zoospores des Algues et les Antheridies des Cryptogames (1851).

Eichler - Syllabus der Vorlesungen über spezielle und medicinisch-pharmaceutisch Botanisch; system still widely used in modified form. (1836)

At present there are a number of systems in use, differing chiefly in respect to the ranks given different groups and the extent to which certain major groups may be combined.

Smith-Pascher - main groups listed as divisions; cryptomonads and dinoflagellates united into Pyrrophyta; heterokonta, diatoms, and golden-brown algae in the Chrysophyta; etc.

Fritsch - English worker, author of the comprehensive Structure and Reproduction of the Algae; recognizes 11 classes, makes morphological criteria basis in classification of the brown algae.

Papenfuss, G.F. (1946) - considers algae a separate kingdom. "Micro-Phycophyta".

W.R. Taylor - marine algae, mostly; responsible for the widely-used classification of the brown algae on basis of life cycles.

FLORAS, DISTRIBUTION, AND taxonomy of Special Groups (mostly modern)

Smith - Pacific Algae "Marine Algae of Monterey Peninsula".

Taylor - marine algae of north-east America, Florida, Caribbean, and Pacific.

Setchell, W.A. and N.L. Gardner (together and separately) - Pacific algae and marine ecology.

Boergesen - algae of Arabian sea, azotic, Danish west Indies, etc.; studies on distribution.

Schutt (1896) - classification of diatoms for Engler and Prantl, based largely on structure of frustule wall.

West, W. and G.S. West (1904-23) - monograph of British desmids (5 volumes).

Rabenhorst - Kryptogamen Flora - has great number algae of Germany, Austria -

LIFE HISTORIES, REPRODUCTION, AND CYTOLOGY

Basis for discoveries in this field laid in Hofmeister's work on higher plants and in Thuret's work on motile unicells. First demonstration of fertilization in plants in 1853 when Thuret watched fertilization in Fucus; J.B. Farmer and J.L. Williams (1896-8) and Strasburger completely work out l.c. of Fucus. Other work has included:

A. de Bary - studies of Oedogoniaceae, some details of l.c. of Chara

Strasburger - chiefly cytological work on the green algae, including Chara, flagellated unicells, and cell wall structure.

Sachs (1882) - details of l.c. of Chara

Pfitzer (1871-82) - papers on diatoms; "Pfitzer's law". *Regeneration of cells thru*

Muller (1889-1909) - diatoms; theory of cytoplasmic streaming to account for motion.
 Goebel - 1928: view that red algae originally had alternation of generations (comp. Svedelius); 1930: interpreted globule of Chara as a metamorphosed branch system.
 → Yamenouchi - cytology of red algae. 1906- showed free-living tetraspore-bearing plants of Polysiphonia to be diploid.
 Guillemond - cell structure of blue-greens

Among the outstanding phycologists now working are:

Cholnoky - numerous studies of green algae and of reproduction in diatoms.

Savvageau - brown algae; life cycles; demonstration of existence of alternation of generations in Laminariales (1915) paved way for Kylin's work (1933) permitting generalization that all browns but Fucales have a. of g.

→ Harald Kylin - probably outstanding student of reds and browns: life histories, pigments, classification, distribution, etc.

→ Geitler - important studies of Cyanophyceae, diatoms, flagellates

→ Svedelius - marine algae; considers alternation of generations in reds to have resulted from delay in reduction-division.

PIGMENTS, and PLASTIDS (AND THEIR PRODUCTS) in algae have long been a matter of interest, at first from the standpoint of cytology and of chemical nature of cellular elements, but more recently because of their importance in the living cell.

Vaucher described pyrenoids in algae in 1803, but they were not investigated or named until 1882 (Schmitz). The direct division of plastids in algae was noted by Nageli (1846); Schmitz later reported that this was always the case.

There have been a large number of papers dealing with the stored carbohydrate or oily reserves of the algae, from their chemical nature to their application to systems of classification. Fritsch or Smith will guide you to recent literature.

Algal pigmentation is another controversial subject. Aside from the photo-synthetic role of the pigments, interest has centered also on taxonomic relationships and on the functions of the so-called accessory pigments. The latter subject led to the elaboration of the idea (first suggested by T. Engelmann - 1883,4) of complementary chromatic adaptation. See bibliography.

CULTURE OF ALGAE has been employed with valuable results in studies of taxonomy, life cycles, physiology, and ecology. The first recorded work of this kind was done by Faminzin in 1871; in 1890 the Dutch bacteriologist Beyerinck isolated and grew Chlorella and Scenedesmus in gelatin culture, using ditch water and later nutrients. Miquel, 1892, isolated and grew diatoms in silica culture; his method, as modified by Allen and Nelson in 1910 is used today. Chodat, E.G. Pringsheim, and H.C. Bold are modern workers who have employed culture methods profitably.

T. Engelmann - Red Algae of Red Sea, devel. to carry on phototaxis at great depth.
 Haidichem - further

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Unger, F. 1834. Ueber die Anthere von Sphagnum. First to observe the antherozoids and to suspect their function.

Nees von Esenbeck. (1776-1858. Observed in 1822 the discharge of the antherozoids in Sphagnum.

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Robert Brown. Spores are seeds.

Schleiden. Mosses, liverworts, clubmosses, ferns, Equisetums...are sexless.

Hofmeister, Wilhelm (1824-1877) Alternation of generations in plants. Described in his classical study ("Vergleichende Untersuchungen der Entwicklung Hoherer Kryptogamen, Leipzig, 1851") also the egg cell, its fertilization and growth into the embryo. The mossplant corresponds to the prothallium of vascular cryptogams.

Fringsheim (1824-1894) "Apospory" in mosses, sporophyte can arise from gametophyte vegetatively. Formulation of Homologous Theory.

Celakovsky (1834-1902) Antithetic Theory.

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Classification of Bryophytes

Mosses

Hedwig. Species Muscorum (1801) first book dealing with mosses. Hedwig, the father of Bryology, used the very useful character of the peristome teeth. 35 genera, many of which stand today.

One of the most monumental works ever written: "Bryologia Europa" of Bruch, Schimper and Guembel (1836-1855) Six huge, beautifully illustrated volumes. Vegetative characters used as well as peristome characters. 136 genera in Europe. General system of classification still stands today.

Radical modification however in Max Fleischers Musci der Flora von Buitenzorg (Java);
Leiden, 1906-1908.

Other general works, references, etc.:

Brotherus, Musci, in Engler and Prantl. Nat. Pflanzenfam. Ed. 2, 1:24-25.
Muellier, in Rabenhorst Kryptogamen Flora (3 vols.)

Hepaticae-liverworts.

Linnaeus- together with Algae, etc, in the Cryptogamia.

Endlicher. Enchiridion Botanicum (1841) First system based on morphological characters

Gottsche, Lindenberg, and Esenbeck. Synopsis Hepaticarum. a classical work whose
classification still stands today.

System of Spruce. The Amazon River explorer.

System of A. W. Evans.

Schiffner. (EAP ed. 1. vol. L 3). Very outstanding.

Wettstein, Fritz

Stephani. Made terrible mess by describing 3000 new species without looking up
the literature.

Genetics

Fritz Wettstein. 1. Crosses with Funaria.

2. Sporophyte tissues are put on a culture medium; these give
rise to a diploid gametophyte which produces on fertilization
a tetraploid sporophyte, etc, etc.
Method evolved by Marchal, Pringsheim and Stahl.
Wettstein made forms with 16 times the haploid chromosome number.

