TRANSACTIONS

OF THE

ILLINOIS STATE ACADEMY OF SCIENCE

INDEX TO VOLUME 32

1939-1940

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1939-1940

ILLINOIS STATE ACADEMY OF SCIENCE

NOTE.—Articles are listed alphabetically by authors, and also are grouped, by title, under the following subjects: Agriculture, Anthropology, Botany, Chemistry, Geography, Geology, Physics, Psychology and Education, and Zoology. Inasmuch as the *Transactions* are issued four times a year—in September, December, March and June—the number 1, 2, 3, or 4 preceding the colon indicates the quarterly issue in which the item occurs.

A

Academy business

Affiliated high school science clubs and scientific societies. 4:273
Affiliations committee report. 4:259
American Association for the Advancement of science:
Report of representative to Academy conference. 4:264
Research grants for 1940-41. 4:263
Annual meeting at Springfield, Minutes. 4:253-68
Auditing committee's report. 4:257
Conservation committee's report. 4:260
Conservation of archaeological and historical sites, Committee report. 4:263
Conservation council delegate's report. 4:262
Council meeting minutes. 4:249-252
Editor's report. 4:257
High school science and clubs, committee report. 4:266
Junior Academy winners of awards. 4:268-72
Librarian's report. 4:257-9
Membership committee's report. 4:263
Memoirs: Boomer, Simeon E., 1:26; Kunz, Jakob, 1:27-8; Mitchell, Catherine A., 1:26; Mumford, Herbert W., 1:29; Noé, Adolf Carl, 1:30-1.
Officers' and committees' reports. 4:253-266
Publications committee report. 4:263
Resolutions committee report. 4:261
Science Club Service, Annual report. 4:267
Section chairmen's reports (1939 meeting): Agriculture (Dungan) 2:39; Anthropology (Ruyle) 2:57; Botany (Lamkey) 2:73; Chemistry (DeVries) 2:99; Geography (Barton) 2:137; Geology (Stark) 2:163; Physics (Johnson) 2:177; Psychology and Education (Carlson) 2:193; Zoology (Townsend) 2:203
Treasurer's report. 4:255

Agriculture

Agricultural adjustment programs, Residual benefits resulting from activities in connection with. Whalin. 2:51-2
Agriculture, Improvement in, through the assistance of vocational-agriculture instructors. Henderson. 2:47-8
Azotobacter flora of the Morrow plots. Appleman and Sears. 2:40-2
Bacteria found in ice cream, A taxonomic study of. Brannon. 2:42-3
Corn yields stabilized by hybrid corn. Copper. 2:43-5
Does it pay to make an individual ear test of hybrid corn? Koehler. 2:50-1
Effects of the soybean crop on soil productivity. Sears and Burlison. 2:54-6
Hybrid corn stabilizes corn yields. Copper. 2:43-5
Hybrid corn, Does it pay to make an individual ear test of? Koehler. 2:50-1

Ice cream, A taxonomic study of bacteria found in. Brannon. 2:42-3
Illinois soils, Vagaries of some Smith. 2:48-9
Improvement in agriculture through the assistance of vocational-agriculture instructors. Henderson. 2:47-8
Insect abundance around wild life area. Farrar and Flint. 2:46
Morrow plots, Azotobacter flora of the. Appleman and Sears. 2:40-2
Relationship in soils of total nitrogen, total replaceable bases and productivity. Snider. 2:53-4
Residual benefits resulting from activities in connection with agricultural adjustment programs. Whalin. 2:51-2
Soil productivity, Effects of the soybean crop on. Sears and Burlison. 2:54-6
Soils, Relationship of total nitrogen, total replaceable bases, and productivity. Snider. 2:53-4
Soils, Vagaries of some Illinois. Smith. 2:48-9
Soybean crop, Effects of on soil productivity. Sears and Burlison. 2:54-6
Taxonomic study of some bacteria found in ice cream. Brannon. 2:42-3
Vagaries of some Illinois soils. Smith. 2:48-9
Vocational-agriculture instructors, Improvement in agriculture through the assistance of. Henderson. 2:47-8
Wild life area, Insect abundance around. Farrar and Flint. 2:46

Anthropology

Artifacts: Engraved shell gorgets from Illinois. Stephens. 2:66
Botany, Prehistoric. Gumbart. 2:58-9
Copper needles, The detection of fraudulent. Mohrman. 2:60-1
Discovery of a buried aboriginal shellheap in the Illinois River valley. Schoenbeck. 2:61-2
Engraved shell gorgets from Illinois. Stephens. 2:66
Indians, Ornamentation among the American. Soper. 2:63-5
Indian villages of the Peoria Lake region. Spooner. 2:67-71

Appleman, M. D. and Sears, O. H., Azotobacter flora of the Morrow plots. 2:40-2

B

Ball, John R., Silurian rocks of southern Illinois. 2:164-5
Barton, Thomas F., Recreation possibilities of the Shawnee National Forest Purchase Units. 2:149-52
Blanchard, W. O., Wanted—more variety in the geographic menu. 2:138-9
Bockstahler, Lester I., Experimental production of vortex rings. 2:178
Booth, Alfred W., Distribution of Japanese cities. 2:160-1
Borger, Harvey, Recovery and preservation of marcasitized and pyritized microfossils. 2:166

Botany

Abscission of the leaves of *Coleus blumei*, Factors affecting. 2:80-1
Abutilon theophrasti, Variations in carpel number of. Shull. 2:74-5
Ash along the axis of herbaceous plants, Differential distribution of. Edgecombe. 2:79
Blackman interpretation of plant growth. Fuller. 2:75-6
Bryophyllum leaves, Relation of cicatrization to evaporation from. Welch. 2:78
Carbohydrate utilization by *Diplodia macrospora*. Stevens and Larsh. 2:82
Carpel number of *Abutilon theophrasti*. Variations in. Shull. 2:74-5
Cicatrization as related to evaporation from leaves of *Bryophyllum*. Welch. 2:78
Coleus blumei. Factors affecting the abscission of the leaves of. Myers. 2:80-1
Composition of prairie vegetation in Illinois. Reihmer. 2:87-8
Conifers, Pollination drops in certain. Cook. 2:93-4
Differential distribution of ash along the axis of herbaceous plants. Edgecombe. 2:79
Diplodia macrospora, Carbohydrate utilization by. Stevens and Larsh. 2:82
Evaporation from leaves of *Bryophyllum* as related to cicatrization. Welch. 2:78
Factors affecting the abscission of the leaves of *Coleus blumei*. Myers. 2:80-1
Flora of Starved Rock State Park, Additions to the. Ries. 2:89-90

Forest lands, Why Illinois settlers chose. Vestal. 2:85-7
Herbaceous plants, Differential distribution of ash along the axis of. Edgecombe. 2:79
Histology of an Illinois Psaronius, Notes on. Moon. 2:95-7
Hormones (growth) and plant growth. Shull. 1:15-8
Illinois: Additions to the flora of Starved Rock State Park. Ries. 2:89-90
Illinois settlers: Why did they choose forest lands? Vestal. 2:85-7
Illinois: Its composition of prairie vegetation. Reihmer. 2:87-8
Leaves, Water absorption by. Thut. 2:77
Oedogoniales of Illinois. Tiffany. 2:90-1
Plant cover for wild animals during the winter season. Terwilliger. 2:98
Plant growth and growth hormones. Shull. 1:15-18
Plant growth, The Blackman interpretation of. Fuller. 2:75-6
Pollen of certain Taxodiaceae. Kaeiser. 2:91-3
Pollination drops in certain conifers. Cook. 2:93-4
Prairie vegetation: Composition in Illinois. Reihmer. 2:87-8
Psaronius, Notes on the histology of an Illinois. Moon. 2:95-7
Smoky Mountain plants. White. 2:82-5
Starved Rock State Park: Additions to its flora. Ries. 2:89-90
Taxodiaceae, The pollen of certain. Kaeiser. 2:91-3

Branigar Jr., Harvey W., The Guatemala Highland. 2:146-8
Brannon, J. M., A taxonomic study of some bacteria found in ice cream. 2:42-3
Bulliet, L. J. and FitzGerald, Alan S., Saturating reactors for control purposes. 2:179-80
Burlison, W. L. and Sears, O. H., Effects of the soybean crop on soil productivity. 2:54-6

C

Carter, Charles W. and Cohee, George V., Structural trends in the Illinois Basin. 2:166-9
Cavan, Jordan T., Social factors determining trends in western colleges. 2:194-6

Chemistry

Absorption bulb for detecting various gases. Simon and Reedy. 2:128-9
Alkyl halides (tertiary), Hydrolysis of. Cheronis. 2:101-2
A pH experiment for the first course in chemistry. Thiessen. 2:131-2
Chemistry: A new approach to first year. Schmeing. 2:127-8
Chemistry of europium. Hopkins and Taebel. 2:132-3
Chemistry; Technics for large group demonstration. Cheronis and Freud. 2:100-1
Cigarettes, Uniformity in. Nicholson and Schuler. 2:118-9
Coal samples: Some chemical changes during storage. Rees and Kalinowski. 2:120-1
Crude oils produced in the old and new Illinois fields: a comparison of their chemical characteristics. Rees and Henline. 2:122-3
Europium: its chemistry. Taebel and Hopkins. 2:132-3
Humic acids from Illinois coals, Preparation of. Harman and Yohe. 2:134-6
Hydrolysis of tertiary alkyl halides. Cheronis. 2:101-2
Illinois coals: Preparation of humic acids from. Yohe and Harman. 2:134-6
Liquid ammonia as a dietary nitrogen supplement. Horvitz and Roberts. 2:124-6
Marihuana. Higley. 2:116-7
Motor fuels over the world. Egloff. 2:103-114
Nitrogen supplement, Liquid ammonia as a dietary. Roberts. and Horvitz. 2:124-6
Petroleum: A comparison of the chemical characteristics of crude oils produced in the old and new Illinois fields. Rees and Henline. 2:122-3
Quantitative estimations in the qualitative course in chemistry. Swift. 2:130-1
Salt solutions (saturated), Special study of vapor pressures of. Rees and Land. 2:119

Technics for large group demonstration in chemistry. Cheronis and Freud. 2:100-1

Tertiary alkyl halides, Hydrolysis of. Cheronis. 2:101-2

Tin sub-group procedure, A modified. Reedy and Hanke. 2:114-5

Uniformity in cigarettes. Nicholson and Schuler. 2:118-9

Vapor pressures of saturated salt solutions, Special study of. Rees and Land. 2:119

Cheronis, Nicholas D. and Freud, Henrietta, Technics for large group demonstration in chemistry. 2:100-1

Cheronis, Nicholas D., Hydrolysis of tertiary alkyl halides. 2:101-2

Cloud, D. T., The education of deaf children by the acoustic method. 2:196-9

Cohee, George V. and Carter, Charles W., Structural trends in the Illinois Basin. 2:166-9

Cook, Phyllis L., Pollination drops in certain conifers. 2:93-4

Copper, Robert R., Hybrid corn stabilizes corn yields. 2:43-5

Cozzens, Arthur B., Natural regions of the Ozark Province. 2:144-5

D

DeVries, John and Way, H. E., Microphotographs of single crystals of zinc containing small known amounts of iron. 2:189-92

Deuel, Thorne, Some new exhibits and undertaking of the Illinois State Museum. 1:23-5

E

Eaton, D. L., A novel homemade electrostatic generator and Zeleny electroscope assembly. 2:178

Edgecombe, A. E., Differential distribution of ash along the axis of herbaceous plants. 2:79

Egloff, Gustav, Motor fuels over the world. 2:103-114

Eigenbrodt, H. J. and Zahl, Paul, The relationship of body size and egg size in Drosophila. 2:204-5

Ekblaw, George E., Some geological factors in the location and construction of the Lake Springfield dam. 2:169-70

Expeditioning in Mexico. Hoogstraal. 2:213-4

F

Farrar, M. D. and Flint, W. P., Insect abundance around wild life area. 2:46

FitzGerald, Alan S. and Bulliet, L. J., Saturating reactors for control purposes. 2:179-80

Flint, W. P. and Farrar, M. D., Insect abundance around wild life area. 2:46

Freud, Henrietta and Cheronis, Nicholas D., Technics for large group demonstration in chemistry. 2:100-1

Fuller, George D., Interglacial and postglacial vegetation of Illinois. 1:5-15

G

Geography

Distribution of Japanese cities. Booth. 2:160-1

Ecological and historical aspects of Leadville, Colorado, as typifying the pure saxicultural adjustment. Gunnell. 2:139-40

Forestry in Illinois. Tomasek. 1:19-22

Forest Purchase Units (Shawnee National), Recreation possibilities of. Barton. 2:149-52

Geographic aspects of inter-areal transition. Lemons. 2:158-9

Geography of the Mississippi Gulf Coast. Josey. 2:140-1

Guatemala Highland. Branigar. 2:146-8

Illinois rainfall. Holcomb. 2:142-4

Ozark province, Natural regions of. Cozzens. 2:144-5

Tornadoes in the middle west, A day of. Lathrop. 2:153-7

Wanted—more variety in the geographic menu. Blanchard. 2:138-9

Geology

Anticline, The age of the LaSalle. Payne. 2:171-3

Covel conglomerate, a guide bed in the Pennsylvanian of northern Illinois. Willman. 2:174-6

Geological factors in the location and construction of the Lake Springfield dam. Ekblaw. 2:169-70

Geologic mapping of Illinois, 1839-1939, Progress in. Weller. 2:173-4

Lake Springfield dam, Some geological factors in the location and construction of. Ekblaw. 2:169-70

LaSalle anticline, The age of. Payne. 2:171-3

Microfossils, Recovery and preservation of marcasitized and pyritized. Borger. 2:166
Pennsylvanian of northern Illinois, The Covel conglomerate, a guide bed in the. Willman. 2:174-6
Petroleum: Structural trends in the Illinois Basin. Cohee and Carter. 2:166-9
Silurian rocks of southern Illinois. Ball. 2:164-5
Structural trends in the Illinois Basin. Cohee and Carter. 2:166-9
Graham, Robert and Hester, H. R., Equine encephalomyelitis. 2:205-7
Gumbart, L. F., Prehistoric botany. 2:58-9
Gunnell, E. Mitchell, Ecological and historical aspects of Leadville, Colorado, as typifying the pure saxicultural adjustment. 2:139-40

H

Hanke, A. R. and Reedy, J. H., A modified tin sub-group procedure. 2:114-5
Hansen, Donald F., Variation in the number of spines and rays in the fins of the brook stickleback. 2:207-12
Harman, C. A. and Yohe, G. R., Preparation of humic acids from Illinois coals. 2:134-6
Haworth, L. J. and Manley, J. H., A high voltage neutron source. 2:183
Henderson, Melvin, Improvement in Agriculture through the assistance of vocational-agriculture instructors. 2:47-8
Henline, P. W. and Rees, O. W., A comparison of the chemical characteristics of crude oils produced in the old and new Illinois fields. 2:122-3
Hester, H. R. and Graham, Robert, Equine encephalomyelitis. 2:205-7
Higley, L. Allen, Marihuana. 2:116-7
Holcomb, E. W., Illinois rainfall. 2:142-4
Hoogstraal, Harry, Expeditioning in Mexico. 2:213-4
Hopkins, B. S. and Taebel, W. A., The chemistry of europium. 2:132-3
Horvitz, Herman J. and Roberts, Richard G., Liquid ammonia as a dietary nitrogen supplement. 2:124-6

I

Iknayan, N. C., Thoracico-abdominal venules, their etiology and treatment. 2:214-9
Illinois State Museum, Some new exhibits and undertakings of. Deuel. 1:23-5

J

Jacobsen, O. Irving, Eye-movements in reading music. 2:199-201
James, Marian F., Studies on starvation in large mouth bass. 2:220-1
Josey, Elizabeth, Geography of the Mississippi Gulf Coast. 2:140-1

K

Kaeiser, Margaret, The pollen of certain Taxodiaceae. 2:91-3
Kalinowski, M. L. and Rees, O. W., Some chemical changes in coal samples during storage. 2:120-1
Knipp, Charles T., Further experiments with singing tubes. 2:181-2
Koehler, Benjamin, Does it pay to make an individual ear test of hybrid corn? 2:50-1

L

Land, G. W. and Rees, O. W., Special study of vapor pressures of saturated salt solutions. 2:119
Larsh, Howard W. and Stevens, Neil E., Carbohydrate utilization by *Diplodia macrospora.* 2:82
Lathrop, H. O., A day of tornadoes in the middle west. 2:153-7
Lemons, Hoyt, Geographic aspects of inter-areal transition. 2:158-9
Levine, Norman D., Observations on *Balantidium coli* in culture. 2:221
Lueth, Francis X., A case of poisoning in the cotton-mouth moccasin. 2:222-3

M

Manley, J. H., A high voltage neutron source. 2:183
Memoirs (see Academy Business)
Mohrman, Harold, The detection of fraudulent copper needles. 2:60-1
Moon, Geraldine, Notes on the histology of an Illinois Psaronius. 2:95-7
Myers, R. Maurice, Factors affecting the abscission of the leaves of *Coleus blumei.* 2:80-1

N

Nicholson, Douglas G. and Schuler, Richard H., Uniformity in cigarettes. 2:118-9

O

Owen, Seward E., Mammary tumor location in mice. 2:223-4

P

Payne, J. Norman, The age of the LaSalle anticline. 2:171-3

Physics

Acoustic efficiency of the telephone receiver, A theory of. Taylor. 2:185-7
Electrostatic generator and Zeleny electroscope assembly, A novel homemade. Eaton. 2:178
Engineers, How they use basic scientific facts—illustrated by a concrete example. Riche. 2:184-5
Experimental production of vortex rings. Bockstahler. 2:178
Microphotographs of single crystals of zinc containing small known amounts of iron. Way and DeVries. 2:189-92
Neutron source, A high voltage. Haworth and Manley. 2:183
Pendulum, The one hundred twenty foot, at Mundelein College. Therese. 2:188
Saturating reactors for control purposes. Bulliet and FitzGerald. 2:179-80
Singing tubes, Further experiments with. Knipp. 2:181-2
Telephone receiver, A theory of the acoustic efficiency of. Taylor. 2:185-7
Vortex rings, Experimental production of. Bockstahler. 2:178
Zeleny electroscope assembly, A novel homemade electrostatic generator and. Eaton. 2:178
Zinc containing small known amounts of iron, microphotographs of single crystals of. Way and DeVries. 2:189-92

Pringle, Ralph W., Psychological functioning of the endocrine glands. 2:201-2

Psychology

Acoustic method, Education of deaf children by. Cloud. 2:196-9
Colleges, Social factors determining trends in western. Cavan. 2:194-6
Endocrine glands, Psychological functioning of. Pringle. 2:201-2
Eye-movements in reading music. Jacobsen. 2:199-201

R

Reedy, J. H. and Hanke, A. R., A modified tin sub-group procedure. 2:114-5
Reedy, J. H. and Simon, Wilbur, An absorption bulb for detecting various gases. 2:128-9
Rees, O. W. and Henline, P. W., A comparison of the chemical characteristics of crude oils produced in the old and new Illinois fields. 2:122-3
Rees, O. W. and Kalinowski, M. L., Some chemical changes in coal samples during storage. 2:120-1
Rees, O. W. and Land, G. W., Special study of vapor pressures of saturated salt solutions. 2:119
Reihmer, Vernoy A., The composition of prairie vegetation in Illinois. 2:87-8
Riche, A. L., How engineers use basic scientific facts—illustrated by a concrete example. 2:184-5
Ries, Donald T., Additions to the flora of Starved Rock State Park, Starved Rock, Illinois. 2:89-90
Roberts, Richard G. and Horvitz, Herman J., Liquid ammonia as a dietary nitrogen supplement. 2:124-6

S

Schmeing, G. M., A new approach to first year chemistry. 2:127-8
Schoenbeck, Ethel, Discovery of a buried aboriginal shellheap in the Illinois River valley. 2:61-2
Schuler, Richard H. and Nicholson, Douglas G., Uniformity in cigarettes. 2:118-9
Sears, O. H. and Appleman, M. D., Azotobacter flora of the Morrow Plots. 2:40-2
Sears, O. H. and Burlison, W. L., Effects of the soybean crop on soil productivity. 2:54-6
Sharp, Cecil A. Z., Tularemia in Illinois. 2:225-6
Shull, Charles A., Variations in carpel number of *Abutilon theophrasti*. 2:74-5
————, Plant growth and growth hormones. 1:15-18
Simon, Wilbur and Reedy, J. H., An absorption bulb for detecting various gases. 2:128-9
Slabaugh, Ruth E., The silverfish in a new role. 2:227-8
Smith, L. H., Vagaries of some Illinois soils. 2:48-9
Snider, H. J., Relationship in soils of total nitrogen, total replaceable bases and productivity. 2:53-4
Soper, Stanley, Ornamentation among the American Indians. 2:63-5
Spooner, Harry L., Historic Indian villages of the Peoria Lake region. 2:67-71
Stephens, B. W., Engraved shell gorgets from Illinois. 2:66

Stevens, Neil E. and Larsh, Howard W., Carbohydrate utilization by *Diplodia macrospora*. 2:82

Stone, Philip C., Notes on the predaceous stink bug, *Apateticus cynicus* Say. 2:228

Swift, Elijah, Jr., Quantitative estimations in the qualitative course in chemistry. 2:130-1

T

Taebel, W. A. and Hopkins, B. S., The chemistry of europium. 2:132-3

Taylor, Hawley O., A theory of the acoustic efficiency of the telephone receiver. 2:185-7

Terwilliger, George L., Plant cover for wild animals during the winter season. 2:98

Therese, Sister Mary, The one hundred twenty foot pendulum at Mundelein College. 2:188

Thiessen, G. W., A pH experiment for the first course in chemistry. 2:131-2

Thut, H. F., Water absorption by leaves. 2:77

Tiffany, L. H., The Oedogoniales of Illinois. 2:90-1

Tomasek, Anton J., State forestry in Illinois. 1:19-22

V

Vestal, A. G., Why the Illinois settlers chose forest lands. 2:85-7

W

Way, H. E., and DeVries, John, Microphotographs of single crystals of zinc containing small known amounts of iron. 2:189-92

Welch, Walter B., A study of the relation of cicatrization to evaporation from leaves of *Bryophyllum*. 2:78

Weller, J. Marvin, Progress in geologic mapping of Illinois, 1839-1939. 2:173-4

Whalin, Oren L., Residual benefits resulting from activities in connection with agricultural adjustment programs. 2:51-2

White, Elizabeth, Plants of the Smoky Mountains. 2:82-5

Willman, H. B., The Covel conglomerate, a guide bed in the Pennsylvanian of northern Illinois. 2:174-6

Y

Yohe, G. R. and Harman, C. A., Preparation of humic acids from Illinois coals. 2:134-6

Z

Zahl, Paul A. and Eigenbrodt, Harold J., The relationship of body size and egg size in Drosophila. 2:204-5

Zoology

Apateticus cynicus Say, the predaceous stink bug, Notes on. Stone. 2:228

Balantidium coli in culture, Observations on. Levine. 2:221

Brook stickleback, Variation in the number of spines and rays in the fins of. Hansen. 2:207-12

Cotton-mouth moccasin *(Agkistodon piscivorus)*, A case of poisoning in the. Lueth. 2:222-3

Drosophila, The relationship of body size and egg size in. Eigenbrodt and Zahl. 2:204-5

Encephalomyelitis, Equine. Hester and Graham. 2:205-7

Largemouth bass, Studies on starvation in. James. 2:220-1

Mammary tumor location in mice. Owen. 2:223-4

Mexico, Expeditioning in. Hoogstraal. 2:213-4

Silverfish in a new role. Slabaugh. 2:227-8

Thoracico-abdominal venules, their etiology and treatment. Iknayan. 2:214-9

Tularemia in Illinois. Sharp. 2:225-6

14 (A-29241)

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Memoirs

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14
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TRANSACTIONS OF THE ILLINOIS STATE ACADEMY OF SCIENCE

Volume 32 September, 1939 Number 1

CONTENTS

	Page
Fuller, George D., Interglacial and postglacial vegetation of Illinois	5
Shull, Charles A., Plant growth and growth hormones	15
Tomasek, Anton J., State forestry in Illinois	19
Deuel, Thorne, Some new exhibits and undertakings of the Illinois State Museum	23
Memoirs	
Simeon E. Boomer	26
Catherine A. Mitchell	26
Jakob Kunz	27
Herbert W. Mumford	29
Adolph Carl Noe	30

LIST OF SPEAKERS

A committee designated by the Council of the Academy has prepared a list of speakers who are willing to present talks on various phases of science before interested groups. Unless otherwise indicated, these speakers are willing to give their services for expenses only. In some cases a small honorarium is expected. A copy of this list of speakers may be obtained gratis by sending a request to:

Robert F. Paton, *Secretary*,
Academy of Science,
Physics Building,
Urbana, Illinois.

NOTICE

The Committee on Research Grants of the Illinois State Academy of Science announces that requests for small grants to aid research will be received up to February 1, 1940. Requests should be accompanied by detailed statements of preceding background, general purpose, and estimated expenses, and supported by three letters of recommendation sent directly by the writers. Grants for individual projects will probably not exceed $75. It is the custom to make grants only to scientists connected with smaller institutions within the State. Correspondence should be directed to C. H. Behre, Jr., Department of Geology and Geography, Northwestern University, Evanston, Illinois.

INTERGLACIAL AND POSTGLACIAL VEGETATION OF ILLINOIS*

George D. Fuller

University of Chicago, Chicago, Illinois

As the observer explores the forests and the remnants of the grasslands of Illinois he is led to inquire what has been the past history of the vegetation of the State. Neglecting the cycads, the horsetails, the ferns, and their associates that formed the coal measures millions of years ago, and considering the past half-million years only, the picture of the plant cover of the hills and valleys is very incomplete. Such plant remains as have been found are encountered, for the most part, in various peat deposits; many of them deeply buried in glacial drift. During the past 50 or 60 years numerous reports have appeared of the finding of the remains of the interglacial vegetation which were encountered in well drillings, mine shafts, and road and stream cuts. These remains were seldom identified with any desirable degree of scientific accuracy. The wood, for example, was named usually on its external resemblance to that of living trees.

During the past quarter of a century there has been developed, however, a more exact and scientific technique for the examination of plant remains found in peat deposits. It is based on the fact that the exines or outer coats of many pollen grains are very resistant to decay when immersed in pond or bog waters and may be identified with accuracy even after intervals of tens or hundreds of thousands of years.

This technique was first developed in northern Europe about 25 years ago. There a group of Swedish workers led by von Post and Erdtman examined peat deposits microscopically and finding in them well preserved tree pollen elaborated a technique now well known under the designation "pollen analysis." Erdtman has been one of the foremost investigators in this field and has accumulated many valuable data (7). He has made the technique internationally known and has devoted much attention to its improvement (9, 10). Many European investigators have used these methods and there has accumulated a great mass of data indicated by the hundreds of titles listed by Erdtman (8) in his bibliography of the subject. The testimony of many investigators and some statistical observations have led to the acceptance of the data of pollen analysis as being reliable within certain limitations.

It is not our purpose to discuss the details of the technique of pollen analysis, except to say that instruments are available by which samples of peat may be taken from bogs from known depths. These samples are so treated that the extraneous substances are removed and the pollen grains made more recognizable. These grains are examined and counted under a compound microscope. Further details of the process may be found in the contributions of Erdtman (8), Sears (16, 17), Godwin (12), Voss (18, 19, 20, 21) and others. It may be significant, however, to examine some of the limitations to be observed in the interpretation of the results thus obtained.

Both American and European investigators have found the pollen of tree species more useful and better preserved than that of herbaceous plants. Such pollens may be recognized as belonging to the genera of the trees producing them, and as found in peat deposits, may be classified with regard to their source on the basis of distance of transport as:

1. Pollen from trees growing on the bog and its immediate margin;
2. Pollen from trees in the forest within a radius of 1000 yards of the margin of the bog;
3. Pollen from trees between 1000 yards and 5 miles of the bog;
4. Pollen from trees more than 5 miles from the bog.

These pollen components may be termed respectively the bog, regional, distant,

*Address of the retiring President of the Illinois Academy of Science, presented at the Thirty-second Annual Meeting, Springfield, Illinois, May 5, 1939.

and remote components. Von Post, Erdtman, and others have shown that the regional component is the largest and most important of these, with the distant component second in size and importance.

This may explain how pollen analysis gives, as a rule, a general picture of the forest type for a rather wide area, not a representation of the local tree growth on the bog itself and its immediate margin. That is to say, the pollen diagram points to the general character of the forest-cover of the whole countryside and this characteristic adds to its value as an indicator of the regional vegetation of past ages.

Amounts of pollen are expressed in percentages of the total tree pollen. It has been found impossible to express the amount of each pollen on an absolute scale. It is therefore true that the amount of pollen from any one species always affects the percentage values for all other species, hence although the results do not show the absolute abundance of any one tree they do indicate changes in the relative abundance of the pollen of different tree genera.

The pollen diagram must not be interpreted in detail, for the presence of a few scattered grains of any particular species cannot be accepted as proof that the species was growing in the immediate neighborhood of the deposit; they may have been windborne from a great distance. Hence they must be neglected unless the presence of the species in the vicinity is assured by other data. It should also be remembered that some tree genera produce much more pollen than others, that certain pollens are much better preserved in bogs and that certain tree genera, on account of their narrower ecological range, are much better indicators than others.

It is therefore evident that a pollen diagram (or diagrams) of an entirely unknown forest would not accurately reveal the tree population of such a forest. But such diagrams would permit a choice to be made from a score of known forest types—the predominating type, or types, could be distinguished in spite of the fact that not all its tree components were represented in the pollen diagram, thus an abundance of *Abies* and *Picea* pollen in the Great Lakes region would make it most highly probable that *Larix*, *Betula*, and *Fraxinus* were also present in considerable numbers in the region adjacent to the bog, and that the forest was of the northern conifer type.

Presentation of Results

From the nature of the data it is most desirable that generalizations based on pollen analysis should be made only upon very considerable accumulations of evidence. In other words, the data from a single bog, even though carefully collected and accurately analyzed, may be used for a general picture of the surrounding forest only when supported by other data. Such accumulations of data, until very recently, have been lacking in America and are still decidedly deficient. In this field, Voss of Peoria has been the outstanding American investigator, and the only one who has studied the interglacial deposits. To him the writer is indebted for the greater portion of the data on which this article is based. Other workers include Houdek of Illinois, a group of workers connected with Butler University in Indiana, Sears and his associates in the Lake Erie region, and Wilson and Hansen in Wisconsin.

The northern half of Illinois seems to be particularly well suited for such studies of past vegetation. At least four ice sheets have crept down from the North to cover portions of its surface, and retreating have left drift in which were depressions that became occupied by ponds and lakes. These have developed vegetation that decayed into peat bogs. Some of these peat deposits have been buried by the moraines of succeeding ice sheets, compressing the peat, but aiding in preserving its store of tree pollens.

The Pleistocene with its glaciations has been investigated by many geologists and many of their data have been presented in interesting form by Daly (6). Leighton (14, 15) and Ball (2) among others have studied the moraines and other evidences of the ice sheets that have visited Illinois. Various estimates have been made of the duration of the ice sheets and of the interval between them. It seems to be particularly difficult to estimate the length of time required for the accumulation and the subsequent disappearance of these immense glaciers. The following estimates taken from the best authorities available, must be regarded as tentative approximations for the past half-million years. The following stages are recognized:

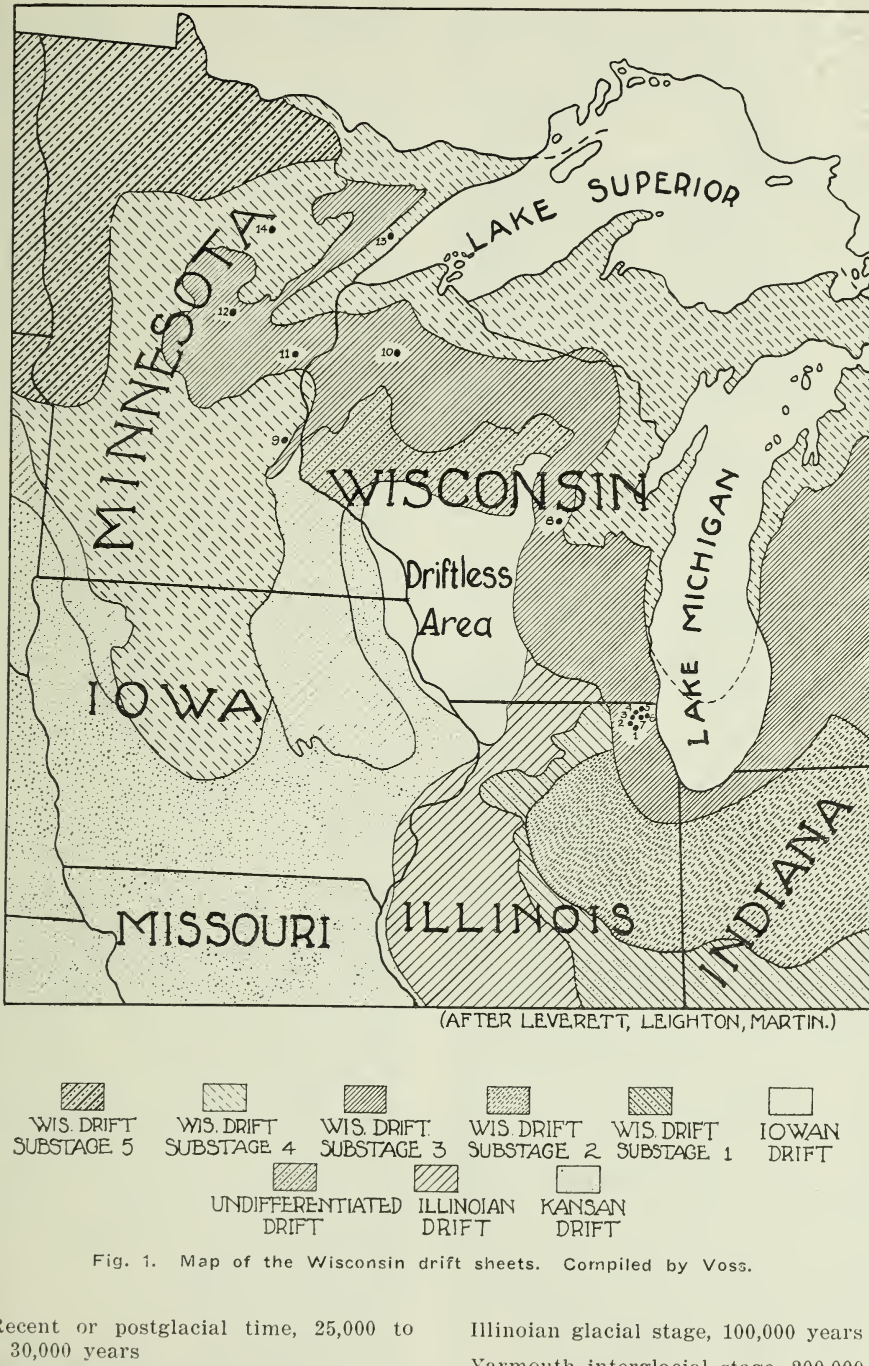

Fig. 1. Map of the Wisconsin drift sheets. Compiled by Voss.

Recent or postglacial time, 25,000 to 30,000 years
Wisconsin glacial stage, 100,000 years
Sangamon interglacial stage, 120,000 years
Illinoian glacial stage, 100,000 years
Yarmouth interglacial stage, 200,000 to 300,000 years
Kansan glacial stage, 100,000 years.

The most complete picture of the vegetation of the northern half of Illinois for the past 25,000 or 30,000 years comes from a group of seven bogs in Lake County found in Cary (3rd) substage of the Wisconsin drift, and investigated by Voss (19), (fig. 1).

The present vegetation of several of these bogs has been described by Waterman (22, 23) and by Kurz (13). They are found scattered in a rolling morainal area in a county that seems originally to have had at least three-fourths of its surface covered with deciduous forests.

The pollen analyses of these bogs show such remarkable agreement in their pollen diagrams that the results are most convincing. One of these diagrams may be taken as representative of the group (fig. 2). In interpreting these diagrams it must be remembered that the seven bogs, being in the same moraine and necessarily of similar age, differ considerably in depth. This necessitates some adjustments in the vertical length of the graphs when we attempt to synchronize the records.

It may be instructive to make such adjustments and to compare the pollen curves for the same species in the group of bogs.

The balsam fir, *Abies balsamea*, may be regarded as a good indicator species. It is found represented by its pollen in all seven Illinois bogs at the bottom of the deposits. The pollen curves from the seven bogs plotted together show an abundance of the species in the earliest centuries of the bog deposits but also show its disappearance relatively early in the history of the deposits (fig. 3). With our present limitations of knowledge it is impossible to more than approximate the time of the disappearance of *Abies* from the deposits and hence from the forests of Illinois, but if we accept the time of the recession of the last Wisconsin ice sheet as occurring some 25,000 years ago it seems likely that fir entirely disappeared during the first 5,000 or 6,000 years or about the end of the first quarter of that period. Data from the bogs of northern Indiana, collected by Houdek and others, although not yet as abundant as those from Illinois, give similar graphs for *Abies*.

These Illinois and Indiana bogs also show the early presence of spruce in the forests of the region and apparently the genus *Picea* persisted for a slightly longer period than did the fir but it also probably disappeared soon after the close of the first quarter of postglacial time. The curves representing the occurrence of *Picea* in the forests near all seven bogs are very similar (fig. 4).

As an indicator the genus *Quercus* seems to rank with *Abies* and *Picea* as very significant. Oak pollen appears in all the bogs of postglacial age that have been investigated. The pattern of its graphs is strikingly different from those of the fir and spruce but this pattern remains very constant throughout all the Illinois and Indiana bogs. It is found in small quantities at the bottom of the deposits, reaches a maximum about the time that the fir and spruce disappear and persists with irregular fluctuations to the present (fig. 5).

No other tree genera give records, comparable in importance to those of *Abies*, *Picea* and *Quercus*. The *Pinus* record would indicate the presence of the genus throughout practically the entire postglacial period with no decided or regular times of maxima or minima. *Carya*, in the Illinois bogs roughly parallels *Quercus* with much smaller percentages of pollen. *Tilia* and *Acer* show a wide distribution both in time and space, but present narrow and irregular pollen curves that are difficult to interpret.

Comparable to the record of the 7 bogs from the Cary or Late Wisconsin stage is that from 9 bogs of the Tazewell or Early Wisconsin substage (2nd) also studied by Voss (20). They occur in moraines of similar age and are found in Bureau and adjacent counties. The bottom of these deposits was laid down 35,000 or 40,000 years ago or probably 10,000 years earlier than the base of the Cary deposits just discussed. The pollen record is similar to that of the more recent deposits except that the fir and spruce pollens appearing most abundantly at the bottom of the bogs persist for a relatively longer time and the period of the dominance of oak is relatively shorter. Doubtless portions of northeastern Illinois were still covered with Late Wisconsin ice while these peat deposits were being laid down.

Passing from the records connected with the Wisconsin Glaciation and the postglacial interval that has succeeded it, we come to the more remote Sangamon Interglacial Stage. The last centuries of this stage were probably some 125,000 or

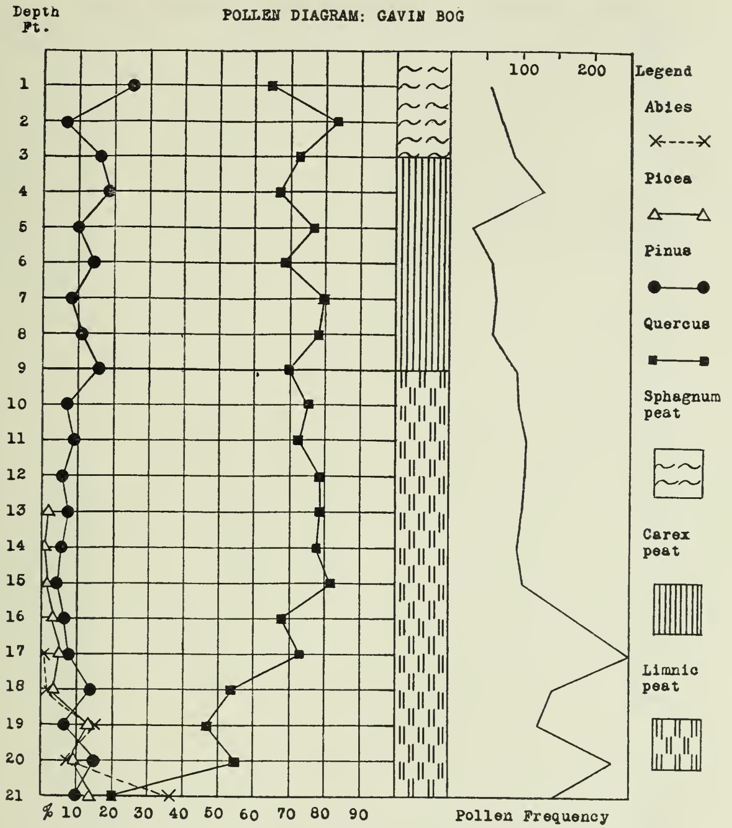

Fig. 2. Pollen diagram of a postglacial bog in Lake County, Illinois. After Voss.

150,000 years ago, and the interglacial period is supposed to have lasted for something like 120,000 years. Recently several peat deposits, known to belong to the Sangamon Interglacial and buried beneath many feet of gravel and loess, have been exposed. Two of these are so thick (135 and 78 inches) that it seems probable that they represent the greater portions of the period. Five of these deposits from Peoria, Bureau, Fulton, Tazewell and Woodford counties, investigated by Voss (21) give a good picture of the climate and vegetation of the period.

The fact that the five records agree so closely adds much to their credibility. The pollen of deciduous trees is conspicuous by its almost entire absence but throughout all the records there is a persistence of fir, spruce and pine with relatively little variation in the proportionate amounts. In one deposit only (the Canton) does oak and hemlock pollen appear. This is the only evidence at present uncovered that there was any marked climatic variation throughout the Sangamon Interglacial although its duration has been estimated at 120,000 years. The persistence of the spruce-fir record indicates a cool climate with a rainfall perhaps comparable to that at present; in other words, a climate similar to that existing today north of Lake Superior. The Canton record suggests that at two intervals there may have been such an amelioration of temperature that some areas of the forest possessed a small proportion of oak, hemlock and associated species. This might mean a climate and a vegetation like that at present existing on the south shore of Lake Superior. These two milder intervals may have occurred before the middle and towards the close of the Sangamon Interglacial Stage and each may have persisted for several thousand years (fig. 6).

The Yarmouth Interglacial Stage is much older than the Sangamon, being

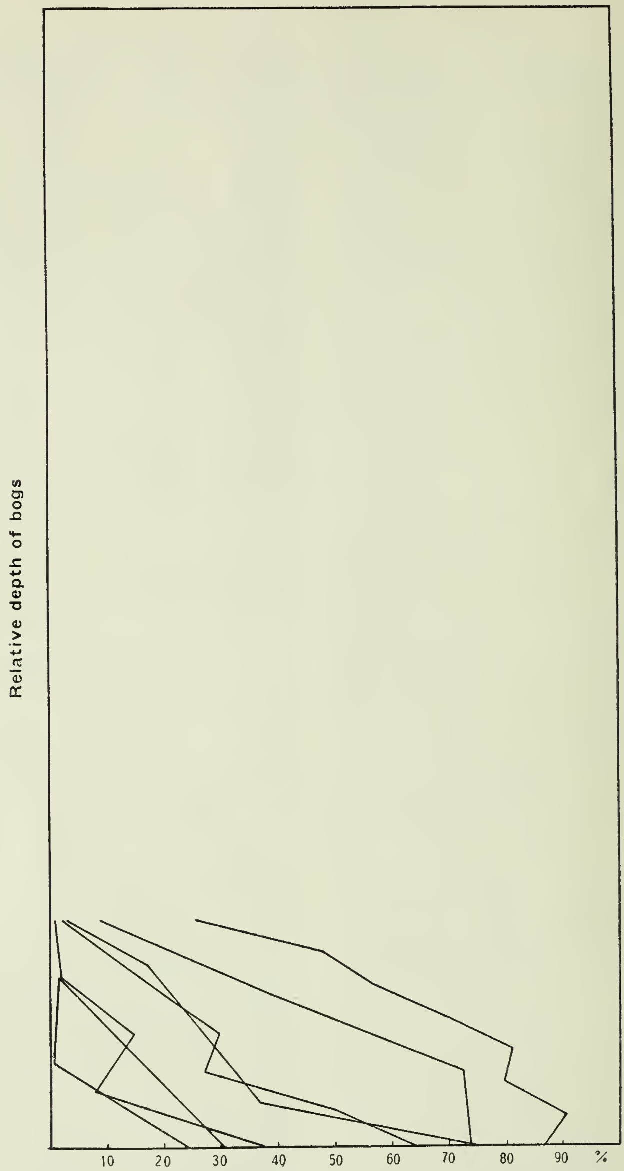

FIG. 3. Graphs showing the occurrence of *Abies* pollen in seven bogs in Lake County, Illinois. The graphs represent depth of bogs vertically and percentages of pollen horizontally. From data by Voss.

separated from it by the Illinoian Glacial that had a duration of perhaps 100,000 years. This would mean that the Yarmouth began over half a million years ago and it seems to have persisted for some 200,000 to 300,000 years. With this prolonged existence it is unlikely that any one peat deposit represents more than a portion of the period. Two deposits of Yarmouth Age found in Adams and Macoupin counties, have recently been studied by Voss (21) partly through the assistance of a grant from this Academy of funds made available by the A. A. A. S.