Plant Geography of Mosses

Herzog, Die Geographie der Moose, Jena, 1926.

Palaeobotany

Just in Am. Midl. Naturalist, c. 1943. Review of 41t.

Mosses preserved in many Quarternary deposits, peat bogs, tufa, etc. Also in amber.

Bryology in the U.S.

Sullivant-Icones Muscorum. Classical work with beautiful plates. Biography of S.
by Rodgers.

Lesquereux (The paleontologist) and James - Manual of the Mosses of N.A.

Modern Books

Grout - Mosses with the handlens
Mosses with Handlens and Microscope
Moss Flora of North America-the most comprehensible book, with keys and
descriptions and plates for all species. (c 1935)

Verdoorn - Manual of Bryology
Had wigier
The Bryologist

Frye and Clark (Washington State University, Seattle)-Liverworts of N.A. the
equivalent of Grout's Moss Flora of N.A. (c.1945-8)

Engler and Prantl Natuerliche Pflanzen Familien
Rabenhorst, Kryptogamen Flora

The Bryologist, Organ of the Sullivant Moss Institute

Outline History of Fungi

Early knowledge of fungi centered around food and medicine. Greeks and Romans distinguished edible and poisonous. In biblical times crop diseases were known and were attributed to deities. For 1000 years after the fall of the Roman Empire in A.D. 476 little was accomplished. The discovery of printing stimulated interest. The herbalist Bauhin in 1623 listed 100 spp. in "Pinax Theatri Botanici." Sterbacek described edible and poisonous fungi in his "Theatrum fungorum" (Antwerp, 1675). Tournefort in 1684 in his "Eléments de Botanique" arranged six groups. Hooke's "Micrographia" 1667 made some inaccurate observations and considered Mucor and others were generated by plant tissues. Dillenius laid foundation for classification of cryptogams in 1719. Pier'Antonio Micheli (1679-1737) established starting point in his "Nova plantarum genera" (Florence, 1729). In this the illustrations and descriptions are so accurate that identification can be made today. Proved that fungi reproduced their own kind from what he called "seed". J.G.Oleditsch (1714-1786) classified 11 genera in "Methodus Fungorum" 1753 but added nothing new. Linnaeus "Species Plantarum" 1753 established binomial system. Assembled fungi under the Class Cryptogamia Fungi. Felice Fontana (1730-1805) published works on rusts of grains in 1767. He was the first to recognize the parasitic nature of fungi. This was a period of herbarium seclusion - not much attempt to study plants in habitats. With the beginning of the 19th century came a change of thought regarding fungi and men tried to get away from ideas of mystic explanation.

Bulliard's "Champignons de France" 1791, gave drawings and descriptions of microfungi. Christian Henrik Persoon (1762-1836) published the first reliable account in "Synopsis Methodica Fungorum." Was first to abandon vague definitions and described two classes each containing 3 orders. This was the first usable classification system. Elias Fries (1794-1878) Sweden, carried on study and devoted much of time to Hymenomycetes. System of classification like Persoon's but modified. Described all known spp. in his "Systema Mycologicum" (1821-1829). Also monographed the Hymenomycetes of Sweden. He wrote a complete text on the H. of Europe including a synopsis of the literature in his "Icones Selectae Hymenomycetum". His system of classification was adopted by the International Congress at the 1210 meeting in Brussels. Fries also was founder of lichen classification in his "Lichenographia Europaea Reformata" (1832) based on organs of fructification. The French mycologist Leveille (1796-1870) in 1837 divided the fungi into the groups Basidiomycetes and Ascomycetes. Corda (1809-1849) Czechoslovakia, was the first to see the value of microscopical characters for the basis of classification. Corda in 1837-1855 published 6 volumes of "Icones Fungorum Hucusque Cognitorum" on Austrian fungi, drawings and descriptions. A similar work by the Tulane brothers "Selecta Fungorum Carpologia" 1861-1865 in 3 vols has beautiful illustrations and is unsurpassed.

The British mycologist Miles J. Berkeley (1803-1889) contributed "Introduction to Cryptogamic Botany" (1837) and later (1850) his "Outlines of British Fungology" in which he described the spp. of the British Isles.

In America mycology was started by Louis David von Schweinitz (1780-1834). His great work was "Synopsis Fungorum in America Boreali Media Digentium" 1834. Schweinitz was the "Father of American Mycology." He collected 3000 spp. in N.C. and Pa. of which 1200 were new spp. The fungal flora of the s.e. U.S. was studied by Rev. M.A. Curtis (1808-1872) and H.W. Ravenel (1814-1887). C.H. Peck (1833-1917) described and published descriptions of many unknown fungi in his "Reports on Botany". J.B. Ellis and B.M. Everhart in 1812 published works on North American Pyrenomycetes. E.A. Burt on the Thelephoraceae. J.C. Arthur has published the most complete treatise on the Uredinales - "The plant rusts" 1929.

Taxonomic works include those of Patouillard (1887), Quelet (1888), Cooke (1871-1888), Massee (1892-1898) and Bresadola (1927-1932) also Engler and Prantl's "Die natürlichen Pflanzenfamilien", Rabenhorst "Kryptogamen Flora Deutschlands", Sydow's "Monographia Uredinearum", Oudemans' "Enumeratio Systematica Fungorum". W.G. Farlow gathered together the parasitic fungi of the U.S. and their hosts in "A provisional host index (1888-1891)"; this was followed by an enlarged edition by Seymour in 1929 - his "Host Index of the Fungi of North America". Also a fundamental work is Saccardo's "Sylloge Fungorum" started in 1882 and comprises now 25 volumes. The latter contains brief Latin descriptions of all known fungi, about 80,000 spp.

Up to the middle of the 19th century fungi were thought to be generated by the substrate on which they were found. It was not until the revolutionary experiments of Pasteur that fungi were shown to be causes of plant diseases. Early men in the field following this discovery include Berkeley (1837), Kühn (1858), de Bary (1866), Hartig (1874), Woronin (1878) and Brefeld (1884-1912). Summary of their work contained in Whetsel's "History of Phytopathology (1918)." Pasteur's work on fermentation started Hausen's researches on morphology and physiology of yeasts. Early work on classification was only based on primarily morphology. Later the importance of detailed structure was realized. This change resulted in de Bary's "Morphologie und Physiologie der Pilze, Flechten, und Myxomyceten (1866)." This work is considered basic in mycology.

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Don McClary Dec 6, 1944

PLANT PATHOLOGY

I. The rise and development of Plant Pathology

The Ancient Era. From the dawn of history to 476 A.D.

Biblical records of the Hebrews; Aristotle and Theophrastus in Greece;

Pliny, Historia Naturalis in Rome.

Medieval Era. From the fall of Rome through the dark ages for 1,000 years.

Practically nothing done during this period.

The Renaissance. All writings based upon the works of the ancient Greeks and Romans.

The transition period. (1700- 1850.) Tournefort, 1705, classified diseases on the basis of cause; Zallinger, 1773, on the basis of symptoms; Fabricus 1774, on the basis of cause also. Microscopes had not come into use for the study of plant diseases so that in most cases it was impossible to detect the true cause of a plant disease. The physiologic or autogenetic theory of Unger and his colleagues developed. By 1850 the parasitic nature of fungus diseases was definitely established.

The Modern Era. (1850-

where west L.C. + potato blight (Phytophthora)
) A great deal of work done. A few important writers: In Germany: De Bary, Kuhn, Frank, Brefeld, Hartig, Schaeter, Sarauz, Van Tubenif, Kirchner, Winter, and Kleban. France: Millardet, Prillieux, and Delacroix. Italy: Comes, Berlese, and Sevestana. Sweden: Erickson. Denmark: Rostrup, Fravn, and Jensen. Russia: Waronin. Holland: Ritzema Bos. England: Berkeley and Ward. Australia: Mc Alpine. *chubroot of cabbage*

Modern Plant Pathology in America.

Burrill (1873) University of Ill. First to teach Plant Path. in connection with Botany. Farlow (1875) Harvard. First to offer a special course.

Pathology in America developed chiefly under two separate agencies. a.

The USDA. b. Agricultural Colleges and Ex. stations of the several states.

II. Summary of important events and the principal developments in the history of Plant Pathology.

The first definite contribution made by Theophrastus (ca. 300 B.C.) in Historia Plantarum.

Pliny, Historia Naturalis ca. 50 AD.

Bacteria discovered by Læwenhæck in 1683. The discovery that bacteria caused disease came at a much later date.

The organization and classification of plant diseases expanded and refined during the 18th. century by Zallinger and others.

The evolution of the autogenetic system or theory of the origin of plant disease took place in the first half of the 19th. century under the leadership of Unger.

The accidental discovery of the efficacy of CuSO_4 in the seed treatment of grain seeds against smut by Prevost. France. 1807.

Sulfer used as a fungicide by Robertson. 1821.

The final proof of parasitism of fungi established by De Bary and others at the mid 19th. century.

1864. De Bary published his paper on the stem rust of wheat proving it to be heteroecious in nature. Telial stage on wheat, aecial stage on barberry.

1860-1864. The founding of the science of Bacteriology by Pasteur.

Plant pathology first taught in the US. Burrill at Ill. 1873.

1875. The first independent course in plant pathology at Harvard under Farlow.

1879-1880. Burrill proves the bacterial nature of the Fire Blight disease of the pome fruits.

1881. Koch and Petri develop the plate techniques of bacterial isolation and the petri dish.

1882. Millardet accidentally discovers the Bordeaux mixture. CuSO_4 and lime. When applied to grapes to keep off little boys it proved a remedy for the downy mildew of grapes.

The establishment in 1885 of a ^{section} division of Mycology in of the Botany div. of the USDA.

1886. Proof of the infectious nature of Mosaic. Mayer.

1887. Development of the hot water method of seed treatment for cereal smuts by Jensen.

1887. the Passage of the Hatch Act. This act paved the way for the establishment of the state Agr. ex. stas. in 1888.

1888. The use of Formaldehyde as a disinfectant. Trillat.
1894. Erickson discovers physiologic races in rust.
1906. Passage of the Adams act. Provided additional funds for the ex. stas.
- 1906-1908. Cardley adapts lime-sulfur sprays for use in control of the apple scab.
1907. Smith, E.F. and Townsend, C.O. of the USDA demonstrate the cause and nature of crown gall.
1909. The formation of the American Phytopathological Soc.
1912. The federal quarantine act.
1910. The substitution of fine dusts in place of sprays in the control of certain diseases.
- 1920 to present. A great deal of emphasis on the virus diseases.
- 1899- 19 09. At this time Orton began working on resistant strains of cotton, cowpeas, and melons in connection with fusarium wilt. From this work stems one of the most important aspects of plant pathology; the breeding of resistant strains.
- 1915 to present. The substitution of copper carbonate, formaldehyde and other compounds in the treatment of seeds for bunt and other seed borne diseases.

III. Types of plant diseases.

The definition of Plant Disease: A plant disease is any alteration that interferes with the plants' normal structure, function, or economic value.

I. Physiogenic plant diseases. Nonparasitic diseases caused by environmental disturbances such as deficiencies in food materials in the soil, excesses of soluble salts in the soil, unfavorable water relations, air and light relations and unfavorable temperature. More limited effects would be chemical and mechanical damage.

II. Diseases caused by viruses. Filterable infectious principles invisible to the light microscope causing such diseases as tobacco, tomato, and potato mosaic; peach and aster yellows; curly top of sugar beet; etc.

III. Diseases caused by parasitic predatory animals.

Protozoa. Sometimes found in the latex of plants but unimportant because important evidence of parasitism is not known.

Nematodes (Belworms) Some very destructive plant diseases such as the golden nematode of potato.

Molluscs. Snails, slugs, etc. of significance in the tropics.

Arthropods. very important but treated under Entomology.

Vertebrates. Especially rodents and birds.

IV. Diseases caused by pathogenic plants.

- a. Parasitic flowering plants. Dodder, mistletoe, Orobanche etc.
- b. Algae and lichens. A few rare plant diseases.
- c. Bacteria. Cause of many important plant diseases: Corn wilt, alfalfa wilt, cotton blight, fire blight, soft rots of vegetables.
- d. Fungi. The bulk of plant diseases stem from this group of plants.

IV. Symptoms of plant diseases.

Direct necrosis. A feature of any disease that induces a rapid and complete death and disintegration of the tissues of the host as it advances in the host.

1. General necrosis. Where the causal agent induces extensive and rapid progressive destruction of the host. Fire blight, damping off, Rhizopus rot of sweet potatoes, wood rots, chestnut blight, Illinois blister canker and spinach blight.

2. Local Necrosis. Causal agent induces the death of cells and tissues in localized areas. Examples: Bean blight, alfalfa leaf spot, crown rust of oats, virus necrosis of tobacco.

Indirect Necrosis. Occurs in those diseases in which the causal agent induces delayed death of the tissues following its activities in the host.

1. Vascular necrosis. Death of tissues results primarily through activities of a causal agent in the vascular elements of the host. Examples: cucumber wilt, flax wilt, Stewart's disease of sweet corn, and cabbage yellows.

2. Cortical necrosis. Death of tissue results primarily through the activities of the causal agent in parenchymatous tissues. Examples: Plum pocket, white rust of crucifers, corn smut, crown gall, club root of cabbage, powdery scab of potatoes, and mosaic of tobacco.

Discoloration. Any change from normal color.

Shot Holes. Perforation of leaves.

Dwarfing or atrophy. Reduction in size.

Hypertrophy. Increase in size of parts. Roots, stems, leaves, flowers, fruits.

Hyperplasia. Abnormal multiplication of cells or increase in number.

Transformation of organs or replacement of organs by new structures.

1. Replacement: By sclerotium, as in ergot of grasses.
2. Transformation of floral organs: petals to foliage leaves, etc.

Mummification: Transformation of fruits into shriveled structures, called mummies.

Alteration in habit and symmetry.

1. Change of position from prostrate to erect or ascending.
2. Change from rosette to cauline type.
3. Change of simple leaves to lobed leaves.
4. Reduction or increase in branching.
5. Change in form of inflorescence.
6. Change in symmetry of flowers.

Destruction of organs. Flowers, seeds, inflorescence.

Dropping of leaves, blossoms, fruits or twigs.

Production of exorecences and malformations.

1. Pustules, warts, tubercles, galls, or tumors.
2. Cankers. Localized lesions generally resulting in corrosion of tissue with final production of an open wound, generally on woody structures.
3. Witches' brooms.
4. Hairy root.
5. Rosettes.
6. Rolling, curling or crinkling of leaves.
7. Roughing of surfaces.
8. Deforming of fruits.