Of these deposits that at Quincy, Adams County, may be taken as revealing the

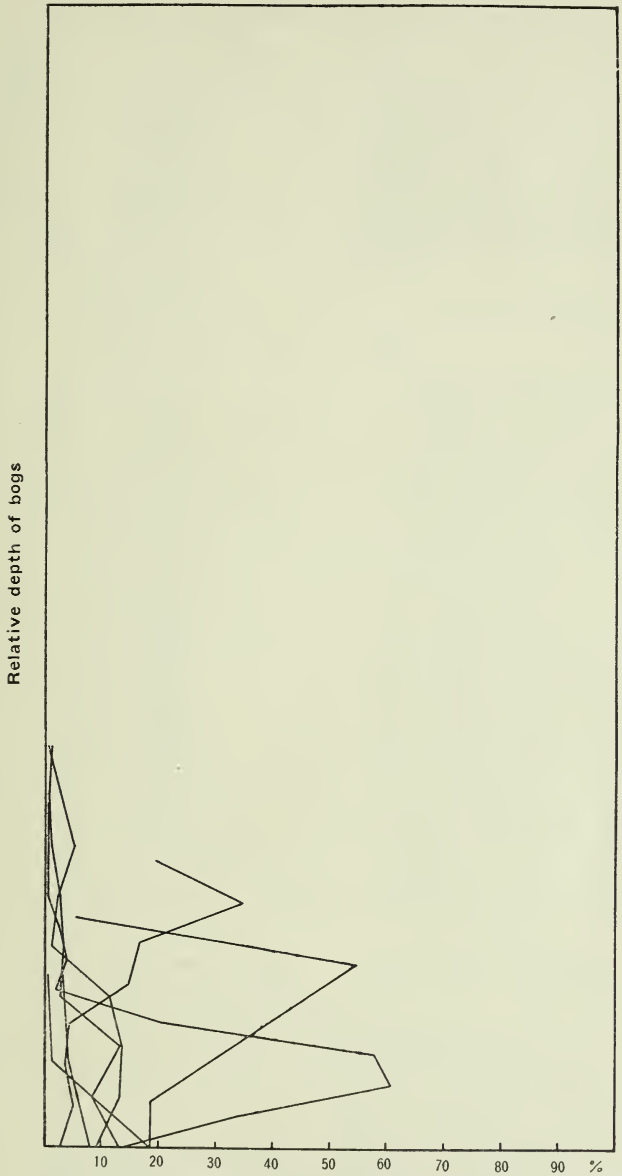

Fig. 4. Graphs showing the occurrence of *Picea* pollen in seven bogs in Lake County, Illinois. The graphs represent depth of bogs vertically and percentages of pollen horizontally. From data by Voss.

forest vegetation of that remote period (fig. 7). The two deposits, however, disclose similar records showing the existence of fir, spruce, tamarack, and pine throughout. In other words, the plant remains indicate the northern conifer forest characteristic of a cool, rather moist climate. This agrees with the conclusions drawn by Baker (1) from his studies of the mollusca of Illinois associated with the Yarmouth period.

Interpretation of the Records

In attempting to obtain a more complete picture of the vegetation of Illinois during the past half-million years we

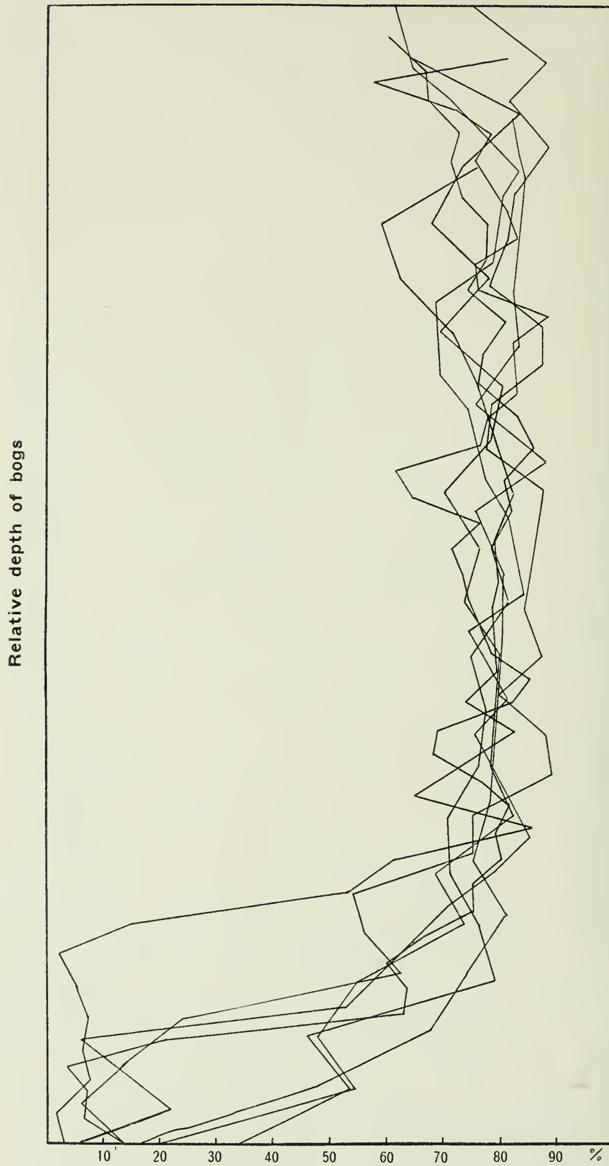

FIG. 5. Graphs showing the occurrence of *Quercus* pollen in seven bogs in Lake County, Illinois. The graphs represent depth of bogs vertically and percentages of pollen horizontally. From data by Voss.

should have as a background the geologic data which have accumulated during the past few decades. These have been brought together in an interesting and relatively non-technical form by Daly (6). They indicate that a climate somewhat cooler than the present obtained for most if not all of Pleistocene time and that precipitation was at least equal to that of the present.

In attempting to translate the bog records into terms of climate and actual vegetation we are faced at the very beginning with the question of whether the forests followed closely upon the margin of the retreating ice sheet or whether a

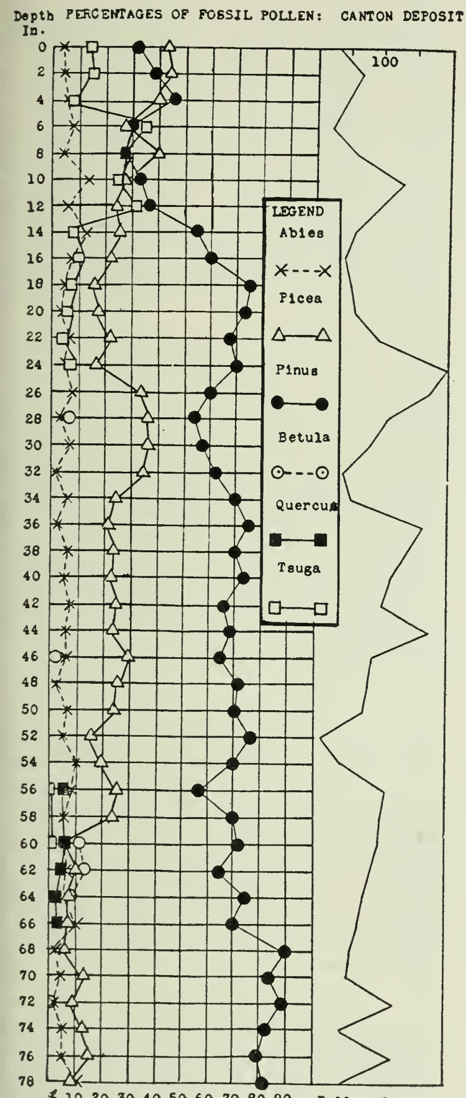

Fig. 6. Pollen diagram of a bog of Sangamon age in Fulton County, Illinois. After Voss.

rather extended period of tundra vegetation intervened. This question is particularly pertinent when applied to postglacial time since Woodard and others have argued in favor of an extended period of tundra vegetation which persisted until invaded by prairie grasses.

Certain facts, however, seem to indicate that there was no wide interval between the ice and the forest. The records of the Early Wisconsin stage and of the Sangamon Interglacial seem to prove that there were conifer forests in north-middle Illinois for many thousand years during which the Wisconsin ice sheet existed in the northern portions of the state. This makes it almost certain that such forests followed closely upon the retreating glaciers. Cooper (5) has recently found a spruce forest following within a few miles the retreating ice front of Alaskan glaciers.

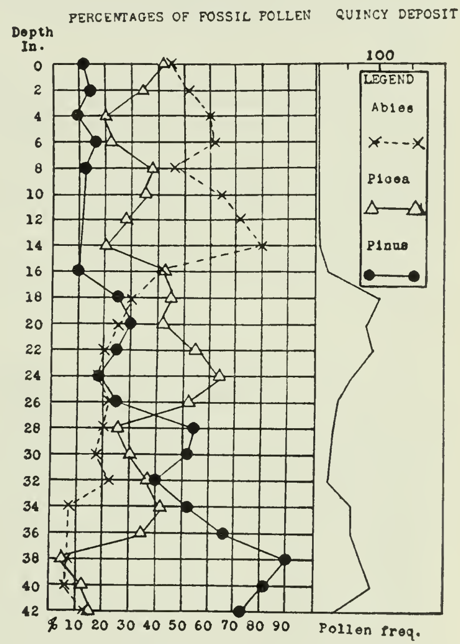

Fig. 7. Pollen diagram of a bog of Yarmouth age in Adams County, Illinois. After Voss.

All these records seem to point to the various substages of the Wisconsin glaciation having been followed closely by a forest of the northern conifer type such as now exists about the shores of Lake Superior. Such a forest must have consisted principally of spruce, balsam fir, species of birch together with some maple. Tamarack, ash and alder also doubtless grew on the swampy areas. This forest seems to have persisted for probably 10,000 to 15,000 years in middle Illinois and perhaps for half that time in the northern portion where the ice sheet had a longer duration.

The greater remoteness in time makes the interpretation of the vegetation of the

Sangamon and Yarmouth periods still more difficult. Recent studies by Braun (3) and by Cain (4), made in parts of the continent not subjected to Pleistocene glaciation, seem to indicate that a flora essentially similar to the present has existed in North America for more than a million years. This means that the same tree genera and probably the same species that now exist in Illinois were present on the continent, and had the same climatic requirements during the Sangamon and Yarmouth, that they have today.

Unfortunately we have little or no direct information as to the relative areas occupied by forest and grassland during those remote periods. The fact, however, that the grassland soils now existing are composed of materials deposited much more recently than the Sangamon and Yarmouth seems to make it highly probable that forests covered a much larger portion of the state than during recent times.

Conclusions

The fossil pollen of Yarmouth, Sangamon and Early Wisconsin interglacial periods supports geological and other evidence that these periods were characterized by cool and moist climates and that during these periods the northern half of Illinois was covered largely with northern conifer forests.

These forests appear to have been similar to those now existing north of Lake Superior, being composed of balsam fir, *Abies balsamea*, spruce, *Picea* spp., pine (*Pinus banksiana* and *Pinus* spp.), tamarack, *Larix laricina*, birch, *Betula* spp., and smaller amounts of associated species. There is at present no evidence that deciduous forests were present during the long Yarmouth period.

Twice during the Sangamon period, there seems to have been a mixture of oaks and hemlocks along with the elements of the more northern conifer forest. These would indicate a somewhat milder climate during some centuries (or thousands of years) in the earlier portion and again towards the end of the period. The data, however, indicate the dominance of northern conifers throughout.

In postglacial times the ice sheet seems to have been rather closely followed by a forest similar to the existing northern conifer forest in which spruce, fir, and pine were notable genera.

This forest seems to have been replaced in Illinois before the end of the first quarter of postglacial time, by a mixed deciduous forest in which oak, hickory, maple, and elm were dominant trees. This deciduous forest seems to have continued, relatively unchanged throughout the later three-fourths of postglacial time.

The pollen record in the Lake Michigan region seems to show no evidence of alternating moist and dry periods during postglacial time.

The pollen record seems to indicate that the forested areas of Illinois were much more extensive during the Yarmouth and Sangamon Interglacial periods and in the early portion of postglacial times than at present. It seems possible that the increasing warmth of the middle and later parts of the postglacial period and greater relative dryness favored the invasion of the forest by the grassland. Our present data are too scanty, however, to determine the relative extent of forest and grassland throughout these interglacial periods.

Acknowledgements

The writer is grateful to Professor John R. Ball, of Northwestern University, for his kindness in furnishing certain geological data, especially regarding the duration of the glacial and interglacial periods. Dr. John Voss, of Peoria, has generously permitted the free use of the abundance of fossil pollen data that he has accumulated, some of which were unpublished at the time of writing.

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PLANT GROWTH AND GROWTH HORMONES*

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THE GROWTH behavior of living organisms has received much attention in recent years as the result of important discoveries concerning the control of growth processes. The discovery of the importance of endocrine glandular secretions in the growth and development of animals, the discovery of vitamins as necessary accessories in the nutrition of animals and man, and the discovery of growth hormones in the tissues of plants have all been powerful incentives to the investigation of the processes of development.

Certainly one of the most interesting and amazing characteristics of the living organism is its power of continuous and harmonious development from the simplest beginning to the complex, highly organized and fully grown individual. Most of our higher plants and animals begin life as a single very slightly differentiated cell, the ovum or egg. This egg cell must usually be fertilized by union with another equally simple cell, the sperm. After the fertilization process has been completed, the egg is no longer quiescent, but begins the process of development by a series of cell divisions. As new cells are formed, the body enlarges, and observation shows that the cells begin to arrange themselves after an orderly pattern belonging to the species involved. Cell differentiation occurs, and tissues and organs emerge in an orderly series of events that excites the wonder and admiration of every philosophical biologist. The course of development continues until the organism reaches its full adult size and form, in accordance with its specific inheritance. It is hard to imagine that the towering redwood and the giant Sequoia were once upon a time housed within the confines of a single undifferentiated cell of microscopic size. And it is indeed just as difficult to think of the elephant, or the horse, or of man himself as beginning life with so simple an organization.

When the process of cell division initiates development, one can then observe that every stage of development prepares the way for the next one following. In the case of plant growth, which alone is the concern of this discussion, the unfolding of the organism occurs usually in two cycles of growth. The first cycle of development extends from the fertilization of the egg to the close of the development of the seed. This is the embryonic phase of development, and the cycle ends when the seed dries down and becomes dormant. In this stage it is resistant to conditions of the environment as long as it remains approximately air dry. Even the embryo plant in a seed is a complex being as compared to the fertilized egg. It has a very short root primordium, a short stem, in many instances two leaves stored full of food (the cotyledons), some embryonic leaves at the upper end of the stem, and tissue systems representing the epidermis, cortex, and vascular regions. It is all in miniature form, still far from the complexity of the adult, but vast progress has been made toward the ultimate goal.

Planted in warm moist earth, the

* Address presented before the General Session of the Thirty-second Annual Meeting, Illinois State Academy of Science, Springfield, Illinois, May 5, 1939.

embryo resumes its activity, enters upon the second cycle of growth, and in orderly succession root system, stems, leaves, flowers and fruit come into being, controlled by the laws of life and heredity, so that each individual faithfully repeats the pattern of its own species. In size, form, and structure, and in the harmony of its development it is recognizable as a member of a definite species, and unlike all other species.

The control of the growth processes of organisms must be affected in part by external forces, and in part by internal factors. We are all familiar with the fact that deficiencies of moisture, necessary elements, light, temperature, etc., modify growth rates and the total growth of the individual. But they act through modification of internal conditions such as the concentration of materials, activity of enzymes, rate of respiration, etc.

The first suggestion that growth responses in plants might be under the control of internal chemical substances was made by Charles Darwin in his book, *The Power of Movement in Plants*, published in 1880. He observed the growth responses of grass coleoptiles to one-sided illumination, and noted that the perceptive and responsive regions of the plant were separated by some distance, and that the stimulus must be transported through the tissues in some manner. The transport of the stimulus was much too rapid for mere diffusion, but Darwin thought there must be some substance which was acted upon by light, and which was capable of rapid transmission of a growth stimulus to the lower part of the leaf sheath.

The term "hormone" was introduced into animal physiology by Bayliss and Starling about 1902, to designate the chemical agents of growth control originating in the endocrine glands. Gradually the use of the term crept over into plant physiology, even before the actual existence of plant growth hormones had been fully demonstrated. The European workers followed in the footsteps of Charles Darwin, and made a great many studies of the responses of the oat coleoptile. In 1910-1911 Boysen Jensen proved the existence of a chemical regulator of growth in the grass coleoptile, but apparently the time was not ripe for the full significance of his work to be appreciated. Many other investigations followed his work, piling up evidence more and more convincing, until in 1928 Went's thorough studies made doubt of the existence of a chemical growth hormone in the oat coleoptile no longer possible. American workers occasionally used the hormone concept to explain growth behavior when they could think of nothing better to suggest. Both growth promoters and growth inhibitors were postulated to explain the behavior of lateral and terminal buds. Appleman's studies of the sprouting of potatoes in 1918 indicated that terminal eyes of the potato inhibited the sprouting of other eyes on the potato, and that the central bud of any given eye suppresses the growth of the lateral buds of the same eye. Removal of the terminal eye, or terminal bud, released the other eyes or buds from restraint.

Jaques Loeb made many interesting studies of Bryophyllum during the last 10 years of his life. Many of the features of geotropic response and regeneration in Bryophyllum were explained on the basis of the distribution of growth substances or hormones. At the time, the idea seemed far-fetched; but at the present time he appears very conservative in comparison with hormone enthusiasts of today. Reed and Halma studied growth in pear trees, and presented telling evidence for the existence of growth inhibitors in the terminal parts of the branches which, flowing down the branches, prevented the lateral buds from developing. Horizontal branches produced sprouts from the upper side of the branch, but sprouts originating on the lower side of the branch grew poorly. The suggested explanation was that the growth inhibiting substance settled into the ventral side of the branch and retarded the growth of sprouts on that part of the stem.

With the discovery of means of detecting growth substances, and of measuring the relative concentration of the hormones by biological assay methods in 1928 (Went), powerful impetus was given to the search for the hormone as a chemical entity. At the time of Went's discovery, no one had the slightest conception as to the nature of the chemical substance responsible for the growth curvatures of oats. Many substances were tested for the presence of growth promoting hormones, and it was soon found that yeast extract, malt extract, and culture media upon which certain fungi and other microorganisms had grown, contained such substances. In 1931 it was found that human urine was a rich source of growth hormone, and during the period from 1931 to 1935 Kögl and his co-workers obtained enough of the growth substance that they could purify it, and determine its chemical constitution. They found, indeed, not one, but two substances, which have been named auxin a and auxin b. The former is auxentriolic acid, and the latter auxenolonic acid. They are relatively weak acids, and are found widely distributed in living plant tissues.

During the four years since these acids were completely identified and named, hundreds of investigations have been made, and the application of the hormone concept to growth control has been extended to cover many phases of development. Such processes as cell division, cell enlargement, and cell differentiation are made subservient to specific hormones. The growth of the tops of plants is claimed to be controlled by top-forming substances originating in the root; and the root development is said to be controlled by root-forming hormones manufactured in the tops of the plant. Flower buds are initiated by hormones manufactured in the leaves under definite conditions which cause the production or the accumulation of the hormone, which is then carried to the region where buds could arise. The hormone initiates the bud, after which the ordinary nutrients, carbohydrates, amino acids, etc., provide for their growth. The afterripening of seeds during chilling, the breaking of dormancy of twigs in late winter, the production of dwarf forms of corn, the rooting of cuttings, the enlargement of fruits, the healing of wounds, the geotropic and phototropic adjustments of plants, and many other growth phenomena have now been given a "hormone" explanation. One could almost say that the entire growth of the plant, from start to finish, is controlled by a complicated set of chemical factors not nearly all of which are known at the present time.

The current definition of a hormone is so broad that it might include almost any chemical factor. A hormone is a substance which, being produced in one part of the organism, is transported to another part of the organism and there influences a specific physiological process. That definition, however, seems to make most of the transportable substances of the plant body play the part of hormones. Would not a sugar, produced in the leaf, and then transported to the root where it influenced the building of cell walls, fulfill the requirement of the definition of a hormone? Or an amino acid, formed in the root of an apple tree, and then carried to the stem apex where it influenced the formation of new protoplasm; would it not also be a hormone? What I am trying to say is that there does not seem to be so very much difference between hormones and the ordinary nutrient chemicals of the plant body, except that the hormones are present in mere traces.

As time goes on, more and more substances are found which in one situation or another promote growth, or inhibit growth, or initiate differentiation. Besides auxin a and auxin b, such substances as vitamins A, B_1, B_2, and C, biotin, pantothenic acid, nicotinic acid, indole acetic acid, thiazole, pyrimidine, oestrone, etc., have been mentioned as possible plant hormones. The number of these compounds may ultimately be recognized as legion, just as we recognize that the enzymes of the cell are very numerous.

Just what are we moving toward? What interpretation is to be made of this great mass of information which is accumulating as the result of world-wide interest in growth phenomena and hormonal control of development? There seems to be a trend toward a rational point of view which deserves to be emphasized. In some instances plants have been found to undergo growth stimulation when thiazole is supplied, in others when pyrimidine is supplied, and in still others neither alone is active, but vitamin B_1 must be administered. The obvious explanation is that some organisms manufacture their own pyrimidine, and if given thiazole can produce vitamin B_1. Others can make their own supply of thiazole, and if furnished pyrimidine they develop vitamin B_1. Still others make neither pyrimidine nor thiazole in sufficient quantity, and these forms must be given vitamin B_1 already formed, to induce growth.

Similarly, vitamin C is present in some organisms to such an extent that adding more of it produces no additional result in growth. Other organisms do not produce vitamin C readily, and if these are given vitamin C it provides a growth stimulus. The obvious conclusion is that we are dealing with problems of nutrition on the one hand, and possibly with catalysis on the other.

If hormones become an actual part of the organized structures of the plant body, as may easily be the case with some of them, they are to be thought of as foods in the same sense as carbohydrates and other macronutrients. If hormones speed up chemical reactions, or change the equilibria of chemical reactions within the tissues, their action is no different from that of other organic catalysts, the enzymes.

It seems to me that we are dealing with a situation not different in principle from that which exists with reference to the inorganic elements needed by living organisms. Some of the elements, such as carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, and mangesium are known to build substance in the plant. Others, such as potassium, manganese, iron, copper, zinc, boron, molybdenum, silicon, etc., are not certainly structural elements, but they have great significance in the use of material, in respiratory and other catalytically controlled processes. Until recent years it was not known that the trace substances, the micro-elements, as they are often called, are necessary for plant growth. When our chemicals were made pure enough, however, and when our techniques became sufficiently rigid it was not difficult to prove the necessity of the trace elements for life and development.

Now we have come on to the same situation with reference to the organic substances. Formerly we discussed only carbohydrates, fats, and proteins with reference to nutrition. When physiological technique had developed to the point where deficient rations could be prepared, the need of vitamins was discovered. And when the endocrine glands were extirpated, the need of the endocrine hormones became obvious. With the discovery of assay methods, the study of trace organic substances in the nutrition of plants became possible. The substances called hormones today are not a homogeneous group of chemicals. They do not form a class of compounds. They are metabolites of various kinds. Some are nutritive without doubt, others are catalytic, just as in the case of the inorganic elements.

The development of the hormone techniques is giving us the first opportunity we have had to study the influence of trace organic metabolites upon growth and developmental processes. It seems obvious that the amazing perfection of the specific developmental processes which carry any given organism through its life cycle is brought about by the production of specific trace metabolites, chemical inciters, inhibitors, correlators of many different kinds. Each species probably has some unique kinds, or unique combinations of trace chemicals which set the specific pattern of growth. It is not possible at the present time to define these unique specific substances, or unique combinations of them. The work is still too general. The great excursion into this field, however, has thrown brilliant light upon the growth processes of plants, and upon their developmental behavior. A sound foundation is being built for other and far-reaching advances which may ultimately provide controls for plant growth which man can operate at will. If we know under what conditions certain trace metabolites are formed, and what responses the plant makes in growth and development when these trace metabolites are present in sufficient concentration, we are only a step away from the complete control of the organism's development. We are moving steadily forward toward this goal, with all indications that practical control will be achieved in the not distant future.

STATE FORESTRY IN ILLINOIS*

Anton J. Tomasek

State Forester, Springfield, Illinois

I WOULD LIKE to take this opportunity to familiarize you with some of the activities and objectives of the State Forestry Division and tell you what has been accomplished and what we propose to accomplish in this important branch of the State government.

The State Division of Forestry was organized in 1926 as a division of the Department of Conservation. It was organized as a result of an increased need for proper forestry practices within the State on the part of the owners of timber land. The organization of the Division was also brought about by interested individuals who analyzed the forestry problems of the State and deemed it imperative that something be done to restore our natural forest areas.

The Division of Forestry operates on funds received from a general appropriation granted by the State Legislature every two years. For eleven years appropriations for this important field of activity had been comparatively small. The average expenditure, per biennium, during this period was approximately $55,000. At the request of Governor Henry Horner and Director of Conservation Thomas J. Lynch, the last Legislature increased the biennial appropriation for forestry for the period July 1, 1937 to June 30, 1939 to $171,000. This increase was warmly welcomed by all lovers of conservation and forestry in the State and has enabled us to inaugurate a well-balanced state forestry program.

The objectives of the Division of Forestry are: first, to promote and assist in the reforestation of idle lands unfit for agriculture; second, to prevent forest fires, not only on State owned land but on private forest lands throughout the State where a sufficient amount of timber is present to warrant expenditures; third, to control erosion by the planting of trees; fourth, to establish State forests to act as demonstration areas in proper timber land management; fifth, to give assistance to Illinois land owners and corporations in their forestry problems; sixth, to disseminate forestry knowledge through the publication of forestry literature.

Of these objectives, the most important work of the Division is to promote and assist in the reforestation of idle lands now unfit for agricultural purposes. We have in Illinois today approximately 3,000,000 acres of such lands which are not being tilled and are not producing any timber crop. In their present state, therefore, their value is nothing. All this vast acreage is entirely in the hands of private land owners. There is no way in which the Division of Forestry can compel such land owners to reforest their lands or put them to some beneficial use. Our approach to this problem is through education, by demonstrating that such lands unfit for agriculture should be producing timber for profit.

The State Division of Forestry is doing everything possible to assist all land owners who are willing to reforest their idle lands. Two State nurseries have been established during the past four years for the production of forest and erosion control planting stock. The largest of these nurseries, the Horner Tree Nursery near Havana, can produce ten million trees annually for such plantings. The second nursery, the Thompson Tree Nursery located at Jonesboro in the extreme southern part of the State and named for the late Director of Conservation, Charles F. Thompson, has a capacity of five million trees annually. Both nurseries have been developed recently to a highly efficient stage, making it possible to produce fifteen millions of trees annually at nominal cost.

Tree seedlings produced at State nurseries are sold to farmers and land owners almost at cost for the reforestation of any lands unfit for agriculture. The following restrictions are placed on trees purchased from the State:

1. Trees are to be planted for the establishment of a new forest, or for the improvement of a forest already existing, and are not to be used for ornamental or landscaping purposes.

* Address presented before the Thirty-second Annual Meeting of the Illinois State Academy of Science, Springfield, Illinois, May 5, 1939.

2. Trees must not be dug, cut off, or otherwise moved and resold, until they are large enough to be sold or utilized as merchantable timber.

3. The planted area must be protected from forest fires, trespass and grazing by domestic livestock.

4. For the purpose of inspecting the planted area, the Division of Forestry, or its agents, will be given unrestricted access to the property on which these trees are planted.

Every effort is made by the Division to prohibit its trees being used for ornamental or landscaping purposes. It is not the intention of the Division of Forestry to sell trees for ornamental purposes in competition with commercial tree nurserymen who have excellent stock suitable for this purpose. Trees produced at State nurseries are produced solely for the purpose of providing planting stock for future forests. In view of this fact trees are sold only in lots of 500 or more.

Interest in reforestation has undoubtedly increased greatly in the last three years. In 1936, 176,000 trees were distributed for forest plantings, in 1937, 655,000, in 1938, 3,740,000 and this spring 4,829,000 were distributed from State nurseries. It can readily be seen, therefore, that the program of planting for future forests in Illinois is rapidly taking hold.

A new program in forest plantings was started by the Forestry Division in cooperation with owners of worked-out strip mine areas in the State during the past year. Undoubtedly many of you have seen the large spoil banks left by strip coal operations. It was deemed feasible by the Division of Forestry that such lands could well be reforested and be put to a profitable use by the production of timber. Conferences were held with the Illinois Coal Strippers Association who were enthusiastic about such a program and the Division of Forestry agreed to make surveys of such areas and provide the owner of strip mine lands with definite recommendations as to future forest plantings on such areas. The surveys were made and eight companies cooperated in actual planting operations during the spring of 1938 and planted 300,000 trees which were purchased from the Division nurseries. The strip mine owners furnished all necessary labor and the work was done under the supervision of a trained forester of the Forestry Division. Planting inspections during the summer of 1938 have proven that this new venture was highly successful since approximately ninety-five percent survival of trees has been obtained. Strip mine companies continued this program with the Division this spring and 1,000,000 trees were planted, the last of the plantings being completed two weeks ago.

Benefits as a result of revenue derived from a timber crop are not all that can be expected of these plantations. In addition, such tracts will provide ideal recreational areas for the public in the future and will provide excellent wild life areas.

Planting trees for future forests in Illinois must necessarily be taken seriously by all owners of lands unfit for agriculture as a definite business proposition and timber should be considered by such individuals as a long term crop. At present, Illinois is a heavy consumer of wood products and pays from twenty-five to thirty million dollars a year on freight on timber shipped into the State. Lands in the State suitable only for the raising of trees, if producing timber at full capacity, would be of material help in reducing this freight bill, thereby effecting a cheaper price in lumber to the consumers in Illinois, and, at the same time, a fine return would be obtained for the owners of forest lands. Taxes are being adjusted in some states on timber land so that every encouragement is given to the owner to plant and maintain his forest area. The greatest problem confronting us today is the fact that many neglect to plant for future forests due to the fact that taxes must be paid over a long period of years during which time there is no return as there is when the owner plants an annual crop. The only remedy to this condition is by passage of tax exemption acts providing for a very nominal tax on forest lands. Such an act, if passed by our State Legislature, probably would be unconstitutional, therefore, it is necessary that at some time in the future our constitution be amended to provide for the tax exemption of forest lands as is being done in many states today.

Serious erosion of soil is going on in many parts of the State, especially in the south. This is taking place particularly on steep hill slopes which have been denuded of timber and which have been improperly farmed in the past. Trees planted on such land, especially the Black Locust, which has a very fibrous root system, are ideal for controlling erosion. In planting this tree for erosion control, it has a three-fold purpose: first, its fibrous root system holds the soil and prevents further erosion; second, in view of the fact that the roots are of a nitrogenous nature it will improve the soil fertility and, third, the Black Locust will produce a crop in view of the fact that Black Locust trees will attain fence post size in from ten to fifteen years and they are ideal for that purpose.

Trees planted on hillsides also serve another very important purpose, that being watershed protection. Undoubtedly the cause of our major floods in the country in recent years has been due to the fact that many of the watersheds have been stripped of their forests, resulting in a rapid runoff to the main streams and rivers. Where such watersheds are well-forested, the falling leaves and litter form a blanket over the forest floor which keeps the soil moist and porous and virtually acts as a sponge, holding the water and releasing it slowly. Illinois has been affected by floods many times in recent years and the reforestation of watersheds, not only in this State but in our neighboring states, is of vital necessity to prevent such reoccurrences.

We have in Illinois today approximately four miilion acres of timbered lands. The original timber stand in Illinois was approximately fourteen million acres or about forty-five percent of the total land area of the State. The major part of the four million acres remaining is located in the southern portion of our State. Practically the entire forest acreage is confined to farm woodlands with the exception of approximately 160,000 acres of land which comprise the Illini and Shawnee purchase units of the U. S. Forest Service in the southern part of the State, 3,400 acres of land which comprise the Union County State Forest and 5,000 acres of land recently purchased by the Division of Forestry as a State Forest in Mason county. Of the four million acres of timberland remaining in the State, approximately two million acres should be given protection from forest fires which is the greatest enemy of a forest area. Until 1937 no forest fire protection was afforded private forest lands in the State. As a result of the increased appropriation granted the State Division of Forestry, we have been enable to inaugurate a program in forest fire protection and at the present time approximately 350,000 acres are under intensive forest fire protection. Our increase in appropriation has enabled us to construct fire towers, purchase forest fire fighting equipment, trucks, and hire forest fire wardens to carry out this phase of our forestry program. In addition to this we have just completed our main forest fire protection headquarters near Benton, Illinois at a cost of $14,000.

Fire in the city is something that can readily be transferred to a visible dollar and cents problem. The damage is plainly seen. The damage done by forest fires can only be appreciated by those who know timber and timber values. There is also a definite loss in dollars and cents but it takes an expert to see it. Every time a fire occurs some of the top layer of soil is destroyed thereby decreasing the fertility of the area. Fires also scar the base of trees, not only causing a loss in lumber when the tree is cut, but provides an entry for disease and insects. Forest fires destroy the habitat for game, its food and, in many cases, the game itself. In addition to this, many indirect losses can be recorded. Forest fires are caused almost entirely by negligence on the part of the public. Smoking in the woods and throwing away a lighted cigarette or match is undoubtedly the most usual cause.

The cooperation of the public is requested in this vital program of forest fire protection. Although the danger is most serious in the southern part of our State, it is also serious in areas such as the Cook County Forest Preserve District which has approximately 35,000 acres of timbered lands, and other timbered sections of our state.

One of the objectives of the Division of Forestry is to establish a number of State forests to provide demonstration areas in proper forest management. Illinois at the present time has two State forests. One of the two, the Union County State Forest located in the southern part of the State, comprises 3,400 acres. Through the efforts of the Civilian Conservation Corps and the Works Progress Administration under the supervision of the State, proper forestry practices on this tract have been inaugurated and, in addition, the area has been developed as an excellent recreational tract for residents of southern Illinois.

Through the efforts of Governor Horner the last State Legislature granted $50,000 for an additional State forest to be purchased in the western part of the State during the present biennium. This has recently been acquired and development work has been started. It is hoped that our program will enable us to have some day a number of State forests located in every section of the State in order that farmers and land owners may be able to visit near their homes, a properly managed forest and a forest area which can bring a profit to its owner. We feel that if the State will point the way by such demonstrational areas, cooperation on the part of the forest land owner can more easily be obtained.

In many of the eastern states, many communities are purchasing potential forest lands and practicing proper forest management, setting these areas aside as community forests. Every effort is being made by the Division of Forestry to interest cities and villages to inaugurate a similar community forest program. Such a forest program is especially fitting where cities or towns own lands surrounding a lake which is their reservoir and drinking supply. It is important that the watersheds of these reservoirs be planted with forest trees to prevent silting. We have sixty-one such reservoirs in Illinois at the present time and under the direction of the Division of Forestry, surveys are being made of them and submitted to the town or city officials with the hope that such areas will be planted, thereby providing a community forest for the people of those cities.

Of the hundred and two counties in Illinois, six counties have forest preserve districts maintained as natural recreational areas. Those counties and the acreage they have at present are as follows:

County	*Acres*
Cook	35,000
DuPage	1,010
Kane	350
Will	613
Winnebago	1,116
Piatt	108

The Cook County Forest Preserve District of 35,000 acres, under the able direction of Charles G. Sauers, general superintendent, serves millions of people annually and illustrates, without a doubt, the value of a forest area to the citizens of a community.

The dissemination of forestry literature by the Division of Forestry, in an attempt to increase interest in forestry, has greatly assisted in furthering our program. Publications issued free of charge at the present time are as follows: "Forest Trees of Illinois and How to Know Them" is a 76-page booklet describing the native trees of the State and explaining as simply as possible how to identify them. Approximately 25,000 copies of this publication are distributed annually to school children and adults. "Elements of Forestry," a 30-page booklet provides general forestry information especially as it pertains to Illinois. Miscellaneous publications on tree planting are also issued.

I have tried briefly to summarize the Department of Conservation, Division of Forestry's duties and activities.

In closing I wish to state that the Division is always happy to receive inquiries on our State forestry program and to assist individuals with any forestry problems that they may have.

SOME NEW EXHIBITS AND UNDERTAKINGS OF THE ILLINOIS STATE MUSEUM*

THORNE DEUEL
Chief, Illinois State Museum, Springfield, Illinois

ON BEHALF of the Illinois State Museum and its staff, I cordially welcome the members and friends of the Illinois State Academy to Springfield and to the Museum. My only regret is that the Museum does not have the facilities to provide its own auditorium and rooms for the use of the Academy and its sections.

I shall touch very briefly on the aims of the Illinois State Museum, by saying that our goal is to develop the exhibits to interest and entertain the average citizen—the non-specialist rather than the scientist—without sacrificing scientific accuracy and to show the life, life forms, culture and industry of Illinois from earliest times to the present against the background of the corresponding environments existing in the region at these periods. It shall further be the task of the Museum to indicate to the people of the State by suitable exhibits the resources and industries of Illinois and the achievements and work of the State Departments and by suitable booklets and pamphlets on these topics to advertise the State both to its own citizens, to those of the other United States and to foreign countries.

Our goal today is to see that all members of the Academy who can conveniently do so, visit the Museum on the fifth floor of the Centennial Building.

Even though we can't provide you with space for your meetings, we would like to entertain you by showing you some of our more recent undertakings and acquisitions of the museum. With this in mind, I urge that no one present at any meeting of the Illinois State Academy go home without seeing four of our new projects and exhibits which I shall mention and describe briefly: (1) the new Oriental Room in the Art Gallery, (2) the Diorama Series, (3) the Langford Fossil Loan Collection, (4) the Herbarium.

The Herbarium is in the Board Room and the Secretary will be glad to show you the new cases and the mounts in transparent envelopes. This now has

Fig. 1. Diorama: A new tool.

* Address presented before the Thirty-second Annual Meeting of the Illinois State Academy of Science, Springfield, Illinois, May 5, 1939.

Fig. 3. Chinese Ancestral Portrait.

Loaned to the Illinois State Museum by Major Thomas Dresser White, United States Army.

Fig. 2. Diorama: Merchant Venturers in Bronze.

about a thousand specimens from the Dr. Vasey collection made between 1845 and 1860, as well as 250 specimens recently collected and mounted by Dr. George D. Fuller of this Academy.

The Langford fossils were collected, selected and developed by George Langford, Sr., and George Langford, Jr., of Joliet, from 225 to 250,000 nodules from the strip mines south of Wilmington, Illinois. In the course of the next month a popular publication describing these fossils, "Leaves and Stems from Fossil Forests", by Raymond E. Janssen will be issued by the Illinois State Museum and will be available to the public at a small cost. This collection, now exhibited in the central aisle of the main hall, will probably eventually become the property of the State.

Of the dioramas, seven of the fifteen scenes projected for the cultural series are completed. These show some of the inventions and discoveries in man's progress underlying modern civilization in Illinois. (See figs. 1 and 2.)

The new Oriental Room in the Art Gallery is just begun. Recently Major Thomas D. White, Air Service, U. S. Army, loaned to the Museum 62 Chinese ancestral paintings which formerly hung in family temples. See fig. 3 for one of these. The Misses Helen and Eliza Condell donated to the Museum an embroidered wall hanging from Canton. Some of these acquisitions have been hung temporarily to give some idea of how the Oriental Room will look when completed. Lighting will eventually all be indirect, the floor covered with inlaid linoleum medallion insets, 3½ feet in diameter, of Persian design. The pilasters will carry painted designs when finished.

For the convenience of Academy members, the Museum will be kept open from five until half after six and guides will be present to show these exhibits. Immediately after the evening meeting the museum will be open until 9:55 for the benefit of those who have been unable to see it earlier. I hope all who can will come again after the evening meeting.

MEMOIRS

SIMEON E. BOOMER
1875-1938

SIMEON E. BOOMER, for 25 years head of the Physics and Astronomy Department at Southern Illinois State Normal University, Carbondale, Illinois, died January 3, 1938, at the age of 63, after a lingering illness of 14 months. Mr. Boomer had been associated with the University for 27 years, coming as head of the Mathematics Department in 1911 and transferring to the Department of Physics and Astronomy in 1913.

Mr. Boomer had a wide range of teaching experience, having taught two years in rural schools, eight years in high school and two years in the University of Illinois Academy before joining the faculty of S. I. S. N. U. As a boy he entered the preparatory school of S. I. S. N. U. and here continued his education until he graduated. Later he received A. B. and A. M. Degrees from the University of Illinois. He was a member of the Illinois State Teachers Association, holding a number of offices in that organization, and also a member of the Illinois State Academy of Science. During his entire residence in Carbondale he belonged to the Presbyterian church and much of the time was very active in its affairs.

Emphasis should be placed on his love of astronomy. Often he expressed profound respect for the inspiring beauty and magnitude of the limitless, mysterious, and unexplored spaces of the universe. His astronomy students will remember the regard for the Creator which he led them to deduce from their study of the sky.

He was a familiar figure in Southern Illinois and will long be remembered by the thousands of students who sat in his classes.

OTIS B. YOUNG.

CATHERINE A. MITCHELL

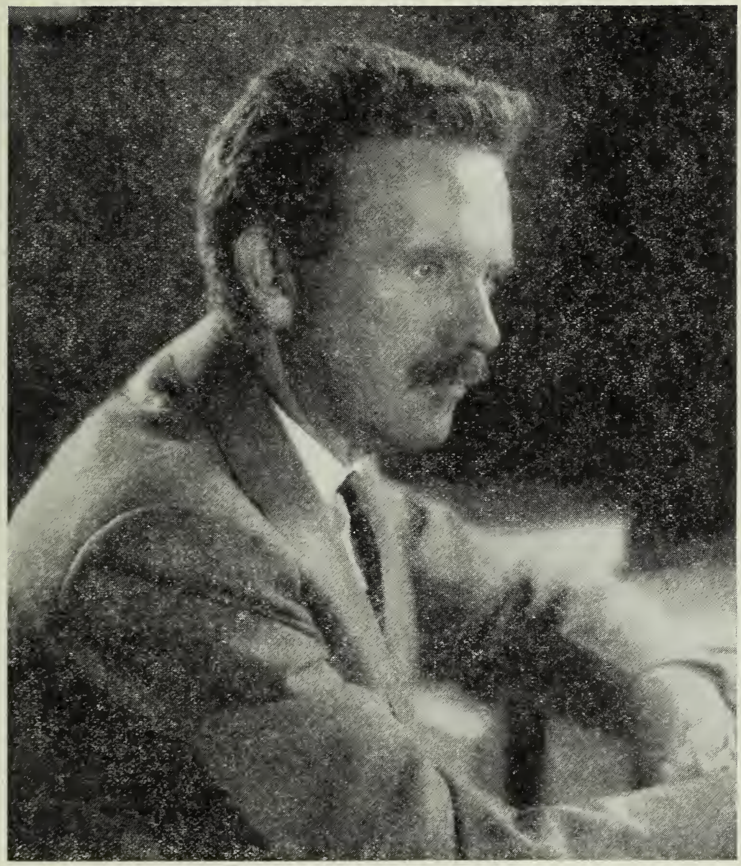
"WITH MALICE toward none and charity for all" was genuinely a guiding motive in the life of Catherine A. Mitchell, who on August 23, 1938, surrendered her earthly life to the life beyond. Known for her loyalty and her kindliness, she was held in esteem and her friendship cherished by all who knew her. The supreme pleasure of her life was not the hilarity of the passing show, but being of service to someone in want or distress. She thus won the profound respect of her friends and acquaintances.

Miss Mitchell was an active member of the Illinois State Academy of Science and of many clubs of nature lovers. She held office in some, and with intense devotion did her share to help preserve for posterity our wild life and our trees and woods. She was never found wanting in her zeal to give the denizens of the fields and forests, and the forests themselves, a chance to live and flourish unmolested. Her deep-seated religion was conservation in the fullest sense of the word, and her love of the out-of-doors was the crowning glory of her life.

She will be missed by the Illinois Audubon Society, of which she was secretary for many years. She held a similar office in the Conservation Council; the Friends of our Native Landscape have a vacant chair in the Board of Directors; the Prairie Club and the Wild Flower Preservation Society have lost one who labored wholeheartedly in their support. Conservationists and naturalists of the entire Chicago area will for years to come have cause to remember the work of Catherine A. Mitchell.

E. T. BAROODY.

JAKOB KUNZ
1874-1938



IN THE PASSING of Professor Jakob Kunz the University of Illinois has lost one of its distinguished faculty members. His death brings sadness to his colleagues and to hundreds of students who knew him as a teacher.

He came to the University when a comparatively young man and became an influential member of the faculty during his twenty-nine years of service. As a teacher, he won the respect of his students with his thorough knowledge of the subjects he taught and his effective presentation of the material. In his scientific investigations, he was aggressive and industrious, so that he soon became well-known as a leader in the domains in which he was interested.

Professor Kunz was born in 1874 in Switzerland and obtained his education there, completing it with the degree of Doctor of Philosophy from the University of Zürich in 1902. He served as a chemist in the Gesellschaft für Chemische Industrie in Basle, Switzerland, 1897-1900; as an instructor and privat-docent in physics in the Zürich Polytechnicum, 1900-1907. He then spent a year in England at the University of Cambridge studying with Sir J. J. Thomson. In 1908 he came to the United States as an instructor in physics at the University of Michigan. The following year he joined the University of Illinois faculty and served as a member of that body until his death. He was a member of the American Physical Society, American Optical Society, American Astronomical

Society, American Association for the Advancement of Science, Sigma Xi, and Phi Beta Kappa. He was also active in the Illinois Academy of Science.

Dr. Knuz's scientific activities were wide and varied. He was known as an outstanding mathematical physicist, but he also engaged in many experimental problems. In 1907 he wrote a book entitled "Theoretische Physik auf Mechanischer Grundlage." He had planned this past summer to complete a second book on theoretical physics which would set forth his applications of analytical functions to the solution of physical problems. Among his experimental projects might be mentioned his work in magnetism, about which he wrote a comprehensive bulletin for the National Research Council; his participation in three solar eclipse expeditions in company with astronomer Professor Joel Stebbins; and his widely-known experiments with the photoelectric cell, a device that has been used extensively in scientific investigations and in engineering applications. Dr. Kunz published numerous papers on his theoretical and experimental investigations, both in this country and abroad.

No estimate of Dr. Kunz would be complete without a consideration of his personality. He had great personal charm, and he was always pleased to meet people and genuinely interested in their affairs. Another outstanding characteristic of Dr. Kunz was his honesty. In all matters, both scientific and otherwise, black was black, and white was white with him, and he was always fearless in expressing his convictions. This honesty of purpose and his stubborn defense of what he thought was right led him into many animated discussions. Dr. Kunz was deeply religious, and he often found occasion to discuss with students and faculty members his beliefs about the relations between science, philosophy, and religion.

We have lost in Dr. Kunz not only an eminent scientist and an inspiring teacher but a man we respect; who based his actions on his ideals with little regard for his material welfare. His example will continue with us as an inspiration.

F. R. Watson.

HERBERT W. MUMFORD
1871-1938

IN THE DEATH of Herbert Windsor Mumford, the entire field of science as well as the farm people of Illinois and his staff of members and co-workers have lost a sincere friend and a wise counselor. He was for many years a member of the Illinois State Academy of Science and of the American Association for the Advancement of Science.

As Dean of the College of Agriculture, Director of the Agricultural Experiment Station and Director of the Extension Service, he sought not personal credit but accomplishment. He had a broad and well-defined conception of the functions of the University and sought their fulfillment zealously.

His interest in the students of the College never lessened no matter how other responsibilities increased. When it became necessary for him to delegate much of the detail work with students, he continued to see them whenever they came to his office even though other conferences had to be interrupted. Had he been free to follow his own desires, he would have spent much more time with students.

The guidance he gave to the men and women of his staff, not only directly but through his unusual gift for planting fertile suggestions in the minds of others, was one of Dean Mumford's greatest contributions. Sympathetic and patient, he was deeply interested in the problems and personal achievements of his staff and in their advancement; and he was anxious to give full credit for good work. Always sincere, and with ingrained and highly developed critical faculties, his view of a situation and his advice were frequently valued even more in retrospect than at the time. A vein of homely humor revealed his underlying friendliness and human understanding. Quietly courageous, he never hesitated to give his honest opinion nor to suggest changes in procedure when convinced that the welfare of the institution or of individuals called for change. For these qualities he was widely recognized, respected, and esteemed.

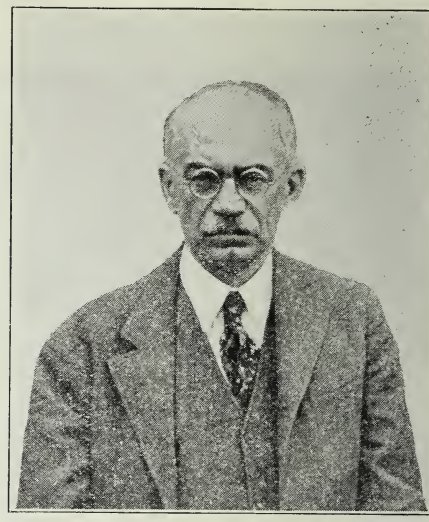
A faithful champion of the man on the farm, Dean Mumford exerted a powerful influence in his behalf, especially when situations arose where the interests of other groups were opposed to those of farm people. He sought earnestly to direct the activities of the Experiment Station and the Extension Service toward the solution of the most important problems of Illinois agriculture.

Striving always for improvement in the discharge of his own responsibilities, he constantly urged the staff to reexamine the research and extension programs of the institution in an effort to make them more effective. He encouraged the teaching staff to secure the best training possible both in subject matter and in teaching methods.

His success as a director of research and an administrator was heightened by the fact that he, himself, was a scientist of rare ability. This was manifest not only in the pioneering investigations which he conceived and carried through in the fields of animal husbandry production and marketing, but also by the scope of the research program which he inspired and fostered among staff members of the Experiment Station.

Thoroughly trained, and endowed with rare native ability, he traveled extensively in the United States, Mexico, Canada, the Argentine, and Europe, developing breadth of understanding and foresight possessed by few. These characteristics contributed to the conception of proper public relations for which he was widely recognized by leaders in the State, by his associates in the Association of Land-Grant Colleges and Universities, and by officers of the Federal government.

ADOLF CARL NOÉ
1873-1939



AFTER THIRTY-SIX YEARS of varied services to the University of Chicago, Adolf Carl Noé died quietly in his sleep early on the morning of April 10, 1939. Dr. Noé who had been in charge of the field of paleobotany for sixteen years, was to have retired on October 1, and he was particularly anxious to put his scientific "affairs in order." Saturday, March 11, therefore, found him at his office busy working on the final chapter of what will doubtless be his most important scientific memorial —the Stutzer-Noé Textbook on Coal. There, in the midst of his labors, he suffered the paralytic stroke from which he was unable to rally.

Dr. Noé was born in Gratz, Austria, on October 28, 1873, the son of Adolf Gustav and Marie (Krauss) von Noé. He attended the University of Gratz from 1894 to 1897, and the University of Göttingen from 1897 to 1899, during which year he came to the United States. Entering the University of Chicago he received the A.B. degree in 1900, and the Ph.D. in Germanic languages, in 1905. Although he was originally interested in the sciences, and had been a "demonstrator" in paleobotany at Gartz, he found it easier in this country to obtain employment teaching languages. After a year of such work at Burlington, Iowa, where, on July 3, 1901, he married Mary Evelyn

Cullatin, Dr. Noé became instructor in German at Stanford University. Returning to Chicago he was instructor and assistant professor of German literature (as well as an assistant librarian) from 1903 to 1923. At this latter date he found it possible finally to return to his field of original interest, and he became assistant professor of paleobotany. The following year he was promoted to an associate professorship and made curator of fossil plants at Walker Museum.

Even before Dr. Noé succeeded in making a place for his subject in the curriculum at Chicago, he had in 1921 become geologist on the staff of the Illinois Geological Survey. This position he occupied until his death, his last active field season having been that of 1938. In addition, he had served in a similar capacity on the State surveys of Kentucky and Iowa. In 1927 he was geologist for the Allan and Garcia Coal Commission to Soviet Russia and did considerable pioneering work, especially in the Donetz coal basin.

In addition to the Stutzer-Noé Text now in press, Dr. Noé was the author of "The Fossil Flora of Northern Illinois," "The Golden Days of Soviet Russia" and "Ferns, Fossils and Fuels," as well as a number of shorter contributions. The now prominent study of "coal balls" was fathered in North America by Dr. Noé, and he and his students did much to bring it to its present position of importance. He was also an able technician, a student working under his direction having perfected the nitro-cellulose peel method for studying sections which now has such wide usage both here and abroad.

During his many summers devoted to the study of the Coal Measures of Illinois for the Illinois State Geological Survey, he made a large paleobotanical collection for the State Survey and for the Walker Museum, and in addition he obtained for Walker Museum, through the auspices of other state surveys and by his own efforts, other large collections from other areas and from formations of several different ages.

Since he had the ability to attract students of real promise, he leaves an active group of younger scientists who will be able to do what doubtless he himself might well have done had it not been for the quarter century Germanic literature hiatus in his scientific career.

His worth was well appreciated in many quarters. He received the Sc.D. from Innsbruck in 1922 and, in 1923, the honorary Ph.D. from Gratz, as well as the gold medal of the University of Vienna. He was a member of the Société Géologique de France, the Geological Society of Mexico, and a fellow of the Geological Society of America as well as of the American Association for the Advancement of Science. He was vice-president of the Paleontological Society in 1931, and the same year held similar office in the Illinois Academy of Science. In 1927 he was chairman of the Chicago Section of the American Institute of Mining and Metallurgical Engineers, and in 1937, he was chairman of the Paleobotanical Section of the Botanical Society of America. In 1934 he became a research associate of the Field Museum and was responsible for the technical direction in the preparation of the museum's great reconstruction of a Carboniferous forest.

Dr. Noé engaged in many extra-curricular activities. He was an enthusiastic horseman, a redoubtable fencer and an expert marksman. For many years he coached the Chicago fencing team and was the instructor of the Rifle Club which he helped to organize. In 1921 Dr. Noé served as treasurer of the American Commission for Vienna Relief so successfully that the grateful nation bestowed upon him the Officers Cross of the Order of the Austrian Republic. Tall and distinguished, of noble birth, Dr. Noé was, in his joviality and innate kindness, kin to all mankind. He was as much at home with a simple coal miner as at the banquet tables of the great and near great. His fame as a raconteur was widespread, and his lectures commonly illustrated with colored slides of his own manufacture, were in constant demand. That such a lovable character out of the "old school" will be keenly missed and kindly remembered, in many circles in addition to the scientific, is a poor understatement. His good friends were legion. They ranged from eight to eighty, from the impoverished to the affluent, from the uneducated to intellectuals.

Dr. Noé is survived by his wife and his daughters, Valerie Noé and Mary Helen Noé, wife of Professor Robert S. Mulliken, of the department of physics, University of Chicago.

Carey Croneis.

STATE OF ILLINOIS
HENRY HORNER, Governor

TRANSACTIONS

OF THE

ILLINOIS STATE ACADEMY OF SCIENCE

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TRANSACTIONS OF THE ILLINOIS STATE ACADEMY OF SCIENCE

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CONTENTS

PAPERS IN AGRICULTURE

PAGE

Extract From the Report of the Section Chairman.......... 39
Appleman, M. D. and Sears, O. H., Azotobacter flora of the Morrow plots.......... 40
Brannon, J. M., A Taxonomic study of some bacteria found in ice cream.......... 42
Copper, Robert R., Hybrid corn stabilizes corn yields.......... 43
Farrar, M. D. and Flint, W. P., Insect abundance around wild life area.......... 46
Henderson, Melvin, Improvement in agriculture through the assistance of vocational-agriculture instructors 47
Smith, L. H., Vagaries of some Illinois soils.......... 48
Koehler, Benjamin, Does it pay to make an individual ear test of hybrid corn?.. 50
Whalin, Oren L., Residual benefits resulting from activities in connection with agricultural adjustment programs.......... 51
Snider, H. J., Relationship in soils of total nitrogen, total replaceable bases and productivity 53
Sears, O. H. and Burlison, W. L., Effects of the soybean crop on soil productivity 54

PAPERS IN ANTHROPOLOGY

From the Report of the Section Chairman.......... 57
Gumbart, L. F., Prehistoric botany.......... 58
Mohrman, Harold, The detection of fraudulent copper needles.......... 60
Schoenbeck, Ethel, Discovery of a buried aboriginal shellheap in the Illinois River valley 61
Soper, Stanley, Ornamentation among the American Indians.......... 63
Stephens, B. W., Engraved shell gorgets from Illinois.......... 66
Spooner, Harry L., The historic Indian villages of the Peoria Lake region.......... 67

PAPERS IN BOTANY

From the Report of the Section Chairman.......... 73
Shull, Charles A., Variations in carpel number of *Abutilon theophrasti*.......... 74
Fuller, Harry J., The Blackman interpretation of plant growth.......... 75
Thut, H. F., Water absorption by leaves.......... 77
Welch, Walter B., A study of the relation of cicatrization to evaporation from leaves of *Bryophyllum* 78
Edgecombe, A. E., Differential distribution of ash along the axis of herbaceous plants 79
Myers, R. Maurice, Factors affecting the abscission of the leaves of *Coleus blumei* 80
Stevens, Neil E. and Larsh, Howard W., Carbohydrate utilization by *Diplodia macrospora* 82
White, Elizabeth, Plants of the Smoky Mountains.......... 82
Vestal, A. G., Why the Illinois settlers chose forest lands.......... 85
Reihmer, Vernoy A., The composition of prairie vegetation in Illinois.......... 87
Ries, Donald T., Additions to the flora of Starved Rock State Park.......... 89
Tiffany, L. H., The Oedogoniales of Illinois.......... 90
Kaeiser, Margaret, The pollen of certain Taxodiaceae.......... 91
Cook, Phyllis L., Pollination drops in certain conifers.......... 93
Moon, Geraldine, Notes on the histology of an Illinois Psaronius.......... 95
Terwilliger, George L., Plant cover for wild animals during the winter season.... 98

PAPERS IN CHEMISTRY

PAGE

From the Report of the Section Chairman 99
Cheronis, Nicholas D. and Freud, Henrietta, Technics for large group demonstration 100
Cheronis, Nicholas D., Hydrolysis of tertiary alkyl halides 101
Egloff, Gustav, Motor fuels over the world 103
Hanke, A. R. and Reedy, J. H., A modified tin sub-group procedure 114
Higley, L. Allen, Marihuana 116
Nicholson, Douglas G. and Schuler, Richard H., Uniformity in cigarettes 118
Rees, O. W. and Land, G. W., Special study of vapor pressures of saturated salt solutions 119
Rees, O. W. and Kalinowski, M. L., Some chemical changes in coal samples during storage 120
Rees, O. W. and Henline, P. W., A comparison of the chemical characteristics of crude oils produced in the old and new Illinois fields 122
Roberts, Richard G. and Horvitz, Herman J., Liquid ammonia as a dietary nitrogen supplement 124
Schmeing, G. M., A new approach to first year chemistry 127
Simon, Wilbur and Reedy, J. H., An absorption bulb for detecting various gases 128
Swift, Elijah, Jr., Quantitative estimations in the qualitative course 130
Thiessen, G. W., A pH experiment for the first course in chemistry 131
Taebel, W. A. and Hopkins, B. S., The chemistry of europium 132
Yohe, G. R. and Harman, C. A., Preparation of humic acids from Illinois coal 134

PAPERS IN GEOGRAPHY

From the Report of the Section Chairman 137
Blanchard, W. O., Wanted—More variety in the geographic menu 138
Gunnell, E. Mitchell, Ecological and historical aspects of Leadville, Colorado, as typifying the pure saxicultural adjustment 139
Josey, Elizabeth, Geography of the Mississippi Gulf Coast 140
Holcomb, E. W., Illinois rainfall 142
Cozzens, Arthur B., Natural regions of the Ozark Province 144
Branigar, Harvey W., Jr., The Guatemala Highland 146
Barton, Thomas F., Recreation possibilities of the Shawnee National Forest Purchase Units 149
Lathrop, H. O., A day of tornadoes in the middle west 153
Lemons, Hoyt, Geographic aspects of inter-areal transition 158
Booth, Alfred W., Distribution of Japanese cities 160

PAPERS IN GEOLOGY

From the Report of the Section Chairman 163
Ball, John R., Silurian rocks of southern Illinois 164
Borger, Harvey, Recovery and preservation of marcasitized and pyritized microfossils 166
Cohee, George V. and Carter, Charles W., Structural trends in the Illinois Basin 166
Ekblaw, George E., Some geological factors in the location and construction of the Lake Springfield dam 169
Payne, J. Norman, The age of the LaSalle anticline 171
Weller, J. Marvin, Progress in geologic mapping of Illinois, 1839-1939 173
Willman, H. B., The Covel conglomerate, a guide bed in the Pennsylvanian of northern Illinois 174

PAPERS IN PHYSICS

PAGE

From the Report of the Section Chairman 177
Bockstahler, Lester I., Experimental production of vortex rings 178
Eaton, D. L., A novel homemade electrostatic generator and Zeleny electroscope assembly 178
FitzGerald, Alan S. and Bulliet, L. J., Saturating reactors for control purposes.. 179
Knipp, Charles T., Further experiments with singing tubes 181
Haworth, L. J. and Manley, J. H., A high voltage neutron source 183
Riche, A. L., How engineers use basic scientific facts—illustrated by a concrete example 184
Taylor, Hawley O., A theory of the acoustic efficiency of the telephone receiver.. 185
Therese, Sister Mary, The one hundred twenty foot pendulum at Mundelein College 188
Way, H. E. and DeVries, John, Microphotographs of single crystals of zinc containing small known amounts of iron 189

PAPERS IN PSYCHOLOGY AND EDUCATION

From the Report of the Section Chairman 193
Cavan, Jordan T., Social factors determining trends in western colleges 194
Cloud, D. T., The education of deaf children by the acoustic method 196
Jacobsen, O. Irving, Eye-movements in reading music 199
Pringle, Ralph W., Psychological functioning of the endocrine glands 201

PAPERS IN ZOOLOGY

From the Report of the Section Chairman 203
Eigenbrodt, H. J., and Zahl, Paul A., The relationship of body size and egg size in *Drosophila* 204
Graham, Robert and Hester, H. R., Equine encephalomyelitis 205
Hansen, Donald F., Variation in the number of spines and rays in the fins of the brook stickleback 207
Hoogstraal, Harry, Expeditioning in Mexico 213
Iknayan, N. C., Thoracico-abdominal venules, their etiology and treatment 214
James, Marian F., Studies on starvation in largemouth bass 220
Levine, Norman D., Observations on *Balantidium coli* in culture 221
Lueth, Francis X., A case of poisoning in the cotton-mouth moccasin 222
Owen, Seward E., Mammary tumor location in mice 223
Sharp, Cecil A. Z., Tularemia in Illinois 225
Slabaugh, Ruth E., The silverfish in a new role 227
Stone, Philip C., Notes on the predaceous stink bug, *Apateticus cynicus* Say 228

LIST OF SPEAKERS

A committee designated by the Council of the Academy has prepared a list of speakers who are willing to present talks on various phases of science before interested groups. Unless otherwise indicated, these speakers are willing to give their services for expenses only. In some cases a small honorarium is expected. A copy of this list of speakers may be obtained gratis by sending a request to:

Robert F. Paton, *Secretary*,
Academy of Science,
Physics Building,
Urbana, Illinois.

Papers In Agriculture

Extract From the Report of the Section Chairman

The Agriculture Section carried fourteen papers, ten of which are herewith published. The others were as follows:

Corn hybrids resistant to bacterial wilt and stalk-rotting diseases, by J. R. Holbert, Funk Brothers Seed Company, Bloomington.

Plowing dates as they affect abundance of corn root aphids, by J. H. Bigger, State Natural History Survey, Urbana.

Abnormalities resulting from crossing individual corn plants, by C. M. Woodworth, Illinois Agricultural Experiment Station, Urbana.

Trends in rural organization, by D. E. Lindstrom, University of Illinois, Urbana.

The twenty-three people attending elected as chairman of the 1940 meeting *Melvin Henderson,* 213 New Agriculture Building, University of Illinois, Urbana, Illinois.

(Signed) George H. Dungan, *Chairman*

AZOTOBACTER FLORA OF THE MORROW PLOTS

M. D. Appleman and O. H. Sears

University of Illinois, Urbana, Illinois

Of all the elements required for the growth and reproduction of plants, nitrogen is the most expensive. It is not only difficult to secure but, next to calcium, it is the most readily lost by leaching. The need for nitrogen as a plant-food element exists in spite of the fact that crops actually live in a sea of nitrogen. Three-fourths of the atmosphere about us is composed of this essential element, an amount sufficiently large to produce 69 million bushels of corn per acre. Yet curiously enough, corn yields on most Illinois soils are limited by a deficiency of available nitrogen. Just as one shipwrecked on the ocean may die of thirst, so may plants suffer from nitrogen starvation when bathed with this element.

Fortunately, farmers have many workers in the soil which help to bridge the gulf between crop-plants and atmospheric nitrogen. One group of these workers is the azotobacter group, one kind of free-living nitrogen-fixing bacteria. These microorganisms depend upon the organic matter of the soil for energy and for non-nitrogenous building material, but secure their nitrogen needs from the atmospheric supply.

Unlike some bacteria, the azotobacter are seldom found in soils having a low pH (acidity value). Consequently, one would not expect to find them in the untreated soils of the Morrow Plots, the oldest agricultural soil-experimental plots in the United States. The pH of the soils in these plots is below the assumed critical pH (5.9 – 6.0) for azotobacter growth as indicated in Table 1.

In 1937, when corn grew on all plots, studies were made of their microorganic population, including azotobacter.

The azotobacter were studied by the soil-plaque (2) and by the selective-culture methods (1). In each case typical azotobacter growth was observed from the soils of all plots. With both methods soil from Plot 3 S.W. produced the most abundant growth and Plot 5 S.W. the least abundant growth of these organisms. These data indicate that under some conditions azotobacter are present in soils more acid than pH 5.8.

Although the experiment was repeated with similar results, the possibility that the growth of azotobacter was the result of contamination of the untreated plots with small amounts of soil from the treated ones still remained. Consequently a dilution method of determining the numbers of azotobacter in the soil of each plot was used. The results of these counts are given in Table 2.

These data indicate that all plots with a low pH contain more than 2,500 azotobacter per gram of soil. This large number of organisms suggests that the positive azotobacter observations given in Table 1 are the result of a natural azotobacter flora and not to contamination. The reason for the low count from Plot 5 S.W. is not clear.

A determination of the numbers of azotobacter in a soil is not necessarily a criterion of the nitrogen fixation which occurs in the soil. Consequently, the nitrogen-fixing ability of the soils was determined in the laboratory. After supplying energy material in the form of mannitol at the rate of one gram per 100 grams of soil, the soils were continuously aerated and incubated at room temperature for a period of 35 days. The results of this determination are given in Table 3.

Table 1—Crop Rotation, Soil Treatment, and pH of the Morrow Plots, Urbana, Illinois

Plot number	Crop rotation	Soil treatment	pH
3 N. W	Continuous corn	None	5.1
3 S. W	Continuous corn	Manure, limestone, rock phosphate	5.9
4 N. W	Corn, oats	None	5.1
4 S. W	Corn, oats, sweet clover, green manure	Manure, limestone, rock phosphate	6.8
5 N. W	Corn, oats, clover	None	5.3
5 S. W	Corn, oats, clover	Manure, limestone, rock phosphate	6.8

TABLE 2—GROWTH OF AZOTOBACTER AT SEVERAL DILUTIONS OF SOIL FROM MORROW PLOTS

Plot number	Growth at dilution of—					
	1 : 100	1 : 500	1 : 1,000	1 : 2,500	1 : 5,000	1 : 10,000
3 N. W.	+	+	+	+	+	—
3 S. W.	+	+	+	+	+	+
4 N. W.	+	+	+	+	+	—
4 S. W.	+	+	+	+	+	—
5 N. W.	+	+	+	+	—	—
5 S. W.	+	+	—	—	—	—

The soil from each plot gained in nitrogen during the incubation period. These results of nitrogen fixation do not prove that azotobacter were responsible for the increase in nitrogen. However, the soils were aerated continuously and it is reasonable to assume that anaerobic nitrogen fixation was very small, if it occurred at all.

With the exception of Plot 5 N.W. the soils receiving field treatment fixed appreciably larger amounts of nitrogen than the untreated soils. This situation occurred in spite of the fact that the numbers of azotobacter were as large on the untreated as on the treated plots. Thus one may reason that a favorable soil condition as well as the presence of azotobacter is necessary for maximum nitrogen fixation.

In spite of the fact that nitrogen fixation was demonstrated in the laboratory, the amount of nitrogen fixed under field conditions is not sufficient to balance the losses due to leaching and crop removal.

Table 4 shows the amounts of nitrogen removed by the crops grown on the plots from 1913-1933 and the total nitrogen losses from the soil for the same period.

Only data from the untreated plots are included in the table because no information is available with reference to the amount of nitrogen added to the treated plots in the manure.

In the continuous corn plots where maximum leaching has occurred, nitrogen fixed by the microorganisms has not been sufficient to balance nitrogen losses due to leaching and crop removal.

In the corn, oats rotation the nitrogen lost from the soil is practically the same in amount as the nitrogen removed by the crops, indicating that fixation has been approximately equal to the removal of nitrogen by leaching and by other means.

In Plot 5 N.W. there is apparently a removal of almost 300 pounds more of nitrogen in the crop than was removed from the soil. This means that in the corn, oats, clover plot the non-symbiotic and symbiotic organisms associated with the red clover crop have not only balanced the loss by leaching but have been able to partially overcome the nitrogen losses due to crop removal.

Undoubtedly, the nodule bacteria have contributed largely to this gain. Thus it is impossible to evaluate the effect of non-symbiotic fixation on the nitrogen addition to the soil.

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1. Fred and Waksman. Laboratory manual of general bacteriology. McGraw-Hill Book Company, Inc. 1st edition (1928), p. 32.
2. Winsgradsky, S. Etudes sur la Microbiologie du Sol: I. Sur la Methode. Ann. Inst. Pasteur. V. 39, (1925), pp. 299-354.

TABLE 3—NITROGEN FIXATION OF MORROW PLOT SOILS UNDER LABORATORY CONDITIONS

Plot number	Nitrogen content of soil (Mgm. per 100 grams soil)		Mgm. nitrogen fixed per gram mannitol
	At beginning	After incubation	
3 N. W.	139.0	142.6	3.6
3 S. W.	162.6	170.0	7.4
4 N. W.	158.6	164.0	5.4
4 S. W.	193.0	212.0	9.0
5 N. W.	171.0	175.0	4.0
5 S. W.	211.6	214.0	2.4

Table 4—Nitrogen Removed by Crops, and Total Nitrogen Lost from the Soil as Indicated by Chemical Analysis

Plot number	Crop rotation	Total nitrogen lost from the soil	Nitrogen removed in the crops
		lbs.	*lbs.*
3 N. W.	Continuous corn	1,210.0	431.0
4 N. W.	Corn, oats	670.0	649.0
5 N. W.	Corn, oats, clover	690.0	976.5

A TAXONOMIC STUDY OF SOME BACTERIA FOUND IN ICE CREAM

J. M. Brannon

University of Illinois, Urbana, Illinois

In the Spring and Summer of 1936, the Dairy Department of the University of Illinois made a survey of the ice cream sold in the State of Illinois. Five hundred samples of ice cream were collected and analyzed for composition and bacterial content. The bacterial analyses of these samples will be considered in this paper.

A small amount of each sample of ice cream was put in a sterile half-pint milk bottle in order to obtain the total bacterial count. These bottles were allowed to stand in a warm room for a few minutes until the small portions of the ice creams melted. Then eleven grams of each sample of melted ice cream were weighed in bottles containing ninety-nine cc. of sterile water. This gave a dilution of one gram of ice cream to nine cc. of sterile water. Besides this, dilutions of one to nine, dilutions of one to a hundred, one to a thousand and one to ten thousand were made. Four media were used to determine coli. These media were eosine methylene-blue agar, red-violet bile agar, 2 per cent brilliant green fermentation tubes, and formate ricinoleate fermentation tubes. The last medium gave the highest number of positives for coli.

A table giving the total bacteria count for all the ice creams would be too large for this paper. The following summary will give an idea of the results secured. Thirty per cent of the samples of ice cream collected had a bacteria count of more than a million per gram. Seven per cent had a count between 1,000,000 and 500,000. Sixteen per cent had a count between 500,000 and 100,000. Seventeen per cent had a count between 100,000 and 50,000 and twenty per cent had less than fifty thousand. Then there was about six per cent which was not included in the above summary but they all had less than a hundred thousand bacteria per gram and most of them had less than fifty thousand. There were sixteen samples which had so many bacteria that the plates could not be counted at 10,000 dilution. Sixty per cent of all the ice creams examined showed the presence of the *coli aerogenes* group.

After the plates were counted, the predominant organisms on each plate were transferred to agar slants to be used for identification. No coli were used because their presence was shown by special media. The descriptive chart was used as the guide to determine the characteristics of these organisms. Most of the media used were prepared according to the formula given in the Manual for Pure Culture Study of Bacteria. Bergy's manual was used to determine the names of the organisms.

Before any attempt was made to classify an organism, it was first transferred to a fresh agar slant and allowed to grow for 48 hours. It was then inoculated into a tube of broth and incubated 24 hours and then it was inoculated into a second tube of broth and allowed to grow for another 24 hours. It was from this second tube of broth that the work of identification was started.

After one spends a few weeks classifying bacteria, he notices discrepancies in the manual. It also becomes apparent that some organisms will not check every time they are run through the procedure called for in the descriptive chart and sometimes when they do seem to check they will not exactly fit any description given in the manual. Some of the organisms reported in this paper were run ten times before satisfactory checks were obtained. It is evident that the classification of bacteria is not an exact science.

A list of the organisms so far classified is as follows:

Genus	Species
Micrococcus	*Viscosus*
"	*auranticocus*
"	*subcitrus*
"	*cosiolyticus*
"	*Mucofaciens*
"	*varicens*
"	*cereus*
"	*subflavescens*
"	*flavis*
"	*ureae*
"	*flavescens*
"	*subcitreus*
"	*luteus*
"	*luteolus*
"	*conglomeratus*
"	*chersonesia*
"	*Frindenneichii*
"	*candidus*
"	*saccatus*
Rhodococcus	*corallinus*
Clostridium	
Pseudomonas	*rugosa*
"	*putida*
"	*synayanea*
Aerobacter	*Levans*
"	*oxytocum*
"	*aerogenes (ropy)*
"	" *(not ropy)*
"	*hibernicum*
Sarcina	*lutia*
"	*Aurantiaca*
Proteus	
Achromobacter	*reticularium*
"	*Lipolyticum*
"	*Venosum*
"	*connii*
"	*viscosum*
"	*hyalinum*
"	*coaduncetum*
"	*heati*
"	*desmolyticum*
"	*fairmounteuse*
"	*putrifacteus*
"	*geniculatum*
"	*aromafaciens*
Flavobacterium	*aurescens*
"	*solere*
"	*aurcentium*
"	*lactis*
"	*Flavescens*
Bacillus	*pransuitzii*
"	*mesentericus*
"	*megatherium*
"	*cereus*
"	*sphaericus*
"	*Teres*
"	*vulgatus*
"	*amorus*
"	*Thermodiastaticus*
"	*graveoleus*
"	*Kaustophilus*
"	*Thermononliquefcoens*
"	*ruminatus*
"	*ablaciis*
"	*simplex*
"	*hessi*

HYBRID CORN STABILIZES CORN YIELDS

Robert R. Copper

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A study has been made to determine whether hybrid corn stabilizes corn yields, and what might possibly be expected in the future by the use of adapted hybrids.

In order to ascertain whether or not hybrid corn has stabilized corn yields, a study was made of data from the 1934 to 1938 Illinois corn performance test bulletins. The annual yields for hybrids and for open-pollinated varieties were taken, and the average yields calculated. The percentage by which the annual yield of each hybrid fell below or exceeded the average yield of that hybrid over a period of years was taken to be yield variability. These annual percentage fluctuations were averaged to represent the variation for a period of years.

The results of the three- and four-year averages (Fig. 1) show that the lowest fluctuation of yields was in the northeastern section of the state, and that the fluctuation increased progressively for the northern and north-central, reaching a peak in the central section. The south-central and southeastern sections had a slightly smaller variability than the central section. Six hybrids in northeastern Illinois fluctuated only 5.5 per cent from the three-year average, while five hybrids in the central section had a very wide variation of 30.7 per cent. Hybrids in the south-central section fluctuated 29.9 per cent, but in this case there were only three hybrids considered.

The percentage variation of the open-pollinated varieties, though higher showed the same tendency to increase from the northeastern section to the central section, as did the hybrids. The lowest per cent fluctuation, 13.3 per cent, occurred in northeastern Illinois, and the highest variation was 35.0 per cent which

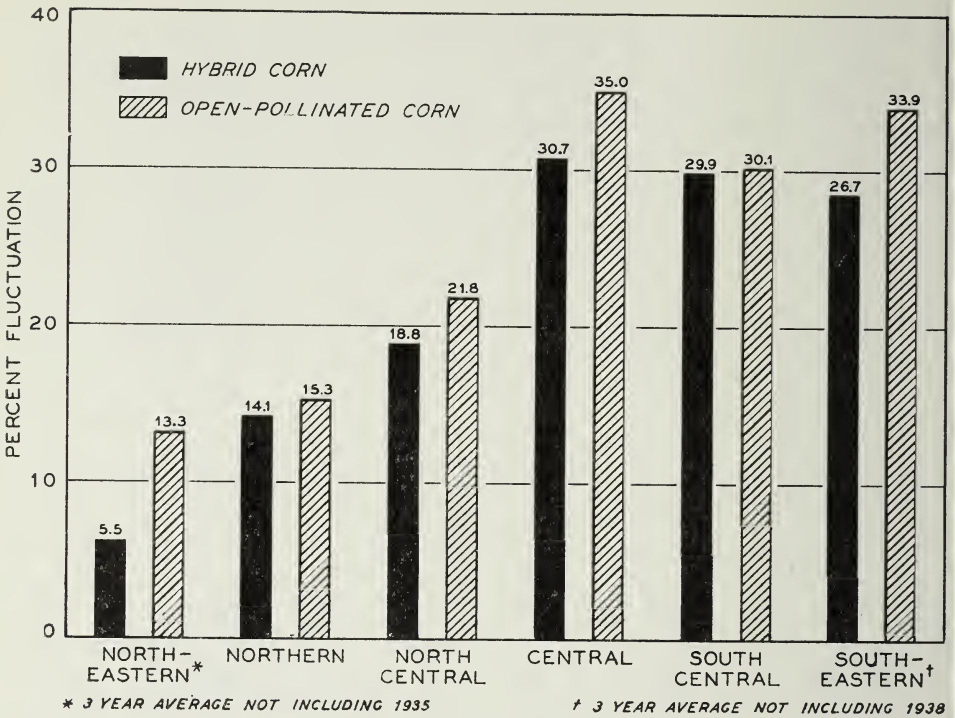
HYBRID CORN
OPEN-POLLINATED CORN
PERCENT FLUCTUATION
40
30
20
10
0
5.5
13.3
14.1
15.3
18.8
21.8
30.7
35.0
29.9
30.1
26.7
33.9
NORTH-EASTERN*
NORTHERN
NORTH CENTRAL
CENTRAL
SOUTH CENTRAL
SOUTH-EASTERN†
* 3 YEAR AVERAGE NOT INCLUDING 1935
† 3 YEAR AVERAGE NOT INCLUDING 1938

Fig. 1

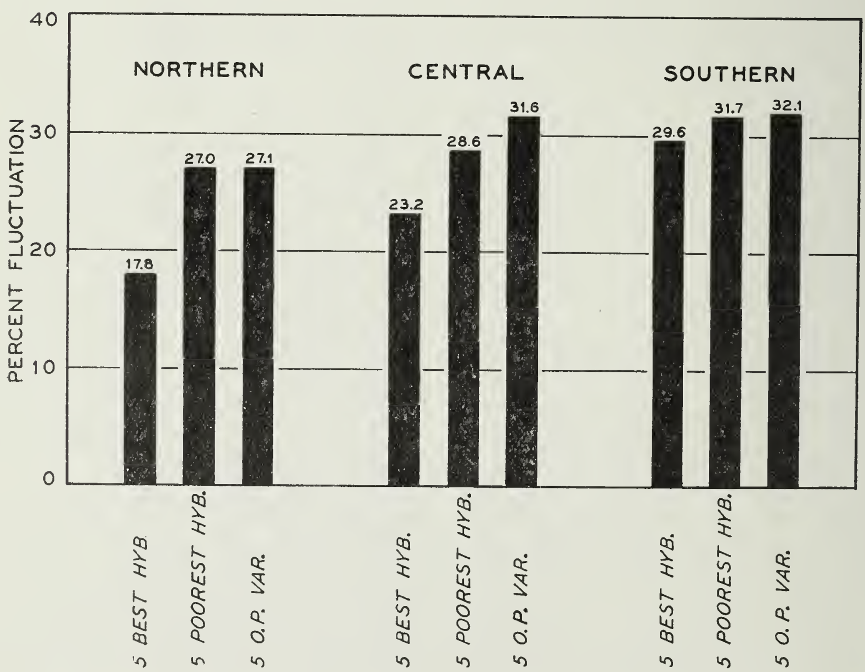
PERCENT FLUCTUATION
40
30
20
10
0
NORTHERN
CENTRAL
SOUTHERN
17.8
27.0
27.1
23.2
28.6
31.6
29.6
31.7
32.1
5 BEST HYB.
5 POOREST HYB.
5 O.P. VAR.
5 BEST HYB.
5 POOREST HYB.
5 O.P. VAR.
5 BEST HYB.
5 POOREST HYB.
5 O.P. VAR.

Fig. 2

occurred in central Illinois. It should be pointed out, however, that there were only two open-pollinated varieties included except in the northern, and south-central sections where there were three.

The difference in per cent fluctuation between the hybrids and the open-pollinated varieties indicates whether hybrids do or do not tend to stabilize yields. In all of the sections, except the south-central and possibly the northern, there is a distinct advantage in favor of the hybrids stabilizing yields. Northeastern Illinois, the section with the lowest variability, had the highest difference between the hybrids and the open-pollinated varieties. South-central Illinois gave only a 0.2 per cent variation in favor of the hybrids stabilizing yields. In contrast to northeastern Illinois, northern Illinois hybrids had an advantage of only 1.2 per cent.

Individual sectional results indicate there is a wide variation among the hybrids. For example, in northeastern Illinois one hybrid had an average annual fluctuation as low as 3.2 per cent, and the one with the most average annual fluctuation had a variation of 9.2 per cent. One hybrid exceeded the average fluctuation of the open-pollinated varieties in the northern, north-central, east north-central, central, west-central, and south-central sections.

A comparison (Fig. 2) was made of the average of the five best hybrids, the average of the five open-pollinated varieties, and the average of the five poorest hybrids for the past five years in three sections of Illinois. In northern Illinois the five best hybrids had nearly a 10 per cent advantage over the open-pollinated varieties and five poorest hybrids in the stabilization of yields. In two of the five years the five best hybrids had a fluctuation of more than 20 per cent. The five poorest hybrids and the five open-pollinated varieties fluctuated more than 20 per cent three and four years, respectively. In central Illinois the five poorest hybrids did not fluctuate as much as the open-pollinated varieties by 3 per cent. The five best hybrids fluctuated 8.4 per cent less than the open-pollinated varieties. The best hybrids fluctuated more than 20 per cent in only one year. Both the open-pollinated varieties and the poorest hybrids varied more than 20 per cent in four of the five years. The five best hybrids for the southern section fluctuated 3.0 percentage points less than the five open-pollinated varieties, and only 1.1 percentage points less than the five poorest hybrids. The five best hybrids and the five poorest hybrids fluctuated more than 20 per cent in three of the five years, and the open-pollinated varieties exceeded this variability in only two of the five years.

All this would indicate a slight tendency for hybrids to stabilize yields in southern Illinois, while in northern and central Illinois adapted hybrids have already definitely stabilized the corn yields.

Explanation of Figures

Fig. 1.—Average annual fluctuations from the average yield for hybrid corn and open-pollinated corn grown in the four years 1935-38, in six sections of Illinois.

Fig. 2.—Average annual fluctuations from the average yield of the five best hybrids, the five poorest hybrids, and the five open-pollinated varieties for the five-year period, 1934-38, in three sections of Illinois.

INSECT ABUNDANCE AROUND WILD LIFE AREA

M. D. Farrar and W. P. Flint*

The question of what combinations of environments bring about the greatest concentration of crop pest insects is one of interest to every Illinois farmer. To get the correct answer to this question is far from easy; in fact we have at present only fragmentary data from which to draw any conclusions that might be used in giving the correct answer.

During the past four years an attempt has been made to gather data that may be used in answering the above question. Most of the work to date deals with the relative abundance and destructiveness of some of our more important field-crop pests in and immediately adjoining forest and wildlife protected areas, and with the abundance of the same pests in intensely-cultivated areas. The first work along this line was done in Christian county, where, through the efforts of the late Col. Seamans, an area of approximately 80 square miles of farm land was organized in such a way that most of the wildlife within the area would be protected. Only preliminary data were gathered in this area when, due to the sudden death of Col. Seamans, the project had to be abandoned.

During the last two and one-half years data have been taken at regular intervals in an adjoining large tract of woodland consisting of about five thousand acres. In this area wildlife of all kinds is carefully protected, and the owner is endeavoring to maintain this area in as nearly a natural condition as possible. This tract is the Allerton estate, and it is only through the permission and cooperation of the owner that these studies have been possible. The project has not been continued long enough to allow us to draw any definite conclusions from the data thus far obtained. Such data as we have indicate that destructive insect pests are not as abundant in and immediately adjoining this area as is the case in an area five miles distant where at least 80 per cent of the land is under cultivation. The data taken have included regular collections of foot-square areas within the protected areas, these collections being made during the months when insects are in hibernation. Similar data are taken at the same time in the cultivated section. Observations on injury to field crops are made during the active season in an area of farm land adjoining the protected woodland, and also in the cultivated areas.

Comparisons in abundance of hibernating insects in areas under observation have been made by the periodic collections of cover containing the insects. Suitable types of insect hibernating quarters were selected and square-foot samples taken. By placing over the trash a metal ring having a square-foot area, all material down to solid soil was gathered into a paper bag. The collection of insects is obtained by placing the trash sample in a metal funnel about 10″ in diameter at the top, with a coarse screen suspended about 5″ from the top. By covering the funnel-top with cloth and heating the top of the funnel with a light bulb, resistance unit, or steam, the insects are driven downward and collected in a bottle of 70 per cent alcohol at the bottom of the funnel. The specimens in alcohol can then be sorted when convenient.

These data to some extent can be applied to the general area of central Illinois. To be of any value the work must be continued over a period of years. It would be decidedly helpful if others could assist in the work by taking similar data at other points in central and northern Illinois.

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IMPROVEMENT IN AGRICULTURE THROUGH THE ASSISTANCE OF VOCATIONAL-AGRICULTURE INSTRUCTORS

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Perhaps this paper could be summarized by the five following statements: (1) Permanent improvement in agriculture is closely associated with education. (2) Vocational-agriculture instructors, because of their training and opportunities for almost daily intimate contact with farm boys and their parents, are in a position to render signal service in improving agriculture. (3) The majority of vocational-agriculture instructors are recognized by the farmers in their communities as being capable leaders. (4) There is a sincere desire on the part of the vocational-agriculture instructors to do all in their power to improve agricultural conditions. And (5) There are several reasons why more assistance is not being given by the vocational-agriculture instructors in programs seeking improvements in agriculture. Perhaps it would be desirable to consider each of these statements in a little more detail.

Permanent improvement in agriculture is closely associated with education. The development and use of improved varieties of seeds, the improvement in the design of farm machinery, and improved farming practices have been the result of education. Teaching occurs when the behavior of an individual is changed. The mere distribution of information is not necessarily teaching. The development of desirable attitudes while not limited to the school, has been considered for years as one of the functions of education and certainly few would attempt to deny that teachers, with their background and training in education and psychology should be qualified to undertake this important educational phase of the work. To mold the thinking and attitudes of an individual so that these will be most valuable for the individual and for society is an art. Proper attitudes play an important part in the objective of a satisfying farm life. Surely permanent improvement in agriculture is closely associated with education.

Vocational-agriculture instructors, because of their training and because of their opportunities for almost daily intimate contacts with farm boys and their parents, are in a position to render signal service in improving agriculture. No other teacher in the entire school system has as good an opportunity to become as intimately acquainted with his students, with their home conditions, their ambitions and desires, and their disappointments and sorrows. He usually enjoys the confidence of the boy and his parents. He is in a key position to reach the farmer and to make suggestions. He visits the boys at their homes; he talks to the parents; often he has the older brothers in part-time classes and the fathers in the adult evening classes. His area of influence may not be as large as that of other agricultural workers, but he often exerts more influence in his local community than do those other workers having larger areas. What individual in the community as much as he, enjoys such opportunities for intimate contact with those upon whom the burden for improvement in agriculture must finally rest?

The majority of these instructors are recognized by the farmers in their communities as being capable leaders. The very fact that 56 vocational-agriculture instructors in Illinois have been in the same position for 10 years or longer is an indication as to how well they are meeting the demands placed upon them, especially when one considers that there were only 187 vocational-agriculture departments in Illinois 10 years ago. It is true that the ability of a leader cannot be measured entirely by years in a given position. In this case we have to consider the vocational-agriculture instructor as intimately associated with his employers, acting as their instructor which makes the generally-satisfactory, long-time tenure seem all the more remarkable.

There is a sincere desire on the part of the vocational-agriculture instructor to do all in his power to improve agricultural conditions. The wise instructor appreciates the responsibility that rests upon him when farmers come to him for advice. He realizes that many will follow his advice and that results will prove whether the advice was good. His home is in the local community which he serves and if he wishes to continue that home and merit advancement, he must satisfactorily advise those who seek his advice.

There are several reasons why more assistance is not being given by the vocational-agriculture instructors to programs for improvement in agriculture. One of the reasons is undoubtedly due to the fact that those in charge of preparing informational material for the teacher do not appreciate his problems and the situation which he faces. Probably much of the published material which is reaching the agriculture instructors represents a sincere effort to improve agricultural conditions and to provide material suitable for use by the teachers. It is a regrettable fact that many of these efforts have more or less failed. Teachers frequently remark that they receive such a mass of material that they do not open it. They may hasten to add that some of it is quite satisfactory but will admit that they do not have time to select out the material that can be used. In a few isolated cases there is perhaps another reason why more assistance is not being given by vocational-agriculture instructors in programs seeking improvements in agriculture. This relates to petty jealousy either on the part of those directing some program or on the part of the vocational-agriculture instructor. Such cases are, however, rare in Illinois.