Exudations. Guttation and bleeding contrasted with formation of exudates.

1. Bacterial exudates. Fire blight.
2. Gummosis. Product of decomposition of tissues. Sets into solid masses,

- clear or amber colored. Common in citrus and stone fruits.
- 4. Resinosis. Abnormal production of resin or pitch from coniferous trees.
- 5. Latexosis. Exudation of milky juice or latex.

Rotting. Soft rots and dry rots.

V. Economic Importance.

- A. Ergot. Ergot poisoning epidemics of Europe.
- B. Late blight of potatoes. *Phytophthora infestans*. The Irish potato famine of 1843-45
- C. Powdery Mildew. *Uncinula necator*. 1850-1857.
- D. Downy Mildew. *Plasmopara viticola*. 1878. Introduced from America into Europe. Again the wine industries were threatened with extermination. Millardet discovered Bourdeaux mixture.
- E. Peach yellows. Great Peach orchards of Maryland, Delaware, and Michigan destroyed.
- F. Curly top. Sugar beet industries of Idaho, Utah, and California almost destroyed.
- G. Flax wilt. Chief reason perhaps, why flax is not an important U.S. crop.
- H. Watermelon wilt. Raising of watermelons becoming increasingly difficult.
- I. Chestnut blight. 1884. American chestnut practically extinct.
- J. Current crop losses. Average frp, 1 to 10% annually approximately an average financial loss to farmers of \$268 a year. Epiphytic years as the stem wheat rust of 1916 a loss of approximately 100,000,000 bushels of wheat valued at \$220,000,000. This amounted to \$3500 to every wheat farmer.

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Freitag 11/3/59

History of Anatomy

The history of anatomy is quite dependent on the history of the microscope since it deals with the very small detail of the plant and its arrangement in the plant. The earliest work was thus practically nonexistent. Most of the anatomy being done after the microscope was invented, and the largest amount being done in relatively recent times by a great diversity of workers.

The first workers which could be classified as anatomists, no microscope.

Aristotle and Theophrastus. Divided plants up into rind, wood, and pith. Recognized these units as heterogeneous layers. Compared them with animal structures.

Cesalpino Thought that the pith was the heart of the plant and contained the living soul. Analogized other structures of plant with those of animals. Canals - veins, etc.

The period up to 1860 was marked by relatively few workers in virgin field.

Hooke, Robert 1665-7 'Micrographia, or some physiological descriptions of minute bodies made by magnifying glasses.' He was not a botanist and discoveries were probably chance. Discovered cells in cork.

Henshaw 1661 Discovered the vessels in walnut wood. About all.

Malpighi 1671 'Anatomes plantarum idea'

Analytically treated with the larger divisions of plant structure and only lightly touched on the cell itself. Thought that the youngest layers of wood were formed from innermost layers of bark. Considered the plant a complex tube system, the tubes beginning in the roots extending up the stem and separating into the leaves etc. one tube for each leaf. Used high power of magnification since he saw pits on conifer wood, but thought them to be deposited grains. Tacked on a treatise on the Hen's eggs during the process of incubation.

Grew, Nehemiah 1671 'Anatomy of plantes begun'

Observed many of the things Malpighi did but tended to theorize concerning them. Used term parenchyma, thought stems and plants were formed by fermentation of the tip and that the cells were the bubbles of foam. Vessel - air passage.

Leeuwenhoek 1695 'Arcana Naturae'

Developed microscopes and found vessels in secondary wood. Cystoliths.

Wolf, Christian Baron von Two works 1723 and 1721.

Worked on starch grains in wheat, thought they were vesicles filled with water.

Ludwig 1742 and Boehmer 1785 'Sloppy'

'White elastic thicker or thinner fibres and threads woven together of differing shape and size form cavities or cells or caverns, and are usually known by the name of cell tissue'.

Others of this type and time were Du Hamel, Comparetti, Senebier, Germany, Hill, who thought of cells as stacked cups, Baron von Gleichen-Russworm.

Wolff, Caspar Friedrich 1759 'Theoria Generationis'

Cells were formed by drops of mucilage secreted at the growing points or mucilage beginners and that these drops of mucilage were separated from the beginning by the intercell laminae or cell walls. Saw no pits. Thought young cell walls were plastic becoming harder and more rigid with maturity, also believed depositions were laid down on walls. Secondary growth due to the tubes formed every year which ran from root to each leaf.

1812-1826 Many improvements on microscope. 120 power to 500 power.

Most attention paid to cell wall, still no attention to its contents.

Mirbel 1801 Cells surrounded by walls with pores in parenchyma and vessels.

Sprengel, Kurt 1802 Thought cells were cavities all connected to one another by tunnels or missing walls, no pores. Saw stomata but thought of them as organs of absorption. Noticed they opened and closed.

Bernhardi 1805 Tried to give names to tissues and cells and define ones already in use.

Link 1807 Understood true nature of starch grains.

Rudolphi 1807 He and Link received prizes for their essays thought they were at opposites in many things.

Treviranus 1807 Also wrote an essay but didn't win prize for it though it was later considered the best. Described intercellular spaces and described the movement of the sap in them.

Mirbel 1808 Enlarged on previous work, found a layer he called cambium.

Moldenhawer 1812 'Beiträge II' Improved the methods of studying Anatomy. Worked on corn and first used technique of maceration. Proposed the origin of secondary wood from the cambium.

Meyen 1839-40 Distinguished the many parts of the cell contents omitted to this time. Intercellular spaces as being filled with air in deference to those filled with rosin, etc. Understood nature of tyloses. Noticed streaming of protoplasm.

von Mohl 1839-50 A very careful worker. Worked on origin and maturation of cells, mainly vessels. First used the word protoplasm and made investigations of it. Thought of cell as fundamental unit of plant structure. Laid the basis for comparative morphology.

Naegeli 1846 Did research on the formation of cells. Discovered that they come from approximately the same type of cells. Discovered apical cell of cryptogams.

3.

Max Schulze, Brucke and Kuhne 1863 "showed that protoplasm was the immediate principle of life.

Theodor Hartig Discovered the aleurone grains in seeds.

Brown, Robert 1831 Discovered the nucleus in the cells of orchids.

Schleiden 1838 Gave the nucleus its name and noticed its general occurrence. Formulated the free cell theory?.

Unger 1841 Concluded that the tissue-cells are formed by division.

Naegeli 1842 correctly observed the division process but didn't realize just what it was.

Hofmeister 1851 Studied behaviour of the nucleus during cell division and formation of the dividing walls.

Hartig, Theodor 1851 Described sieve tubes.

Naegeli 1858-63 Theory of intussusception.

Molecules laid down between other molecules in the cell wall.

Worked on vascular bundles and helped to explain secondary thickening.

Sanio, Carl 1863 Student of wood.

Following is a list of work mainly undertaken after 1860 listed under the parts studied.

The Cell

A. Protoplasm.

Schulze, Max 1854-63 First to offer definite proof that the protoplasm of plants was nearly identical to the sarcode of animals.
Upheld by Haeckel 1862 and Kuhne in 1864.

Brucke Believed the protoplasm had a solid cell-body surrounded by a streaming fluid.

Cienkowski 1863 Two fluids of different densities.