I have attempted to show that permanent improvement in agriculture is closely associated, if not dependent upon, education; that vocational-agriculture instructors, because of their training and intimate contacts with farm boys and their parents, are in a position to render outstanding service in improving agriculture; that the majority are recognized by the farmers in their communities as being capable local leaders and that there is a sincere desire on the part of the vocational-agriculture instructor to do all in his power to improve agricultural conditions. Certainly we all hope that vocational-agriculture instructors and those charged with the responsibilities of various programs for agricultural improvement will work together in the future even more harmoniously than in the past, and that, insofar as funds, time, and ability will permit, every effort will be made to improve teaching aids with the assistance of the vocational-agriculture instructors.

VAGARIES OF SOME ILLINOIS SOILS

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How often it happens that farm practice is based on what is popularly called "snap judgment." The trial of a new fertilizer treatment gives a certain result—if favorable, the practice is adopted without more ado, but if the result happens to be unfavorable, the thing is condemned and the matter is settled, presumably.

Experimental fields often return results of a single season that are by no means normal or reliable. To illustrate such a case we might turn to the record of the famous Morrow Plots located on the University campus. On one of the plots last year the yield of corn was 62 bushels an acre. Two years before, the yield of this same plot was 16 bushels an acre. Careful tests frequently reveal just such discrepancies in annual yields. A fair test of this kind ought to run over a period of three to five years before very much confidence can be placed in the result. Similarly, the trial of a new variety of seed cannot show its reliability on a single year's test because of the numerous circumstances that can turn the result one way or another. Weather conditions seldom remain constant from one year to another and, therefore, a specific variety cannot be expected to react identically in different seasons.

Fortunate are we who are charged with investigational work, when we have a field with a long-continued record to refer to—one in which the vicissitudes of a single season will not necessarily upset the whole history of the field.

Illinois has a number of long-time soil experiment fields located at different points in the state. There are more than two dozen such fields that have a record of 24 years or more. The oldest one of these fields is located on the campus of the University and is known as the Morrow Plots. These plots were established 63 years ago. Here we have represented three different systems of cropping, a three-year rotation of corn, oats, and clover; a two-year rotation of corn and oats, and a plot that remains continuously in corn year after year.

Naturally, great differences have resulted in the productiveness of these plots. For example, two years ago when all the plots were planted to corn, the yield on the continuous corn plot, without treatment, was 43 bushels an acre, while on the plot under the three-year rotation the yield was 67 bushels. The outstanding truth demonstrated on these plots is that crop rotation, beneficial as it is, will not of itself permanently maintain the fertility of the soil, in spite of a rather widespread belief to the contrary. This important fact is of such a nature that it can be demonstrated only by long years of careful observation. No single year's test could have told us this fact with any reliability.

Let us turn briefly to some of the other long-continued soil experiment fields. For the most part these fields are laid out to represent the livestock system of farming as well as the grain system. In the former system organic matter is maintained in the soil by the use of animal manure, while in the grain system the plowing under of legume crops along with stalks or other crop residues takes the place of the manure.

There is a very great range in the natural productiveness of these 25 fields. In a recent summary of the results from the untreated soil or the check plots, the most productive of these fields yielded over six times as much per acre as the least productive field.

It was found further that, with a single exception, every field responded with some gain in yield by one or more of the various treatments applied. In general, the largest gains were made on the soils that were naturally lowest producing. It happened that on the field showing the highest natural productiveness there was no gain whatever in yield by any treatment tried.

The greatest gains in yields from the seven fertilizer systems compared were made on the fields of low natural productiveness. On several of these fields of poor soil the yield was increased to three-fold by the use of the most effective fertilizer applied.

It is of interest to observe what kind of fertilizer gave the highest yield. As already mentioned, only in one case of the 25 fields no fertilizer gave an increase. Manure, used alone, gave the highest yield on two of the fields. In seven cases the effective combination was residues and limestone, while on nine other fields it was manure and limestone. On three fields the best results were secured by the use of the combination of residues, limestone and phosphorus and on three fields the winning combination was residues, limestone, phosphorus and potassium.

Thus we find that no single combination of plant food will serve best on all soils, but what is of equal importance that these fields have taught us, is that a similar study a few years later will show that their fertility requirements in many cases will have changed; at least, in the past, a change in their requirements has been shown from time to time. In other words, soil conditions do not remain stationary.

Herein lies the benefit of the long-time experiment field. The majority of these fields showed from the beginning a benefit from the application of limestone. A few fields, however, showed no distinct advantage for several years in adding limestone, but after a time under the cropping system, a need for lime gradually developed. This same principle has been illustrated in the use of other fertility elements such as phosphorus and potassium.

These experiences bring home the fact that the farmer's soil problem is never settled once and for all, but for the highest success constant watchfulness and study must ever be maintained.

DOES IT PAY TO MAKE AN INDIVIDUAL EAR TEST OF HYBRID CORN?

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With the advent of hybrid corn, changes in the handling of seed ears were introduced, most important of which is an improvement in drying methods. Individual ear testing, formerly recommended for best results with open-pollinated corn, was discontinued. Some aspects of whether or not ear testing might be worth-while in hybrids have been investigated by the writer during the last few years. A number of hybrids were used, the seed ears were harvested reasonably early and dried down to about 12 per cent moisture. The ears were then culled to remove all those that showed discolorations or blemishes. Gerination was practically perfect throughout. Favorable weather conditions prevailed during the fall while the seed was produced, and again during the spring after the seed was planted. *Fusarium moniliforme* was the principal seed infection found during this period.

Less variability in hybrids.—In the better types of open-pollinated corn grown in Illinois, it is usually an easy matter, by means of a proper germination test, to select from the same seed lot a group of ears free from fungus infection and another group of which nearly all kernels are infected with *Fusarium moniliforme.* In attempting to make similar selections in hybrids the writer found more difficulty. Such difficulty was outstanding in the fall of 1937 when ten double crosses all produced in the same field with the same pollen parent, but different with respect to female parents, were ear-tested on a germinator. In some hybrids Fusarium seed infection ran high, while in others it was low. The selection of 10 ears with uniformly high infection and also 10 ears nearly disease-free, out of 200 ears tested in each hybrid could be made satisfactorily in only a few cases, but was impossible in certain of the hybrids. In some, a lack of disease-free ears was the limiting factor, while in others it was a lack of highly infected ears. The lack of variability often found with a given hybrid seed lot offers little opportunity for improving the lot through elimination of undesirable ears by means of a germination test.

Less injury from Fusarium moniliforme seed infection.—Some hybrids have apparently shown better resistance than common types of open-pollinated corn to the seedling disease caused by *Fusarium moniliforme*. This conclusion was reached when the results from planting highly infected seed were compared with results obtained from nearly disease-free seed. During the three years, 1936-1938, thirteen different tests of this kind, each with a different Illinois Hybrid, were made. After the seed was selected for planting, composite tests made with a germinator showed an average of 8.5 per cent *Fusarium moniliforme* in the seed lots used as nearly disease-free seed, and 86.8 per cent in the infected seed. When the same seed composites were first surface-sterilized to kill all but the internal infections and then tested on sterile media in petri dishes, there was 2.0 per cent infection in the nearly disease-free seed and 50.1 per cent in the infected seed. When untreated seed was used the average decrease in yield from heavy infection as compared to light infection for the three-year period was 1.8 bushels with mathematical odds of 226:1, indicating that the decrease had significance and was not due to chance. When the seed was treated with ethyl mercury phosphate before planting, the decrease in yield was only 0.4 bushel.

The small difference obtained would not have justified the commercial practice of ear testing. The principal reasons for this small average difference as compared to a difference of 5.9 bushels in open-pollinated corn for a nine-year period ending in 1929 (reported on page 61, Illinois Bulletin 354) are probably three: (1) better resistance to injury from *Fusarium moniliforme,* (2) less difference in actual infection between the infected and nearly disease-free seed lots in the hybrids used because of less opportunity for selection of wide differences in infections, and (3) favorable spring growing conditions during the three years in which the hybrids were used.

Better seed drying conditions.—Rapid drying equipment is an almost necessary adjunct to large scale seed corn production. An experiment to determine the effect of different rates of drying on internal seed infection was conducted with several widely grown hybrids in 1937 and 1938. The ears were hand-picked when the grain was at about 30-per cent moisture and divided at random into three lots, each of which was placed under a different drying condition. One lot was dried to 12-per cent moisture in four days, another in four weeks, while the third group still contained 17-per cent moisture at the end of three months when the ears were dried rapidly to 12-per cent. The first lot simulated kiln-drying conditions practiced by most of the large hybrid seed corn producers, while the second lot represented first-class rack drying as ordinarily practiced by careful farmers and seedsmen who do not have forced hot-air drying equipment. infection to an almost negligible amount in these tests. The total internal seed infection with the various fungi concerned was 5.1, 18.3 and 69.0 per cent, respectively, for the three different drying conditions.

Rapid drying decreased the internal seed

Conclusions

From the results obtained under the conditions of these experiments it can be concluded that an individual ear test for the detection of disease with the object of eliminating diseased ears from the seed lots would not have been of enough benefit to prove economically sound. The reasons why it did not appear to be of marked benefit as compared to results obtained earlier with open-pollinated corn appear to be fourfold: (1) less variability in hybrids, (2) less injury from *Fusarium moniliforme* seed infection in some hybrids, (3) improved seed drying conditions, and (4) better disinfectants for treating the seed.

RESIDUAL BENEFITS RESULTING FROM ACTIVITIES IN CONNECTION WITH AGRICULTURAL ADJUSTMENT PROGRAMS

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An Abstract

The purposes of the AAA programs have shifted emphasis as activities have progressed, but from the very beginning they have centered around the following ideas:

1. Stabilizing an adequate agricultural production according to need.
2. Conserving and improving the soil resources.
3. Helping farmers secure a fair share of the national income.

These ends have been striven for through the functioning of the various farm programs and through the educational work undertaken in connection with them. The educational work has been under the supervision of the Agricultural Extension Service but has been delegated as far as possible to local people in the various counties and communities.

Improvement of the farmers' financial status during recent years and importance of conservation of the soil are now generally recognized. The purpose of this paper, however, is to call attention to some less frequently mentioned benefits accruing from activities growing out of the application of the AAA programs.

In general, the benefits and accomplishments have been of a type that will carry on even if the AAA program should disappear. They are the invaluable by-products which are not easily measured in dollars and cents, but rate high in the scale of human progress.

Development of leadership.—One of the most noticeable of these benefits has been the uncovering and development of a vast amount of capable leadership among farm groups. In the beginning, most farmers elected to positions of responsibility were the older men of the community who had indicated their capacity through participation in activities of the farm bureau or other community organizations. At

that time most farmers were hesitant to get up in a local meeting and express themselves. Today many of these positions are held by younger men who have developed as the programs have unfolded. Not only are these men making good leaders, but an increasing number of farmers have developed to the point where they get up and talk freely at local meetings.

General understanding of economic conditions affecting farmers' welfare.—In recent years farmers have acquired a broader understanding of the basic factors affecting agricultural welfare. They are not only familiar with the conditions that influence the local situation, but have a reasonable understanding of those broad factors influencing agriculture generally, such as export and import situations, competition of other agricultural products, industrial conditions, labor incomes, credit conditions, supply situations, and governmental activities. Part of this improvement has resulted from the educational programs which have been developed as a part of AAA activities.

Understanding of principles of good farming and careful farm planning.—In cooperating with the AAA programs most farmers were immediately confronted with the problem of adjusting farm operations. This situation offered opportunity for presenting those factors associated with good farming and for calling attention to some tried fundamentals in planning a profitable farming system. The explanation of why the particular bases or allotments were given to a farm and why they were different from those assigned to another farm brought home the results of variation in farm practices employed in the local community in the past. The cause for change in crops and their adjustment in relation to each other, along with the possibility of reduced income on the farm served to give added incentive for applying any new information helpful in meeting these problems on individual farms.

Development of community cooperation and action.—The benefits already mentioned have applied more directly to the individual. There are others which apply to the group rather than to the individual. Farmers tend to act independently of each other. The AAA programs have been voluntary but have required rather general cooperation of farmers if they were to be effective. The local set-up of the AAA programs and the means for obtaining desired ends, as well as causes for such action, have all been conducive to cooperation of farmers in accomplishing a common result on a scale that was thought to be impossible a few years ago. Not only have farmers worked together for this common end, but a better understanding of the factors back of the agricultural situation and of the far-reaching effects of these conditions have improved the understanding and cooperation between agriculture and other groups.

Methods and aids in presenting educational material to farm people.—A tremendous task was thrown upon the Agricultural Extension Service when the AAA commodity programs were launched. Within a relatively short time the entire agricultural group had to be informed concerning the principles, purposes, and details of a new program. Consequently, too much was thrown at people in too complicated and concentrated doses within a relatively short time. Great progress has been made in regard to what should be presented, and in what manner and in what form such presentation should be made.

Collecting valuable information for future use.—One of the most valuable benefits resulting from AAA activities has been the volume of information made available. A large portion of the cropland has been measured and the use made of it has been recorded for various years. This information has been helpful to farmers, to agricultural census and other agricultural workers as a check on their statistics, to various research agencies interested in land use and farm planning, and to other public agencies, such as taxing bodies. The determination of major crop yields on all farms over a number of years has been valuable as a basis for a check on crop estimates and for setting up reliable actuarial figures for crop insurance. It is hoped that by the end of 1939 aerial photographs for all Illinois counties will make available a wide range of information to many agencies. The immediate purpose has been to obtain uniform measurement of fields, but the photographs will also be useful to the army, the highway and conservation departments, land-use planning agencies, and other organizations.

RELATIONSHIP IN SOILS OF TOTAL NITROGEN, TOTAL REPLACEABLE BASES AND PRODUCTIVITY

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A critical study of the productivity of soils in relation to total nitrogen content must necessarily involve a consideration of a number of other soil factors. Total nitrogen in soils is very closely related to total organic carbon, which in turn is proportionately related to total organic matter, and organic matter in soils is related to physical condition, water-holding capacity, color and other soil conditions, all of which are closely associated in soils and may influence productivity.

Soil reaction, that is acidity or alkalinity, is always considered in connection with productivity and is closely related to the active bases in soils, which in this region are composed mainly of calcium and magnesium.

Generally speaking, those mineral soils which have a relatively high nitrogen content are among the more productive soils. Productivity is usually found to be in almost direct proportion to the amount of total nitrogen in the surface layer. W. McLean[1] has suggested that either total nitrogen or total organic carbon be used as an index of fertility for soils of the same general region.

The following study was conducted in order to determine the relationship that might exist between total nitrogen, total replaceable bases (Ca + Mg) and the productivity of soils on 12 widely distributed Illinois experiment fields. The soils upon which these fields are located represent considerable variation in soil type, and soil maturity, and some small climatic variation. The soils used in these chemical analyses represent the untreated check plots which contain only the native fertility, and the corn and wheat yields were averaged from the same untreated plots.

The reaction of these soils ranged from pH 4.7 to pH 6.0 and the total nitrogen varied from approximately 1,000 pounds up to 5,000 pounds an acre. The replaceable total bases varied from approximately 700 pounds up to 7,300 pounds an acre. The long-time average corn yields varied from 10 bushels an acre up to 58 bushels an acre. The wheat yields varied from approximately 3 bushels up to 30 bushels an acre. The chemical composition of the soils as well as of the crop yields represent values of rather extreme variation; however, the low crop yields were on soils with low nitrogen and low base content, and the high crop yields were on soils with relatively high nitrogen and high base content, as shown graphically in Fig. 1.

On soils with a relatively low total nitrogen content the crop yields apparently correlated more closely with the replaceable base content of the soils, as illustrated by the results plotted in Fig. 1

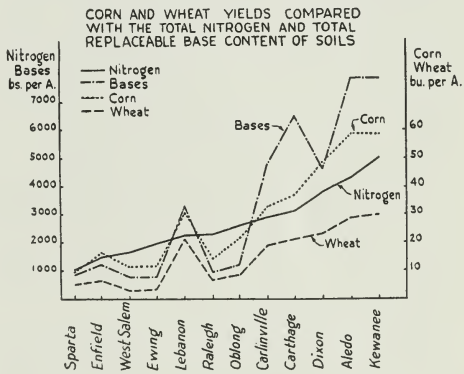

Fig. 1.—Relationship between total nitrogen and total bases in soils and the production of corn and wheat on twelve experiment fields.

from the Sparta, Enfield, West Salem, Ewing, Lebanon, Raleigh, and Oblong fields. On this group of fields the total nitrogen ranged from approximately 1,000 pounds at Sparta to 2,600 pounds an acre on the Oblong field, and the base content varied from approximately 700 pounds up to 3,200 pounds an acre. On the remaining fields, Carlinville, Carthage, Dixon, Aledo, and Kewanee the total nitrogen ranged from 2,800 pounds at Carlinville to approximately 5,000 pounds an acre on the Kewanee field and the total base con-

[1] The carbon-nitrogen ratio of soil organic matter. Jour. Agri. Sci. 30: 257. 1930.

tent varied from approximately 4,500 pounds up to 7,300 pounds an acre. On this latter group of fields with a relatively high nitrogen content the corn and wheat yields followed rather closely the upward trend of the nitrogen curve and apparently were not greatly affected by fluctuations in the amounts of total bases in the soil as illustrated by the curves.

Summary

It is apparent from these results that the total nitrogen content of soils when considered alone may not always be a reliable gauge to their fertility and finally to their productivity. Soils which are relatively low in total nitrogen and total bases are apparently influenced in the production of corn and wheat by the total base content as well as by the nitrogen content. Soils which are relatively high in total nitrogen and total bases produce corn and wheat in yields per acre which are somewhat closely related to the total nitrogen content of the surface layer of soil.

EFFECTS OF THE SOYBEAN CROP ON SOIL PRODUCTIVITY

O. H. Sears and W. L. Burlison

University of Illinois, Urbana, Illinois

Soybeans have gained in popularity among Illinois farmers more rapidly than any other legume crop. In 1914 only 2,000 acres were grown in the state, whereas the last four-year average production (1936-1939) was more than 2,000,000 acres. This acreage exceeds that of all other important legumes in Illinois.

As early as 1903, a rotation experiment including soybeans was begun at Urbana. This rotation, consisting of one year of soybeans and three years of corn (soybeans, corn, corn, corn), has been unchanged, and there are now data for thirty-six consecutive years.

One-half the plots are harvested for seed and the other half harvested for hay. On the plots where seed is harvested, the threshed straw is returned to the land and, on the plots harvested for hay, manure is applied at the rate of one pound for each pound of crop harvested. In addition, some plots in each half series receive rock phosphate treatment. Cornstalks are returned to the land on all plots.

At the beginning of the experiment, a rotation of soybeans, corn, corn, corn was believed not to be a good one. It was used for the purpose of comparison with two other four-year rotations having one and two years of corn in these respective rotations.

Curiously enough, the yields of soybeans have increased slowly but gradually. This fact is shown by Fig. 1.

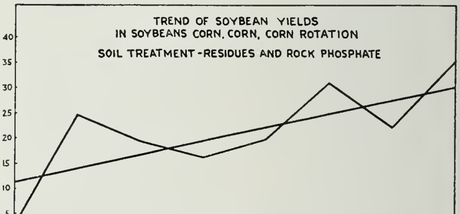

Fig. 1

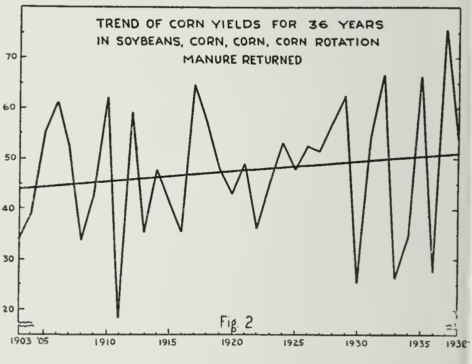

Fig. 2

The increase in yields of soybeans during the early years of the rotation is due in part to the gradual development of an active nodule bacteria flora. Good commercial inoculants were not available in 1903 and, as a result, nodulation of the soybean crop was dependent upon "natural" inoculation. Consequently, several years were required before maximum nodulation was obtained.

TABLE 1—CORN YIELDS IN A SOYBEAN, CORN, CORN, CORN ROTATION ON SOILS RECEIVING DIFFERENT FERTILIZER TREATMENTS, URBANA

(Averages for 36 years, 1903-1938)

Year after soybeans	Yields from plots treated with [a]				Average, all treatments
	RrP	R	M	MrP	
	bu.	*bu.*	*bu.*	*bu.*	*bu.*
First	50.8	46.5	51.6	53.8	50.7
Second	45.3	42.7	47.6	49.7	46.3
Third	43.2	39.6	41.5	44.8	42.3

[a] R = crop residues—cornstalks and threshed bean straw.
M = livestock manure—one ton for each ton of crops grown.
rP = rock phosphate.

The yields of corn have been consistently highest the first year after soybeans, and have been lowest the third year after the soybeans. These yields are given in Table 1.

Undoubtedly the physical condition of the soil is a factor affecting these yields. The tilth of the soil is much better after soybeans than after corn. The first year after soybeans the land is pulverized easily and a good seedbed may be prepared without difficulty, whereas in the third year after soybeans, the land appears cloddy and a good seedbed is difficult to prepare.

The biological activity of the soil is another factor affecting the yields of corn after soybeans. This fact is shown in Table 2.

The average number of microorganisms of the soil is highest the first year after soybeans and lowest in the third year. By referring to Table 1, it may be seen that the highest corn yields are secured on the plots having the highest number of microorganisms and vice versa. Either the same factors which are responsible for high corn yields are responsible also for large numbers of organisms, or else the large number of microorganisms affect the productivity of the soil. There is reason to believe the latter is the case.

One of the functions of soil microorganisms is the production of available

TABLE 2—AVERAGE MILLIONS OF MICROORGANISMS PER GRAM OF AIR-DRY SOIL IN A SOYBEAN, CORN, CORN, CORN, ROTATION ON SOILS RECEIVING DIFFERENT FERTILIZER TREATMENTS, URBANA, 1928

Year after soybeans	Millions of microorganisms per gram of air-dry soil from plots treated with [a]				Average, all treatments
	R	RrP	M	MrP	
First	12.6	15.1	14.7	15.5	14.5
Second	9.1	12.0	10.4	13.4	11.2
Third	8.2	10.2	8.6	10.9	9.5

[a] R = crop residues—cornstalks and threshed bean straw.
M = livestock manure—one ton for each ton of crops grown.
rP = rock phosphate.

TABLE 3—AVERAGE AMOUNT OF NITRATE NITROGEN PER ACRE IN SOIL IN A SOYBEAN, CORN, CORN, CORN ROTATION, ON SOILS RECEIVING DIFFERENT FERTILIZER TREATMENTS, URBANA, 1928

Year after soybeans	Pounds of nitrate nitrogen per acre in soil of plots treated with [a]				Average, all treatments
	R	RrP	M	MrP	
First	21.6	30.2	29.2	29.8	27.7
Second	17.8	13.4	14.5	19.8	16.4
Third	11.7	13.4	13.1	15.1	13.3

[a] R = crop residues—cornstalks and threshed bean straw.
M = livestock manure—one ton for each ton of crops grown.
rP = rock phosphate.

nitrogen—an element limiting crop yields in many soils. An examination of Table 3 shows that there are 27.7 pounds per acre of nitrate-nitrogen the first year after soybeans, as an average for all treatments. With the same soil treatments the nitrate-nitrogen average is 16.4 and 13.3 pounds for the second and third years after soybeans, respectively.

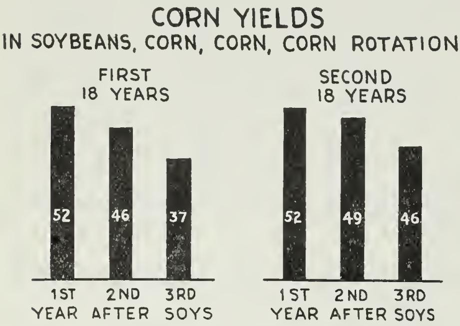

Fig. 3

The general trend of corn yields has been slightly downward where the soybeans are harvested for seed, and definitely upward where they are harvested for hay. The latter trend is shown in Fig. 2.

By grouping the yields in two 18-year periods this upward trend of corn yields is found to be due to increased yields in the second and third years after soybeans, rather than in the first year (Fig. 3).

PAPERS IN ANTHROPOLOGY

Extract From the Report of the Section Chairman

The Anthropology Section carried twelve papers, six of which are herewith published. The others were:

A cache of southwest Indian pipes, by William F. Schultz, University of Illinois, Urbana.

The site of Fox Indian-French battle of 1730, by Stanley Faye, Aurora.

Some comments concerning the so-called banner-stone, by Byron Knoblock, LaGrange.

Mound remains in Peoria County, by Floyd Barloga, Peoria Academy of Science, Peoria.

Migration and influences in Illinois from the Lower Mississippi valley region, by Thorne Deuel, Illinois State Museum, Springfield.

Some Mayan customs of today, by James Myers, Springfield.

The fifty persons attending the meeting elected as chairman for the 1940 meeting *Fred Barloga,* 1423 North Glen Oak, Peoria, Illinois.

(Signed) J. B. Ruyle, *Chairman*

PREHISTORIC BOTANY

L. F. Gumbart

Macomb, Illinois

Little of a definite nature can be said about the Mound Builder's knowledge of Science other than his broad knowledge of the cardinal points, the symmetrical nature of his earth-works and the beauty of his stonework and pottery. We do feel that he, as well as the Indians, knew his corn, beans and squashes and pumpkins, having developed these cultivated plants so far back that time does not know just how or when it was done. We do know that the Indian runner went for days on a small poke of parched corn and very little water and that corn was a matter of worship to him and basically so, for it was his real standby food, often grown communally and in much the same process as our present Illinois farmer, in hills and rows and hoed at least three times during growth. The planting and tending was carried on in many respects like a religious service with a joyous aspect, with a song and dancing. The men had their part in the festivities and helped with work as well as the squaws. Had it not been for the stores of corn that the eastern Indians were glad to share with the whites the first few winters they were on this continent, all the colonists would have perished. We make many things from corn but the food staples were all made and used by the Indians much as we use them now, corn flakes alone excepted. Parched sweet corn has a much better and finer flavor when carefully made. The Indian called popcorn, flowering corn, surely a fine name for this delectable food. He extracted sunflower seed oil and oil from nuts and acorns that he used as we use butter or salad oil. He knew his salads and greens also and here we must give the squaws particular credit, all agreeing that there were famous cooks among them whose art was studied and emulated by all ambitious young women. Harvey Lee Ross, who came to Fulton in 1821 and whose father improved the land that afterward became Lewistown, Fulton County, says the Indians used to gather in numbers along Potato Creek in that county and gather roots weighing six to eight pounds that were not unlike our so-called Irish potato when cooked.

The botanists call it *Ipomoea pandurata*, Man of the Earth, and it is a close relative of the troublesome bindweed and morning glory of our corn fields. I find no reference that indicates its cultivation and it is seldom seen in these parts. The white man's hogs made short work of it when they roamed the woods pasture. The roots as well as the seeds of *Helianthus giganteus*, giant sunflower, were valued dinner pot fillers and our Indian turnip, Jack in the Pulpit, was made edible by roasting or boiling till the acrid taste was removed. *Camassia quamash*, a wild hyacinth, with a four to six-ounce bulb, was counted a delicacy as were its cousins the onions and garlic. Milkweed and berry sprouts were used as we use asparagus and the Chinese bamboo sprouts, and the Indians introduced to our pioneers many plants that made good greens, quite a few of them better than the much joked about spinach. Berries and cherries of all sorts were eaten fresh as well as dried for fall and winter. Nuts of all kinds including the acorns were carefully prepared and stored for the time of snow. Acorns were crushed, soaked and washed to extract the tannin, then dried and made into flour for baking, cooking or seasoning, being very nourishing. Chestnut meal was often mixed with cornmeal, and the reputedly poisonous buckeye was used in much the same way. I often find these nuts with squirrel marks and am tempted to try the taste but forbear because of the bad reputation. Nuts that were particularly oily were pounded in a mortar, shells and all, the shells floated off and the residue boiled, allowed to cool, and the grease or oil skimmed off and saved for seasoning, the bulky part making good porridge when mixed with cornmeal or other flour. Many of the larger grass seeds, particularly wild rice, were fully threshed and winnowed, then stored against a cold winter's need, when careful pounding made wholesome flour. The Missouri bread-root, pomme blanche, *Psoralea esculenta*, with a deep growing turnip-shaped root, was highly prized and at one time the white man contemplated cultivating it instead of the Irish potato.

The French voyageurs found it very satisfying.

I must not forget that our first Americans knew and used many of the fungi or mushrooms and found them quite tasty as well as nourishing. Traces of many of these food items have been found in burial pots but are much harder to identify than are the bone remains of feasts prepared for the dead. We must except from this statement the various types of corn, the real food staple, many charred granaries of which have been exposed to the view of the modern digger.[1]

The Indian knew and used maple sugar and often traded it to the whites for sundry trinkets. I think they taught us how to make it.

The gathering of medicinal plants by the Indians was attended by quite a deal of religious litany and ceremony. Everything that was used in the gathering had to be ceremonially clean and blessed, powdered tobacco seems to have been one of the purifying agents. Not only the medicine men but many of the older squaws went along in the search for "Nebezoon" or medicine. Among the plants gathered and used by the Indians much as we learned to use them as pioneers, were boneset, spikenard, mandrake, prickly ash, calamus, wintergreen, lobelia, golden-seal, ginseng, cranesbill, male-fern, maidenhair-fern, dock, mint, sheep sorrel, witchhazel, Oswego tea, spruce and pine gum, sassafras, apple root, elder-bark, white oak bark, a sovereign remedy for poison ivy when made into strong tea and used as a wash after the parts were well scrubbed with common soap and brush. These were in our country, but we must not forget that the Peruvian Indians gave us quinine, and tropical and semi-tropical Indians used cacao leaves much as our Indians used corn on long journeys. Our modern use of chocolate as a concentrated food dates back to their time. When gathering medicine, they were very careful to conserve the plants. They never took the first one they found and always passed it with a prayer and a tobacco ceremony and when they did take a plant they talked to it and made a point to plant three or four seeds in its place. The carefully gathered plants and bark were dried in the lodge, carefully tied up in little leather or cloth bags and kept in a dry place. Dr. Benjamin Rush, one of the founders of our republic and an able doctor for his time, studied the Indian remedies and wrote down many of their formulae for future reference and use. He made quite a study of alcohol and its effects, publishing a paper about it in 1785. Many of his medical followers still use some of the old tried remedies of our Indian predecessors, and doubtless they used many from Mound Builder contacts or knowledge. My mother was greased and fed with Seneca oil for colds when a child. This we now know as petroleum and use the clean vaseline, kerosene or paraffin oil made from it. Indian children were given slippery elm with calamus or wintergreen for belly-ache, and the older folks mixed clay with Solomon's or golden seal for the same trouble; mandrake was a good purge and blackberries or their roots a good astringent, as we know today. Boneset tea was sovereign remedy for colds and fevers with our grandmothers as well as the Indians. Of course we must remember that the medicine man had many incantations and weird ceremonies, but the above will help us to understand that there was much real knowledge behind his seeming tomfoolery and that his natural remedies, with hot and cold baths and manipulations had much to do with the relief of the patient. Don't forget that our own doctor's personality and presence do much to help his medicine to be effective.

[1] The so-called Irish potato was omitted from the above because there seemed to be some controversy as to its origin, which has been claimed in Asia, in Colorado and in South America. Bailey's Horticultural Encyclopedia says: "Chile is its native heath," and the best information I now get is that the Inca Indians developed it and adapted it to various climates by planting it in their valleys and well up into the mountains. The inference to be drawn is that it worked north through Mexico and into Colorado, and is decidedly an American Indian development.

THE DETECTION OF FRAUDULENT COPPER NEEDLES

Harold Mohrman

University of Illinois, Urbana, Illinois

Since the discovery of a number of long, slender, copper needles in the famous Temple Mound of Le Flore County, Oklahoma, there have appeared a number of imitations to meet the demand of collectors. These fraudulent pieces are quite common among collections. One large collection contained over thirty, and almost every collector has a specimen, or has had an opportunity to purchase one. The price which is usually charged is from seventy-five cents to two dollars.

The specimens studied for this paper were from the collection of B. W. Stephens. Because of their light green-colored corrosion, he doubted their authenticity immediately after their purchase, about two years ago. Copper, which corrodes naturally in the soil, has a deep green color while the fraudulent needles are a much paler green.

The specimens were first measured and found to be from nine to eleven inches in length. The diameter of each, when measured with a micrometer, was found to be exactly the same, one hundred sixty-thousandths of an inch. This corresponds within two one-thousandths of an inch to number six gauge wire on the B. and S. scale. This diameter was found to be exactly the same throughout the entire length except for approximately one-half inch on each end which had been ground or hammered to a blunt point.

The needles were cleaned for a portion of their length by washing with dilute aqua regia which left a bright clean surface. After this treatment, they were studied under a microscope for any characteristics which might reveal their past history. The first thing noticed was a number of parallel striations extending in perfectly straight lines, the entire length of the needle. Such striations are easily observed on copper wire of heavy gauge which has been drawn through a die in the process of manufacture.

Also observed were a number of broad, shallow scratches such as would be made by scraping the insulation from high tension insulated wire.

The ends of the "artifacts" were not all exactly alike. One needle had abruptly tapered points which were hollow at the tips. This piece had been plainly hammered to a point. The marks from hammering were somewhat obliterated by a subsequent grinding, but were still visible under the magnifying glass. A study of the other two needles showed that they had been ground to a finer point than the first and there were no hollow tips.

The Indians who used native copper had their source of supply from the deposits in Northern Michigan and Isle Royal. This copper is practically one hundred per cent pure except for any occluded impurities. Copper, used in making electrical wire, is as nearly pure as it is possible to make. Because of this it was decided not to attempt any analysis of the specimens to try to distinguish them on the basis of the composition of the copper itself. A comparative study of the crystalline structure of native and refined copper was beyond the scope of this investigation.

Conclusive evidence of the nature of the corrosion on the fraudulent pieces was obtained by a quantitative chemical analysis. The corrosion was scraped from the needles, dissolved and analyzed. It was found to contain thirty-six per cent cupric chloride, the remainder being accounted for as water of hydration, dirt, and copper. There was no evidence whatsoever of copper carbonate which is the corrosion deposited by natural processes.

By the action of weak acids in the soil and carbonic acid in rain water, copper exposed to the elements attains a deep green color due to the formation of a coating of *verdigris*, a hydrated or basic copper carbonate. This process is very slow under natural conditions and many years are required to give a thick, tight-clinging coating. Because of this it is only natural to suspect that whoever was making these artifacts should have some quicker method. The composition of the corrosion gave evidence that it had been put on electrolytically. The coating was somewhat flaky, of a lighter color, and there were frequent air spaces beneath the flakes such as form from polarization of an electrode.

The fraudulent needles were artificially corroded by making them the positive electrode in an electrolytic cell. To overcome the fact that copper chloride is very soluble in water and would dissolve as fast as it was deposited the electrodes were probably placed close together and contact effected by merely splashing muriatic acid over them while they were connected to some source of direct current. Such an experiment can be carried out by any high school student of physics.

These observations lead to but one conclusion. Some enterprising dealer in relics conceived the idea of attempting to satisfy the demand for the fine Temple Mound needles by making imitations. Copper wire about number six gauge was scraped free of insulation, then cut into lengths of about ten inches, straightened, the extremities pointed by hammering and grinding. Then without any attempt to cover the striations by hammering, such as would result from the work of the aboriginal coppersmiths, the "needles" were electrically corroded.

As a final warning to anyone who might be tempted to buy copper needles from Oklahoma, beware of a light green flaky or crystalline corrosion appearing on perfectly round pieces of uniform diameter. Only by educating the persons who collect relics can the makers of fraudulent artifacts be put out of business.

DISCOVERY OF A BURIED ABORIGINAL SHELLHEAP IN THE ILLINOIS RIVER VALLEY

Ethel Schoenbeck

Peoria, Illinois

A buried shell deposit which has been determined to be of artificial origin and which is consequently believed to be a shell heap made by early inhabitants was discovered in the Illinois river valley in 1937 by George Schoenbeck, member of the Peoria Academy of Science, and of the State Archaeology Society.

It is the purpose of this paper to give a report of the discovery, including a description of the site and its location, and a brief statement of the geologic situation.

The deposit was exposed as a bed, or layer, in the face of a roadside cut at a point three miles distant from the present channel of the Illinois river.

It was discovered in the summer of 1937 and reported on the day of the first examination, in July, to the geology section of the Peoria Academy of Science; later, in March and April of 1938, the site was shown to Anson M. Simpson, director of the archaeology section of the Academy, and to Dr. John Voss, paleontologist, each of whom made an examination. Shells, charcoal, and pieces of broken rock were collected, including one piece, excavated by Dr. Voss and Mr. Schoenbeck, which, it is thought from its appearance, may have been used as a hammer stone. Photographs of the site were made by Dr. Voss and the author.

It was the opinion of the Peoria Academy members that the deposit, which was composed of shells with charcoal in association, was a refuse heap left by aborigines who had dwelt along the Illinois river in time past, and that it was, possibly, of very great age. A report to this effect was made to the Illinois State Geological Survey by Mr. Simpson, as leader of the archaeology section, accompanied by a request for an examination to determine the nature of its origin, whether natural or artificial, and to ascertain the geologic relations and age which would explain its underground position so distant from the present Illinois river.

In response, two examinations were made, one on June 7, and the other on June 20, 1938, by Dr. George E. Ekblaw, Geologist and Head, Areal and Engineering Geology Division, and a report was given July 15, 1938. Shells were submitted to Frank C. Baker, Curator of the Natural History Museum, University of Illinois, for identification and his report was included by Dr. Ekblaw.

The deposit is located in the extreme northwest corner of Sec. 11, T. 28 N., R. 3 W., Woodford County, one mile south of the Marshall-Woodford county line, almost directly across the Illinois river from Chillicothe. It is situated in the east side of a roadside cut made in connection with the current improvement of the Lacon-Peoria highway along the base of the east wall of the Illinois river valley. The cut was made through a long talus slope extending from the valley wall all the way down to the flat bottom of the Illinois valley.

The shell deposit is in a band, irregular in depth, and ranging from one to three feet above the base of the cut. It's highest point is at approximately the deepest part of the cut and it slopes gently northward, steeply southward. With the shells is a considerable amount of charcoal. The deposit was visible for more than eighty feet of the length of the band.

The shells were identified by Mr. Baker as of seven species, including

Amblema rariplicata
Cyclonaias tuberculata
Quadrula pustulosa
Elliptio dilatatus
Elliptio crassidens
Pleurobema coccineum
Lampsilis ventricosa

He reports that all of these mussels live now in the Illinois river in the vicinity of the deposit.

All of the shells are mature and with them are associated neither young nor immature pelecypods nor any species of gastropods. That the shells are all mature specimens of a limited number of species, that with them are associated neither immature shells of the same species nor representatives of other species, and that they are associated with charcoal would indicate that they were accumulated by artificial rather than natural means. This is the conclusion given in the report of Dr. Ekblaw.

The report further states that the location of the shell heap is accounted for by the fact that the Illinois river channel ran along the east valley wall in the vicinity of the deposit in relatively recent time, eroding the base of the wall; and that it did so at a time contemporaneous with, or subsequent to, the accumulation of the heap by the Indians or earlier inhabitants, is the interpretation. The material covering the shells is a part of the new talus which has washed down since the river migrated farther out in the valley. Estimated age was given as in the hundreds.

Attention might be called, at this time, to a possible significance in the size of the shells, which are uniformly small,—being smaller, in comparison, than those found on other Indian sites of the region,—and in the fact that there has not been collected yet even one large shell such as has been found, not infrequently, at other sites.

Concerning the lack of fashioned stone tools in the material so far excavated, remarked by Dr. Ekblaw in his report, Mr. Simpson reminds us that other shell banks without implements have been recorded and cites one mention of such contained in J. W. Foster's "Pre-Historic Races of the United States," page 162, in which five locations in Maine and Massachusetts are listed. It is suggested that the lack of artifacts made by hand of the man who discarded the shells might indicate an age that would reach back to a time when he had none.

In conclusion may it be stated that up to the present time, although excavations and study of the find have been limited, the site distinctly offers opportunity for future scientific exploration.

ORNAMENTATION AMONG THE AMERICAN INDIANS

Stanley Soper

Bardolph, Illinois

In nearly every collection of Indian artifacts will be found some articles which were once part of the personal adornment of our native Americans. This is at least partly due to the fact that every American Indian wore some token to indicate personal, tribal or ceremonial distinction at one time or another.

One of the most common type of ornaments is beadwork in some form. Beads were made of many materials. Shell, bone, steatite, clay, quartz, serpentine, magnetite, turquoise, jasper, hematite, soapstone, slate, copper, pearls, ivory, horn, claws, teeth, quills, seeds and nuts were used.

The shell beads were probably the first to come into use, since the shells of mollusks were probably used for utensils at a very early time. Being found near water, naturally they would be used as a dipper. Natural perforations occur in such shells as the haliotis and a thong could easily be slipped through and tied, thus enabling the shell to be transported by hanging about the neck. Some of them were later artificially perforated to facilitate carrying. These became valuable from a utilitarian standpoint. The Indian began to wear them and here is born an ornament.

Beads were worn by both sexes, most commonly hung around the neck but strings were also worn on the arms, wrists, waists, lower limbs, hair, and sewn on headdresses, coats, leggins and moccasins much as the Indians do yet today.

Copper beads were probably first made by perforating small glacial nuggets which may or may not have been worked. They were probably picked up because of their pleasing color and upon beginning to work them the Indian found that he was not chipping as was true of stones, but was shaping, so he continued to hammer the masses until the desired shapes were reached. The use of copper as ornaments probably originated near its source of supply which was the Lake Superior region but became disseminated through trade, being more valuable as it went farther from its source. Most of the copper beads would be considered crude from a standpoint of craftsmanship as they were quite often made by beating the copper out into sheets and rolling it so as to leave a hole, or beaten out into a wire and coiled to make a spring like bead. These beads vary a great deal in length but not so much in diameter. This working of sheets of copper was probably responsible for giving some experimenter the idea of plating with copper. This became quite an art. Hollow reeds were well adapted to being plated with copper and it did not take so much of it to accomplish the same effect as before. I have a hollow reed core of such a bead in my possession. A headdress belonging to an important personage found in a Hopewell Mound near Chillicothe, Ohio by Moorhead, consists of a high frontal piece made of sheets of copper covered with indented figures out of which rise a pair of horns imitating the antlers of a deer. The antlers had been of wood plated with copper. Wolf jaws have been found covered with thin copper sheets. Shell, bone, and wood have also been found covered with copper. Long copper breast plates on each side of the chest have been found in burials. These probably were worn as protection and ceremony as well as ornament. The chief uses of copper as personal ornaments are as beads, gorgets, bracelets, pendants, breastplates, pins—perhaps worn in the hair, ear disks, ear rings, and lip ornaments. Although the pleasing color, ease of working and ability to take a high polish must have made copper very valuable to the Indian, it seems to be found chiefly in association with Hopewell burials.

Shell beads are the most common of all. I believe the greater part of these are the flat disc beads. They are made from many kinds of fresh and salt water shells. Beads of conch shells from the Gulf of Mexico have a wide distribution and are found in all stages of development into utilitarian and ornamental objects. Tubular, cylindrical, and barrel shaped beads were made from the central column of the conch while thick discs were made from the shoulder. The cylindrical beads usually show part of the whorl groove but in some cases it is entirely absent. Usually they have been drilled from both ends. The disc beads were made from pieces of shell which were first grooved or notched and broken out. They were then drilled, usually from both sides and the circumference ground to a circular rim. Sometimes they were ground smooth on the flat sides. Very likely the polished pearl-like finish made very attractive ornaments.

In the Don Dickson collection are two strings of beads—one of cylindrical conch shell beads making a string over 18 feet long and another over 15 feet made of over 900 discs of conch shell. In each case the entire string was found about the neck of a single individual. All the beads are carefully made and uniform in size.

Beads made by rubbing off the shoulders of small shells such as the Marginella and passing the string through this opening and through the natural one are frequently found. Sometimes openings are rubbed in two opposite sides for stringing. In the removal of the Powell mound in the Cahokia group thousands of these Marginella beads were found. They were placed together with alternating layers of bark with as many as five layers of beads over some of the burials.

Shells having a natural conical spiral shape were often drilled through the shoulder for suspension. I have one such that has been cut off and had some object placed in it in such a way that it serves as a rattle which was strung with the other beads.

Strings of fresh water clam shells have been found on the ankle. These have been closed on the inside by flat pieces of wood or shell and pellets inserted to give a musical rattle on movement. There are usually two strings encircling the ankle.

Tubular or barrel shapes seem to predominate as types of stone beads although disc beads are also found. These were harder to make and probably this accounts for their scarcity. The materials for these beads were slate, steatite, cannel coal, quartz and hematite. The last are rather rare.

Tubular bone beads which are sections cut from a hollow bone are found quite often to be in strings encircling wrists or ankles. I presume this is from the fact that they made a more or less musical rattle when loosely strung. These beads may be quite short but are usually from one to two inches long.

I have in my possession a tubular shell bead 2⅛ inches in length and ⅝ inches in diameter that is curved to such a degree that one would consider drilling impossible yet a drilling the size of a medium broom straw has been made 1¼ inches from one end and 1⅛ inches from the other. This makes ¼ inch wasted drilling where they meet. By twisting, the straw can be pushed through the hole. Light will not come through because of the amount of curve. To say that the Indians were skillful at this work is certainly an understatement.

Considerable value must have been attached to bone beads as I have one which was worn until ⅝ inch of its 1½ inch length is worn through. It has a high polish.

Pairs of bone rings over an inch in length and about the same in diameter have been found in burials. The position would indicate that they may have been used to slip over the braids of hair.

Canine teeth of the bear and incisors of the elk were used in strings about the neck. The bear teeth were usually drilled and hung in such a way as to have all the points turned the same direction which was usually toward the left of the wearer. They have frequently been found to have one or two drillings which reach to the natural hollow of the tooth. Some have been found with fresh water pearls set in, glued with the gum of certain resinous trees. Mr. Charles Harris and I took a string of 10 elk incisors from about the neck of an individual in a burial mound in Schuyler Co., Illinois. These white gleaming teeth made a very attractive ornament and were likely trophies of a former hunt as well. At the Don Dickson mounds at Lewiston, Illinois, can be seen a bracelet of the jaw bones of a wolf, teeth intact, which are drilled for fastening together with thongs. In the same collection is an ornament which was probably worn suspended from the neck and is made from the upper human plate with teeth intact. It is drilled in front and back for suspension. Another odd necklace is made from finger bones drilled through the ends into the natural hollows and strung lengthwise.

Fresh water pearls are found in great abundance in some burials. They were especially plentiful in the Ogden mound in Fulton County.

Some clay or pottery beads are occasionally found but are not very well made as a rule. They were probably made by people lacking in material or skills to make better beads.

Pendants and gorgets of many kinds made chiefly of stone and shell make up a class of ornaments upon which the American Indian seemed to ply his greatest skill. Pendants are found mainly in Hopewell sites. They hung from the neck of the wearer, took many unusual shapes and sizes but nearly all were bar like in shape. Some of the larger, heavier stone gorgets have been found singly on the inside of the wrists. These may have been bow string protectors as some suggest and undoubtedly had some deep significance as a charm to the wearer. However the most beautifully made are the circular gorgets of shell, engraved with the spider, cross, or rattlesnake, and sometimes with the bird and human face inscribed. Another rare ornament that may belong in this class is a shell object usually about 8 or 10 inches long and 3 or 4 inches wide, which is more or less dipper shaped. These have been found on the forehead of the wearer, small end up. Most of these have three perforations, one in the center and the other two toward the small end.

Colorful adornment in the form of paint was used to indicate tribal, ceremonial, or individual distinction on important occasions such as at deaths, feasts, wars, or marriages.

Paints were used by both sexes on face, body, and sometimes the hair. Pigments were made from iron bearing minerals such as ochres and stained earth. Black was derived from charcoal, soot, or graphite, green and blues from copper bearing ores, red and yellow from hematites, white from limestone or kaolin, and browns, yellows, oranges, and purples from stained earth. These pigments were mixed with some animal grease or saliva and applied. In some tribes the grease was applied first and the powdered pigment rubbed on. Red, the color signifying the blood of life and death was the most used as it was thought to give the wearer added powers of protection or charm. Black was the usual color worn at a death and was probably not so much a sign of mourning as hope for protection from the departed spirit.

Feathers of the eagle to be worn in the hair or made into fans were held in high esteem. The standard value at one time was one pony as equal to twelve perfect black tipped golden eagle tail feathers. Feathers were worn only after being won by an act of bravery. The number, notching and coloration varied in individual tribes. Only a few of these colorful war bonnets have been preserved.

In conclusion, I hope that in this brief compilation concerning the Red Man's habits of adornment will be found some things of interest and use to the members of the Society.

ENGRAVED SHELL GORGETS FROM ILLINOIS

B. W. Stephens

Quincy, Illinois

It is common knowledge that the various forms of pierced engraved shell gorgets and shell gorgets with plain surfaces, which probably had different designs painted upon them, were worn by the Indians as ornaments. Doubtless these gorgets were not worn for mere personal adornment but had certain specialized uses; such as, Insignia, Amulets, and Symbols. As Insignia they were doubtless badges of ceremonial office or of distinction. It seems evident that the designs engraved upon them were indicative of the official position held, were specific records representing brave deeds accomplished, or were awards for some notable feat of strength or daring. As Amulets they were supposed to be invested with supernatural protective power. The designs if any, were usually derived from dreams or imaginary visions, hence, as a result of these individual experiences and ideas, it is seldom that any two are discovered bearing identical designs. As Symbols they were intended to possess a religious character and were generally indicative of clan or totem. Many are inscribed with mythological characters and a few specimens contain geometric designs which may be suggestive of time hieroglyphics, or the Order of Ceremonial work.

Other designs, of which The Cross, The Spider, The Serpent and The Scalloped Disk are examples, have been found in Indian burials in southern Illinois. These are not simply inscribed individual ornaments but more elaborate ones on which many fairly accurate duplicate designs were used. The large number of these precludes the theory that they were products of idle fancy and made merely for individual gratification. This is very evident when we consider the amount of labor and patience required to engrave them. The frequent recurrence of the same design and the wide distribution of individual types or forms, although varied to some degree, still retain enough of the original "type design" to be easily classified as belonging to one of the above mentioned groups.

The Illinois River area has been especially productive of the Cross type gorget. Many of these specimens are cut entirely through the shell. All attempts to connect the use of this design by the aborigines with that of the "white man's cross" have failed. However, it is known that the first explorers were accompanied by Christian zealots, who made a gallant attempt to root out native superstitions and as a substitute to introduce the Christian faith. The Cross being the insignia of this religion, the emblem was doubtless accepted by the natives as the only tangible feature of a belief too intellectually profound for their comprehension. Although other phases of Christianity may have been forgotten by the savages, the Symbolic Cross could have remained in the "Mind's eye," and they may have copied this design upon the shell and worn it in the same manner as they had been accustomed to wear their beads or other ornaments.

That the Indian would select a spider as a basis for ornamental design is not strange when we consider it was from the spider that the Indian was supposed to have learned to weave, make nets for seining fish, etc.; thus the spider would be held in high esteem. Because of the resemblance to the tarantula, with its deadly powers, the spider would be likened to the rattle snake, which was used very extensively in design ornamentation.

It is well known that the serpent plays an important part in the ceremonial life of the Indian, which may account for the fact that more Serpent or Rattlesnake gorgets are found in Illinois than any other engraved design.

The Scalloped Disk design, possibly indicating a circle or Sun Symbol, must have had some special significance in the mythology, customs or religion of the Indian. Many of the tribes were Sun Worshippers, especially the Natchez, and it therefore seems possible that this rosette or Scalloped Disc gorget may have been designed for religious use.

As a general rule the engraved shell ornaments are found in rock crypt burials and are considered as belonging to the "Stone Grave People."

THE HISTORIC INDIAN VILLAGES OF THE PEORIA LAKE REGION

Harry L. Spooner

Peoria, Illinois

Peoria Lake is an expansion of the Illinois river about twenty-one miles in length. The village of Chillicothe is located at its upper end and the cities of Peoria and East Peoria at its lower end. From time immemorial, this region has been a favorite haunt of the aborigines. Before the coming of the white people, the lake was circled by villages and camps of prehistoric peoples. After these left the country, the Illinois valley was successively peopled by Shawnees and Illinois, and later by the allied tribes of Pottawatomies, Ottawas, Chippewas, Kickapoos, Winnebagoes, Miamis, Sauks, and Foxes. Quite likely some time elapsed between the prehistoric occupation and the building of villages along Peoria lake by the historic tribes. In the Peoria lake region, however, I include not only the immediate vicinity of the lake, but a few miles up the river and a few miles west of the lake. This territory then includes several villages whose residents were closely united with those on the lake and who usually acted in concert with the latter.

Little information is available of an early Shawnee occupation, but there is some evidence that a group of Shawnees had a village between the present villages of Rome and Mossville.

Following the Shawnees, the groups making up the Illinois confederacy occupied the valley for a period of two centuries or more. Tradition says that the Illinois had a large village on the east side of the head of Peoria lake, where they were attacked by a large body of Pottawatomies from the Wabash while they were holding a religious festival and were unarmed. Most of the Illinois were slain and the Pottawatomies took away everything of value that the Illinois possessed. This is supposed to have happened about 1635. After the expulsion of the Illinois from this region in 1769, the Pottawatomies had a village at or near this same site.

The first the white people really knew about the Illinois villages, however, was in 1673, when Louis Joliet and Father Marquette came up the Illinois from the Mississippi. There is no definite evidence that there was a permanent village on Peoria lake at this time. The explorers stopped somewhere along the river at a camp of Peoria Indians and Father Marquette baptized a child there but he does not say it was on Peoria lake. If it were here that he stopped, it must have been a temporary camp of the Peorias, as he himself says the next year, 1674, that the only village on the Illinois river was that called Kaskaskia, nearly opposite Starved Rock, near modern Utica.

Peoria lake was called by the Indians Lake Pimitoui, meaning "there are plenty of fat beasts there." This explains why no villages had been built. The Illinois tribes used this region as a hunting ground and had not built a permanent village because this would frighten and disperse the game. That this region was used as a hunting ground is proved by statements of La Salle, who, on two occasions, in 1680 and again in 1682, found the big village at Kaskaskia deserted and its inhabitants hunting around Peoria lake, their camps being at its lower end.

There is no definite record of an Indian village on the lake until 1692, when Tonti and La Forest built the second Fort St. Louis below the "Narrows," and moved here from Starved Rock. Some of the Peorias remained at Kaskaskia but the big majority of the inhabitants there followed to Peoria, where they built a large village. Here Father Gravier built a chapel and converted many of the Indians, including Rouensa, the head chief. The Peoria village contained 300 cabins, or 1200 fires, which would mean a village of approximately 6000 people.

At this time the Illinois tribes living at Peoria were the Kaskaskias, Peorias, Moingwenas, Coiraccentanon, Tamaroa, and Tapouara. The Peorias and Coiraccentanon together were as numerous as the other four tribes. Peoria continued to be the only village on the lake until after the Illinois were driven from the region by the allied tribes.

The village was divided in 1700, when the Kaskaskias, in spite of the protests of the Peorias and Moingwenas, moved to southern Illinois and founded a new village, which they called Kaskaskia after the old one near Starved Rock.

In 1705 the Indians at Peoria murdered a French soldier and the Peoria chief, Mantouchensa, was ordered to Montreal to make amends. He refused to go and the governor-general of Canada withdrew all traders from Peoria. With their withdrawal, most of the French inhabitants and some of the Indians left the place. These included Father Gravier, who had been wounded by an Indian.

Six years later, the Peoria chief, Kolet, was visiting at Cahokia and heard Father Marest preach. Kolet was converted and induced Father Marest to re-establish a mission at Peoria. This was done in 1712 and the same year a garrison and a trading-post were again re-established. The village was now repopulated by both French and Indians.

In 1715 and again in 1718, the Illinois at Peoria helped in a war against the Foxes. In 1722 the Peorias captured the son of a Fox war chief and burned him at the stake. The Foxes retaliated, drove the Peorias to the top of Starved Rock, and after a battle, compelled them to give up eighty of their women and children as the price of saving their lives.

Most of the Peorias at both Starved Rock and Peoria, in fear of the Foxes, abandoned their homes and joined their kinsmen at Kaskaskia on the Mississippi, leaving central Illinois to the control of the Foxes. These, however, made no attempt to form a permanent village on the lake. In 1730, they attempted to march east and join the Iroquois. They were detected in the act by the few Peorias who had remained around Starved Rock. The latter sent word to the French commandants at St. Joseph, Fort Chartres, and the Wabash, who responded and practically annihilated the Foxes. Two years later the Peorias who had gone south returned and took up their residences again at Peoria.

In 1736 some of the Peorias took part in a battle with the Chichasaws. By this time their number had dwindled to about 250. During the next 27 years, life for them was comparatively tranquil and the population increased to 700, according to a French official report, which gave the population and also said that the post at Peoria yearly produced 250 bales of peltries.

The final exodus of the Peorias took place in 1769. In this year a Peoria Indian killed Pontiac, the great Ottawa chief. In retaliation, the Ottawas enlisted the aid of the Winnebagoes, Kickapoos, Pottawatomies, and Miamis and attacked the Peorias, whose number had been augmented by the other Illinois tribes, who had gathered at the old Kaskaskia village. After a fierce battle, the Peorias retired to the top of Starved Rock, where 1200 of them, of which 300 were warriors, were starved to death, only a few escaping. Those who were not present at the siege, being mostly the old men, the squaws, and children, fled the country, one group going to Vincennes, Indiana, and the rest joining their kinsmen at Kaskaskia and Cahokia.

With the destruction of the Peorias by the allied tribes, the latter now took possession of the rich lands formerly held by the Illinois. This explains why, when the first white settlers came to the Peoria lake region, they found Pottawatomies, Ottawas, Miamis, Sauks, Foxes, and Kickapoos, occupying villages but short distances from each other. In fact, many villages were made up of members from several of these tribes.

Just how many villages there were of the allied tribes in the Peoria lake region is uncertain. About 1778 Jean Baptiste Maillet, a trader in the French-Indian village at Peoria, built a new village one and a half miles lower down the lake. Within a few years the rest of the French followed. The old village was given to the Indians, who inhabited it until the log buildings rotted down. This village was supposed to have been between the present Caroline and Hayward streets in Peoria in the vicinity of where the old pottery ruins now are.

The Kickapoos early took advantage of the situation in the region and they settled at Peoria, making it their headquarters for a considerable period. About the same time a Pottawatomie chief named Wappe came from the Wabash and settled at what is now Tiskilwa but was better known as Indiantown and later as Comas' village. It is located on the Bureau river a few miles northwest of Chillicothe. It became a large village, having at one time 300 lodges and 1500 inhabitants.

Within the next few years, several other villages were established, either on the lake or in close proximity to it. The principal of these were: Gomo's village on Senachwine creek near the present village of North Chillicothe; Senachwine's village, a half mile north of the village of Putnam; Black Partridge's village at the Big Springs, north of the village of Spring Bay, on the east side of the lake; Crow's village, at the mouth of Crow creek, directly across the river from Chillicothe; Markwhet's village, near Lacon; Shick Shack's village at the mouth of Clear creek; and a village at Sparland. Some years later Little Deer's village was settled near Gomo's village and Pamawatam established a Kickapoo village at Mossville. The other villages were predominantly Pottawatomie although members from several tribes were interspersed with them. Shortly before 1812, the Piankashaws built a village a half mile from Peoria. The site of this is not known but the writer believes it to have been on the east side of the lake near the Dixon fish ponds.

In 1781 Senachwine and some of his followers joined an expedition that captured the fort of St. Joseph, in Michigan.

In 1794, many of the Indians of the Peoria lake villages fought against General Wayne in the battle of the Fallen Timbers. Among the Peoria lake chiefs who took part were Black Partridge, Gomo, and Senachwine. In the treaty of Greenville the next year, the Indians ceded to the United States a small piece of land at Peoria.

By this time the Illinois Indians had made several cessions of land to the United States. The last of these was made by the Peorias in 1818.

In 1810 the Shawnee chief, Tecumseh, visited the villages of Gomo, Black Partridge, Senachwine, and Comas, as well as the Indians and French at Peoria to induce them to join him in a war to exterminate the white population, but they were all opposed to his plan.

In 1811 Governor Edwards sent Captain Levering to the Peoria lake region to demand the surrender of some Indians who had stolen horses and murdered settlers in southern Illinois. He met all the tribes in council and they finally promised to deliver the murderers when they caught them.

The next April Gomo, Senachwine, Black Partridge, Shick-Shack, and Little Deer attended a council at Cahokia called by the governor. Pledges of friendship were made but the peace did not last long.

The people in the south part of the state did not think very highly of the Indians at Peoria. About this time they made a petition to Governor Edwards to establish a fort or block house "at the seditious village of Peoria—the great nursery of hostile Indians and traitorous British Indian traders."

In a letter to Secretary of War Eustis of May 6, 1812, Governor Edwards said that the Indians were concentrating their forces about Peoria, and, with five days' previous notice, could rally a force of 1000 warriors, independent of any assistance from the Prophet, chief of the Winnebago village on Rock river. On June 23 he addressed another letter to Eustis saying he had just had a communication that stated the Indians "around Peoria are now not less than 700" and that they could reach Kaskaskia within four or five days. In another letter in August, the governor said all the Indians had tendered their services to the British and were only awaiting directions from them.

In the summer of 1812 Tecumseh sent emissaries again to the Peoria lake region and met the tribes in council at Gomo's village. They offered the Indians a large sum of money if they would join the British. They also pointed out the importance of capturing Fort Dearborn at Chicago. Although the chiefs did not approve of this, many of the young men left at once for Chicago. Black Partridge followed and tried his best to avert a clash. When he found it impossible, he did not join in the terrible massacre that followed the evacuation of the fort, but rather, saved several white people from death and later was active in securing the release of white prisoners.

Two months later more emissaries appeared in Peoria to get the Indians to attack Fort Wayne and Fort Harrison. They visited Gomo's and Black Partridge's villages but were threatened with death if they did not leave.

In the fall of 1812 Black Partridge's village was destroyed by Governor Edwards while the warriors were away on a hunt and Black Partridge himself was on the Kankakee securing the release of Captain Helm, a prisoner from the massacre at Fort Dearborn. About thirty Indians, young and old, were killed, most of them being old men and squaws. Several papooses were slain, one soldier inhumanly running his bayonet through a little child and holding it high over his head. Upwards of 4000 bushels of corn were destroyed besides a prodigious quantity of beans and dried meat, pumpkins, tallow, and peltry. Eighty head of horses with their trappings, about 200 brass kettles, a great quantity of a variety of silver and Indian ornaments, guns, bags of gunpowder, flints, etc., were brought off. The houses, all strong and well built, some large enough to accommodate fifty persons, were burned.

Immediately after burning this village, a party was dispatched to Peoria, who burnt a village lately constructed by the Miamis within a half mile of Peoria.

A little later, Captain Craig burned the French village at Peoria because the governor accused the French of harboring the Indians who marauded in the southern portion of the state. Some of the women and children were left at the burned town without food or shelter while the men were all taken away on the boat as prisoners. In this extremity, Gomo, who had been watching from the woods, furnished these homeless people with food and canoes and they went down the river, where they arrived after several days and much suffering, at Kaskaskia. No tale of Indian savagery is more replete with inhuman and cruel acts than the destruction of Black Partridge's village and of Peoria by a supposedly civilized governor of Illinois.

The result of these affairs was to make the Indians more fierce than ever against the Americans. Black Partridge and a body of followers now harassed the settlements in the south and killed several white settlers. While there they learned that the governor was planning another foray on the Indian villages around Peoria, so they returned to their homes.

In September, 1813, General Howard arrived at Peoria lake. The Indian scouts had discovered his coming and all the people from all the Indian villages deserted their own villages and collected at Comas' village at Tiskilwa. Howard sent Captain Christy to Gomo's village and burned it, together with a quantity of corn. Christy went up the river as far as Starved Rock and then came back to the mouth of Bureau creek. He sent a detachment under Lieut. Robinson to go up the creek and find the Indians. They went seven miles and then, seeing a number of tracks of Indian ponies, became scared and retreated to the boats, reporting they had not seen any Indians. It was lucky for Robinson that he did not go the three miles further to the Indian village as the Indians were lying in ambush. The probabilities are that none would have escaped alive as the warriors were ten to one and many of them mounted, while the troops were on foot.

General Howard built a fort at Peoria, called Fort Clark. He was attacked by Black Partridge while building it, but the Indians were repulsed. Black Partridge could not get most of the Indians to aid him and so gave up the struggle. Black Partridge, Senachwine, Comas, Shick-Shack, Crow, and Gomo went to St. Louis and signed a peace treaty after which Fort Clark was abandoned.

From this time, the Indians of Peoria lake were generally peaceable. The only ones who were not were a handful of disreputable Indians from Tiskilwa under the half-breed, Mike Girty. This gang murdered a considerable number of white settlers during the Black Hawk war.

In 1814 an old preacher named Wigby preached to the Indians at Senachwine's village and Senachwine was converted. In this same summer a French Canadian trader, Jacques Jarret, stopped at Crow's village to trade. He had a young American named Ford as his clerk. Some of the Indians made Ford a prisoner and were going to kill him. Jarret finally effected his ransom by giving the Indians a large quantity of goods.

Antoine Des Champs, a trader for the American Fur Co. in 1816 met more than 1000 Indians at Peoria and gave them presents as an inducement to trade with his company.

In 1827 General Lewis Cass, general Indian agent for the Northwest, met the Peoria lake Indians in council at Crow's village in an effort to prevent them joining with the Winnebagoes in a war on the white settlers. He was successful and pledges of friendship were made.

In 1830 a great feast was held at Tiskilwa, called by Black Hawk, to induce the Pottawatomies to join him in a war against the whites. Senachwine made answer to Black Hawk in a speech which has been copied and re-copied as one of the finest pieces of Indian oratory in existence. His speech ruined Black Hawk's prospects.

A short time after this, Senachwine died suddenly on his return to his village from a short horseback trip. He was buried on the green knoll back of his village, where his grave may be seen to this day. In 1937 a marker was erected there to his memory.

The winter of 1830-31 was known as the "winter of the deep snow." During this winter many acts of kindness and heroism were done by both the Indians and the whites for each other. The Indians at Black Partridge's village kept at least one white family from starving during that winter, dividing everything they had with the whites.

John Hammet, a pioneer settler on Senachwine creek, describes the Indian village at Sparland at this time. He says they had about 30 acres of corn and pumpkins, the finest he ever saw. The corn was planted in hills, like sweet potatoes, the hills being arranged in perfectly straight rows and squares, while the several grains in each hill were planted with like geometrical precision. The hills were circular, two feet in diameter, and one foot high, the top being flat, and they stood about six feet apart. There were 30 to 40 stalks in each hill, planted in circles, the stalks being about six inches apart. It was the small eight-row variety, was carefully cultivated by hand, and thus treated, grew to magnificent proportions and matured early, escaping the fall frosts which nipped later varieties.

During the winter of 1831-32, the Indians around Lacon started to move west of the Mississippi. They first collected their dead upon the frozen river, packed in wooden troughs. When this was done, all hands joined and with a mighty push they moved across the river.

In February, 1832, another council was held at Indiantown by Black Hawk but he was no more successful than before. The Tiskilwa Indians, knowing they would not be safe in a war between Black Hawk and the whites, bade farewell to their beautiful village and moved west of the Mississippi.

The Indians who were left around Peoria lake gave no trouble during the Black Hawk war. By 1837 nearly all of them had moved across the Mississippi.

For the first few years, some of them used to return occasionally to look on the scenes of their youth and the graves of their ancestors, but with the fencing up of their trails and the plowing over of their villages and graves, the visits ceased. Today, of all the villages in the Peoria lake region, Senachwine's is the only one where the exact spot occupied by the Indian cabins can be pointed out. William Wheeler now owns the farm and keeps the grave of Senachwine intact, while he can show one just where the Indian cabins stood.

PAPERS IN BOTANY

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

The Botany Section carried 23 papers, 16 of which are herewith published. Titles of the others were:

Botanical demonstration, by Sister M. Ellen O'Hanlon, Rosary College, River Forest.

A teaching device chart showing family relationships among angiosperms, by Blanche McAvoy, Illinois State Normal University, Normal.

Illinois lichens, by Opal Hartline, Illinois State Normal University, Normal.

Mega- and micro-sporangiate cones of Mazocarpon, by James M. Schopf, Illinois State Geological Survey, Urbana.

Studies of the relation of cell wall structure to the final configuration of the primary xylem of the higher plants, by E. L. Stover, Eastern Illinois State Teachers College, Charleston.

A radiographic study of anthesis in LILIUM SPECIOSUM RUBRUM, by Sister Mary Therese, Mundelein College, Mundelein.

Variability of composition in Brownfield Woods, by A. G. Vestal and Charlotte Young, University of Illinois, Urbana.

Average attendance at each of the two sections was 80, and a chairman for the 1940 meeting was elected: *P. H. Tiffany,* Chairman Botany Department, Northwestern University, Evanston, Illinois.

(Signed) ERNEST M. R. LAMKEY, *Chairman*

The paper given by Evelyn I. Fernald has been reserved for future publication, it is entitled:

A report of progress of the study of the native and naturalized plants of Winnebago County, Illinois, by Evelyn I. Fernald, Rockford College, Rockford, Illinois.

VARIATIONS IN CARPEL NUMBER OF *ABUTILON THEOPHRASTI*

Charles A. Shull

University of Chicago, Chicago, Illinois

The genus Abutilon is represented in that part of the United States and Canada covered by Gray's Manual by a single species, *Abutilon theophrasti*, commonly known as the Velvet Leaf. It belongs to the Malvaceae, and, in common with other members of this family, possesses a flower with 5 sepals united at the base, 5 petals, numerous stamens, and a variable number of carpels. Gray gives the carpel number as 12 to 15, but the range of variability appears always to be greater than this, especially if the plants represent all types of habitats where it grows. The number usually ranges from 10 to 16, with a very few ovaries with as many as 17 carpels.

Having used *Abutilon theophrasti* for class studies of variation in a course in genetics about 25 years ago, the writer has been interested in the peculiar problem presented by these plants since that time, and has counted many thousands of them in widely separated localities. In the autumn of 1935, studies were made near Lafayette, Indiana; Lexington, Kentucky; Homewood, Illinois; Lawrence, Kansas; and St. Paul, Minnesota. This report deals only with the material collected at Homewood, Illinois on September 21, 1935. The total number of plants counted at Homewood was 87, with 3462 ovaries. The range in carpel number was from 10 to 17 on the group as a whole, with a very strong mode on 15. Approximately 60 per cent of the ovaries belong to the modal class; and more than 99 per cent are included in the modal and submodal classes; less than 1 per cent have carpels more numerous than the modal class. The distribution of carpel number for these 87 plants is shown in figure 1, curve A, with scale along the left margin.

Well developed plants very frequently exhibit half-curve variability in carpel number; that is, the variates all fall upon or below the mode, none occurring above the modal number. Five moderately vigorous plants are plotted in curve B, figure 1, scale along the right margin. In every population of Abutilon plants one finds individuals which exhibit this half-curve variability. The largest single plant collected at Homewood bore 353 ovaries, distributed with reference to carpel number per ovary as follows:

11	12	13	14	15
3	7	22	81	240

When the plants grow in difficult habitats, as in hard untilled soils, along roadsides, in heavy grass, or in severe competition with other plants in cultivated fields, the poor nutritional condition of the plants is reflected in a reduction of the carpel number. Curve C

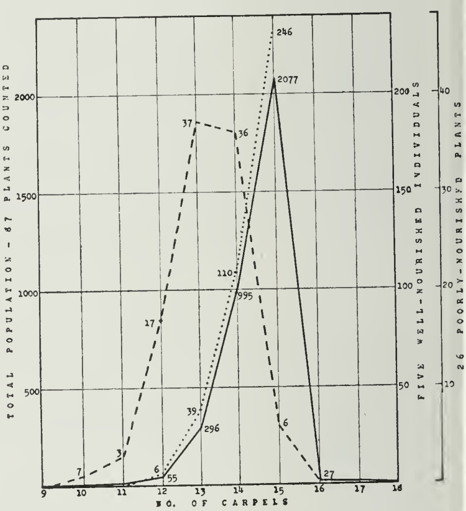

Fig. 1

in figure 1 was constructed from the counts of ovaries from 26 starved plants that had altogether only 100 ovaries, about 4 per plant (Scale in interior of fig. 1). The range is now 10 to 15, the mode on 13 instead of 15, and the number of ovaries with 15 carpels is only about 17 per cent of the total instead of 60 per cent.

The explanation of half-curve variability is difficult, at best. If all of the ovaries had 15 carpels, we might explain it as an hereditary expression of the 5-parted condition of the floral organs, with 5 x 3 as a fixed arrangement in floral ontogeny. Even if the mode is on 15 in plants with fair or abundant nutrition, there is as yet no evidence that an early stage in ovarial development has a 5-lobed primordium which subsequently develops three carpels to each lobe. The mere fact that preliminary observations have yielded no evidence of such 5-parted condition does not prove, however, that the tendency to produce carpels in five groups of three each may not be present. The earliest primordia examined seem to have all of the carpels differentiated, just as they will be in the completely developed ovary.

It is evident that the actual number of carpels formed is a function of the nutrition of the plant. With poor nutrition (starvation from poor soil, competition, etc.) the number of carpels is reduced. The range starts with lower numbers, and the modal condition is depressed. The writer has considered the possibility that inheritance of the 5-parted condition on the one hand, and the partial failure of nutrition on the other, might account for the total behavior. One might expect that if every primordium received a full and equal distribution of nutrients, and just right for the development of 15 carpels, the tendency to develop the floral organs in 5-parted condition would show up in lack of variability in number—all of them with 15 carpels. But if some primordia receive not quite enough food, or mineral elements, or water, or hormone the number falls to 14, or 13, etc., because of insufficient material or insufficient growth stimulus. The greater the degree of malnutrition, the greater the carpel number varies from the inherited modal condition.

These ideas have served only as a working hypothesis, and have made the study of carpel number in *Abutilon theophrasti* something more than a mere counting exercise. Such examples of variation are worthy of penetrating and profound study, for it is only by such investigation that we may hope to understand the behavior of organisms showing pronounced half-curve variability of any of their characteristics.

THE BLACKMAN INTERPRETATION OF PLANT GROWTH

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V. H. Blackman in 1919 suggested that plant growth, as measured by dry weight increase, could be interpreted on the basis of the compound-interest law, which is represented by the formula

$$W_1 = W_0e^{rt},$$

in which W_1 is the final dry weight of the plant, W_0 is the initial weight of the growing tissue (e. g., a seed), r the rate of growth (interest), t the time during which growth has occurred, and e the base of natural logarithms. The value r Blackman described as the "efficiency index of dry weight production." It is essentially the average daily rate of growth during a given period measured in terms of days. Blackman reported experiments which showed a correspondence of plant growth with this law.

If the correspondence is valid, the final dry weight achieved by a plant during its growth period depends upon: 1. The dry weight of the original tissue (e. g., a seed); 2. The rate of increase (r); 3. The length of the growth period. The experiments reported here were designed to: 1. Determine the r values of Alaska peas, Hubbard squash, and sunflower; 2. Determine whether or not there is a correlation between the dry weight of seeds and the ultimate dry weight of the plants which grow from them; 3. Determine the extent of such correlation.

Seeds of the three species were separated into two groups, in one of which one cotyledon was removed or a portion of it cut away, in the other of which none of the food storage tissue was removed. Twenty-four seeds were used in each group. The seed coats were removed in both sets, since seed coat material is not available as a source of food for growth. The seeds were weighed carefully and were then planted in sterilized soil in 4-inch pots, which were watered daily with 80 cc. of sterile tap-water until the

Table I—Weights and Coefficients

	Peas	*Squash*	*Sunflower*
Average dry wt. of whole seeds	.1515g.	.1871g.	.0655g.
Average dry wt. of cut seeds	.0936	.0956	.0266
Average dry wt. of plants from whole seeds	.4452	5.396	3.532
Average dry wt. of plants from cut seeds	.2759	6.061	2.395
Growth period (days)	35	52	47
Correlation coefficients	.439	—.008	.484

Table II—Efficiency Indices (*r* Values)

	Peas	*Squash*	*Sunflower*
Plants from whole seeds	.0307 (3.07%)	.0646 (6.46%)	.0848 (8.48%)
Plants from cut seeds	.0309 (3.09%)	.0796 (7.96%)	.0957 (9.57%)

epicotyls had appeared above the surface of the soil. From this time on, the plants were watered daily with the same quantity of unsterilized tap-water. The plants were allowed to grow until the first flower buds appeared, after which they were completely dried and weighed.

The dry weights of the plants were compared with those of the seeds from which they grew, and the correlation coefficients were determined from the formula.

$$C = \frac{Sxy}{\sqrt{(Sx^2)\ (Sy^2)}},$$ in which x represents the deviations of the seed weights from the average, y the deviations of the plant weights from the average, and C the coefficient of correlation. A coefficient between 0 and 1 indicates a positive correlation, a value between 0 and –1 indicates a lack of correlation.

The *r* values were determined according to the transposed formula

$$r = \frac{1}{t} \log_e \frac{W_1}{W_0}$$

A summary of the weight data and the correlation coefficient are presented in Table I, and the *r* values are indicated in Table II.

The results of the experiments may be summarized as follows:

1. The efficiency indices of Alaska peas, Hubbard squash, and sunflower *(Helianthus annuus)* are stated.

2. There is a striking constancy in the efficiency indices of the plants grown from the whole and the cut seeds. In squash and sunflower, the higher indices of the plants from the cut seeds are possibly attributable to inequalities in external conditions during growth, or to wound acceleration in the early stages of seedling development, an advantage which persisted throughout the growth period.

3. There is a positive correlation between seed weight and plant weight of peas and sunflower, though the correlation coefficient is low. In the squash, there was little variation in the average final weights of the plants, despite considerable differences in seed weights. Thus, it appears that in squash there is little correlation, if any, between seed weight (at least within the limits used) and final weight achieved by the plants which grow from the seeds. Since external conditions were kept as uniform as possible, it is scarcely possible that variations in these conditions could have induced markedly different growth phenomena. The possibility of wound stimulation, mentioned above, might be emphasized once more in this connection.

WATER ABSORPTION BY LEAVES

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Do leaves absorb water, is a question that has been asked by botanists. The answers have been various and confusing. A consideration of the factors involved show that under ordinary conditions mesophytic leaves may absorb liquid water in reasonable amounts but absorb very little or no water in the form of vapor.

The absorption of water by a leaf presupposes a deficit of water in the leaf cells. Such conditions are the result of transpiration, assimilation and an inadequate supply. Under the most ordinary conditions, at least during the daytime, leaf cells show some degree of water deficit. This deficit has been termed by the several workers as "suction force," "suction tension," "turgor deficit," "diffusion pressure deficit" and others. The terms imply that due to the unsaturated water conditions within the cell the cell possesses an ability to absorb available water.

Deficits as high as 10 atmospheres osmotic value are common in the leaf cells of transpiring plants; 20, 30 or even higher atmosphere deficits may occur in some leaves. Such osmotic value deficits represent positive water absorbing ability. Such cells placed in water will absorb it if no impervious layer intervenes. The crisping of vegetables in water is an illustration of this phenomenon. Leaves from some plants can be made to act as absorbing organs. If a stem with two or more leaves is removed from the plant and if one leaf is submerged in water, it will absorb sufficient water to keep the stem and other leaf or leaves in a fairly turgid condition. Such submerged leaves may act as absorbing organs for several months and supply the exposed leaves with water. Leaf and stem tips without such supply will wilt and dry in a few days.

For leaf cells showing a deficit of 10, 20, 30 or more atmospheres the absorption of water vapor is more difficult. The figures of 10, 20 and 30 atmospheres represent a vapor pressure deficit of .14, .30 and .49 mm. Hg. respectively with water having a vapor pressure of 23.76 mm. at 25° C. These deficits represent relative humidities of 99.4, 98.7 and 98 per cents. Leaves in light have from slightly above to several degrees higher temperatures than the surrounding air. If the air at 25° C. has 100 per cent humidity or 23.76 mm. Hg. vapor pressure; approximately one-third of a degree C. higher leaf temperature will cause the vapor pressure of the leaf showing a deficit of 30 atmospheres to equal that of the air. A temperature of more than one-third of a degree C. in the leaf will cause the leaf to lose water to the air even if quite wilted. Slight temperature differences thus make it impossible for wilted leaves to absorb water vapor. The tendency for the stomata of wilted leaves to close in the daytime, the closing of stomata at night, the exposure of only cutinized surfaces by some leaves at night as well as slight temperature differences make it rather difficult if not impossible for mesophytic leaves to absorb water vapor.

A STUDY OF THE RELATION OF CICATRIZATION TO EVAPORATION FROM LEAVES OF *BRYOPHYLLUM*

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The leaves of *Bryophyllum calycinum* are known for their ability to retain their moisture after they have been removed from the plant. While leaves were drying in the laboratory, the weights of an uninjured leaf and a leaf that had one square centimeter of the upper epidermis removed were compared. Little difference was found due to the loss of water from the two leaves even though the injured leaf had a new wound inflected at the end of each week until a total of ten square centimeters of the surface had been removed. Since such a little difference was seen an investigation of the wound and the healing of the wound was made.

Wounds were made at the end of the petiole, along the margin of the leaf, and in the center of the leaf blade. After four hours the cells, four or five rows wide, along the cut surface had collapsed to the extent that the cell walls could no longer be recognized and the epidermal cells had rolled inward over the exposed tissues.

After four days these collapsed cells had decomposed and the next two or three layers of cells had lost their cytoplasm. These two layers make up the pseudocicatrice which took a characteristic ligin stain. The cicatrice formed below the pseudocicatrice by the division of the first layer of living cells. The living cells divided for as many as twelve times. The layer of cicatrice is as thick at the end of the first week as it will become.

The cells of the cicatrice became suberized soon after they were produced. The outermost wall of the living cells show a suberin test in a chlor-zinc-iodine solution. Suberization of the cicatrice continues until all the cells are suberized. This complete suberization took about ten weeks, until there were no living cells in the tissue produced by the wound meristem.

No direct correlation was made between the evaporation from the leaf and the cicatrization of the leaf of *Bryophyllum.* The pseudocicatrice and the cicatrice do undoubtedly play an important part in the reduction of evaporation from a wounded leaf. The fact that the leaf will produce a cicatrice after it is removed from the plant is a very striking one.

DIFFERENTIAL DISTRIBUTION OF ASH ALONG THE AXIS OF HERBACEOUS PLANTS

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To better understand the chemical composition of herbaceous plants it is often necessary to know the quantity and distribution of minerals along the axis of the plant. The work was undertaken in the hope that a fuller knowledge of this problem might be forthcoming.

One piece of literature was available to the writer. Tukey and Green[1], working on the rose plant, Rosa multiflora (Thumb), found that there was an increasing ash and water gradient on the basis of dry and wet weights when the ash and water estimates were made along the axis of the stem from base to tip.

Among the several plants sampled in this study were tobacco, cabbage, tomato, and Bryophyllum. The plants were grown for four months in the greenhouse under rather uniform conditions of light, temperature, humidity, and soil composition. At the end of the growth period the plants were uprooted and lengths of tissue, each one centimeter long, were taken from the basal, the middle, and the apical regions of the stem.

The samples for ashing consisted of composite sets of stem tissue, each piece from a specific area of the stem under examination. The fresh or wet weight, the oven-dry weight, and the ash weight of the samples were obtained. These weights were used in calculating the increasing or decreasing ash gradients along the axis from base to the tip of the stem.

The data of this investigation seem to show that in herbaceous plants there is an increasing ash gradient on the basis of dry weight and a decreasing ash gradient on the basis of wet weight along the axis from base to tip of the stem. There is also an increasing water gradient from base to tip of the stem when the estimate is made on the basis of wet weight.

In the main, these findings agree with those found by Tukey and Green for the rose plant. They record an increasing ash and water gradient along the stem from base to tip in all instances.

It appears then that the increasing ash content for herbaceous plants, from the base to the tip of the stem, is due in part to a greater accumulation of such materials as carbohydrates and fats at the base than at the tip of the stem, which materials contain less minerals, and in part, at least, to an increased accumulation of protoplasm toward the tip of the stem apparently accounting for the increase of ash content in that region.

[1] Plant Physiology, 1934.

TABLE I—THE PERCENTAGE ASH CONTENT (A) OF THE STEM TO THE DRY WEIGHT (D. W.) AND TO THE WET WEIGHT (W. W.) AND THE PERCENTAGE OF WATER (W.)

Stem	Base	Middle	Tip
1. *Tobacco* (White Burley)			
% A/D. W	5.89	10.14	12.93
% A/W. W	1.17	1.03	.89
% W/W. W	87.15	91.68	92.65
2. *Cabbage* (New Jersey)			
% A/D. W	4.63	5.42	7.24
% A/W. W	1.38	1.36	1.22
% W/W. W	66.72	71.83	83.43
3. *Tomato* (Bonny Best)			
% A/D. W	8.39	11.73	16.03
% A/W. W	1.29	1.11	1.08
% W/W. W	86.66	90.72	91.95
4. *Bryophyllum pinnatum*			
% A/D. W	11.97	18.15	19.55
% A/W. W	1.26	1.12	.97
% W/W. W	89.45	94.23	94.88

FACTORS AFFECTING THE ABSCISSION OF THE LEAVES OF *COLEUS BLUMEI*

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Early workers showed that the abscission of leaves is preceded by the formation of an abscission layer at the base of the petiole. The solution of the middle lamella of the cells in this layer causes leaf fall. Sampson (4) working with *Coleus blumei* studied the anatomical and chemical changes taking place during abscission. He reported that the abscission layer begins to form in the third pair of leaves of a plant bearing 8 pairs of leaves, the latter abscissing. The pectose of the middle lamella is changed to pectin and pectic acid causing the separation of these cells. By removing the blades he could accelerate the abscission process in the petioles, the lower ones abscissing in a few days. He reported that no abscission layer was formed in the two youngest petioles below the terminal bud when the blades were removed, and that they failed to absciss. La Rue (3) using *Coleus blumei* and other plants reported that the removal of the blade greatly accelerated abscission but that a small portion of the blade inhibited abscission. He applied indole acetic acid and materials containing growth substances to debladed petioles and abscission was inhibited. He concluded that indole acetic acid inhibited the development of the abscission layer in debladed leaves and that a small quantity of some substance manufactured in the blade, not food, inhibits the abscission of leaves.

Several thousand *Coleus blumei* plants were grown for carrying out this problem. They were grown from cuttings in a greenhouse in flats, later being transferred to 3½-inch pots. The plants selected for use bore 7 to 8 pairs of leaves. Coleus is easily propagated by cuttings and has opposite leaves. The latter made it possible to use various treatments on the half of the leaves and to use the others as controls.

Effect of certain organic acids on the abscission of debladed petioles.—Treating debladed petioles with lanolin containing 1% acetic acid or 1% butyic acid did not inhibit abscission.

Effect of indole acetic acid on the abscission of debladed petioles. — The blades of 8 plants were removed and one petiole of each pair was smeared over the cut end with lanolin containing 1% indole acetic acid and the opposite petiole smeared similarly with plain lanolin. The average time for abscission ranged from 3½ days for the oldest untreated petioles to 19 days for the youngest untreated petioles. The treated petioles abscissed in a much longer time ranging from an average of 26 days for the oldest to 93 days for the youngest. A concentration of 0.1% indole acetic acid was less effective in inhibiting abscission. Freehand and rotary microtome sections showed that abscission layers developed in all the petioles both treated and untreated. Abscission layers were present in various stages in the leaves at the time of treatment from none in the youngest petioles to one practically mature in the oldest. This may explain the slower abscission of the youngest petioles. There was some inhibition of the abscission layers in the treated petioles. This was more evident in the youngest petioles. In the older petioles where the abscission layer was well developed at the time of treatment the inhibition was not so evident. The abscission layers developed in spite of the high concentration of indole acetic acid and formed nearly as rapidly as in the untreated petioles, yet it took 5 to 8 times as long for the treated petioles to absciss. This indicates that the indole acetic acid affects the latter part of the abscission process more than the development of the abscission layer.

Measurement of growth substances diffusing from petioles.—The double decapitation *Avena* technique described by Went and Thimann (5) showed that the most growth substance diffuses from the petiolar end of the third and fourth pairs of leaves. The abscission layer is beginning to form in the third leaf. The amount of growth substance per square centimeter of leaf area, however, was highest in the youngest leaves and lowest in the older leaves. This agrees with the results obtained by Avery (1) using tobacco. The material diffusing from a petiole treated with 1% indole acetic acid gave a much greater response with *Avena* than the material diffusing from untreated leaves with the blade intact.

Effect of the expanding part of the leaf on abscission.—The place of expansion of *Coleus* leaves was found by marking leaves of various ages into squares and measuring the increase in size of the different squares. The results were much the same as Avery (1) obtained with tobacco, expansion being greatest at the base and least at the tip. The tip of a leaf ceases expanding when it is less than ⅓ of its final size. To find out if the growth of the leaf had any effect on the abscission process different parts of the leaf blades were removed, the cut edges being smeared with lanolin to prevent desiccation. A leaf with a portion of the base left intact was much more effective in inhibiting abscission than a leaf with the base removed and the tip and midrib left intact. Sections showed that a small portion of the base inhibited the development of the abscission layer while the tip of the blade was less effective. Leaves with ⅞ of the blade removed abscissed in a shorter time than leaves with ½ of the blade intact. And leaves with the base of the blade severed from the midrib but left attached to the intact tip abscissed in a longer time than leaves with only the tip intact. The midrib with all the blade removed did not inhibit abscission.

Completely severing the blades and sealing them to the petiole with a small piece of glass tubing filled with lanolin or agar did not decrease the time of abscission. Leaves with the petioles cut more than halfway through from each side completely severing the vascular system abscissed in a longer time than debladed leaves.