De Bary 1864 and Hanstein 1870 One fluid with varying properties.

Velten 1873-6 Protoplasm was a fibrillar structure. Upheld by Remak 1844 and Max Schulze 1871 and Flemming 1882.

Fromman 1867 Reticulum of solid substance and intervening non-living fluid. Heitzmann 1873.

Strasburger 1876 Net like substance with coarse vacuoles of two types.

Schmitz 1880 Added to this theory with limiting layer on the networks.

All the preceeding thought of the granules as the nodules of protoplasm or where fibers crossed.

Altmann 1886-90 Rejected the reticular theory and thought that the granules were living parts of protoplasm and moved in a non-living fluid.

Berthold 1886 Two fluids with the relation of an emulsion.

Blutschli 1889 Reticular appearance of protoplasm due to the optical appearance of a finely vacuolated foam structure.

B. Cell membrane, Vacuolar membrane, Etc.

Butschli Thought that they were simple parallel fibers on surface.

Pfeffer Definite membranes composed of proteins.

Chodat and Boubier 1898 Method of slow plasmolysis. Thought that the cell wall was infiltrated by protoplasm, and that the ectoplasm adhered to the cell wall.

De Vries 1886 Tonoplasts. Vacuoles of bodies which swelled due to inside osmotic pressure.

C. Relations of protoplasm of contiguous cells.

Hanstein 1864 Showed definitely that there are pores or pits.

Strasburger 1882 Showed for sieve tubes that they were pits and strands of protoplasm passing thru them. Gardiner and Hill in 1900 corroborated him.

Heitzmann 1873 Thought there was intercellular protoplasmic continuity.

Gardiner 1897 Killing and fixing by use of osmic acid and uranium nitrate and then stained with saffranin. Showed there were protoplasmic strands thru the pits and walls.

D. Nucleus

Robert Brown discovered it as mentioned.

Strasburger 1882 Included it as part of protoplasm.

Hertwig, Strasburger, Kolliker and Weismann 1884 Observed that it was connected with inheritance.

Schmitz, Strasburger and Flemming 1879-1880 Nucleus consisted of homogeneous substance and fibrous substance. Flemming called the staining portion chromatin. Schwarz called the non-staining portion linin.

Heidenhain 1893-4 Two types of linin, one granular and one not granular.

Klein 1878 Studied nuclear membrane.

Meischer 1871 Studied chemical composition of nuclei. Mainly nuclein.

Kossel 1893 Showed nuclein to be same as chromatin.

E. Cell wall.

Naegeli 1858-63 Growth by intussusception.

Strasburger 1887 Growth by apposition.

Hofmeister 1867 Cell wall a living structure.

Wiesner 1886 Walls of living part, non-living granules and water.

Pfeffer 1892 Thought walls formed in several ways.

1825 Wall was thought to be of cellulose and pectose.

Fremy 1859 Used ammonio-cupric sulphate and dissolved out the cellulose then studied remaining structure.

Kabsch 1863 Used swollen cells and located pectic materials in middle lamella only.

Vogl 1863 Using roots found mostly cellulose in wall and thought it intergraded with the pectosic middle lamella.

Wiesner 1864 Found cellulose changing to form the pectosic lamella.

Sanio 1873 Cells held together by gelatinous material from cellulose wall.

Mangin 1893 Worked on chemical properties of pectins and their composition in plants. Cellulose entirely different from pectic materials and couldn't give rise to pectic materials. Middle lamella almost entirely calcic pectate.

Hofmeister 1867 Studied deposition of new cell walls.

Sachs 1878 Showed that new wall is laid down at right angles to old. Distinguished between periclinal and anticlinal walls.

Errera and Berthold 1886 Wall laid down to present least surface possible

F. Tissues.

Sanio 1863 Thickening ring. Layer corresponding to cambium that gave rise to main part of stem and bark tissue.

Hanstein 1868 Three histogenetic layers of cells in root and stem apex. Dermatogen, periblem, and plerome.

Janczewski 1874 Classified plants by (1) Three layers distinct and another which gives rise to root cap. (2) Dermatogen and periblem arising from a common meristematic layer with distinct plerome, calyptragen, (Monocots.) (3) Plerome and periblem sharply defined, but a common initial layer for the dermatogen and root-cap. (Dicots.) (4) Non layered meristematic zone over the apex.

confirmatory Treub 1876, Famintzin 1875, Eriksson 1878, Flahault 1878 and Olivier 1881.

Van Tieghem and Douliot adhered to Hanstein idea til 1889.

Douliot 1890 Agreed for Dicot. but for monocots found only a dermatogen distinct from a common initial group giving rise to both periblem and plerome.

Van Tieghem 1891 No dermatogen, but instead an outer layer of periblem which he called Epiblema in Monocots. In Dicot. divided into two layers the inner forming the dermatogen, the outer the root cap. No calyptragen.

Russow 1872 Recognized Sanio's thickening ring which he called meristem which formed the xylem only. Existem formed the other two outer layers and Pith formed from the Endistem.

Koch 1893 Used Lilac and noticed that some layers formerly held as constant vary between node and internode. Meristematic tissue thus can grow as a whole and no good basis for Hanstein's layers.

Schmidt, A. 1924 Was formulator of "Tunica Corpus".

Sachs In Lehrbuch classified tissues on function.

De Bary Classified them on grounds of the history of their development.

Van Tieghem 1870 Formulated idea of steles in root. described pericycle cortex, and endodermis. 1872 had a similar plan for the stem. Found exceptions to his plan.

With Douliot 1886 Recognized Astely, Polystely, and Monostely.

Jeffrey 1897 Protosteles and siphonosteles.

G. Miscellaneous.

Sachs 1868 Explained the small cells of autumn wood as being due to the increased pressure they were formed under caused by formation of previous spring cells.

Hartig 1880 Annual ring caused by changes in nutrition.

Pericycle described in roots by Naegeli and Leitgeb 1867 Called it pericambium and was in roots only.

Falkenberg 1876 found it in the stem.

Mangin 1882 Showed that adventitious roots arise from it.

Leaf. Hofmeister 1868, Naegeli and Schwendener 1869, Leitgeb 1871, Chaglin 1874, Goebel 1880

Ovules and embryos. Hanstein, Famintzin, Guignard 1880, Treub 1882, Campbell 1898-900.

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Jostes - Practical Plant Anatomy

ECOLOGY STUDENT SEMINAR

17 January 1950

Alfred G. Etter
Robert A. Dietz

Part One: Background

I. Aim of Ecology.

--To understand the relationships existing between the organism and the mass of external factors (environment) surrounding it, with a view towards using this information for the long range benefit of mankind.

II. Dilemma of Ecology.

- a) Although ecology is as old as biology, past work has been almost entirely descriptive.
 - 1) Confusion in terms. (leading to---)
 - 2) Confusion in concepts. (or vice versa)
- b) Broadness of field, leading to division and compartmentalization.
- c) Future outlook.

Part Two: Applied Ecology

--With special emphasis on work done at the
Washington University Experimental Farm
(Brookhill) at Clarksville, Pike County, Mo.

Selected Bibliography, annotated.

N.B. There are libraries full of books on or about ecology or some aspect of it. Most of these are dull, too specialized, or out of date. For the biologist without training in ecology who is interested in a general insight into the field, the following books are recommended. Those interested in more specific aspects will find excellent books in biology libraries, some even in ours.