Conclusions

Removal of the blades of *Coleus* leaves accelerates abscission of the petioles. Application of lanolin containing 1% indole acetic acid inhibits the abscission process partially by inhibiting the development of the abscission layer but mostly by inhibiting the latter part of the abscission process, the solution of the middle lamella. The amount of growth substance diffusing from the petiolar end of the leaves is greatest during the time when the abscission layer is beginning to develop. The material diffusing from the base of a petiole treated with 1% indole acetic acid caused a greater response with *Avena* than did the material diffusing from an untreated petiole with the blade intact. The presence of a small portion of the blade will inhibit the development of the abscission layer. The expanding portion of the leaf, i. e., the base of the blade, is more effective in inhibiting the abscission layer than a part of the leaf in which expansion has ceased, i. e. the tip of the blade. These and other experiments indicate that while growth substances may affect the development of the abscission layer other factors or substances formed in the growing portion of the leaf are more important in the inhibition of the abscission of *Coleus* leaves. This factor or substance will not move across an agar or lanolin bridge but does move through living cells.

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CARBOHYDRATE UTILIZATION BY *DIPLODIA MACROSPORA*

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While studying the growth of certain fungi in culture Miss Kinsel[1] observed that *Diplodia macrospora* Earle is unable under any conditions thus far secured, to grow on culture media containing only monosaccharides as sources of carbohydrates, but grows freely on culture media containing starches or cane sugar. In following up so unusual a discovery, it seemed desirable to determine first of all whether this limitation was characteristic of the species as a whole, or merely of the single strain which she used in her work. The writers accordingly undertook to assemble for testing a number of different isolations of this relatively rare corn fungus. In all, 24 isolations were obtained and tested. Two of these came from samples of Argentine corn turned over to us for study by the Chicago office of Federal Grain Supervision, Bureau of Agricultural Economics. Fifteen were obtained from corn stalks in the fields of Alabama, Florida, and Tennessee during January and February, 1938.[2] Seven were furnished us by Mr. Paul E. Hoppe from materials secured in the course of his annual survey for the relative prevalence of various corn ear rot fungi. These last came from Alabama, Tennessee and Mississippi.[3]

On the advice of Dr. A. J. Moyer of the Bureau of Chemistry and Soils, a more dilute medium was substituted for the one used by Miss Kinsel. This solution in which the fungus grows much more rapidly contains KH_2PO_4, 0.3 gm., Mg SO_4, 0.25 gm., KNO_3, 2.0 gm., 3 per cent of sugar by weight and distilled water to make one liter. A number of other nitrogen sources were tried, using quantities sufficient to give amounts of nitrogen equivalent to 2 gm. KNO_3 per liter.

Under the conditions of the experiment, all isolations of *D. macrospora* failed to grow in media containing only cerelose (commercial corn sugar) as a source of carbohydrate, while all grew readily when cane sugar was used. This difference held regardless of the source of nitrogen. Numerous isolations of *D. zeae* (Schw.) Lev., grew readily in the solutions containing cerelose. It is apparent that the unusual physiological characteristic discovered by Miss Kinsel is widely distributed in this species which should serve as an object of much further investigation.

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PLANTS OF THE SMOKY MOUNTAINS

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If you are a scientist interested in plants from a taxonomic or ecological view point, or if you are an amateur botanist interested in exploring and collecting new plants, or if you are a nature lover interested in the many intricate phases of nature, you will find the Smoky Mountains to be an alluring place. While other of our American mountains may be noted for their glaciers, or hot geysers, or stupendous waterfalls, the charm of the Smokies lies in the luxuriant growth of plants which covers everything. In 1926 an area of 150,000 acres on the border of Tennessee and North Carolina was purchased from more than 6,000 owners and set aside as the Great Smoky Mountain National Park to be kept in its unspoiled condition for all time. Since that time the area has been expanded to more than 400,000 acres.

Anyone who loves trees will surely love the Smokies. When one looks up at mountains thickly covered with trees or from the mountain top looks down on millions of tree tops, he comprehends in a small way the "symphony" of a forest. Fir, spruce, pine, oak, ash, maple, and many others all blending their characteristic shades into one harmonious whole.

With the exception of a few areas known as "balds" these mountains are completely covered with trees. Fogs are abundant and rainstorms are frequent. This abundance of moisture and also the range of temperature is reflected in the vegetation. Here trees become giants and shrubs become the size of trees. Tulip poplars *(Liriodendron Tulipifera)*, reach a diameter of nine feet and those of six feet are not rare. Hemlock, oak, ash, and maple sometimes reach more than five feet in diameter. Cherry, buckeye, black gum, spruce, and others grow larger than elsewhere. One hundred and forty species of trees have been recorded in the Smokies. Growing within a mile of one another one may find trees indigenous to southern Canada and northern Georgia. In the valleys and on the lower parts of the mountains there are hemlocks, tulip poplar, gums, and maples. Hardwoods are found on the lower peaks with beech and cherry being dominant. On the highest peaks are found Frasers fir and red spruce.

The shrubs of this region are very spectacular. The Smokies are famous for the rhododendron, azalea, and mountain laurel. The purple rhododendron *(Rhododendron catawbiense)* begins to bloom on the mountain slopes in early June. Some of these grow to more than twenty feet in height. Where they are not associated with trees they become impenetrable thickets and are known as heath balds. These thickets are locally known as "slicks" because the shiny surface of the leaves gives a slick appearance to the mountain side. Some heath balds have a remarkable development of moist fibrous brown peat frequently one to two feet deep. The purple rhododendron usually follows the ridges and is found with the firs. The white rhododendron *(Rhododendron maximum)* with its large waxy white flowers follows the lower ridges and sometimes streams. In low places it also forms thickets and has been known to reach a height of forty feet. There is also the dwarf rose-pink rhododendron, *(Rhododendron punctatum)* which is found on the summits or slopes with the purple.

There are four species of azalea, locally known as honeysuckle. The pink azalea *(Rhododendron nudiflorum)* grows through the woods and thickets. The white azalea *(Rhododendron viscosum)* is often a low branching shrub, but may become ten feet tall. It frequents swamps and its white blossoms are very fragrant. The smooth azalea *(Rhododendron arborescens)* may become twenty feet in height. Its pink and white flowers have a spicy fragrance. About the middle of June a whole mountain top may seem to be on fire with the flame azalea *(Rhododendron calendulaceum)*.

The mountain laurel *(Kalmia latifolia)* is called "ivy" by the mountain people. Its cap shaped blooms of white and pink may be found in profusion in May and June along roads and trails and on the mountain slopes.

Two other interesting members of the heath family are leucothoë *(Leucothoë Catesbaei)* and sand myrtle *(Leiophyllum buxifolium)*. Leucothoë, known as "dog hobble" is a shrub growing from three to six feet high, with bright green, lustrous, evergreen leaves, and smooth highly colored bark. It branches profusely from the ground to the top. Its flowers are clusters of small bell-shaped pink blossoms which occur in May and June. It is found along the mountain trails and associated with the rhododendron on the heath balds. A path on top of Mt. Le Conte leads through a dense growth of sand myrtle about knee high. This is a prostrate, much branched shrub, with rough broken bark and small dark green shiny evergreen leaves. At the ends of the branchlets may be found a few exquisite tiny white flowers tipped with pink or red. Sand myrtle is found in many small exposed areas at high altitudes. It fastens itself in crevices and covers many windswept rocks.

Some other shrubs which lend beauty to the landscape are dogwood *(Cornus)*, blueberry, *(Vaccinium)*, Devil's Walking Stick *(Aralia spinosa)*, black haw *(Viburnum prunifolium)* and several other members of the honeysuckle family. The waahoo *(Evonymus atropurpureus)* is particularly showy in October when its seed pods burst open displaying the orange colored seeds.

Common along the trails are such vines as Dutchmen's pipe *(Aristolochia macrophylla)*, trumpet vine *(Tecoma radicans)*, virgin's bower *(Clematis)*, wild grape *(Vitis)*, and green brier *(Smilax)*.

With perhaps the exception of December, some plants may be found in bloom in the Smokies at any time of the year. In January, spruce, fir, hemlock, partridge berry, *(Mitchella repens)*, and some green briers begin to bloom. Then follow the maples, willows, and bluets. Later, hepatica, phlox, violets, bloodroots, red bud, service tree, trailing arbutus, virginia bluebells, and meadow rue are found. In the summer come lady slipper and other orchids, iris, bleeding heart, silver bell *(Helesia carolina)*, sand myrtle, galax, columbine, daisies, spiderwort, and a host of others. There are seven kinds of trillium with various forms and colors ranging from white, yellow, and pink to deep maroon. In autumn there are asters of several colors, various species of mints, butterfly weed, lobelia, St. John's wort, golden rod, and sunflowers. In October comes the witch hazel which continues blooming into November.

Dr. A. H. Sharp of the Botany Department of the University of Tennessee says, "There are no less than 1,500 species of flowering plants to be found in these mountains in the growing season." O. M. Schantz of Chicago, a great Smoky Mountain enthusiast, has made thirty-nine trips to these mountains and on each trip has discovered new plants many of which are thought to be rare. Of the forty-six ferns listed for Tennessee he has found thirty-seven growing within a few miles of one another. Arthur Stupka, Park Naturalist of the Great Smoky Mountain National Park, reports that thirty ferns and twelve so-called fern allies have been collected within the boundaries of the park.

Dr. Sharp has recorded one hundred species of liverworts and two hundred twenty species of moss and new ones are being added constantly. There seems to be moss everywhere; carpeting the ground, clinging to the bark of trees, and making a thick pad over rocks. On rocky slopes may be seen moss perhaps a foot in thickness, and always saturated with water. At many points where rock cuts have been made for trails, one finds water dripping from overhanging moss the whole distance of the cut.

One cannot help but be fascinated with the colorful, fleshy fungi which he will find along almost any trail. On the trail to Abrams Falls we found them every few feet; masses of coral mushroom *(Clavaria)*, several species of russula, the yellow sulphur mushroom *(Polyporus sulphureus)*, the white deadly amanita *(Amanita phalloides)*, brackets of many sizes and colors, and hosts of others. The study of these interesting plants in the Smokies is still in the pioneer stage. Dr. L. H. Hesler of the Botany Dept. of the University of Tennessee has classified eight hundred species of fungi since 1934. He says that intensive collection may reveal a thousand more different kinds.

This region is also a slime mould collector's paradise. Sixty-three have been recorded thus far. Practically no study has been done on the lichens and algae of the region.

Besides the heath balds which were previously mentioned there are areas known as grassy balds which present a very interesting feature of the Smoky Mountain flora. They are tops of mountains having a herbaceous cover, grass and sedge being dominant. There is no tree line, as we think of it in other mountains. In fact the highest peaks are forested and these grassy balds are only scattered dots throughout the whole. They vary in size from one-fourth acre to one hundred acres. A description of one of these balds will give an idea of what they are. Following the ridge from Clingmans Dome, the highest peak in the park, for two miles, one comes to the end of the ridge. Here inclining to the southwest is a treeless area of approximately seventy acres. It is at an altitude of 5,860 feet, that is 800 feet lower than Clingmans Dome. The sod is very deep and heavy. The cover is dominately sedge with some oat grass *(Danthonia)* and a few other herbaceous plants. This expansive area is dotted with a few widely scattered shrubs, viburnum, gooseberry, and rhododendron. The shape of the area is roughly square in outline. The east and south sides are bounded by fir and spruce of average size. On the west and north there is a border of shrubs,—low brambles grading into higher shrubs and tall rhododendron which border fir and spruce. There is a spring on the southwest corner. There is no evidence of fire or grazing. Other balds vary in size, shape, herbaceous cover and soil moisture. Most of them tend to a southern exposure, but not all. These grassy balds have been called a "forest enigma" and present an ecological problem which is only now being solved. There is no legend of Indian occupancy. Early theories gave fire or extreme climatic conditions to be the cause of these balds. More recent theories are that they are of ancient human origin. It is no doubt true that several different factors have entered into the formation of a bald and that respective balds have been initiated by entirely different causes.

Because the Smoky Mountains contain an unusual variety of plants it follows that the animals which are dependent directly or indirectly on the plants are also found in abundance. Many species of mammals, birds, reptiles, insects, and other groups are found; and their relationship to one another and to the flora present interesting and challenging problems. This region is truly a nature lover's paradise.

WHY THE ILLINOIS SETTLERS CHOSE FOREST LANDS

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In some accounts of the gradual conversion of most of central and northern Illinois into farm lands, the early farmers are made to appear simple-minded because they occupied forested areas instead of the more fertile prairies. The two first-occupied southern districts near the Mississippi and the Wabash were well settled before 1818. From this beginning, "the frontier line of settlement moved steadily northward, more rapidly along the streams and forested belts than in the prairie" (Ridgley, 1921, Geography of Illinois, p. 144). Ridgley quotes H. H. Barrows (1910, Geography of the Middle Illinois Valley): "The prairies of Illinois aroused the wonder of all early travelers. They were generally shunned by the first comers for several reasons:

(1) Absence of trees was thought to mean that they were infertile.

(2) Timber was imperatively needed for buildings, fences and fuel.

(3) They did not afford running water for stock or mills.

(4) There was no protection from the bitter winds of winter, which, above all else, made that season disagreeable.

(5) To the farmer, the prairies with their tough sod and matted roots constituted a new and altogether unknown problem."

Barrows then proceeds: "With the growth of population all the woodland was presently occupied, and newcomers were crowded out upon the prairie. The small prairies were presently encircled by a belt of farms. Later, another ring was established inside the first, and farther out on the prairie, and by a continuation of the process the entire prairie was finally occupied."

Two sets of conditions have changed so gradually as the result of this occupation that we have quite failed to grasp how profound the changes have been. It is almost impossible for us to visualize first, how few and how primitive were the facilities and resources available to farmers of the period between 1820 and 1835, and second, how greatly different from the present condition of prairie lands was that which the early farmers experienced. The difficulties of attempting to farm prairie lands were real and formidable. First place among them may be assigned to the generally poor drainage of the flat or gently rolling prairie uplands. Poor drainage was emphasized in 1932 by E. A. Norton and R. S. Smith as the foremost condition contributing to both absence of trees and tardiness of occupation. Artificial drainage was begun tardily, and took many years to accomplish. Though it has gone too far in many areas, and though resulting changes have been profound, the more extensive prairie flats are still flooded several feet deep after heavy rains. Putting those flats under cultivation amounted to actual reclamation projects, entirely beyond the reach of small communities of pioneer farmers. Some of them were carried out only after surrounding areas had been farmed for sixty years. One quotation from a history of Cumberland County (J. H. Battle, 1884, p. 114) will illustrate the drainage problem. "The early settlements were all made in some point of timber, at Muddy Point, Sconce's Bend, Nees' Ford, Greenup, Woodbury and Bear Creek, thus encircling the central part of the county, which for years was almost a marsh, water standing all over the prairie portion until August . . . There was little natural drainage, and the rain fell upon the ground, after saturating the soil, until the whole prairie area was one great swale." The statement is probably exaggerated, but poor drainage may well have been the basis of the feeling by some settlers and by later historians that prairie lands were infertile. The next sentence in Battle's description: "Accustomed to a timbered and rolling country, the first settlers could not believe that the open land could ever be tilled; and it was practically impossible for the pioneers, few in number and limited in resources, to cultivate it." I believe we can readily credit at least some of the farmers with enough common sense to recognize it as a problem of drainage, even though in places it remained for years an insoluble problem.

An article, "The Prairie State" (Atlantic Monthly 7:579-595, 1861) includes an account of the railroad begun in 1845 to run from Chicago to Galena. The first part was built as far west as Des Plaines river. "These twelve miles of road between the Des Plaines and Chicago had always been the terror of travelers. It was a low, wet prairie, without drainage, and in the spring and fall almost impassable. At such seasons one might trace the road by the broken wagons and dead horses that lay strewn along it."

The solution of the drainage problem probably came about automatically and simply. Not all prairie areas were so flat and wet, nor did everyone regard them as useless. Even in 1818 many prospective settlers had an ambition to find quarter-sections including "a proper proportion" of forest *and* prairie. Such pioneers as Richard Flower and Morris Birkbeck recognized from the first that the prairies could be highly productive. The early settlements were more commonly at the border of forest and prairie rather than well within extensive forests, and the ordinary early use of prairie lands was for grazing. Increasing demand for new areas to farm led to conversion of the higher parts of rolling prairie pastures into plowland, in spite of primitive plows and limited animal power.

Development of steel plows in the 1830's accelerated further breaking up of prairie sod, solving difficulty No. 5 of Barrows' account, and extending cultivated fields into flatter and lower areas. In turn this concentrated attention squarely upon the drainage problem. Open ditching, land-furrow plowing, shortening and deepening stream-channels by dredging, and tile drains, were the expedients tried. The last two were truly effective. These and other changes worked by man had a cumulative effect in accelerating run-off and erosion, thus further deepening channels and lowering ground-water levels.

The water-supply problem, the windbreak and hedge problem, the fencing and fuel problems, and the hazards of prairie roads, were other difficulties in prairie farming which likewise have gradually been solved, each a story in itself in which Illinois farmers played a major part.

What at first would seem a mere annoyance to prairie pioneers was another serious problem, which is nearly forgotten today. Another quotation from Battle (p. 432) will make it clear: ". . . the swarms of "green-headed flies" which infested the prairie practically disbarred the traveler from using the larger part of the day in prosecuting his journey. The unfortunate animal exposed to their attack would be covered with these voracious insects . . . and such was the vigor and effectiveness of their attacks that no animal could sustain it long . . . work and travel were practically suspended from nine o'clock until . . . evening. The timber was free from these pests and the early trails led along its border, but even these trails were abandoned in the heat of the day. Traveling was consequently done principally at night, which gave rise to very serious experiences."

In the Illinois Monthly Magazine for July, 1831, an unnamed writer, probably James Hall, the "conductor" of the magazine, describes the "buffalo paths" resulting from migrations between the alluvions of the larger rivers and the upland plains. "In the heat of the summer they would be driven from the latter by prairie flies."

Lively accounts of the greenheads are found in several papers, notably that of C. W. Short (1845) and reminiscences of F. M. Perryman (1908), describing conditions in 1842. These flies are small tabanids (horseflies and deerflies) of one or several species probably in the genus Chrysops. Their more or less amphibious larvae presumably developed in the prairie sloughs and mudholes. Such wet areas were reduced in number and extent as the settlers gradually were able to drain the prairies, and in consequence the fly problem was solved.

The difficulties and hazards of early occupation of prairie lands are thus seen to be numerous, definite and formidable. Psychological reasons for avoiding prairie were probably eliminated before the physical handicaps were overcome. A summary listing of the difficulties, with emphasis on the first two as most important, might be as follows:

Poor drainage; Lack of timber for buildings, fences and fuel; Difficulties of tillage; Lack of protection from wind, especially in winter; Difficulties of travel and transport; Water-supply difficulties; Prairie flies.

THE COMPOSITION OF PRAIRIE VEGETATION IN ILLINOIS

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Although the prairie has had no small place in the interest of botanists since the early years of the nineteenth century, much of that interest has been speculation concerning its origin, its maintenance and the advance or retreat of forest along its borders. Early taxonomic studies were usually observations by travelers passing over the state, and by others whose primary interest was not in securing a technical and complete work on prairie composition, but more of a casual study of the outstanding species. In many instances specific names were not given or the common name only was used. Studies made later in the century were much improved. But many of these writers did not include habitat data with their species list. At the three-quarter mark in the last century, Illinois prairie soil was already mostly under the plow and virgin areas were mainly found in those flats that were most difficult to drain, along railroad rights of way and in sandy bottoms which were too poor for cultivation. Thus, before accurate data had been taken for a complete study, the prairie was no more. The only way a complete listing of species could be made was to collect all of the available lists which were made of local bits of prairie, and to incorporate this material, together with information obtained from herbarium study, into an inclusive annotated list.

Until Gleason wrote his thesis at the University of Illinois in 1901, no one had attempted to gather these loose ends together. His study was based on his own fairly comprehensive field data which were supplemented by the contributions of G. P. Clinton, H. V. Chase of Wady Petra, and Professor L. M. Umbach of Naperville. From the time Gleason made his study, up to the present, no one had attempted a similar study of the prairie.

The present work is based upon Gleason's list and other lists made by competent men in different sections of the State. Most of these lists were included in flora of particular counties or sections. In addition lists of smaller size or of certain families or groups were considered.

Due to the kindness of Dr. Tehon of the Illinois Natural History Survey, a catalogue of all plants of the State of Illinois was put at the writer's disposal. This catalogue was made up from specimens found in the herbaria at the Missouri Botanical Garden, The Field Museum, Northwestern University, Illinois

Normal University, The University of Illinois and the Natural History Survey collection.

Because of the availability of the catalogue the writer, in a comparatively short time, was able to go through all the material concerning the prairie to be found in these herbaria and to include data which otherwise could not have been included.

The various habitats of each species were noted, and as the list of counties in which each species had been found was given it was possible to determine a rating for frequency of distribution by counties; in some records abundance data were also available.

Early writers gave various estimates of the total number of species represented on the Illinois prairie. Most of the men placed the number at about two hundred. Gleason's total raised the number to four hundred fifteen. The present listing shows the probable number of prairie species to be half again as large.

The study brought some very interesting facts to light.

About 10% of the total number of species was found in sand prairie, and was found in no other type of habitat. This suggests the controlling effect sand has upon vegetation. No other prairie soil has such characteristic ground cover. Of course many other species grew in sand, but were also found on other types of soil, therefore could not be called characteristic of sand prairie.

The plasticity in water relations of prairie plants is shown by the varied situations in which the same species was to be found. About 30% of the total number was found only in xeric prairie conditions, 17% was found only in mesic conditions, and 6% in only hydric situations. (By hydric situations is meant those places such as stream borders, on the margins of prairie swamps, etc.) But aside from these more exacting species there were 24% found in both xeric and mesic habitats, 16% which were found in mesic and hydric habitats, 3 species were recorded in xeric and hydric extremes, and 7 species were found in all three types of habitat.

Twenty-three per cent of the total number of species were found also associated with woodland. This suggests that some few of these socalled prairie species are relicts of former woodland vegetation which are able to persist in prairie. Probably many more than the 23 per cent recorded are plants which are equally at home in prairie and open forest, clearings or openings in forest land, or "barrens" of the eastern United States. In Gleason's later writings he has indicated that many prairie species were recruited from the flora of the deciduous forest region.

"Frequency" is not used in this work in the way it usually is in ecology: as indicating the percentage of plots in one locality in which the species occurs. The term in this case is taken to mean the number of counties of Illinois in which the species appears in the collection records available. Those species which were recorded from three counties or fewer were designated as infrequent, those collected in from four to twelve counties were designated as occasional, and those found in more than twelve counties designated frequent.

Fifty-three per cent of the species were found to be frequent in Illinois counties, 30% were found to be occasional, and 15% were infrequent.

As might be expected, most of the additions to Gleason's list have been species with "occasional" or "infrequent" ratings. Of the "frequent" species, 70% appear in Gleason's list; of the occasional species, 38%; of the infrequent species, 26%.

ADDITIONS TO THE FLORA OF STARVED ROCK STATE PARK

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In this Academy's Transactions for 1924 Dr. Frank Thone[1] published a list of 397 vascular plants found in Starved Rock State Park. During the summer of 1938, while the present author was employed as park naturalist by the Illinois State Natural History Survey, work was started on an herbarium of the flora of the park. In the period from June 15 to October 15, 310 species were found in the park. Specimens of 285 of these were pressed. Of this number, 133 were species not reported by Thone. Specimens of a number of the commonest trees, shrubs, and other plants, and particularly specimens of the rarest species, were not collected. All specimens have been deposited in the Herbarium of the Illinois Natural History Survey at Urbana. The nomenclature in the following list of additions to the flora of Starved Rock State Park is, with the exception of a few species now generally recognized as distinct, that of Britton and Brown's Illustrated Flora of the Northeastern States and Canada.

I am indebted to Dr. L. R. Tehon, Botanist of the Illinois Natural History Survey, for checking my determinations of some of the specimens and identifying the rest. I also wish to thank Theo M. Smith of the National Park Service, stationed at Starved Rock, Floyd Werner of Ottawa and Mr. Charles Huckins of LaSalle, Illinois, for their helpful assistance in both field and laboratory during the summer.

Alsinaceae
  Cerastium longipedunculatum Muhl.
Amaranthaceae
  Amaranthus hybridus L.
Asclepiadaceae
  Acerates floridana (Lam.) A. S. Hitchc.
  Asclepias amplexicaulis J. E. Smith
  Asclepias exaltata (L.) Muhl.
Berberidaceae
  Caulophyllum thalictroides (L.) Michx.
Campanulaceae
  Campanula uliginosa Rydb.
Caprifoliaceae
  Lonicera sempervirens L.
  Viburnum acerifolium L.
  Viburnum affine Bush
  Viburnum lentago L.
Cichoriaceae
  Nabalus albus (L.) Hook.
Commelinaceae
  Tradescantia reflexa Raf.
Compositae
  Artemisia Arbrotanum L.
  Aster cordifolius L.
  Aster dumosus L.
  Carduus nutans L.
  Cirsium discolor (Muhl.) Spreng.
  Cirsium lanceolatum (L.) Hill.
  Coreopsis palmata Nutt.
  Cynthia virginica (L.) D. Don.
  Erigeron ramosus (Walt.) B. S. P.
  Eupatorium maculatum L.
  Helianthus annuus L.
  Helianthus hirsutus Raf.
  Helianthus strumosus L.
  Hieracium scabrum Michx.
  Lactuca floridana (L.) Gaertn.
  Lactuca spicata (Lam.) Hitchc.
  Liatris graminfolia (Walt.) Kze.
  Liatris spicata (L.) Willd.
  Lepachys columnifera (Nutt.) Rydb.
  Solidago altissima L.
  Solidago squarrosa Muhl.
  Solidago juncea Ait.
  Sonchus arvensis L.
  Sonchus oleraceus L.
  Vernonia altissima Nutt.
  Vernonia fasciculata Michx.
  Xanthium pennsylvanicum Wallr.
Convallariaceae
  Uvularia perfoliata L.
Convolvulaceae
  Convolvulus sepium L.
  Ipomoea pandurata (L.) Meyer
Cornaceae
  Cornus rugosa Lam.
Corrigiolaceae
  Anychia canadensis (L.) B. S. P.
Cruciferae
  Arabis canadensis L.
  Brassica juncea (L.) Cosson.
  Erysium officinale L.
Cuscutaceae
  Cuscuta arvensis Beyrich
Cyperaceae
  Carex annectens Bicknell
  Carex granularis Muhl.
  Carex vulpinoidea Michx.
  Cyperus strigosus L.
Euphorbiaceae
  Chamaesyce Preslii (Guss.) Arthur
Fagaceae
  Quercus ellipsoidalis E. J. Hill.
Fumariaceae
  Corydalis sempervirens (L.) Pers.
Gentianaceae
  Dasystephana flavida (A. Gray) Britt.
  Dasystephana villosa (L.) Small
Geraniaceae
  Geranium carolinianum L.
Gramineae
  Agrostis perennans (Walt.) Tuckerm.
  Bromus tectorum L.
  Hordeum jubatum L.
  Lolium perenne L.
  Melica nitens Nutt.
  Panicum clandestinum L.
  Panicum dichotomiflorum Michx.
  Spartina michauxiana Hitchc.
Hypericaceae
  Hypericum mutilum L.
  Hypericum prolificum L.

[1] Thone, Frank. 1924. Preliminary check list of the vascular plants of the Illinois State Park at Starved Rock, LaSalle County. Trans. Ill. St. Academy of Sci. 17:100-106.

Juncaceae
- Juncus balticus Willd.
- Juncus effusus L.
- Juncus Torreyi Coville

Labiatae
- Hedeoma pulegioides (L.) Pers.
- Lycopus virginicus L.
- Mentha spicata L.
- Monarda mollis L.
- Scutellaria cordifolia Muhl.
- Stachys tenuifolia Willd.
- Teucrium occidentale A. Gray

Leguminosae
- Astragalus carolinianus L.
- Baptisia bracteata Ell.
- Apios tuberosa Moench.
- Cracca virginiana L.
- Chamaecrista fasciculata (Michx.) Greene
- Cassia marilandica L.
- Desmanthus illinoensis (Michx.) MacM.
- Lespedeza violaceae (L.) Pers.
- Meiboma Dillenii (Darl.) Kze.
- Meiboma paniculata (L.) Kze.
- Meiboma viridiflora (L.) Kze.
- Melilotus officinalis (L.) Lam.
- Phaseolus polystachys (L.) B. S. P.
- Psoralea pedunculata (Mill.) Vail.

Liliaceae
- Lilium superbum L.

Lobeliaceae
- Lobelia spicata Lam.

Menispermaceae
- Menispermum canadense L.

Oleaceae
- Fraxinus pennsylvanica Marsh.

Onagraceae
- Oenothera muricata L.
- Stenosiphon linifolium (Nutt.) Britt.

Orchidaceae
- Corallorrhiza odontorhiza (Willd.) Nutt.

Oxalidaceae
- Xanthoxalis grandis Small.

Plantaginaceae
- Plantago Rugelii Dcne.

Polygalaceae
- Polygola viridescens L.

Polygonaceae
- Fagopyrum esculentum Moench.
- Persicaria lapathifolia (L.) S. F. Gray

Polypodiaceae
- Dryopteris intermedia (Muhl.) Gray
- Dryopteris marginalis (L.) A. Gray
- Woodsia obtusa (Spreng.) Torr.

Primulaceae
- Lysimachia Nummularia L.

Portulacaceae
- Portulaca oleraceae L.
- Talinum teretifolium Pursh.

Ranunculaceae
- Viorna Viorna (L.) Small

Rosaceae
- Agrimonia gryposepala Wallr.
- Geum virginianum L.
- Potentilla canadensis L.
- Potentilla recta L.
- Prunus americana Marsh.
- Rosa palustris Marsh.

Salicaceae
- Salix longipes Shuttlew.

Saxifragaceae
- Astilbe biternata (Vent.) Britt.
- Heuchera hirsuticaulis (Wheelock) Rydb.

Scrophulariaceae
- Verbascum Blattaria L.

Solanaceae
- Physalis pubescens L.

Umbelliferae
- Daucus Carota L.
- Deringia canadensis (L.) Kze.
- Sanicula marylandica L.
- Sanicula trifoliata Bicknell
- Zizia aurea (L.) Koch.

Urticaceae
- Parietaria pennsylvanica Muhl.
- Urtica gracilis Ait.
- Urticastrum divaricatum (L.) Kze.

Verbenaceae
- Verbena angustifolia Michx.

Vitaceae
- Vitis vulpina L.

THE OEDOGONIALES OF ILLINOIS

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The Oedogoniales is one of the orders of the Chlorophyceae, or green algae. The single family, Oedogoniaceae, comprises three genera: *Oedogonium*, *Bulbochaete*, and *Oedocladium*. The filaments of *Oedogonium* are unbranched but those of the other two are branched. The vegetative cells of *Bulbochaete* have laterally placed setae while those of *Oedocladium* are devoid of such setae.

Both *Oedogonium* and *Bulbochaete* are widely distributed in fresh water throughout the world. *Oedocladium* is so far known only from Germany, India, Puerto Rico, Florida, North Carolina, Virginia, Massachusetts, New Jersey. The species of *Oedogonium* and *Bulbochaete* have been reported mostly from North America and Europe, but that probably is the distribution of algologists rather than Oedogoniales. Further investigation will doubtless reveal very general distribution of most species.

There have been reported for Illinois to date 79 species and varieties of the Oedogoniales. The numerical distribution in nearby states is as follows: Michigan 101, Iowa 89, Ohio 87, Indiana, 79, Kentucky 34, Wisconsin, 3.

As a matter of record the 67 species of *Oedogonium* and 12 species of *Bulbochaete* known to occur in Illinois are the following: *Oe. acmandrium* Elfv., *acrosporum* De Bary, *amplum* M. & W., *angustum* (Hirn) Tiff., *americanum* Trans., *aster* Wittr., *bohemicum* Hirn, *borisianum* (LeCl.) Wittr., *boscii* (LeCl.) Wittr., *braunii* Kuetz., *capilliforme* Kuetz., *capitellatum* Wittr., *cardiacum* (Hass.) Wittr., *concatenatum* (Hass.) Wittr., *crenulatocostatum* Wittr., *crispum* (Hass.) Wittr., *cyrptoporum* Wittr., *curvum* Pringsh., *cyathigerum* Wittr., *echinospermum* A. Br., *epiphyticum* Trans. & Tiff., *fragile* Wittr., *franklinianum* Wittr., *globosum* Nordst., *gracilius* (Wittr.) Tiff., *gracillimum* W. & L., *grande* Kuetz., *howardii* G. S. West, *hystricinum* Trans. & Tiff., *idioandrosporum* (N. & W.) Tiff., *illinoisense* Trans., *intermedium* Wittr., *irregulare* Wittr., *laeve* Wittr., *macrandrium* var. *aemulans* Hirn, *macrandrium* var. *propinquum* (Wittr.) Hirn, *magnusii* Wittr., *majus* (Hansg.) Tiff., *mitratum* Hirn, *multisporum* Wood, *oblongellum* Kirch., *oblongum* Wittr., *obtruncatum* Wittr., *ouchitanum* Taft, *paludosum* (Hass.) Wittr., *paucocostatum* Trans., *pisanum* Wittr., *plagiostomum* Wittr., *pratense* Trans., *praticolum* Trans., *pseudoboscii* Hirn, *punctatostriatum* De Bary, *pungens* Hirn, *pusillum* Kirch., *rugulosum* Nordst., *rufescens* var. *exiguum* (Elfv.) Tiff., *subplenum* Tiff., *sociale* Wittr., *suecicum* Wittr., *taphrosporum* N. & H., *tentoriale* N. & H., *upsaliense* Wittr., *varians* W. & L., *vulgare* (Wittr.) Tiff., *vaucherii* (LeCl.) A. Br., *welwitschii* West, *wolleanum* Wittr.

Bulbochaete brebissonii Kuetz., *crassiuscula* Nordst., *crenulata* Pringsh., *insignis* Pringsh., *intermedia* De Bary, *minor* A. Br., *mirabilis* Wittr., *nana* Wittr., *nordstedtii* Wittr., *reticulata* Nordst., *varians* var. *hawaiensis* Nordst., *varians* var. *subsimplex* (Wittr.) Hirn.

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THE POLLEN OF CERTAIN TAXODIACEAE

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Pollen of the Taxodiaceae which have been examined are characterized by the absence of bladders or any well marked furrow and by the presence of a thick intine with a thin, flecked (except in *Sciadopitys*) exine which becomes easily ruptured and often completely cast off when the grains are placed in water. Of the eight genera of this family which Pilger (1) lists, size ranges and descriptions of the pollen for certain species of five genera are given by Wodehouse (2) together with illustrations of each one of the five with the exception of *Glyptostrobus*. The size ranges are as follows:

1. *Cryptomeria japonica* D. Don 23.9–31.9μ
2. *Cunninghamia sinensis* R. Br. .... 34.2–40. μ
3. *Glyptostrobus heterophyllus* Endl. 29.6–30.8μ
4. *Sequoia gigantea* Torr., and *S. sempervirens* (Lamb.) Endl. .... 28.5–41. μ
5. *Taxodium distichum* (L.) L. C. Rich .... 27.4–31. μ

These measurements are those of expanded pollen. The writer in preparing pollen for examination followed Wodehouse's (3) methyl-green-glycerine-jelly method in order to obtain comparable material and to prevent the rupturing of the exine which was found to persist in water mounts. Material of the following species has been examined: *Cryptomeria japonica*, *Cunninghamia lanceolata* (*C. sinensis*), *Sciadopitys verticillata*, *Sequoia gigantea*, *S. sempervirens*, *Taxodium ascendens*, and *T. distichum*.

Difference in the size of the pollen of the two species of *Sequoia* were noted, *S. sempervirens* having the larger pollen. Pollen of *Taxodium ascendens* is quite similar to *T. distichum* except possibly in size. The size range of *T. ascendens* pollen, although within the limits given by Wodehouse (2) for *T. distichum*, is generally somewhat smaller in various samples tested. Results of a statistical study of the size ranges of these forms are to be published elsewhere.

Since the pollen of *S. sempervirens* was collected more recently than that of *S. gigantea* (though both were samples from "mature" cones), there appeared the possibility that the difference might be accounted for on this basis. However, Wodehouse's (3) analine oil gentian violet method for observing pollen in the unexpanded condition also revealed consistent size differences. Assuming the two specific grains to be a perfect sphere and using the average of the volume of five hundred grains for each species, the total volume of *S. sempervirens* was found to be a little more than twice that of *S. gigantea*. It is interesting in this connection to note that the chromosome number of the former species is twice that of the latter one.

Numerous fresh collections of *Taxodium distichum* were sent to the writer through the kindness of Dr. Delzie Demaree of Monticello, Arkansas. The increase in the size of the microspores from the time of their escape from the microspore mother cell wall up to the time of shedding from the sporangia could be measured in this species. By measuring the longest diameters of the microspores, which were mounted in the same kind of medium, it was found that the increase was from about 20μ to 30μ within a period of approximately five days.

Sciadopitys verticillata (Thumb.) S. & Z. pollen was examined with special care since no published description can be found in the literature by the writer. The grains are unusual in that the exine, although thin as in other members of the group, is distinctly granular rather than flecked in appearance. Dry pollen show very deep folds, a condition often observed in unexpanded grass pollen. There is present one small thin ungranulated region on the exine which may represent the vestige of a germinal furrow. The intine is excessively thick. The size of the grains varies considerably. Measurements varied from approximately $36\text{-}44\mu$ in diameter, the maximum being larger than the maxima of any other genus of the Taxodiaceae. Only a few days after his book on "Pollen Grains" had gone to press Dr. Wodehouse succeeded in obtaining pollen of this species. His description agrees with the writer's own findings and he makes the following additional observation: "They differ from those of all other conifers in the texture of their exine which resembles the ventral surface of the grains of Tsuga."

Thick intines are present in pollen of all of the genera examined. Even in pollen treated with analine oil followed directly by xylol and then Canada balsam, this inner layer or intine appears much thicker than the exine. In the methyl-green-glycerine-jelly medium the grains become fully expanded and here again the dye stains the exine, leaving the thicker intine unstained though markedly visible by contrast. In water mounts the intine swells enormously and sometimes quite rapidly in some cases. A thick intine is often associated with grains having a thin exine. It is without doubt a distinguishing characteristic of the grains of this family so far examined, of the Cupressaceae, and of the Gramineae in general. Both of these latter groups, as well as the Taxodiaceae, have pollen with thin exines.

An extraordinarily thick intine is also observable in *Cunninghamia* (the thickest of any of the Taxodineae examined), but the pollen of this species has a somewhat more conspicuous "pore" than does *Sciadopitys* pollen which shows only a thinner spot on the exine and which appears smooth in contrast to the granular portion surrounding it.

Some confusion exists as to the presence or absence of a furrow or pore in *Cunninghamia*. Wodehouse (2) on page 248 of his "Pollen Grains" states that "in those (pollen) of *Cunninghamia* there is no trace of furrow or pore. . . .", whereas on page 271 of the same publication he lists *Cunninghamia sinensis* and states that the germ pore is a minute papilla, frequently not apparent. In recent correspondence Dr. Wodehouse writes, after examination of a sample of this species sent to him by the writer, that "the grains are similar to those of *Juniperus*, with exceptionally thin exine and thick intine. In spite of this, however, the germinal furrow *is represented* (italics mine) by a thin rounded pore in the exine through which the intine may occasionally bulge slightly as a flattish papilla." My own observations are in full accord with the latter statement. As has been noted above, a thick intine is also observable in pollen of other members of the family. The swollen intine observed in water preparations showed a positive reaction when tested with Ruthenium Red. It was impossible by this method to detect whether or not the intine consists of more than one layer. It appeared homogeneous in all cases examined. The capacity of this callose material (2) to swell greatly in water is thought by some botanists to be a pollination mechanism. The entire surface of such grains functions as a furrow, for the exine may be completely removed as a result.

By arranging the various genera examined in a linear series based on the "pore" character alone this sequence may be listed:

Cryptomeria—single germinal furrow represented by a projecting papilla; papilla longer than in *Sequoia* and less bent

Sequoia—single germinal furrow represented by a projecting and bent papilla

Taxodium—single germinal furrow represented by a germ pore less prominent than in genus above, conical and unbent

Cunninghamia—single rounded pore, papilla flattish

Sciadopitys—germinal furrow represented by a thin spot on the exine

In the character of its exine, however, *Sciadopitys* appears unique. It is of interest in this connection, to note that this genus is placed in a separate subfamily (Sciadopityoideae) by Pilger (1), and on the basis of its embryogeny in a separate family by Buchholz (4). Pope (5) has shown that in angiospermous pollen the shapes and sizes of grains in the various genera of a family are generally similar, although some families show striking differences.

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POLLINATION DROPS IN CERTAIN CONIFERS

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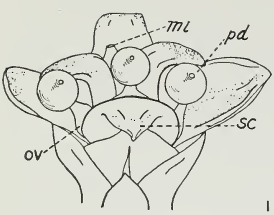
The occurrence of drops of liquid at the tips of the ovules of conifers at pollination time has been recorded for a number of species (Chamberlain, 1935)[1]. Very little, however, has been said concerning the time of their formation, their size, duration, nature, and actual function as part of the pollination mechanism. During the last season, I had occasion to observe the ovules of *Biota orientalis* and *Thuja occidentalis* closely; and the formation and behavior of pollination drops in these species was noted incidentally.

These two species, the Chinese and the American arbor vitae, are both planted in Illinois as ornamentals. Central Illinois is almost at the northern limit of the range of the Chinese arbor vitae and at the southern limit of that of the American arbor vitae. Both species do fairly well, however, and they cone freely annually. The ovulate cone axes elongate in January in the greenhouse and in late February or early March outside; and the protecting leaves separate exposing the cone scales. In *Biota*, fig. 1, the cone scales become thick and fleshy throughout, and as they expand, the tips flare backwards, thus freely exposing the six upright ovules. The open cone of *Biota* is one of the most beautiful among the conifers in its symmetry, coloring, and waxiness. The cone of *Thuja occidentalis*, fig. 2, differs from that of *Biota* in that the cone scales remain thin and stand erect, so that the six to ten ovules per cone are not as freely exposed. When the cones of both species are at the stage of development described, drops of liquid appear at the tips of the micropyles. These drops occur first about a week before pollen is shed. The diameter of the drops becomes several times larger than that of the micropyles, reaching 0.5 mm.; and as the drops stand poised upon the ovules they reflect everything about them in miniature. Depending upon the humidity of the surrounding air, a drop may disappear and reappear an indefinite number of times on the same ovule, or

[1] Chamberlain, C. J. 1935. Gymnosperms. Structure and evolution. University of Chicago Press.



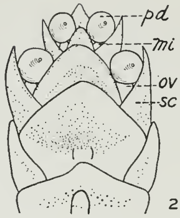


Fig. 1 (left).—Ovulate cone of *Biota orientalis* at pollination time.

Fig. 2 (right).—Ovulate cone of *Thuja occidentalis*. Campus, University of Illinois. February 23, 1939.

Both figures x 10½. Abbreviations: sc, scale; ov, ovule; mi, micropyle; pd, pollination drop.

it may remain apparently unchanged for a number of days. I have watched drops on the same ovules in the laboratory for nine days. It may be that some of the liquid evaporates while the volume of the drop remains constant through the addition of fresh liquid from the ovule. The drops continue to be present or to form afresh while pollen is being shed and even for a few days after all the microsporangia are empty; so that their period of formation and duration covers from ten to fourteen days.

The behavior of the pollen grains in the liquid of the drops is interesting. When numerous grains are shaken by hand on the ovules bearing drops, it is apparent even to the naked eye that the liquid is very quickly absorbed by the grains. If grains are present in sufficient numbers, they absorb the liquid and form a tiny yellow plug at the tip of the micropyle. In natural pollination, of course, only a few grains fall upon each drop.

When pollen was morphologically mature but still unshed in 1939, drops were present in great abundance. They adhered easily to a dissecting needle, and so were collected and placed upon a glass slide under the microscope. Pollen grains were then mounted in the liquid and observed. Immediately the intines began to take up the liquid in such quantity and with such rapidity that they burst the exines with almost explosive force; and the binucleate grains with their thick intines floated out leaving collapsed and wrinkled exines. When pollen that was shed naturally was mounted in the liquid, it behaved similarly but more slowly. After ten minutes, however, most of the grains had freed themselves from the exines. The dryness of the shed pollen may account for its slowness in swelling. In ovules sectioned a few hours after pollination, grains with swollen intines and cast-off exines were present in the micropyles and on the disintegrating nucellar surfaces.

It seems feasible to assume that in the Chinese and American arbor vitae, at least, the liquid of the pollination drops originates from the breaking down of the surface cells of the nucellus; and that the behavior of the grains in the drops is part of the normal process of the development of the male gametophyte.

NOTES ON THE HISTOLOGY OF AN ILLINOIS PSARONIUS

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The specimens studied were collected by Schopf and Carroll in 1938.[2] The material was well preserved and the peel method was used for sectioning. In addition to a microscopic study of the whole nitrocellulose peels, portions of these films were mounted in balsam and examined at high magnification.

Figure 1 shows that the character of the stem is in general similar to other species of polystichous *Psaroniae* that have been described from American[3] and European collections. The vascular system is polycyclic; i. e., the meristeles are arranged in a more or less concentric pattern, as in certain modern tree ferns of the Cyatheaceae. The central meristeles are smaller and are much more irregular in their relations. The vascular strands are surrounded by ground tissue which includes irregular sclerenchymatous bands. Large mucilage ducts, apparently lysigenous in origin, are also present in the ground parenchyma. In the peripheral region the mucilage ducts are larger, more frequent and more regularly arranged. Often there are two ducts present on the concave adaxial side of the leaf trace meristele. The stem is bordered by a mass of adventitious cortical roots.