Allee, Emerson, Park, Park and Schmidt. Principles of Animal Ecology, W.B. Saunders and Co., Philadelphia, 1949. QL751 AL52. Excellent--emphasis on animals but there are over 100 pages on plant and plant community ecology. This book is a worthy successor to Hesse Allee and Schmidt's Ecological Animal Geography.

Braun-Blanquet, Fuller and Connell. Plant Sociology McGraw-Hill, New York, 1932. A classic by the famous European ecologist. Many views herein are at variance with those of many American ecologists. QK901 B738P Fy

Clements and Shelford, Bio-Ecology. John Wiley & Sons, New York, 1939. Unbelievably dull and difficult to read, but no other book contains such a mine of information nuggets hidden away among the pages of dull. (Full responsibility for this statement rests with the junior speaker) QH541 C591

Elton, Animal Ecology, Sidgwick and Jackson, London, 1947. Good. One of its virtues is that it's short. QL751 EL 84

Weaver and Clements, Plant Ecology, McGraw-Hill, New York, 1938. QK901 The basic American work on this subject.

There are several "standard" "easy" college texts on Ecology, some of which have been recommended by our staff members, which are at best shallow and/or distorted glimpses into the field, and the reader is encouraged to look elsewhere if he wants to make the most of his time. Among these are Daubenmire (Plants and Environment) Coasting (Plant Communities) and McDougall (Plant Ecology)

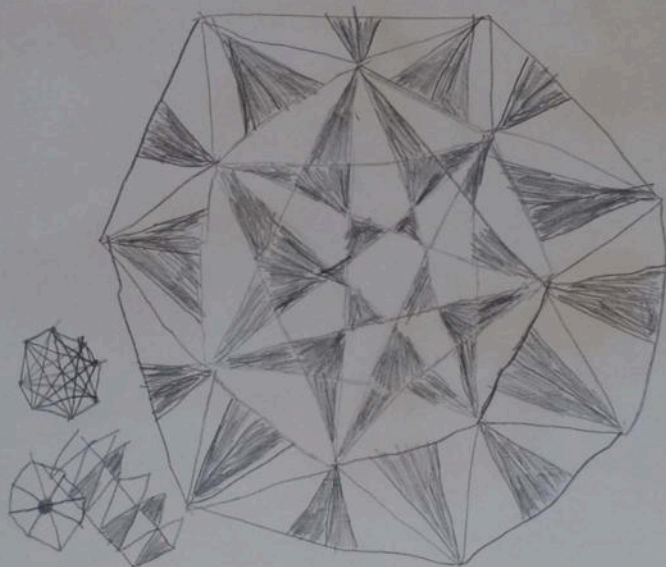
Periodicals

Articles of interest and importance in the field of ecology are found in every general-interest periodical in the fields of botany, geology and zoology. Some publications consistently publish more ecological notes and studies than others. Among the latter is the American Midland Naturalist (University of Notre Dame, Notre Dame (sic) Indiana. The latter publication has also published a very fruitful book recording the papers and discussions at the Ecological Symposium. (Amer. Mid. Nat. Monograph No. 1. ---same series as Jones' Flora of Illinois---not in our library but in that of the Mo. Bot. Gdn.)

The Magazine Plant and Soil (The Hague, Netherlands, in English) covers one segment of ecology and is in our library

Ecology is the publication of the Ecological Society of America and is the best (and nearly the only) publication in the field as a whole in this country. Coasting is the Editor-in-chief, Durham, N.C. the home base.

The space below has been generously contributed by the speakers for notes of a scientific nature which come to your minds while listening to us



I. STUDY OF EXISTING CLIMATE

A. BEFORE 1800

Embryonic general science of the weather, not divided into distinct fields

1. CLASSICAL PERIOD

East-west climatic belts controlled simply by latitude.

2. PERIOD OF EXPLORATION

Varenus (1650) showed temperature not strict function of latitude.

Galileo invented thermometer (1593), Toricelli invented barometer (1643)
Upsala pioneered climatic exploration. Weather observations by
Linnaeus' collectors.

Increasing flood of observations. Adoption of arithmetic mean for
summarization. Search for natural laws.

B. AFTER 1800

Gradual divergence of climatology as study of periodic variation and
meteorology as study of non-periodic variation.

1. CLIMATOLOGY AS STUDY OF AVERAGE WEATHER

Dominant concept to present time. Uncritical use of mean.

A. DESCRIPTIVE

1. STUDY OF INDIVIDUAL ELEMENTS

Elements studied determined by nature of instruments.

a. SIMPLE DATA TABULATIONS

Enormous quantity of published summaries of mean monthly and
annual values of elements at particular stations.

Hann, editor Met. Zeitschrift (1866-1920), published much
data from all parts of world. Assembled in his Handbuch
(1883, later editions).

Köppen (1930--) Handbuch, carried on by Geiger, monographs
of regional climates by various experts. Probably last
attempt at encyclopedia of descriptive climatic data.

b. GRAPHICAL PRESENTATION

Early use of rectangular coordinates for time plots.)

Successful mapping followed invention of isarithmic map by
Humboldt (1817). Recognition of geographic patterns.

Became standard tool for mapping means of individual
elements from 1850 to present. Dove, Buchan, Supan,
Teisserenc de Bort made early good maps of temperature,
pressure, cloudiness, rainfall.

Winds required special graphic devices for summarization.

Resultants shown by arrows. Maury (1848-60) first compiled
winds at sea from records of ship logs.

Mean maps of separate elements remain important tool of
climatology, definite but limited value.

2. COMBINATION OF ELEMENTS INTO CLIMATIC TYPES

Gradual acceptance of isarithms as real boundaries. Since late
19th century attempts to define climatic regions on basis of
isarithms, particularly mean temperature and precipitation.

Supan (1879) first classification of temperature regions,
arbitrary borders. Also subjective delimitation of unique
climatic provinces of world.

Hult (1893) refined Supan's system.

Köppen (1884) classified temperature regions on basis of
natural vegetation, emphasizing seasonal variation. Later
(1900) incorporated moisture factor into definitions of
climatic regions and finally (1918) developed system which
has come into general use. Actual classification of repeating

climatic types rather than division of earth into unique climatic regions. Underlying concept: quantitative gradations in climate produce qualitative discontinuities in vegetation. Adopted de Candolle's (1874) classification of vegetation according to temperature and moisture tolerances:

- A. Megatherms--no winter
- B. Xerophytes--dry
- C. Mesotherms--distinct but mild winter
- D. Microtherms--severe winter, distinct summer
- E. Hekistotherms--no summer

Sought isarithms of mean temperature and precipitation which coincide with borders of these vegetative types. Subdivisions of major types also defined by mean isarithms. Letter symbols: Af, Cs, etc. became standard in teaching climatology.

Penck (1910) classified climates in terms of effect on soils and landforms: nival, humid, dry. Subdivided on basis of seasonal changes in elements affecting runoff and weathering. Thornthwaite (1931-33) attempted to refine Köppen's moisture factor by substituting precipitation-effectiveness index for direct precipitation values.

Overestimation of usefulness of climatic classifications.

B. RATIONALIZATION

1. Empirical FORMULAS

Belief that natural laws would be revealed by mathematical equations describing observed data.

Brewster (1821) mean annual temperature expressed as function of distance from two "cold poles."

Similar later attempts. No approach to understanding dynamics.