Narrow bands of secondary growth are irregularly present on as many as ten of the meristeles. Secondary tracheids are laid down in quite regular rows. Fig. 2 shows a camera lucida drawing of a section through a secondary growth band with ground parenchyma at the right and primary xylem at left. Secondary xylem may be centrifugal or centripetal or both in its direction of growth. In longitudinal section these secondary tracheids show scalariform pitting as in fig. 3. The presence of secondary meristelar growth in *Psaronius* is an anomalous feature which seems previously unreported. Among modern ferns, the Ophioglossaceae are commonly known to produce secondary xylem. Farmer and Hill (1902)[4] have pointed out that in *Angiopteris evecta* and in some species of *Marrattia* certain cells situated next the meristele may undergo division forming secondary tracheids. The meristematic cells may occur singly or in groups. Secondary xylem in both Marrattiaceae and *Psaronius* is another point which may indicate their relationship.

It seems likely that phloem entirely surrounded individuals meristeles. Groups of parenchyma cells are scattered among the tracheids in the meristele as shown in figs. 4 and 5.

The free roots associated with this *Psaronius* may become quite large (2 to 3 cm. in diameter). The thick outer sclerenchyma is lost when they leave the peridermous cortex of the stem. Most of the cortex is lacunar as shown in Fig. 6. This is a character common to roots of modern hydrophytes and it probably indicates a similar environment for *Psaronius*. The stele is not precisely delineated from the cortex since no layer of cells can be definitely identified as endodermis. Phloem tissue is not definitely distinguishable though some of these small parenchymatous cells between the xylem rays must have assumed this function. The stellate xylem body is generally well preserved. It may be pentarch, or hexarch as shown in fig. 7, and probably varies within the same species. The protoxylem cells all appear scalariform in longitudinal sections and lack the char-

[1] This research has been carried on in the Coal Division Laboratories of the Illinois State Geological Survey. The author wishes to thank Dr. M. M. Leighton, Chief of the Survey, and members of the Coal Division for the opportunity to study this material and for the use of equipment and facilities provided.

[2] Schopf, James M. A significant collection of American coal balls. Chronica Botanica IV; 384-385, 1938.

[3] See Gillette, N. J., Morphology of Some American Species of Psaronius, Bot. Gaz. 99:80-102, 1937.

[4] Farmer, J. B. and Hill, I. G. On the arrangement and structure of the vascular strands in *Angiopteris evecta* and some other Marrattiaceae. Annals of Bot. XVI; 371-402, 1902.

acteristic annual or spiral thickenings. This is unusual since the position of the protoxylem is very definitely indicated by the small size of the tracheids.

There are other unusual features associated with this *Psaronius* stem, so that it will probably be necessary later to describe it as new species.[5] The presence of secondary growth in stem meristeles and the absence of spiral or annular tracheids in protoxylem areas of the free roots seem to be new features hitherto unreported from American *Psaronius* material.

[5] Description of the genus *Psaronius* and several previously described species are treated by Hirmer, M. Handbuch der Palaobotanik I. München und Berlin, 1927, pp. 545-566.

Explanation of Plate.—Histology of *Psaronius*

Fig. 1.—Segment of stem: Scale indicated. This, and other figures except fig. 7, from I. G. S. Coal Ball 137.

Fig. 2.—Meristele with secondary growth.

Fig. 3.—Longitudinal section through secondary xylem showing scalariform pitting.

Fig. 4.—Segment of meristele. Small xylem cells top center and below at left may represent protoxylem. Some of the thin walled tissue above and below may be phloem.

Fig. 5.—Longitudinal section through meristele. Note included parenchyma (see also fig. 4) and scalariform pitting.

Fig. 6.—Lacunar cortex of free growing *Psaronius* root.

Fig. 7.—Central tissues of free growing *Psaronius* root. Dark cells between stelar rays have secretory contents. From I. G. S. Coal Ball 203A (T 1).

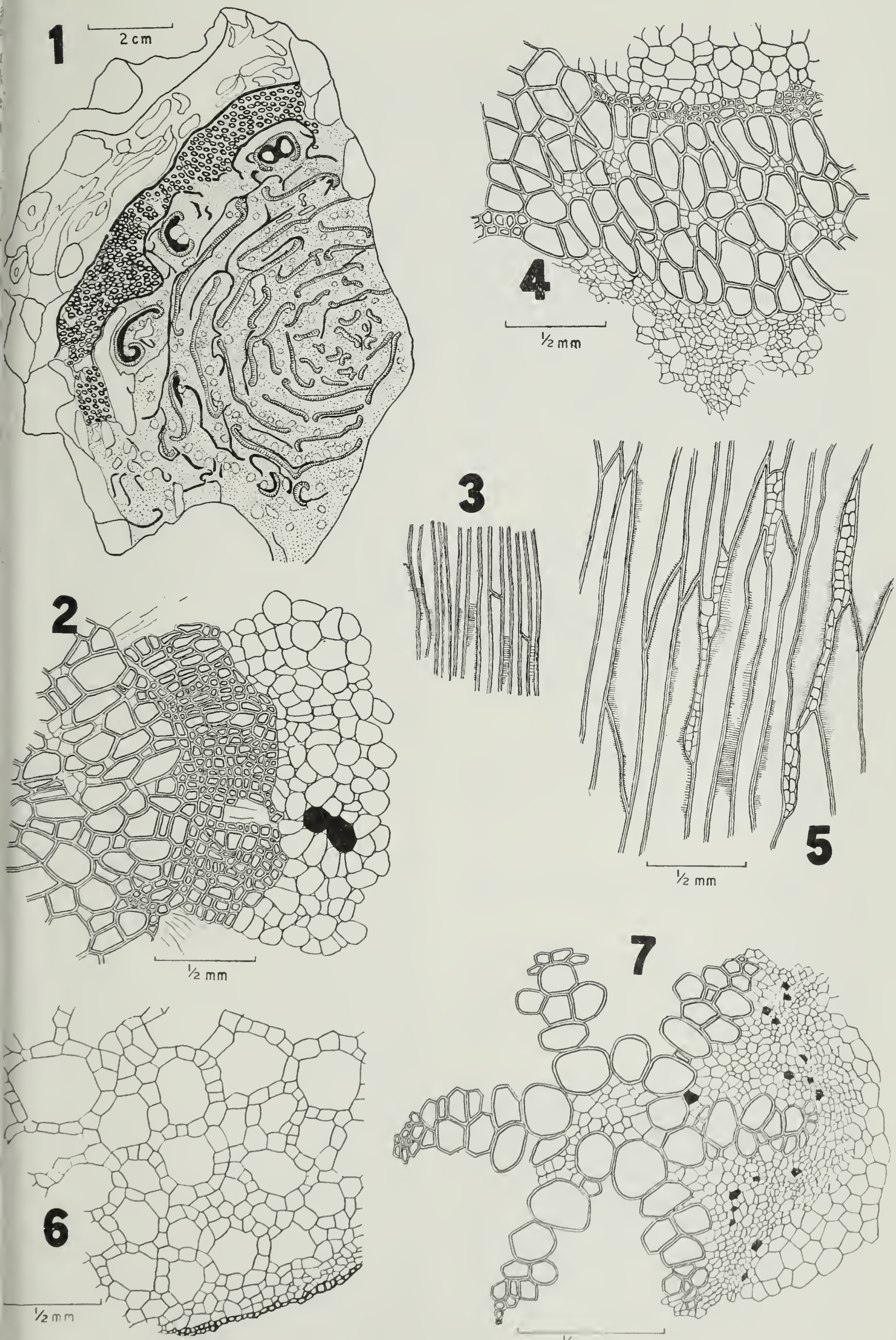

PLATE I

PLANT COVER FOR WILD ANIMALS DURING THE WINTER SEASON

George L. Terwilliger

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The writer has considered for some time past the relations that exist between the plants and animals of Northern Illinois. Through vocation (teaching of biology) and avocation (hunting) I have tried to find out just what might be done in our area to encourage a suitable plant growth to protect the animal life during both summer and winter seasons. Through personal observation and some data obtained by members of college classes in Animal Ecology I have arrived at a few conclusions. They follow briefly:

1. Summer plant cover is quite satisfactory in most areas. Small grains, hay crops, fence and hedge rows, even corn fields, offer considerable protection to nesting and feeding life. Nesting in hay fields is hazardous to wild life, however, in that incubation and cutting are oft times overlapped and many accidents occur.

2. Modern farming methods tend to discourage the old hedge rows and weedy fence rows, both of which are of considerable value to wild life, summer and winter.

3. Road commissioners are more and more trying to make parkways of the roadsides, which in turn reduces natural cover crops.

4. Many of the forms that make excellent cover in the summer are of little value as winter cover crop as they tend to snap off easily or have their leaves blown off.

Whether we consider pheasants, quail and partridge or rabbits the need of adequate protection through the winter season is of prime importance. Hedge rows have been, and are, one of the very best means of affording a good hiding place. They are usually associated with briars and bush. These in turn tend to hold up the grasses and weeds and make permanent hiding places and areas where the seeds are held out of the snow. Long rows of cover seem better than one large clump in that the wild life has a better chance of escape from any natural enemies that might be in the area. The presence of pigeon grass and various other weeds affords food material for quail and pheasant and the bark of the shrubs and fruits from roses and red haws will take care of the food needs of the rabbits.

In the pictures which have been taken to illustrate this talk I have endeavored to show contrasting condition of summer and winter cover. Some that look excellent in August will not hide a pheasant or a rabbit in December. Corn, for example, will have most of its leaves snapped off before spring arrives. Many of the smaller grasses will become matted and worthless as cover. Many farmers will have removed hedges and cut or burned out the weeds of the fence rows. This practice is probably conducive to good farming, but it is tough on the wild life.

On a trip made the latter part of April some areas were found where the plant cover was still erect and sufficiently dense to be of value as a cover. In one rather marshy area the old growth of rushes and smartweed made a framework on which the leafy sedges hung in abundance. This created one of the finest covers that I have seen. Another area which afforded excellent protection consisted of stinging nettle, pigweed, goldenrod, wild aster, giant ragweed, smart weed and pigeon grass. This association not only stood up well during the winter but kept a fair share of its foliage and still had seeds in the flower heads.

The local sportman's club is sponsoring a movement whereby it will furnish seed of a "Game Bird Cover Mixture" to any farmer who will set aside some small area to be used as a sort of a refuge. If more farmers would leave a wide turn at the corner, or a good growth along ditches and not burn out the fence rows the problem of coverage for wild life would be greatly lessened.

Papers In Chemistry

Extract From the Report of the Section Chairman

The program of the Chemistry Section carried 22 papers, 16 of which are herewith printed. The remaining six were entitled as follows:

Structure of vinyl polymers: the polymer of methyldbromoacryolate, by J. C. Cowan, University of Illinois, Urbana.

The structure of polyvinyl chloride, by Carl S. Marvel and James H. Sample, University of Illinois, Urbana.

Synthetic resins, by Charles L. Levesque, University of Illinois, Urbana.

Some curious growths of copper sulfate crystals, by J. B. Magnuson, Augustana College, Rock Island.

Project work in the High School, by John C. Chiddix, Normal Community High School, Normal.

Some practical applications of the glass electrode, by Forrest Anderson, Wilkins, Anderson & Co., Chicago.

Average attendance at the sessions was 75.

As chairman for the 1940 meeting, those present elected *James Neckers,* Southern Illinois State Normal University, Carbondale.

(Signed) John de Vries, *Chairman*

TECHNICS FOR LARGE GROUP DEMONSTRATION

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The use of the lecture demonstration method for large group instruction involves many difficulties. In the development of the Survey course of the Physical Sciences in the Chicago City Colleges the lecture demonstration method was adopted. With the lecture sections running as high as three hundred students most of the usual types of demonstration apparatus are unsatisfactory on account of visibility; therefore the three colleges embarked on a program of developing specially built equipment, first through a shop, then through the collaboration of WPA project 3702. The following pieces of apparatus have been found useful.

1. Test tube rack, 37 x 9 x 13 cm. with openings for 40 x 300 mm. test tubes. The rack has a bulb and reflector below to illuminate the tubes. Test tubes of 65 x 500 mm. size are used occasionally. To increase visibility the tubes may be sand-blasted.
2. Apparatus showing the reaction of nitrogen and oxygen at high temperatures, consisting of an inverted 5 liter or 10 liter round bottom flask provided with a 4-hole rubber stopper for the copper electrodes, inlet and outlet of air.
3. Model Geyser, five feet high, made of sheet iron to illustrate the action of a geyser. The apparatus consists of a constricted vertical tube which is filled with water and has a source of heat at the bottom. A large tray on top serves to collect the erupted water.
4. Long wire apparatus to illustrate magnetic forces acting on a wire which is carrying an electric current. The terminals are attached to a source of direct current; when the commutator is at the lower position the current flows in the same direction in both wires which then attract each other. Reversing causes repelling. A number of other standard pieces of apparatus were built on a larger scale, such as apparatus for the magnetic field of a helix, collision apparatus, thermal expansion of metals, etc.

Aside from the use of larger pieces of apparatus and special illumination to increase visibility, it has been found that for large group demonstrations the experiments have to be carefully selected and rehearsed. The function of the demonstration experiment must be critically evaluated. In the experience of the authors, it has been found that although a skilled experimenter, acting with assistants, can perform many more experiments in three lecture periods per week even while lecturing, than a neophyte can perform even in six laboratory periods. Such a procedure defeats the function of demonstrations. Aside from the motivation and arousal of interest which is often desirable in large group demonstration, the chief function of the demonstration is believed to be observation of events and facts, their explanation and the checking of the explanation. Unless a demonstration experiment is carefully and slowly performed and explained, it fails to accomplish its main objective. It has been found advantageous to select the experiments, avoid a large number, perform a few, prepare the students for each, and explain in detail each step.

However, even with the best of efforts many students are found to be dissatisfied with being merely onlookers to demonstrations. To satisfy the normal desire to handle things for themselves, a survey experiment room was developed where the students were free to go whenever they pleased and view at close range the demonstrations of last week's lectures. Other exhibits were added on related topics. This has led slowly to the development of simple experiments for the non-professional student. Among those that can be briefly mentioned are (a) evolution of oxygen from hydrogen peroxide by the addition of manganese dioxide, (b) determination of the densities of various metals or objects having approximately the same volume, (c) change of state by using ethylene bromide which has a melting point of ——°C. (d) use of a pH universal indicator to demonstrate differences between strong and weak acids and bases, and the relative hydrogen ion concentration of soil, saliva and other common substances.

Work is in progress toward this end. In general, the authors are firmly convinced that there are certain concepts in science which are difficult if not impossible for the average student to understand without some first hand experience with the facts from which conclusions are drawn and the *methods* which are used to check these conclusions.

HYDROLYSIS OF TERTIARY ALKYL HALIDES

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The hydrolysis of tertiary halides has been reported several times in the literature.[1,2,3] There is quite a disagreement, however, as to relative amounts of carbinol and olefin in the results reported. French, McShan and Johler report on the hydrolysis of tertiary butyl chloride at 50° C. using 0.01 normal alkali (KOH) a yield of 96.71 per cent of carbinol and 1.3 per cent of olefin. On the other hand, Woodburn and Whitmore report the hydrolysis of tertiary amyl chloride and bromide, both at room and reflux temperatures, and in presence and absence of alkali, yield mostly olefin at higher temperatures.

The methods of analysis used by French and his collaborators are to collect olefin over water and then to estimate it by gasometric analysis. The carbinol was determined by the refractive indices of the aqueous distillates. Woodburn and Whitmore fractionate the aqueous and organic layers through an adiabatic column. The data as to the composition of the hydrolytic mixture do not seem to be quantitative.

In an extensive investigation of the rates of ammonolysis of the alkyl halides, it was noted that the tertiary alkyl halides react very rapidly with both aqueous and alcoholic ammonia to yield large amounts of olefins and very little amine. This observation and the lack of agreement in the literature as to the composition of the hydrolytic mixtures of alkyl halides led to the present investigation.

Method.—Measured amounts of the halides and water were sealed in ampoules and heated at the temperature indicated. The ampoules were rapidly cooled, opened, and the contents extracted with purified n-hexane. The organic layer was analyzed for unreacted halide by shaking with standard silver nitrate and for olefin by using standard bromide-bromate. The accuracy of this method for the estimation of olefin in presence of halide and carbinol was carefully checked, using known amounts of 2-methyl-butene-2. For samples containing as little as 30 mgs. of olefin, the error was not above 20 parts per thousand.

Results.—The results of several runs are summarized in tables I, II, and III.

Table I shows the composition of the equilibrium mixture when one mole of

TABLE I—HYDROLYSIS OF TERTIARY AMYL HALIDES AT 100° C.
(one mole halide : 10 moles water)

Halide	No.	Time heated hrs.	Halide ion produced %	Unreacted halide %	Total %	Olefin %	Carbinol %
Chloride	120	100	70.9	27.5	98.4	60.2	12.3
Chloride	121	100	70.7	29.2	99.9	60.1	10.7
Bromide	102	100	87.8	10.2	98.0	61.4	28.4
Bromide	103	100	88.5	8.8	97.3	60.7	30.5
Iodide	122	100	87.6	10.7	98.3	49.5	39.8
Iodide	123	100	87.3	10.2	97.5	51.0	38.8
Bromide[a]	124	100	99.3	0.2	99.5	83.5	16.1
Bromide[b]	125	100	99.1	0.4	99.5	81.1	18.5

[a] One mole of sodium hydroxide added.
[b] Sodium hydroxide, 2.5 moles added.

tertiary amyl halide is hydrolyzed with ten moles of water at 100° C. The extent of hydrolysis is the same in the case of bromide and iodide but less for the chloride, while the amount of olefin is about 60 per cent for the chloride and bromide, and 50 per cent for the iodide. Alkali increases the amount of olefin but does not suppress entirely the formation of carbinol.

The conclusion that equilibrium mixtures result is shown in table II. Approximately the same composition is obtained in samples of: (a) One mole of bromide with 10 moles of water; (b) One mole of carbinol with one mole of hydrogen bromide and nine moles of water; (c) One mole of olefin with one mole of hydrogen bromide and 10 moles of water.

The effect of increase in the amount of water is shown in table III. As expected, the amount of amyl bromide decreases, but olefin, rather than carbinol shows an increase.

Comparison with the results obtained with tertiary butyl bromide shows some unexpected results. The amount of olefin is negligible, diminishing rather than increasing with alkali.

The conclusion is reached that no single generalization can be made about the hydrolysis of tertiary alkyl halides. The influence of the radical on the direction of the reaction is very marked.

TABLE II—COMPOSITION OF EQUILIBRIUM MIXTURES OBTAINED BY:

a. Hydrolysis of tert-amyl bromide
b. Hydrogen bromide and tert-amyl alcohol
c. Hydrogen bromide and 2-methyl-butene-2 at 100° C.

Mixture	No.	Hours heated	Halide Ion produced %	Unreacted halide %	Olefin %	Carbinol %
Bromide-1 mole, Water-10 moles	100	100	88.4	7.1	60.7	32.1
	101	100	89.2	7.1	60.1	32.9
ter-amyl alcohol-1 mole, Water-9 moles, HBr-1 mole	108	100	88.7	8.1	61.4	30.3
	109	100	91.1	7.2	60.1	32.4
2-methyl-butene-2—1 mole, Water-9 moles, HBr-1 mole	110	100	90.5	9.05	60.6	30.3
	111	100	93.0	8.1	60.1	31.1

TABLE III—COMPOSITION OF HYDROLYSIS MIXTURES OF TERTIARY BUTYL AND AMYL BROMIDES UNDER VARIOUS CONDITIONS

Tertiary Bromide	Moles of H_2O per one mole Halide	Temp. °C.	Time heated hrs.	Composition			Carbinol %
				Halide Ion %	Unreacted Halide %	Olefin %	
Amyl	10	100	24	89.2	7.1	60.7	32.1
Amyl	40	100	24	98.6	1.7	70.8	27.5
Amyl	100	100	24	99.0	0.9	77.1	22.0
Butyl	100	100	24	99.5	0.0	9.5	90.5
Butyl	100	50	24	99.2	0.0	1.3	98.7
Butyl	10	100	24	89.9	9.2	40.9	49.1
Butyl	100[a]	50	24	99.6	0.0	3.2	96.8
Butyl	100[b]	100	24	99.2	0.0	5.4	94.6

[a] Plus 3.75 moles of NaOH.
[b] Plus 3.75 moles of NaOH.

[1] H. E. French, W. H. McShan and W. W. Johler, JACS 56, 1347.
[2] H. Milton Woodburn and F. C. Whitmore, JACS 56, 1394.
[3] Edward Hughes, JACS 57, 708.

MOTOR FUELS OVER THE WORLD

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Since the world wide adoption of the automobile, the problem of procuring sufficient motor fuel of high quality has been constantly enlarging. For those countries containing sufficient supplies of crude petroleum, the problem has to do only with a constantly increasing quality demanded by the more highly efficient motor vehicles of today. The European countries with exception of Russia and Rumania are almost totally lacking in crude oil supplies, and consequently various indigenous materials are processed to form substitutes for motor fuels.

In the United States crude oil production has reached over 1,200,000,000 barrels per year. The motor fuels derived from this petroleum in the form of straight run gasoline have octane ratings as low as 15 which is much too low for use in the high compression motor of today.

High efficiency of motor fuels is dependent upon the structure of the hydrocarbons present in the gasoline. The hydrocarbons in motor fuel belong to five groups: paraffins, olefins, cycloparaffins, cycloolefins, and aromatics. Of this group, the branched chain paraffins are considered best for present day motor fuels, especially for aircraft engines. The branched chain olefins have lower octane ratings than the corresponding paraffins, while the cyclic paraffins, methyl cyclopentane and cyclohexane are still lower, ranging between 77 and 79. The aromatics, benzol, toluol, and xylols have over 100 octane rating, but due to their carbonizing tendencies have not been generally used in airplane engines.

The researches in the oil industry are tending toward the production of fewer hydrocarbons in gasoline so that the combustion conditions of the modern motor may be controlled to a nicety. Precise control is not possible with the heterogeneous mixtures of hydrocarbons now in general use. The ideal motor fuel would contain but a single hydrocarbon, or perhaps a half dozen, each to suit the climatic conditions prevailing over the country.

Cracking of gasoline and heavy oils.—Gasoline produced from the distillation of crude oil containing relatively high percentages of straight-chain paraffin hydrocarbons is subjected to temperatures of the order of 1025° F. and pressure of 750 pounds to the square inch. The gasoline of low octane rating is converted into a 68 to 78 octane product, depending upon the composition of the original gasoline. The paraffinic hydrocarbons under the high temperature and pressure conditions are converted into olefinic, cycloparaffinic, and aromatic hydrocarbons of greatly improved octane ratings. Some cracking or reforming units process over 12,000 barrels of gasoline a day. During 1938 about 240,000,000 barrels of gasoline derived from the atmospheric pressure distillation of crude oil were produced, of which 25 per cent was reformed into motor fuel of high octane rating.

When cracking crude oil or heavy oils such as kerosene, gas oil, or fuel oil, a combination distillation-cracking unit or a cracking unit alone is used. The largest combination unit, treating about 35,000 barrels of crude oil a day, produces 68 per cent of 70 octane rating gasoline. Dependent upon the type of oil processed, the conditions of temperature may range between 900 and 1025° F. and pressure to over 750 pounds per square inch. Under these conditions, the yields of motor fuel range from 50 to over 75 per cent with octane ratings from 58 to 78 depending upon the quality of the cracking stocks.

The estimated volume of cracked gasoline produced from heavy oils in the U. S. during 1938 was 270,000,000 out of a total of 510,000,000 barrels derived from the refining of crude oil.

The catalytic cracking of oil has been developed by Universal Oil Products Company so that higher octane motor fuel can be produced than from high temperature-pressure cracking. A cracking test using a Mid-Continent gas oil yielded 85 per cent of 81 octane motor fuel. When the cracked gases from this operation are polymerized selectively and then hydrogenated, a 12 per cent yield of a 96 octane rating motor fuel results. Branched-chain paraffin hydrocarbons (largely isooctanes) make up the motor fuels which are particularly suitable for airplane use. In addition to this yield of isoparaffins, 73 per cent of an 81 octane motor fuel resulted from the catalytic cracking of Mid-Continent gas oil. Such yields of high octane gasoline are not obtainable from the high temperature-pressure cracking of the same Mid-Continent gas oil. The process of catalytically cracking oil will profoundly influence automotive engine designers, as the speed and efficiencies of motor vehicles and airplanes will depend upon these types of gasoline.

The Houdry catalytic process produces an 80 octane motor fuel in 45 per cent yield on a once-through basis. A number of catalytic cracking units are now under design, construction, and operation in the United States.

Hydrocarbon gases from cracking.—In addition to the volume of cracked gasoline derived by the reforming and the cracking of oil, approximately 350,000,000,000 cubic feet of cracked gas is produced yearly. For a number of years the gas from the cracking reaction was utilized only as fuel under boilers and stills. The cracked gases contain olefinic hydrocarbons such as ethylene, propene, and butenes in addition to methane, ethane, propane, and butanes. The commercial value of the hydrocarbon gases from the cracking process and natural gas has been greatly increased by the ever growing demand for high octane motor fuel. There are three polymerization processes in commercial use, two of which are thermal and use high pressure and the other is catalytic and operates at low temperature and pressure. The type hydrocarbons present in the motor fuels produced by the thermal process are olefins, paraffins, cycloparaffins and aromatics. The catalytic polymerization process produces a branched chain olefin gasoline.

Octane rating and pay load.—The manufacture of isooctane having 100 octane rating in large quantities has had a profound influence on the design and operation of modern airplane motors. From the former expensive method of producing isobutenes from butyl alcohol, and synthesizing isooctane ($25 a gallon), we are able to polymerize the normal and isobutenes present in the butane and butene fraction derived from the cracking process. The butenes react with one another and then, on hydrogenation, are converted into 90 to 100 octane motor fuel.

By the use of 100 octane motor fuel it has been estimated that each pay load could be increased by $2,000 on the China Clipper ships flying from California to the Orient. In engines designed to make use of the higher-quality fuels, it has been estimated that each additional octane number is worth from two to five cents per gallon in the earning power of the gasoline. A limiting factor on the value of octane increase is that the heat value must be maintained, or the octane increase must be discounted by about two numbers for each per cent lowering in heat content of the fuel compared to hydrocarbons, if fuels such as ethyl alcohol, ethers, or ketones are used. Hydrocarbon fuels contain the highest energy content on a weight basis, and therefore higher octane ratings mean increased take-off and pay-load ability and cruising range. The increase from 85 to 100 octane fuel in airplanes raises the pay load from 20 to 30 per cent, cuts the take-off distance in half, increases speed from 20 to 30 per cent, and the altitude climb 25 per cent or more.

Since significant oil resources are lacking in every European nation except Rumania and Russia, the subsidized and compulsory use of substitute motor fuels is practiced by most European powers to obtain economic and military self-sufficiency.

In 1937 Europe satisfied 18 per cent of its motor fuel requirements with substitute fuels; in 1938, an estimated 25 per cent. The estimated extra cost of the substitute fuels consumed in Europe during 1937 over what comparable quantities of imported gasoline would have cost was $235,000,000, equivalent to 32 cents for every gallon of substitute fuel consumed. The extra cost of such fuels in 1938 will probably be increased to $300,000,000.

Constituting 7 per cent of all motor fuel consumption, synthetic gasoline hydrogenated from coal and carbon monoxide moved up in 1937 to an apparently permanent position as Europe's

TABLE I—EUROPEAN PROPORTIONS OF SUBSTITUTE FUELS IN 1937*

IN METRIC TONS

Country	Alcohol	Benzene	Oil from Coal and Synthetic Gasoline	Shale Spirit	Total Substitutes	Total light Motor Fuel Consumption	Per Cent Substitutes
Germany	210,000	430,000	800,000	------------	1,440,000	2,640,000	54.5
Estonia	------------	------------	------------	7,300	7,300	14,300	51.9
Czechoslovakia	50,600	12,000	------------	------------	62,600	220,000	28.5
Lithuania	1,294	------------	------------	------------	1,294	5,700	22.7
Hungary	10,516	3,100	------------	------------	13,616	69,100	19.7
Poland	7,955	10,000	------------	------------	17,955	98,200	18.3
Latvia	2,154	------------	------------	1,300	3,454	19,400	17.8
Yugoslavia	3,806	------------	------------	------------	3,806	30,200	12.6
Belgium	------------	36,700	------------	------------	36,700	408,800	9.0
France	153,400	80,000	13,000	1,500	247,900	2,827,000	8.8
United Kingdom	16,000	230,000	120,000	26,000	392,000	4,840,000	8.1
Italy	37,000	------------	------------	------------	37,000	483,500	7.7
Austria	2,300	8,200	------------	------------	10,500	146,300	7.2
Sweden	15,247	500	------------	------------	15,747	503,200	3.1
Holland	------------	10,800	------------	------------	10,800	392,600	2.8
Finland	------------	200	------------	2,700	2,900	112,500	2.6
Switzerland	50	3,000	------------	------------	3,050	203,900	1.5
Total	510,332	824,500	933,000	38,800	2,306,622	13,014,700	17.7

* Total European light motor fuel consumption, including countries not enumerated, was 14,344,000 metric tons.

primary and cheapest substitute fuel, even though costing governments and consumers an estimated $79,514,500 more than an equivalent amount of imported gasoline. Previously the main substitute fuel, benzol, dropped to second place during 1937 when it accounted for 6.3 per cent of total European motor fuel consumption and cost governments and consumers $49,463,000 more than the same amount of imported gasoline. Power alcohol which represents 4.3 per cent of European motor fuel consumption declined in use 25 per cent in 1937 from the previous year, lowering that product to third rank among substitute fuels. Its estimated cost over imported gasoline, including subsidies, was $104,060,500. Of the numerous secondary substitute fuels, compressed gases were the most important, supplanting an estimated 190,000 tons of gasoline, and showing signs of continued increase in usage.

Coal and carbon monoxide hydrogenation.—In 1937 when 7,500,000 barrels of synthetic gasoline were produced by direct hydrogenation of coal and by hydrogenation of carbon monoxide derived from coal, this gasoline became established as Europe's primary substitute fuel. Both hydrogenation processes were developed in Germany and there is an annual production of 17,000,000 barrels of synthetic gasoline from units now (March 1939) operating and building or designed. About 1,300,000 barrels a year are produced in England from direct coal hydrogenation to gasoline. One catalytic unit in France at capacity operation can convert water gas from coal into 110,000 barrels of motor fuel annually. No other countries are using these processes at present.

Direct hydrogenation of coal into gasoline is carried out at pressures of the order of 4,000 lbs. and temperatures of about 850° F. in the presence of catalysts. (See fig. 1.)

The second process, the hydrogenation of carbon monoxide (Fischer-Tropsch process), is carried out at atmospheric or super-atmospheric pressure in the presence of catalysts and temperatures of the order of 350° F. (See fig. 2.) This latter process yields a mixture called "Kogasin Oil," comprising motor fuel, kerosene, Diesel oil and paraffin wax, and motor fuel production from it in Germany will be 530,000 tons annually from units now operating and under design and construction.

Exact and official figures on production costs of motor fuel from hydrogenation processes are lacking, but a number of European sources privately place them at 17 and 19 cents per U. S. gallon.

Indicating far lower costs than for any other liquid substitute fuel in Europe, including benzol, oil shale spirit, and alcohol, these prices point to the main reason why synthetic gasoline hydrogenated from coal has emerged as Europe's primary gasoline substitute. Costly however obtained, self-sufficiency in motor fuel naturally is desired at the lowest price. Another important factor is that all other significant liquid substitutes are only partial substitutes and must be blended with larger amounts of gasoline for satisfactory operation in present day automobiles, whereas synthetic gasoline from coal so closely approximates the qualities and characteristics of gasoline from oil that its use alone is practicable. Production of synthetic gasoline from coal offers nations like Germany, with ample coal resources and technological facilities, the only promising route to motor fuel self-sufficiency which has appeared throughout Europe. Largely by this means Germany became 54.5 per cent self-sufficient in light fuel requirements in 1937, and its self-sufficiency during 1938 will probably be further increased.

Prevailing costs of gasoline from coal in Europe must not be considered conclusive. Private data from American sources closely in touch with foreign coal hydrogenation operations indicate that these costs translated to U. S. conditions today would range from 14 to 16 cents per gallon. In any remote future when the United States might need to process coal into motor fuel, materially lower prices would result from the thorough application of American petroleum refining technology, effecting substantial reductions in capital and operating costs which in European units, the first constructed, have been high.

Benzol motor fuel.—The prime source of benzol motor fuel is the high-temperature carbonization of coal, which yields gas, coal tar, and metallurgical coke. The gas is scrubbed with oil or activated carbon and the coal tar is distilled, giving a maximum yield of 3 gallons of benzene of 90 octane rating per ton of coal. It is blended with lower grade fuels to raise their antiknock value.

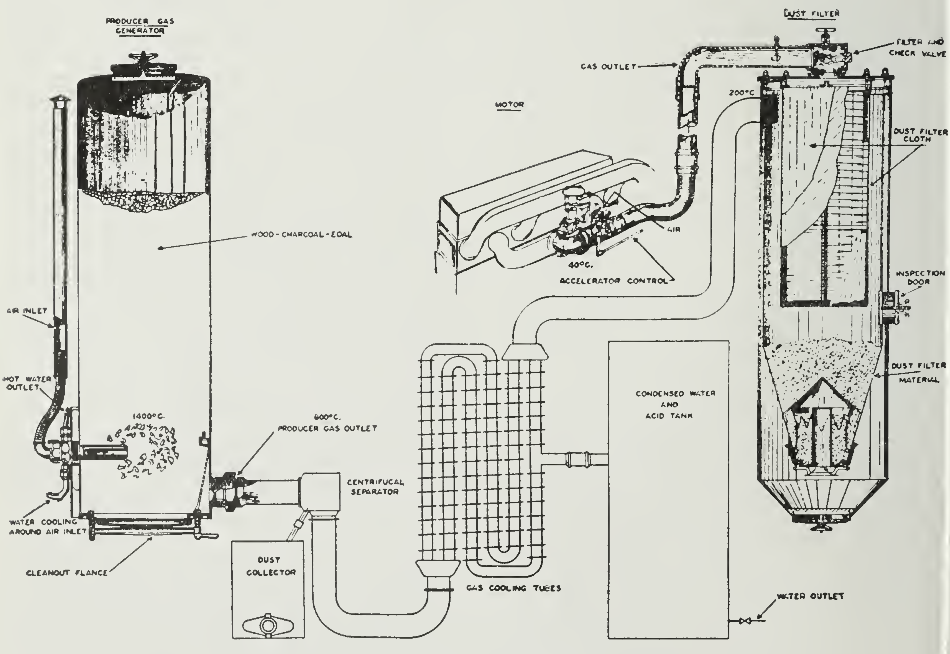

Fig. 1.—Motor fuel from coal hydrogenation.

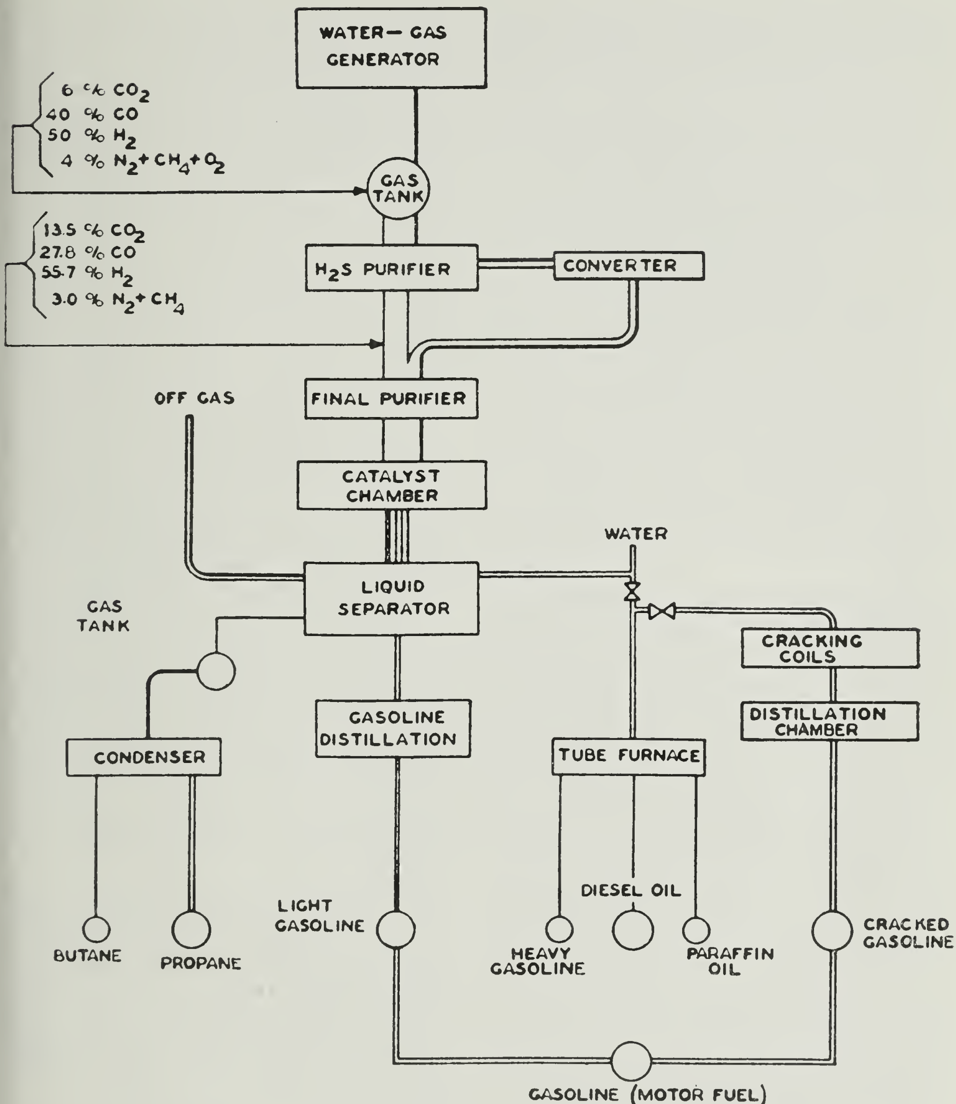

Fig. 2.—Motor fuel from water-gas reaction, Fischer-Tropsch process.

The benzene and toluene in this type fuel are diverted in wartime to munitions manufacture. The Mining and Power Commission of the French Chamber of Deputies recently reported: "Benzene would also have to be reserved in time of war for the manufacture of explosives. Its production, moreover, is limited by the activity of coke ovens and gasworks and is therefore capable only of slight expansion. . . ."

The cost to European consumers was $49,463,000 more for benzene motor fuel than it would have been for gasoline, as a result of loss of taxes, governmental subsidies, and benzene production costs. Expressed another way, it was 20 cents more for each gallon of benzene fuel consumed.

Compressed gas.—Natural gas and combustible gases rank fourth among substitute fuels; they are derived from hydrogenation of coal and carbon monoxide to hydrocarbons, and from the cracking process. The replacement of 250,000 tons of gasoline throughout Europe in 1938 is estimated.

Motor vehicles are converted into the compressed gas consuming type at costs ranging from $150 to $300. Primary changes are: a) installation of racks to hold the steel cylinder weighing 115 lbs. and more empty; b) addition of regulating valves to control the flow of gas into the motor; c) substitution of a special gas-air mixer in place of a carburetor. Cruising ranges on 2 cylinders of city gas, methane, or propane-butane are respectively 25, 85 and 225 miles. Service stations refill or replace the empty cylinders. The methane, ethane, propane and butane are stored up to 4,000 lbs. per square inch pressure in the steel alloy cylinders attached to the automotive vehicle.

Motors burning compressed gases are subsidized and granted tax reductions by the German and Italian governments. The fuel for an estimated 25,000 of such vehicles in Germany will replace 150,000 tons of gasoline in 1938. On a gallon of gasoline basis, city gas in Germany costs 43 cents, motor methane 41 cents, and propane-butane 61 cents. Natural gas used in Italian vehicles supplants about 40,000 tons (350,000 bbls.) of gasoline annually, and it is expected that within two years the use of methane from natural gas and coal carbonization will be four-fold greater than it is at present.

Alcohol motor fuels.—The increased use of power alcohol was demanded in Central Europe from 1930 to 1937 by heavy governmental subsidies. Alcohol motor fuel consumption increased in Europe during 1930 to 1936 from 59,000 to 648,000 tons. However, a sharp decline took place in 1937 with the use of only 510,000 tons, a drop of 25 per cent. A more drastic drop is indicated for 1938. Alcohol may be eliminated as a source of power as a result of the staggering economic losses involved, its diversion to other uses, and its encroachment upon food supplies.

A loss of European income of about $105,000,000 was incurred during 1937 alone, based upon subsidizing the producers, tax losses, and higher fuel costs. These losses resulted from the marketing of 510,300 tons of alcohol out of a total 11,882,600 tons or 4.3 per cent of the motor fuel used in Europe.

Germany and France have been the heaviest consumers of power alcohol, and their supply was derived primarily from sugar beets and potatoes. Germany required a 10 per cent blend of alcohol with gasoline, but four years after the legal requirement, it was found that there was insufficient alcohol produced in the country to fulfill the law. In order to meet government specifications, it was necessary to import alcohol to cover the deficiency. During 1937, synthetic methanol was used in Germany to the extent of 70,000 tons to make up the 10 per cent alcohol quota, but it was not sufficient to stop the drain on basic foodstuffs entailed by so drastic a requirement in motor fuel. The percentage of alcohol required in motor fuel was reduced from 10 to 8.5 per cent in October, 1937, and to 6.9 per cent in April, 1938.

In France the sugar beet is grown primarily for the purpose of furnishing power alcohol, so that there is no excessive drain on foodstuffs. The laws requiring from 10 to 35 per cent alcohol in motor fuels were for the purpose of absorbing the products of the vineyards and beet farms; but as a result of drought neither group was able to produce the legal amount of alcohol required for blending.

The Germany subsidy to the potato alcohol producers is about $130 per ton of power alcohol or about 39 cents per gallon. In order to increase alcohol production 100,000 tons a year from farm products, France legislated in June, 1938, to the effect of paying $12,500,000 for this amount of alcohol, which figures a subsidy of about 36 cents per gallon.

Power alcohol consumption reached a peak of 321,300 tons in France, in 1935, dropping to 153,400 during 1937, a shrinkage of over 52 per cent. During 1935 France used over 55 per cent of the total power alcohol of Europe and about 33 percent during 1937; an estimate is given for 1938 of less than 25 per cent of the total. The power alcohol goal set by law has not been reached (the percentage alcohol blend during 1937 was 5.4 per cent) as a result of natural causes and to diversion of alcohol to other uses such as munitions manufacture.

In Germany the use of alcohol from agricultural products has fallen off sharply—i. e., 20,000 tons during 1937 compared to 1936. Of the 210,000 tons of alcohol used during 1937, methanol represented 70,000 tons, leaving 140,000 tons of ethanol derived from potatoes, etc. This alcohol tonnage of 140,000 is about the same quantity as was used in Germany five years ago.

Power alcohol consumption for Germany and France is shown in table II.

The data showing the alcohol consumption and percentages of the total motor fuel consumed during 1937 in European countries are shown in table III, the alcohol used in motor fuel ranging from 0.3 per cent for the United Kingdom to 23.0 per cent for Czechoslovakia:

Great Britain has never compelled the use of power alcohol for blending purposes in order to subsidize the agricultural industries. This is probably due largely to the fact that the raw material, molasses, must be imported.

The British Government further encourages alcohol motor fuel blends by exempting both their alcohol and benzene content from the import duty on motor fuel, which was 8d. per Imperial gallon (about 16 cents per U. S. gallon).

Increased gasoline taxes have formed only a part of the encouragement given to power alcohol. In most European countries alcohol is heavily subsidized—i. e., Germany 39 cents per gallon and France 36 cents per gallon; the government monopolies pay higher prices to distilleries than to distributing companies. The monetary losses entailed due to power alcohol use in the countries of Europe during 1937 was $104,060,500.

The following table shows alcohol tax losses, subsidies, and extra cost to consumer above tax-paid gasoline:

Germany	$53,738,000
France	36,634,000
United Kingdom	1,538,000
Italy	4,145,500
Czechoslovakia	3,032,500
Hungary	1,677,500
Yugoslavia	930,000
Sweden	849,000
Poland	584,000
Latvia	367,000
Austria	383,500
Lithuania	181,500
Total	$104,060,500

Europe's power alcohol policies have made difficulties for motorists which have been little recognized in the United States. The instability of alcohol supplies has caused repeated changes in the octane ratings of fuel sold the public. No sooner do car operators and automobile manufacturers adjust engines to run on fuels of a given antiknock value than an increase or decrease in the supply of power alcohol results in the raising or lowering of the antiknock value of fuels and in making readjustments necessary.

On June 17, 1938, the French Government was confronted with a surplus of wheat and imposed an additional tax of 20 centimes per liter (2.1 cents per U. S. gallon) on gasoline to subsidize the manufacture of power alcohol primarily from wheat to the amount of 1,250,000 hectoliters (32,875,000 U. S. gallons) annually, with the result that alcohol again must be blended in essence tourisme and a further change in octane rating is made necessary.