2. THEORETICAL EXPLANATION

Attempts to derive observed climates from basic controls.

Theoretical computation of relative amounts of solar radiation received at "outer limit of atmosphere" followed by computation of absolute values when solar constant determined in late 19th century. Precisely expressed by Milankovitch (1920-30).

Attempts to apply increasing knowledge of physics of atmosphere to precise mathematical explanation of observed climatic means. Coining of term "dynamic climatology" by Bergeron (1930). Investigations by Hesselberg (1932). Link between theory and observed means achieved only in general non-quantitative terms.

2. CLIMATOLOGY AS STUDY OF MEAN FREQUENCIES OF ACTUAL WEATHER

A. DESCRIPTIVE

1. STUDY OF INDIVIDUAL ELEMENTS

Frequency summaries since early times, required by some types of observations: ship's records of precipitation, wind direction.

Wind rose invented by Brault (1870).

Increasingly used in applied climatology. Less abstract than simple means, actual conditions not buried.

Plotted as isarithms in same way as ordinary means.

2. COMBINATION OF ELEMENTS INTO WEATHER TYPES

Frequencies of many elements combined to express probability of occurrence of any complex of conditions. Classification of weather types rather than fictitious means.

Requires special summaries of basic data. Practicable with punched-cards and machine tabulation.

B. RATIONALIZATION

Study of frequencies of actual weather patterns permits understanding of dynamics of climate. Analysis of weather patterns under different types of air-flow, basic control of climate at any particular place. Isolation of homogeneous situations.

Von Buch (1820) used surface wind direction as frame of reference for other weather observations. Technique developed by Dove (1827):

After 1800 recognition of interdependence of pressure and air-flow.

Köppen (1874): "The condition that primarily determines the character of the weather produced by a wind is its trajectory: whence does the air come, over what kind of a route, and how rapidly?" Classified 2 years of synoptic maps according to pressure pattern relative to St. Petersburg, summarized occurrence of other phenomena during these patterns. Essentially modern concept of synoptic climatology.

Long period of divergence of climatology and meteorology.

During last war AAF Weather Service developed similar approach.

Pressure patterns over area classified from daily synoptic maps, frequency of each pattern in each month computed. Frequency of weather elements, singly and in combination, computed for each pattern. Interpreted directly as probabilities.

Synoptic climatology meeting ground for climatology, meteorology, and theoretical atmospheric physics.

II. STUDY OF LONG-RANGE CLIMATIC CHANGE

A. INSTRUMENTAL RECORDS

Weather observations accumulating since middle of 18th century. Examined for long-range trends or cycles.

1. Trends.

Khrenheim (1824) gradual temperature change in Europe since 1756, milder winters, cooler summers.

Other trends discovered since, many uncertain. Rise in winter temperatures in high latitudes of N. Hemisphere, especially N. Atlantic.

2. Cycles.

Controversial.

B. GEOLOGIC RECORD

Evidence from fossil record and marks of glaciation.

1. CHRONOLOGY

Best known for North Europe, De Geer (1940).

Evidence on quaternary climates summarized by Zeuner (1945).

2. THEORY

Internal changes in earth not adequate explanation.

Milankovitch (1930-38) calculated required changes in insolation.

Simpson (1939-40) theoretical basis of glaciation.

III. BOTANICAL APPLICATION

Complete references to most of important works cited can be found in: John Leighly--Climatology since the year 1800; Transactions of the American Geophysical Union 30:658-672. 1949.

Important paper on past climates: Sir George C. Simpson--Possible causes of change in climate and their limitations; Proceedings of the Linnaean Society of London 152:190-219. 1939-40.

Most useful non-technical reference: U.S.D.A. Yearbook: Climate and Man. 1941.

Plant Geography Seminar

I. Introductory remarks

Since I am only a naïve beginner in the study of plant geography, I have taken the liberty to outline for you the paper written by Hugh Raup "Trends in the Development of Geographic Botany" in Ann. Assn. of Am. Geog. 32: 319-354, 1942. Mr. Raup, one of the best known present day plant geographers, is in a much better position to review the field than I ever shall be. He is apparently rather strong in his feeling concerning certain phases of plant geography, and in these parts, I should like for you to remember that it is he speaking, not I.

I have done some reading in this field, and find that most of it is, to say the least, wordy. Therefore, I'm very thankful for Mr. Raup's resume.

In presenting the material in the manner I've chosen, I've tried to keep in mind the purpose behind our seminar--to present you with an overall view of the science under discussion, and to provide a bibliography which may prove useful to you some time in the future.

It is well to keep in mind that most of the material here presented is largely of a general nature, and the conclusions drawn by some of the workers are based on little data, or inferences are made to fit a pattern for all plants when actually they have knowledge of only a few. Anyone who has had the problem of speciation to work with knows that each problem is somewhat different, and any law drawn up to govern the total action will be so full of ifs that it will be practically useless.

Needless to say, the bibliography is not complete, nor is there any need for it to be so. The works mentioned have, in most cases, been placed in the bibliography.

~~I. H.~~ Historical--Floristic geography

A. Pre-renaissance

1. First geographers, the so-called proto-botanists.

- a. First interest was to provide right combination of plant, soil, and climate to produce desired results.
- b. Greek naturalists, i.e. Theophrastus were a culmination of many

floristic regions. Later evidence of mutability of species required inclusion of the evolution of genera and species in explanation of distribution. These workers have not ignored additional factual material concerning physical factors of climate, soil and local physiography.

5. Empirical nature of phytogeographic knowledge.

- a. Naïvely achieved, with inductive reasoning, from observation to observation, with a keen outlook for coincidence.
- b. Accumulation of mass of factual material as basis of knowledge of geography of species of plants.
- c. Presently practised by those especially trained as taxonomists.
- d. Largest interest particularly of tropical plants e.g. Smith and Koch on Espeletia (1935), Tryon on Doryopteris (1944), but outstanding works on temperate and boreal regions e.g. Woodson on Asclepias, Fernald and Hulten.

6. Problems, accomplishments and workers--a collection of outstanding works, far from a complete list.

- a. Gray on affinities of North American flora (1884).
- b. Darwin on influence of Pleistocene glaciation and significance of barriers (1859).
- c. J. D. Hooker on distribution of arctic plants (1862).
- d. J. D. Hooker (1847-60) and Robert Brown (1814) with generalizations on botanical affinities of Anarctic and Australasian regions.
- e. Hemsley (1885) a classic study on insular floras and their geographic significance.
- f. Fosberg, F. R. (1948) a summary of the derivation of the Hawaiian Island floras.
- g. Derived from floristic geography is the great body of criticism of Willis's theory ~~xxxix~~ of "Age and Area"--it might be well to quote Willis's theory, after he had altered and altered it to meet all objections--"The area occupied at any given time in any given country, by any group of allied species at least ten in

number, depends chiefly, so long as conditions remain reasonably constant, upon the ages of the species of that group in that country, but may be enormously modified by the presence of barriers such as seas, rivers, mountains, changes of climate from one region to the next, or other ecological boundaries, and the like, also by the action of man, and by other causes".

- h. h. Gleason, H. A.--Vegetational history of the Middle West--an outstanding example of the inductive method among a circle of facts.

7. Complications of floristic geography.

- a. Easily becomes a mere cataloging of facts, without reality.
- b. Difficulty of correctly defined taxonomic units.
- c. Source of errors in use of negative evidence--based on absence of plants from certain regions, as well as their presence in others. Accuracy rests here on completeness of exploration of a region and upon proper delineation of species.

II
III. Historical--physiographic plant geography

A. Pre-Darwinian

1. Alexander von Humbolt (1805) used structural categories, or morphological forms rather than individual species for classification. He made no effort to relate his life-forms to function, but used these forms only for a more facile description of vegetation features without going into taxonomic detail.
2. Following Humbolt, Grisebach (1872) elaborated this technique using some 54 categories of plants.
3. Other workers following up this method of floristic plant geography were Alphonse deCandolle (1855) whose classic work correlated life-form and temperature; Edward Forbes (1846) advanced Willdenow's "anterior" or "historical cause" in a study of the British flora, establishing the basis of the "theory of persistence". His work is apparently a basis for Darwin's reasoning.
4. Three points of view evident at advent of Darwinian thought
 - a. Floristic in nature, using the distribution of taxonomically

determined species as units of study.

- b. The second utilized form categories of plants which might or might not coincide with taxonomic units.
- c. The third dealt with communities of plants which lived together in supposedly more or less balanced economy.
- d. These three followed same method of reasoning--for explanation of of plant distribution. They especial fields of climatology and geology were basis for comparisons within their own field.

B. Effect of Darwin on Plant geography.

1. Up to this time, the species was considered as an unchangeable factor, existing in past, present and future without change, and the world had undergone no vast changes.
2. Darwin established a cause and effect relationship between existing form of a plant and its physical surroundings--must have adjustment of structure and function.
3. Systematics first field to be affected by Darwin's ideas--plants to this time had been classified "naturally" but never "phylogenetically", since there was no notion of the idea of mutability nor of the concept of time in a changing world.
4. Darwin's work threw out the previously useful "anterior cause", special dreation, and put serious doubt on possibility of parallel evolution.
5. By use of development of geological knowledge, Darwin postulated that isolated ranges at present were due to wide separation because of newly erected barriers between the two present areas.

C. Adjustments of physiographic plant geography following Darwin.

1. Conscious effort made to make the categories of the physiographers of biological, or functional, significance rather than that of pure form as previously used. "The amount of teleogy that then developed in efforts to find functions for plant parts has probably never been surpassed".

of plant, the power of vegetative propagation, the duration of shoots, etc.

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A. Floristic

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a sufficient number of characters to make the system more flexible.

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a. Theophrastus--practical knowledge of the Greek country side, plus information from travelers in Southern Asia who supplied abundance of problems of general distribution of vegetation.

(i) Interested in geographic distribution and local selection.

(ii) His classification was on form and habitat selection.

(iii) Conscious of geographic zones of hardiness, of preference of plants for light or shade, north or south slope tolerance, significance of mountain and plain, competition among plants, dispersal mechanisms and some notions of what is now called succession.

(iv) Knowledge was empirical, and conclusions seem to be derived by simple inductive reasoning.

B. From Renaissance to present

1. Basis established at time of Greeks served until period of herbalists in 15th and 16th century.

2. Systematic botany and geography developed hand in hand--the new knowledge from wide travels such as Tournefort's to the near East in 1717, plus development of practical nomenclature by Linnaeus gave new facts and tools for examining processes of distribution.

3. The great floristic geographers developed in the 19th century, starting with Willdenow (1792, 1805) and culminates with J.D. Hooker, Asa Gray (1859, 1884) and Engler (1879-82). Following these men in the 20th century are men whose names are very familiar--Mason (California), Good, Turrill (British) and Raup (Harvard).

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7. Woodson, R. E. Jr. ⁽¹⁹⁴⁷⁾ Notes on the "Historical Factor" in
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PLANT GEOGRAPHY SEMINAR

I. Floristic geography

A. Pre-renaissance

1. First geographers, the so-called protobotanists.
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 - b. Greek naturalists, i.e. Theophrastus were a culmination of many generations of protobotanists.
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5. Empirical nature of phytogeographic knowledge.
 - a. Naively achieved, with inductive reasoning, from observation to observation, with a keen outlook for coincidence.
 - b. Accumulation of mass of factual material as basis of knowledge of geography of species of plants.
 - c. Presently practised by those especially trained as taxonomists.
 - d. Largest present interest particularly of tropical plants, e.g. Smith and Koch on the genus *Eupetia* (1935), Tryon on *Doryopteris* (1944), but outstanding works on temperate and boreal regions e.g. Woodson on *Asclepias*, Fernald, and Hulten.
6. Problems, accomplishments and workers--a collection of outstanding works, far from a complete list:
 - a. Gray on affinities of North American flora (1884).
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- d. J. D. Hooker (1847-60) and Robert Brown (1814) with generalizations on botanical affinities of Antarctic and Australasian regions.
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- g. Derived from floristic geography is the great body of criticism of Willis's theory, ~~affixxxxxxx~~ of "Age and Area".
- h. Gleason, H. A. (1923). Vegetational history of the Middle West. An outstanding example of the inductive method among a circle of facts.
7. Complications of floristic geography.
 - a. Easily becomes a mere cataloging of facts, without reality.
 - b. Difficulty of correctly defined taxonomic units.
 - c. Source of errors in use of negative evidence--based on absence of plants from certain regions, as well as their presence in others. Accuracy rests here on completeness of exploration of a region and upon proper delineation of species.

II. Physiognomic plant geography.

A. Pre Darwinian.

1. Alexander von Humboldt (1805) used structural categories, or morphological forms rather than individual species for classification. He made no effort to relate his life-forms to function, but used these forms only for a more facile description of vegetation features without going into taxonomic detail.
2. Following Humboldt, Grisebach (1872) elaborated this technique using some 54 categories of plants.
3. Other workers following up this method of floristic plant geography were Alphonse deCandolle (1855) whose classic work correlated life-form and temperature; Edward Forbes (1846) advanced Willdenow's "anterior" or historical cause in a study of the British flora, establishing the basis of the "theory of persistence". His work is apparently a basis for Darwin's reasoning.
4. Three points of view evident at advent of Darwinian thought:
 - a. Floristic in nature, using the distribution of taxonomically determined species as units of study.
 - b. The second utilized from categories of plants which might or might not coincide with taxonomic units.
 - c. The third dealt with communities of plants which lived together in supposedly more or less balanced economy.
 - d. These three followed same method of reasoning--for explanation of plant distribution, they used the fields of climatology and geology as a basis for comparisons within their own field.

B. Effect of Darwin on plant geography.

1. Up to this time, the species was considered as an unchangeable factor, existing in past, present and future without change, and the world had undergone no vast changes.
2. Darwin established a cause and effect relationship between existing form of a plant and its physical surroundings--must have an adjustment of structure and function.
3. Systematics first field to be affected by Darwin's ideas--plants to this time had been classified "naturally" but never "phylogenetically", since there was no notion of the idea of mutability nor of the concept of time in a changing world.
4. Darwin's work threw out the previously useful "anterior cause", special creation, and put serious doubt on possibility of parallel evolution.
5. By use of development of geological knowledge, Darwin postulated that isolated ranges at present were due to wide separation because of newly erected barriers between the two present areas.

C. Adjustments of physiographic plant geography following Darwin.

1. Conscious effort made to make the categories of the physiographers of biological, or functional significance rather than that of pure form as previously used. "The amount of teleology that then developed in efforts to find functions for plant parts has probably never been surpassed".
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