Armaments and alcohol policies.—Recent events have confirmed previous analyses showing that the primary reason for compulsory use of alcohol in motor fuel in Europe is the desire of the countries to develop and maintain their alcohol industries for the purpose of national defense; this is done not merely as a protection against failure of petroleum supplies in wartime due to blockades but to assure adequate capacity for manufacture of a prime raw material in making munitions—namely, alcohol. Significantly, the war scare which gripped all Europe during 1937 was accompanied by a sharp decline of alcohol used in motor fuel. This decrease was far too great to be explainable solely by crop shortages in sugar beets, the main source of alcohol in France and Italy, and must be attributed to the large quantities of alcohol consumed for armament purposes. Classified as confidential military information, diversion of alcohol from motor fuel channels to use in making munitions has seldom been publicly mentioned. In at least one instance, however, it has been reported as a cause for the decline in France of alcohol for motor fuel purposes during 1937. Numerous informed sources abroad privately acknowledge that similar diversion of alcohol is also an important factor for the decline of alcohol for use in motor fuel in Italy and probably in Germany.

Table II—Power Alcohol Consumption in Germany and France, 1930-37

Year	Germany	France	European total
	(Metric tons)		
1930	?	28,000	59,000
1931	50,000	52,100	121,000
1932	95,000	69,100	182,000
1933	135,000	180,000	362,000
1934	170,000	203,000	445,000
1935	170,000	321,300	576,000
1936	207,000*	303,900	646,000
1937	210,000*	153,400	510,000

* Includes methanol: 47,000 tons in 1936, 70,000 tons in 1937.

Table III—Power Alcohol Consumption in European Countries, 1937

Country	Power alcohol consumption	Total light motor fuel consumption	Alcohol
	(Metric tons)		(Per cent)
Germany	210,000	2,640,000	8.0
France	153,400	2,827,000	5.4
Czechoslovakia	50,600	220,000	23.0
Italy	37,000	483,500	7.6
United Kingdom	16,000	4,840,000	0.3
Sweden	15,200	503,200	3.0
Hungary	10,500	69,100	15.2
Poland	8,000	98,200	8.1
Yugoslavia	3,800	30,200	12.6
Austria	2,300	146,300	1.6
Latvia	2,200	19,400	11.1
Lithuania	1,300	5,700	22.7
Total	510,300	11,882,600	4.3

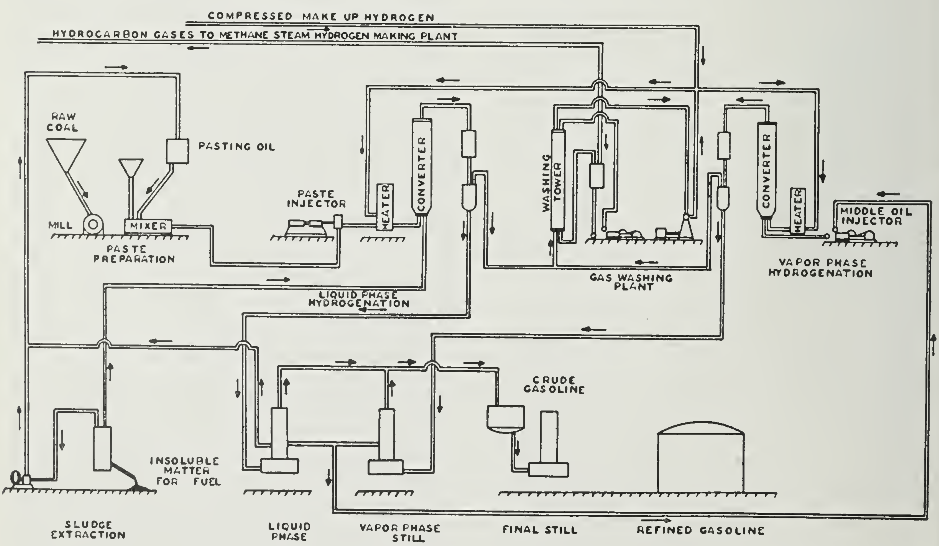

Fig. 3.—Producer gas motor fuel system.

Because of the natural inclination of foreign nations to avoid this sensitive topic, it is likely that the desire to maintain a vital wartime industry in a continuous condition which permits operations at peak capacity has been greatly understressed as a cause of Europe's compulsory use of alcohol in motor fuel. A realistic appraisal of the situation compels the conclusion that this consideration has been a basic incentive for Europe's power alcohol policies, possibly outweighing even the desire to overcome vulnerability to wartime failure of petroleum supplies due to blockade. At times incapable of meeting all peacetime requirements as in 1937, most European nations clearly do not have alcohol industries of sufficient capacities to meet motor fuel needs and wartime scale of munitions manufacture simultaneously. Indications are that at least one major European nation does not contemplate the use of any alcohol in motor fuel in the event of war. The pleas of automobile manufacturers and others have been rejected to advance the octane ratings of various fuels on the grounds that in wartime no alcohol would be available for that purpose, that the country's limited supply of tetraethyl lead would be used up in military fuels, and that commercial vehicles consequently should not be adapted to fuels of high antiknock value in face of the probability that they would have to run on straight gasoline of relatively low antiknock value in time of war.

The Mining and Power Commission of the French Chamber of Deputies recently reported: "So far as alcohol is concerned, wartime requirements for the explosives industry, for solvents, and for medicinal purposes would be so great that they would far exceed domestic production. This is borne out by the experience of the Great War, when French consumption amounted to between 5 and 6 million hectoliters, of which domestic output was able to supply 1 million hectoliters only. In time of national emergency alcohol would be far too valuable to be used as a motor fuel.

Producer gas from wood.—Wood and coal as producers of gas upon which automotive engines can run are not primary sources of motor fuel. The estimated total of wood-burning vehicles in Europe is about 9,000, with 4,500 in France, and 2,200 in both Germany and Italy, with Russia planning to put 56,000 wood-burning vehicles into use during the next two years. The 450,000,000 pounds of wood which they consume replace about 53,000 tons of gasoline annually.

At Holten, Germany, (May, 1938), the cost of dried wood was 51 cents per sack of 82 pounds, and about 16 cents' worth (25 lbs.) gives about the same distance performance as a gallon of gasoline. At first glance this seems cheap, since the retail price of motor fuel in Berlin was 59 cents per gallon in June, 1938. However, 36 cents of that price was tax, while wood is not taxed and wood-burning vehicles pay only one-half the regular vehicle tax. The government subsidizes conversion of vehicles to wood-burners, costs of which run from $300 to $500, depending on the size and work required. Labor, repair and depreciation costs are high, due to frequent cleanings necessary of fouled generating equipment and its relatively short life. The 30 per cent lower heat value of wood gas compared to gasoline reduces the power output. The cumbersome generating equipment, weighing 1,850 pounds in cases of 90-horsepower 5-ton trucks, cuts down payloads an average of 20 per cent. Except when specially equipped to start on gasoline, excessive warm-up periods are necessary, ranging from 10 to 20 minutes.

In fig. 3 is shown a typical generator for producing gas from wood. In Europe these devices for generating producer gas are termed "gasogenes."

A few gas producer motor vehicles, the exact number of which is undetermined, operate on brown coal, lignite, anthracite coal, and peat coal alone or mixed with wood or wood charcoal. Belgium favors an 80 to 20 mixture of anthracite and charcoal. Lower fuel costs are claimed than when city gas is used, but high ash formations, discharge of high percentages of sulfur dioxide in the exhaust gases, and slag formations which attack the ceramic lining of generators, have halted the progress of these producer gas fuels.

Oil shale motor fuels.—Production of motor fuel from oil shale in Europe during 1937 is shown in the following table, in metric tons. Unworked deposits of oil shale also lie in Sweden, Spain and Czechoslovakia.

	Metric tons
United Kingdom	26,000
Estonia	7,300
Finland	2,700
France	1,500
Latvia	1,300
Total	38,800

The extra cost of the above quantities of shale gasoline compared to imported gasoline and from losses in taxes, government subsidies, and production costs was $1,848,500. Of this amount the major share, $1,309,000 was borne by the motorists of Great Britain. The estimated extra cost of motor fuel from oil shale per ton produced was as follows in 1937: $50 in the United Kingdom; $37 in Estonia; $36.30 in Finland; $70 in France; $41 in Latvia. Estonia has worked its oil shale deposits commercially since 1922, and has never used any other type of substitute fuel. Except for 2,700 tons of oil shale spirit and 200 tons of benzol annually (1937), Finland consumes only gasoline derived from crude oil.

Assuming 22 gallons of oil yielded per ton of shale, estimated reserves of oil in Scotland are 280,000,000 tons or a potential 6,160,000,000 gallons of oil. Approximately 1,400,000 tons are worked annually (1937) from which 100,000 tons of marketable products are extracted, consisting of motor fuel, kerosene, Diesel oil, wax and ammonium sulfate. Shale motor spirits in Great Britain are exempt from the tax of 15 cents per U. S. gallon on imported gasoline, and their estimated cost of production is 15 cents per U. S. gallon. Because of their low octane rating, shale spirits give satisfactory performance in modern engines only if cracked or blended with higher octane fuels.

Estimated reserves of shale are as follows in four other countries: 3,500,000,000 tons with an oil potential of 675,000,000 tons in Estonia; 1,800,000 tons with a motor fuel potential of 100,000 tons in Italy; 5,000,000,000 tons in Sweden, 630,000,000 tons of which can be cheaply mined and converted into 32,000,000 tons of oil; 21,000,000 tons in France. Small scale tests with oil shale have been carried out in Italy, but there has been no commercial production to date. An experimental unit in Sweden processes 75 tons of oil shale daily, from which a yield of 3 tons of oil is obtained.

Ammonia, hydrogen, acetylene, and coal dust as motor fuels.—The desperate desire of nations to make themselves self-sufficient in substitute motor fuels is reflected in the experimental work going on with such substances as ammonia, hydrogen, and acetylene.

Synthetic ammonia has been used in Italy as a motor fuel substitute. The ammonia is dissociated to hydrogen and nitrogen by means of a so-called catalytic disintegrator, maintained at a temperature of 850-1100° F. by the exhaust gases from the motor. Vaporization of the liquefied ammonia is accomplished by releasing the pressure in the storage tank and counteracting the refrigerating effect thus encountered by means of a disintegrator which utilizes the heat from the motor exhaust. In Cherso, Italy, a test using a Fiat passenger car developed 31 miles per hour in a road test. As a motor fuel the low heating value of ammonia (4.450 kcal. per kg.) does not lend itself to wide use. The high cost involved in the use of ammonia is another factor retarding its use.

Experiments on acetylene as a fuel indicated that acetylene cannot do the full work of a gasoline engine and that thermal efficiency is highest with dilute air-gas mixtures.

Hydrogen as motor fuel in the form of compressed gas has also been tried. The results so far certainly do not look very promising.

The methods of using coal dust as a motor fuel are slowly being worked out in Germany as a result of the further desire for self-sufficiency. The first coal-dust engine for "practical purposes" was ordered for a German power station in April, 1938. It has been suggested that a "great future" awaits the new engine since the fuel may be purchased at low cost, and also the coal used is indigenous to the country.

The development of the coal-dust engine dates back 50 years or so. Indications still show that the original difficulty of fuel feed has not been overcome since coal dust "cannot" be inducted into the motor in the same manner as liquid fuel. Special abrasive resistant cylinder walls, pistons, and rings are also necessary since the wear on ordinary steel cylinders (0.28 inches during 150 hours operation) becomes so great in a short time that the efficiency and operation of the motor are greatly impaired. Cast-iron cylinders showed 0.008 of an inch after 2 hours, 33 minutes. Chromium plated cast iron showed one-seventieth of this corrosion.

Petroleum Press Service Journal, December 30, 1938, stated that:

"It cannot yet be said with certainty whether the coal-dust engine will reach such a stage of development that it can be used for the propulsion of road vehicles; but it can be said with certainty that this will not be the case for the next ten years. The oil Diesel needed twenty-five years' development before it could be used for such purposes. The difficulties to be overcome in this respect by the coal-dust engine are considerably greater.

Summary of substitute motor fuels.—The substitutes for petroleum gasoline in Europe in 1937 composed of synthetic gasoline and benzene from coal, alcohol, and oil shale amounted to 203,306,622 tons or 15,250,000,000 barrels, or about 18 per cent of the total gasoline consumption. The tonnage of substitute fuels for each country is shown in table I.

In addition to the liquid substitutes given, two other types are produced from the gases of coal and wood. It is estimated for 1938 that compressed and producer gas from coal and wood will substitute for 243,000 tons of petroleum gasoline or 1,823,000 barrels, and about 25 per cent of the total European requirements for motor fuel will come from substitutes. The cost of European substitute fuels at average rates of exchange during 1937 is shown in table IV.

Import duty, taxes, and prices.—The highest gasoline prices in Europe are in Italy, Germany, and Lithuania and are 76, 63, and 59.6 cents per U. S. gallon, respectively. The import duty and tax per gallon of gasoline in Italy is 51 cents and for Germany 36 cents. Detailed data are shown in table V.

As a matter of contrast, the average retail price for regular grade gasoline in the United States was 19.5 cents a gallon, of which 5 cents was tax (June 1938).

Table IV—Cost of European Substitute Fuels at Average Rates of Exchange During 1937

Country	Alcohol tax, losses, subsidies, and extra cost to consumer above tax-paid gasoline	Benzene	Synthetic and L. T. C. gasoline	Shale Spirit	Total
Germany	$53,738,000	$30,238,500	$70,952,000		$157,928,500
France	36,634,000	6,564,500	2,523,500	$ 105,500	45,827,500
United Kingdom	1,538,000	9,660,000	6,039,000	1,309,000	18,546,000
Italy	4,145,500				4,145,500
Czechoslovakia	3,032,500	Not calcd.			3,032,500
Hungary	1,677,500	Not calcd.			1,677,500
Yugoslavia	930,000				930,000
Sweden	829,000	Not calcd.			829,000
Poland	584,000	Not calcd.			584,000
Latvia	367,000			53,500	420,500
Austria	383,500	Not calcd.			383,500
Estonia				282,500	282,500
Lithuania	181,500				181,500
Finland		Not calcd.		98,000	98,000
Total	$104,040,500	$49,463,000	$79,514,500	$1,848,500	$234,866,500

Table V—Retail Prices, Import Duty and Taxes on Motor Fuel

Country	City	Gasoline Price	Import Duty	Import Duty and Tax
		(Cents per U. S. gallon)		
Italy	Rome	73	49	51
Germany	Berlin	59.6	31	36
Lithuania	Kaunas	63.1	23.2	23.2
Bulgaria	Sofia	50	28	39
Czechoslovakia	Prague	42.4	5	16.1
Palestine	Jerusalem	41.4	20.7	20.7
Yugoslavia	Belgrade	40.9	6.7	23.5
Switzerland	Zurich	38.2	19.2	19.2
Hungary	Budapest	38	8	26
Estonia	Tallinn	38	8.1	21.1
Latvia	Riga	37.8	14.4	21.6
Greece	Athens	37.5	19.9	21.2
United Kingdom	London	36.2	15	15
Belgium	Antwerp	36	20	20 + 9% ad valorem
France	Paris	31.8	18.5	19.5
Norway	Oslo	27.5	None	9.5
Denmark	Copenhagen	26.4	None	11

A MODIFIED TIN SUB-GROUP PROCEDURE

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Introduction.—Many schemes have been proposed for the analysis of the tin subgroup but the difficulty experienced by elementary students in the analysis of this group would seem to indicate the desirability of developing a scheme of analysis which would be rugged enough to insure success even with the non-expert technique of elementary students. With this in mind, the following scheme is proposed. Table I shows the procedure in condensed form. The procedure may likewise be applied to semi-micro analysis, where the use of a centrifuge instead of filtration processes increases the speed of analysis and further simplifies the technique.

Explanatory.—It is assumed that the group II sulfides have been extracted with ammonium polysulfide, and the tin sub-group sulfides precipitated by the addition of a slight excess of HCl solution.

Separation of arsenic from tin and antimony.—The extraction of the sulfides of antimony and tin with concentrated HCl leaving arsenic sulfide in the residue (A. A. Noyes procedure) seems to be suited to the capabilities of the beginner. Usually this extraction is carried out at too high a temperature, in which case the free sulfur present will melt and form a protective layer impeding the extraction of the sulfides. A temperature of around 70° C for about 10 minutes has been found to be satisfactory.

Detection of arsenic.—In the usual scheme of analysis, the arsenic sulfide is converted into magnesium ammonium arsenate. There is no real need for this. In this scheme, the arsenic sulfide is dissolved in concentrated HNO_3, the remaining sulfur skimmed off (note 1) the solution evaporated to dryness during the dissolving process, and then treated with a few ml. of very dilute NH_4OH (note 2) plus a few drops of 3 per cent H_2O_2 (note 3). The ammonium hydroxide is neutralized with dilute acetic acid creating an ammonium acetate buffer with the solution slightly on the acid side (note 4). Silver nitrate added to this solution will then precipitate the characteristic red-brown Ag_3AsO_4 (note 5 below).

Notes

1. The sulfur is skimmed off because it reacts with the HNO_3 forming SO_2 which in turn will reduce arsenate to arsenite.
2. If any tin is present at this point, it will be in the form of SnO_2 which has the ability to strongly absorb arsenic acid. Treating with NH_4OH brings about the desorption of the arsenic acid.
3. The H_2O_2 is added simply to insure complete oxidation of the arsenic.

4. If the solution is either ammonical or too strongly acid, the Ag_3AsO_4 will not precipitate.

5. It is best to add silver nitrate solution in excess because if any chloride or antimonate is present, its white silver salt will precipitate. This causes no harm because with excess silver nitrate, the red-brown Ag_3AsO_4 will still be detectable.

Detection of antimony and tin.—Our attention now may be turned to the antimony and tin in the concentrated HCl filtrate. It is best to boil off about one half of the HCl and then dilute back to the original volume (note 1). A good separation of antimony from tin may be affected using displacement of the antimony with sheet lead (note 2). The tin is not displaced but it is reduced to the stannous form in which condition the usual test with $HgCl_2$ may be made (note 3). The metallic antimony sloughs off the lead surface as a characteristic black curdy precipitate which is sufficient confirmation for antimony (note 4). If a double check for antimony is desired, a phosphomolydic acid test may be made on a drop of the concentrated HCl filtrate containing trivalent antimony and tetravalent tin. Phosphomolydic acid is reduced by strong reducing agents to compounds of indefinite composition but characterized by an intense blue color. The success of this test depends upon the fact that the H_2S liberated when the tin subgroup sulfides are dissolved will reduce the antimony to the trivalent state but leave the tin in the tetravalent state. This trivalent antimony is a strong enough reducing agent to give the molybdenum blue color with phosphomolydic acid. The test is best carried out as a spot test. A drop of the solution and a drop of the reagent are placed on a piece of filter paper, the filter paper being held above boiling water. For usual amounts of antimony, the boiling water technique may be left out.

Notes

1. If the HCl concentration is very high, the treatment with metallic lead will result in an unnecessarily large amount of lead in solution. The sensitivity of the $HgCl_2$ test for tin is less in concentrated HCl solution.

2. The sheet lead must be tin free. It may be cleaned by boiling with dilute HNO_3 and then washing with distilled water.

3. If a large quantity of $PbCl_2$ is formed, it will precipitate as white crystalline $PbCl_2$. This may be dissolved by warming the solution since $PbCl_2$ is quite soluble in hot water, or better yet, the solution may be cooled before the addition of $HgCl_2$ and the $PbCl_2$ filtered out.

4. If copper is present in the unknown, some of it finds its way into this HCl extract and will be deposited on the lead. It is quite different in appearance however and need not be confused with antimony. If arsenic is present in this solution, it too may be displaced. It tends to form a brown colloidal solution and hence is quite different in appearance from the black metallic antimony.

Table I—Procedure for Analysis of Tin Sub-Group

<table>
<tr><td colspan="3">Tin Sub-Group Precipitate: As_2S_5, Sb_2S_5, SnS_2, S. Add 10 cc. of concentrated HCl. Heat to just below the boiling point for 10 minutes.</td></tr>
<tr><td rowspan="2">Residue: As_2S_5, S. Add 5 cc. of Conc. HNO_3 and evaporate just to dryness. During the evaporating process, the S may be skimmed off with a stirring rod. Add water and a few drops of NH_4OH and a few drops of H_2O_2. Boil until no odor of NH_3 is apparent. Add 2 drops of HAc and an excess of $AgNO_3$ solution. A precipitate of red-brown Ag_3AsO_4 confirms arsenic.</td><td colspan="2">Filtrate: Sb^{+++}, Sn^{++++}, HCl. Boil off some of the HCl and dilute to 10 cc. Add a small piece of sheet lead and warm with periodic shaking for 10 minutes.</td></tr>
<tr><td>Precipitate:
Black curdy metallic Sb confirms antimony.</td><td>Filtrate: Sn^{++}
Add $HgCl_2$ solution. A satin like precipitate of Hg_2Cl_2 and Hg indicates tin.</td></tr>
</table>

MARIHUANA

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Marihuana *(Cannabis sativa)* is an attractive plant that grows in neglected back yards, vacant lots, on the roadside, in river bottoms where there is waste, uncultivated land; in fact anywhere in a temperate climate. It grows luxuriantly in every state in the Union. In many places it grows so luxuriantly that it crowds out other weeds such as ragweed and others of large size. It reaches maturity in about three months and attains a height of from four to sixteen feet or more. The stalk is from a quarter of an inch to two inches thick, and is very fibrous and tough. It is from the fiber that the plant derives the name hemp.

The leaves are of a rich, dark green color on the upper surface and light green beneath. They vary in width up to an inch and are sometimes more than eight inches long. The leaves are long, narrow and definitely pointed, having saw-tooth edges. The leaf surface is covered with numerous hairs which secrete an amber-colored resin, containing cannabine, or cannabinol, which is supposed to be the narcotic that causes the intoxication.

The greenish flowers are nearly an eighth of an inch in diameter. They give off a characteristic odor and are unattractive. The fruit, called hemp seed, is smooth and globular. It is a little larger than common birdseed. A light colored oil is obtained from it.

Under various names, marihuana has been known ever since the time of Homer and Herodotus, both of whom mention it in their writings. In Africa, central Asia, and India it has been known for many centuries. The variety from India *(Cannabis indica)* is known as Indian hemp. The name Indian hemp, however, is now applied to marihuana in general.

Marihuana, under the name Indian hemp, was brought to New England by the early settlers about three centuries ago. They grew it for its fiber from which they made rope, hats, and sometimes clothing. Later, when manila was introduced, Indian hemp fell into disuse and was no longer cultivated.

The Spanish conquerors brought it to Mexico about a century earlier than it was introduced into New England. The Mexicans took it up readily. It was from Mexico that marihuana spread across the border into Texas and the Southwest. It is only during the last ten years that it has spread to the extent that it has become a recognized national menace. Now it grows in every State and it has spread even to Canada.

The dried leaves and seed are made into cigarettes that look very much like the ordinary cigarette, except that the ends are tucked in so the contents will not fall out, as it is much finer than tobacco. Sometimes it is introduced to the victim by mixing it with the tobacco of the ordinary cigarette; and sometimes the marihuana is placed in the middle of the cigarette, the ends being filled with tobacco. These are some of the devices resorted to by those who sell marihuana for profit.

The marihuana cigarette is sold only by peddlers; no regular dealer would dare to sell it in any form, for he would soon be arrested and punished according to law. The law is very severe. The peddlers sell mostly to the underworld in the large cities; but, during the last five years they have increasingly infested high school communities until now these peddlers may be found around high schools in any part of the country.

It is in the high school community that it is easiest for the peddler to work. The pupils receive little or no instruction on narcotics of any kind. They see older people indulging narcotic habits of one form or another every day, and observe no immediate resulting harm. They reason that they should get their share of the pleasures of life also. This is especially true of those who have already become victims of the ordinary cigarette habit. Since these cigarettes do not satisfy, boys and girls who smoke them are always ready to try something new, especially when the new cigarette is described in glowing terms and is given to them free.

A common practice of the peddler is to approach a boy or girl who is smoking the common cigarette, and to ask for a light for the cigarette he wants to smoke.

Of course the request is readily granted. Then the peddler offers his victim one of his 'special' cigarettes describing it in fascinating words. The peddler usually gives his victim several marihuana cigarettes free so the habit will become established. In a few days the ordinary cigarette no longer satisfies as it did, and the victim hunts up the peddler. This time the peddler sells them for whatever he can get. Usually, he gets from ten cents to a half a dollar apiece for them. In this way the peddler establishes his trade.

Since everything that is done is personal, he is not easily found out and he sometimes continues in business a long time. The profits are enormous. The customary price of marihuana is from $50 to $150 a pound wholesale. In cigarettes, it brings several times this price.

One not informed naturally wonders why it is that a thing as common and as easily grown as marihuana, should sell for so high a price. The one who is just introduced to the habit seldom knows what the plant looks like. Besides, the plant is available only during its growing season which is but three months during the year; but the smoker must have his cigarettes regularly. Furthermore, after the marihuana habit is followed for a short time, it no longer satisfies and the victim turns to morphine or heroin with but little further interest in marihuana and the peddler plies his trade with new victims.

The marihuana addict is enslaved just as truly as is any other narcotic addict. The effect, however, is very different. Instead of the narcotic peace and contentment so characteristic of many of the other forms, marihuana has the opposite effect. Its victim is fully as much disturbed over his condition as is the alcoholic victim in the last stages of delirium tremens. Usually, before he reaches the extreme condition of discomfort, he is an easy victim to morphine and heroin. The dope peddler, who sells marihuana cigarettes, knows that this is true, and that he can make more money from his victim by shifting him over to the morphine habit; for this will make him a customer for the rest of his life. The course of the narcotic trail begins with tobacco or alcohol passing on to marihuana, morphine, and finally to heroin. It is a very dangerous thing at its source, and it becomes more dangerous farther on. The end, no matter where it may stop, is always death itself.

The effects of marihuana smoking follow soon after the first indulgence. The effects vary considerably, depending on the amount of indulgence, and on the temperament of the individual. The earlier effects are in the nature of foolish fancies and fascinating hallucinations. This is followed by mental depravity which ends in madness, if the extent of indulgence be sufficient.

The addict does some of the most unaccountable things. If driving a car, he greatly underestimates his speed; also the distance of an approaching car. Thus, without being aware of it, he takes chances that are nothing short of madness itself. He continues in his course until he meets with an accident that is usually fatal. Accidents of this kind are seldom reported in connection with the real cause. Usually, the officers do not suspect the true cause, and of course overlook it in the investigation.

Socially, the victim has his friends as usual; but suddenly he imagines that even his most intimate companion is his worst enemy planning to kill him. The addict imagines further that for his own protection he must kill his enemy first. In this way, he commits some of the most atrocious murders that have ever been known. Or, he may commit other crimes of the very worst kind. Afterward it often occurs that he has no recollection whatsoever of what he did, and is even surprised when told of his deed. To him it appears impossible that he should ever have done what he is accused of.

Most of the unbelievable crimes committed within the last few years are directly traceable to marihuana. Bandits bent on desperate deeds usually prepare by indulging in marihuana, or some similar narcotic in order to 'get up courage' that would not otherwise be possible.

The problem must be gotten under control, or the results will become far more serious than at present. It is true that we have drastic laws; but they are not effective because of a police force insufficient in numbers, training, and experience. This back-yard weed that has so suddenly become a national menace must be brought under control soon if the nation is to be safeguarded.

UNIFORMITY IN CIGARETTES

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Considerable work has been done in the determination of the characteristics and chemical constitution of products formed during the burning processes in cigarettes. Bradford and coworkers have done considerable work (1) in the determination of volatile acids and bases present in cigarette smoke, while Forbes and Haag (2) have investigated the presence of hygroscopic agents in cigarette smoke.

In the course of smoking different brands of cigarettes, it has been observed that some blends apparently burned more rapidly than others and that differences in weight (tightness of the wrapping) were also evident. As a result of these observations it was decided to undertake a study of some of our popular brands of cigarettes by means of a mechanical smoking machine and arrive at definite figures to support the above observations.

Table I

Brand	Number of Packages Opened	Number of Samples	Av. Wt. of a Cigarette Before Smoking in Grams
1	11	33	1.09
2+*	17	51	1.09
3+	11	33	1.12
4	8	24	1.10
5	10	30	1.10
6	10	30	1.10
7	5	15	1.10

+ Cork tipped. Average weight of cork tip=0.014 grams.
*+ Mentholated.

Two concentric snug fitting brass tubes were mounted in such fashion that the inner tube acted as a piston while the outer tube was fitted with a taper of suitable size to admit the end of a cigarette. A reduction gear and electric motor were mounted and connected to the brass tube "piston" in such a manner that the piston would make seventeen strokes per minute. The volume of air drawn into the cylinder on the "suction" stroke approximated 35 ml. On the "compression" stroke, the gases within the cylinder were discharged through a side valve consisting of a smooth aluminum disk resting on a square polished brass surface.

Each package of cigarettes used was opened and each of three adjacent cigarettes tested as follows: (1) The cigarette was removed from the pack and accurately weighed, (2) inserted in the smoking machine and "smoked" for two minutes (thirty-four strokes), (3) rapidly removed and extinguished in a CO_2 atmosphere, (4) the unburned portion and all ashes were again weighed, and (5) the approximate length of the unburned portion was measured to the nearest millimeter.

Table II

Brand	After Smoking		Av. Loss in Wt.	Av. % Burned
	Av. Wt.	Av. Length		
1	0.6518 g.	30.7 mm.	0.44 g.	40.7
2	.6204	26.7	.47	43.2
3	.6689	29.8	.45	40.5
4	.6796	32.7	.42	38.6
5	.8451	45.9	.36	32.7
6	.7416	37.7	.36	33.1
7	.6711	32.7	.43	39.5

No attempt was made to cover the entire "field" of available cigarettes and the total number of samples run on any one brand was a result of the convenience and consideration of friends who were willing to "enter their brand in the study." The entire investigation was completed in approximately six weeks. The data as presented in this report should not be interpreted as having definite bearing on the present status of any brand of cigarette at the present date. Tables I, II, and III show a general summary of the data obtained in this study.

TABLE III

Brand	In Any Single Package			Av. Deviation from Av. Wt.
	Maximum Wt. in Grams	Minimum Wt. in Grams	Maximum Diff. in Grams	
1	1.17	1.00	0.17	0.04
2	1.21	1.00	.21	.06
3	1.35	1.12	.23	.07
4	1.14	1.04	.10	.03
5	1.29	1.06	.23	.05
6	1.19	1.05	.14	.05
7	1.19	1.07	.12	.04

In conclusion, we may say that for the most part there is a rather definite uniformity in the weight in individual packages. One often encounters two adjacent cigarettes which will vary as much as 23 per cent in weight. The heavy cigarette burns more slowly than a correspondingly lighter cigarette.

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SPECIAL STUDY OF VAPOR PRESSURES OF SATURATED SALT SOLUTIONS*

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AN ABSTRACT

In 1936 the American Society for Testing Materials published tentative specifications for "Classification of Coal by Rank"[1] providing that the lower rank bituminous coals be classified according to their moist mineral matter free B.t.u. values. In 1938 these specifications were advanced to standard (A.S.T.M. Designation D 388-38).[2] It was proposed that the method of Stansfield and Gilbart[3] be adopted as the standard method for determining moisture in coal having visible surface moisture for such classification. Before making this method standard, however, it seemed advisable to obtain further information as to its applicability. Accordingly a study of its application to Illinois coals was undertaken in this laboratory.

The procedure described by Stansfield and Gilbart may be described briefly as follows: Five gram portions of 14-mesh coal were brought to equilibrium at various humidities, moisture was determined on these samples, and the determined moisture values were plotted against humidity values. The curves were extrapolated to cut the 100 per cent humidity axis and this point was taken as the bed moisture of the coal. Various saturated salt solutions were used to provide the desired humidities.

As the work progressed it became desirable to confirm the values assumed to be correct for these solutions under actual working conditions. For this purpose a Rayleigh or "Rocker Arm" type of manometer[4] was used together with necessary thermostats, gauges, etc. A detailed description of the apparatus as used together with a description of the procedure followed may be found in Illinois State Geological Survey Report of Investigations No. 58. Results for saturated solutions of nine different salts, $KClO_3$, K_2SO_4, $BaCl_2.2H_2O$, KCl, $NaCl$, NH_4NO_3, $Ca(NO_3)_2.4H_2O$, $KC_2H_3O_2$ and $LiCl.H_2O$ were determined and compared with values taken from International Critical Tables. The results obtained compare favorably with these values.

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SOME CHEMICAL CHANGES IN COAL SAMPLES DURING STORAGE

O. W. Rees and M. L. Kalinowski*

The oxidation of coal has received considerable study, especially in the commercial aspects of the problem. In addition some work has been done on the relation of oxidation to analysis.[1, 2, 3, 4] Ease of oxidation increases, in general, with decrease of rank of the coal; for example, the high volatile bituminous coals such as are found in Illinois oxidize rather easily on exposure to air. An understanding of the oxidation or weathering characteristics is therefore desirable in the use and study of these coals.

Knowledge of the effects of different kinds of storage of laboratory samples of coal is of the greatest importance to the coal analyst. Oxidation of coal samples may influence the analytical results markedly, so that it is important that analysis take place before such changes have occurred.

Some of the factors which influence the oxidation and deterioration of coal are rank and type of coal, volatile matter content, sulfur content, size, amount of handling, presence of moisture, accessibility of oxygen, temperature, and kind of storage. Recently we had the opportunity of determining the effect of cold storage on calorific and sulfate sulfur values. A description of the methods of sampling, storage, and analysis follows.

Sampling and Storage.—Special column samples about 10 by 12 inches in cross section, and representing the entire thickness of the coal seam were cut in several different mines, and brought to the laboratory. Approximately one-fourth of each column was cut for study and the remaining samples were placed in long wood boxes which were carefully covered with paraffin and stored in the store room of a local ice plant. The temperature of this store room was controlled thermostatically at 30 to 32° F. The samples were allowed to remain in storage for about one year when they were removed and portions about 4 inches in cross section by the length of the coal seam were cut out and the rest of the coal discarded. These newly cut column samples were returned to the storage boxes, two or three being placed in each box to conserve space, the boxes were again paraffined, and returned to the storage room of the ice plant. After having been stored about 3½ years they were removed, crushed and analyzed.

At the time the column samples were cut in the mine, channel samples taken adjacent to the column samples were obtained for analysis. Owing to the fact that the analytical laboratories of the Geological Survey were in the process of building and organization at that time, analyses of these samples were delayed for some time. While the calorific values obtained by these analyses may be somewhat lower and the sulfate sulfur values somewhat higher than the original values for the coal as taken from the mine, they serve very well for comparison with the values obtained for the samples after long storage.

Analysis.—Analyses of all samples were made according to the standard procedures of the American Society for Testing Materials, A. S. T. M. Designation D-271-33[5] with the exception that sulfate sulfur determinations were made according to the procedure of Powell and Parr.[6]

Results.—The results of analyses for 13 coal samples, both before and after storage for 4½ years, are given in table 1. B.t.u. values are given for the moisture and ash-free basis for better comparison while the sulfate sulfur values shown are moisture free values. Reference to this table will show definite losses in heating values and increases in sulfate sulfur values.

An attempt was made to correlate the loss in B.t.u. of the various samples with certain items of their proximate analysis. It was found that a rough correlation might be made between the ratio of fixed carbon to volatile matter and the per cent loss in B.t.u. taking place during storage. This correlation is shown in table 2. Reference to this table will show a tendency for the loss in heat value to decrease as the ratio of fixed carbon to volatile matter increases. The

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TABLE 1—ANALYSES OF COALS BEFORE AND AFTER STORAGE

Sample	B. t. u.—moisture and ash free				Sulfate sulfur—moisture free			
	Before Storage	After Storage	Loss B. t. u.	Loss %	Before Storage	After Storage	Gain %	Gain % of original
A	14,186	13,703	483	3.40	0.09	0.44	0.35	390
B	14,205	13,751	454	3.20	0.09	0.51	0.42	470
C	14,140	13,766	374	2.64	0.12	0.46	0.34	280
D	14,073	13,824	249	1.77	0.10	0.45	0.35	350
E	13,981	13,849	132	0.94	0.19	0.36	0.17	89
F	14,295	13,923	372	2.60	0.14	0.35	0.21	150
G	14,102	13,585	517	3.67	0.04	0.40	0.36	900
H	13,872	13,446	426	3.07	0.06	0.55	0.49	820
I	14,001	13,568	433	3.09	0.06	0.33	0.27	450
J	13,862	13,707	155	1.12	0.10	0.24	0.14	140
K	14,395	14,303	92	0.64	0.02	0.05	0.03	150
L	14,463	14,263	200	1.38	0.05	0.15	0.10	200
M	14,561	14,223	338	2.32	0.03	0.08	0.05	170
Av	14,164	13,839	325	2.29	0.08	0.34	0.26	330

TABLE 2—COMPARISON OF RATIO OF FIXED CARBON TO VOLATILE MATTER TO LOSS IN CALORIFIC VALUE [a]

Sample	Volatile Matter	Fixed Carbon	Loss Per cent[b]	Fixed carbon / Volatile matter
A	46.95	53.05	3.40	1.13
B	46.53	53.47	3.20	1.15
C	47.90	52.10	2.64	1.09
D	48.22	51.78	1.77	1.07
E	45.40	54.60	0.94	1.20
F	45.63	54.37	2.60	1.19
G	47.08	52.92	3.67	1.12
H	46.98	53.02	3.07	1.13
I	46.00	54.00	3.09	1.17
J	45.93	54.07	1.12	1.18
K	40.40	59.60	0.64	1.48
L	40.93	59.07	1.38	1.44
M	39.10	60.90	2.32	1.56

[a] All values moisture and ash free basis.
[b] Loss heat value in per cent.

fact that exceptions to this general tendency appear indicates that other factors are involved in the oxidation of the coal.

The increase in sulfate sulfur is due to the oxidation of other forms of sulfur in the coal. However, attempts to correlate these increases with other analytically determined constituents proved unsuccessful. It is unfortunate that pyritic and organic sulfur values for the coal after storage are not available for comparison with those determined before storage. Such a comparison might show the relative tendencies of these two forms of sulfur to oxidize to sulfate sulfur under the conditions of storage studied.

It would be interesting to compare the rate and amount of oxidation taking place in these samples as stored with the rate and amount of oxidation taking place in similar samples stored at higher temperatures. However, it has been shown that appreciable oxidation did take place as evidenced by resulting lower heat values and higher sulfate sulfur values.

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A COMPARISON OF THE CHEMICAL CHARACTERISTICS OF CRUDE OILS PRODUCED IN THE OLD AND NEW ILLINOIS FIELDS

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Through the discovery and development of new fields, the annual production of crude oil in Illinois has increased rapidly in the last few years until it now approaches the 1908 peak of 33,000,000 barrels, with the result that Illinois now ranks fifth as a major producer. Because of this increased activity, it will be of interest to compare some of the chemical characteristics of the new crudes with those obtained from the older fields.

The comparisons presented herein are based on analyses made in the University of Illinois analytical laboratory and the State Geological Survey laboratories. For the most part these analyses were made according to standard procedures of the American Society for Testing materials[1] and the U. S. Bureau of Mines.[2] Due to incomplete analyses particularly in regard to the crudes from older fields, it has been necessary to estimate some of the characteristics of the oils. In making these estimations the characterization factor developed by members of the staff of the Universal Oil Products Company[4] has been employed wherever it was possible. Although this method is not to be considered infallible, it provides a very satisfactory means of obtaining some of these characteristics for purposes of approximate comparison. In conjunction with the "characterization factor" it has been necessary to obtain approximate average boiling points of some of the crudes from true boiling point curves of typical Mid-Continent crudes based on yields of 410-425° F. end point gasoline according to Nelson.[3]

It may be of interest to discuss briefly the "characterization factor." Mathematically, it is defined as the ratio between the cube root of the average boiling point and specific gravity at 60° F. Its utility lies in the fact that it serves as a means of evaluating the properties of an oil from a minimum of analytical data. For example, by determining specific gravity at 60° F. and viscosity at 100° F. we may estimate the average boiling point, average molecular weight, and the nature of the base of the crude. Numerically, a "characterization factor" value of 12.5-13.0 indicates a paraffin base oil, while values of 10 or below indicate an aromatic or naphthenic base. Intermediate values between 10 and 12 correspond to mixed bases.

Members of the staff of Universal Oil Products Company[4, 5, 6] have correlated kinematic viscosity and gravity data with "characterization factors" and cubic average boiling points. The latter is defined as the cube of the summation of the product of the cube root of the average boiling point of each fraction constituting the crude and the volume per cent. In addition, they have correlated A.P.I. gravity and average molecular weights with characterization factors and with the mean average boiling point, which is the arithmetic mean between the cubic average boiling point of the oil and molal average boiling point. All these boiling points are determined from the volumetric average boiling point by adding a correction factor which is a function of the slope of the true boiling point curve from an Engler distillation.

There are no viscosities or true boiling point curves available on oils from the old fields. However, gravities, gasoline, kerosene, and fuel oil yields are available. From data obtained from Nelson[3] it was possible to plot a series of true boiling-point curves corresponding to various gasoline yields of the crudes. By graphical integration, volumetric average boiling points were obtained. In this manner the necessary characteristics were determined for evaluating the crudes. The method was checked on new field crudes where viscosity-gravity data were available and it was found to give satisfactory results (table 1).

Another factor influencing the estimated and actual results obtained from old field data is sampling. In cases where ab-

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TABLE 1—SUMMARY COMPARISON OF CHEMICAL CHARACTERISTICS OF CRUDES FROM OLD AND NEW FIELDS

	Old		New	
	Range	Average	Range	Average
A. P. I. Gravity	28.7–40.3	33.5	33.8–46.9	38.3
Kinematic Viscosity (Centistokes)	3.9–13.3	6.6	4.1–7.4	5.0
Viscosity (Saybolt seconds)	39–71	47.5	40–50	42.5
Gasoline Yield—per cent (425° F.—end point)	16.5–40.3	26.8	24.7–38.5	33.1
Volumetric Average Boiling Point °F	586–172	657	606–676	638
Cubic Average Boiling Point °F	546–672	617	566–636	598
Characterization Factor	11.79–12.24	11.94	11.9–12.9	12.22
Average Molecular Weight	187–243	219	200–240	216
Sulfur Per Cent	0.15–0.35	0.24	0.18–0.40	0.32

normally low gasoline yields were obtained along with correspondingly low A.P.I. gravities and high viscosities, there is reason to believe that a fresh sample was not taken. The crude was apparently taken from a reservoir in which it had been standing for some time instead of from a flowing well. However, where a sufficient number of samples have been taken in any one locality the effect of this factor is immediately apparent and the sample is not considered to be representative of that locality.

Results.—Data for samples produced in old fields located in Clark, Crawford, Jackson and Wabash counties show crudes ranging in A.P.I. gravities from 28.7 to 40.3, Saybolt viscosities from 39 to 74, gasoline yields from 16.8 to 41.6 per cent, volumetric average boiling points from 580° F. to 707° F. and average molecular weights ranging from 190 to 265 (table 1).

Data for samples from new developments show crudes ranging in A.P.I. gravities from 33.8 to 46.9, Saybolt viscosities from 41 to 50, gasoline yields from 29.2 to 38.2 per cent, volumetric average boiling points from 593° F. to 660° F. and average molecular weights ranging from 200 to 240 (table 1).

If we now compare the characteristics of the crudes from the older and newer fields (table 1) the following general comparisons are apparent.

Crudes from the new fields in general show higher A.P.I. gravity values, lower Saybolt viscosities, higher gasoline yields, lower average volumetric boiling points and lower average molecular weights than those from the older fields. Sulfur values for the newer oils, on the basis of the few values available, appear to be somewhat higher, in general, than those for the oils from the older fields. Characterization factors for the crudes of the new fields are appreciably higher, indicating that these oils are more paraffinic than those from the older productions.

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LIQUID AMMONIA AS A DIETARY NITROGEN SUPPLEMENT

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That urea and ammonium carbonate may be effectively used as dietary nitrogen supplements in ruminant animals has been reported (1) (2) (3). Also it has been shown that proteins are ammonolyzed in liquid ammonia, and thereby increase their nitrogen content (4). This report is concerned with the use of ammonolyzed proteins and other ammonolyzed foods as a source of nitrogen in the diet of non-ruminant animals such as albino rats. Earlier work has shown that ammonolyzed casein causes a loss of weight in young albino rats when it is used to replace other proteins in a standard diet, (Protein 18%, starch 46%, butter 15%, moist yeast 15%, salt mixture, Harris 3%, cod liver oil 3%). Later work has been done in which different constituents of the diet were treated with liquid ammonia or ammonium hydroxide, or the whole diet was mixed with ammonium carbonate and kept in a closed container. Preliminary reports have been made (5).

The method of treating casein, starch and dry powdered yeast with liquid ammonia is simple. The material is placed in a suitable container and anhydrous liquid ammonia is run in until the thick paste which forms at first becomes fluid-like with stirring. On settling, a layer of liquid ammonia should rise above the thin paste. The container is then closed, and attached to a mercury seal. This protects the contents of the container from absorbing moisture from the air. The excess liquid ammonia boils off in about 24 hours, being recovered if desired, and a hard mass of the semi-transparent material remains. This can be powdered, and the fumes of ammonia gas can be removed with a vacuum pump. The material has a very faint odor of ammonia, but contains a considerable amount of the latter, as shown by Kjeldahl determinations, bound in the form of a derivative. That derivatives have been formed is evident since the excess nitrogen cannot be removed entirely after heating the materials in a vacuum oven at 100° C. for 24 hours. For example, as shown by the data in table I, the nitrogen content of starch (group 6)

Table I

Groups	Modified diet and method of feeding		Increased wt. of N as % of total wt.	Results
1	Casein treated with liq. NH_3	Mixed with rest of diet before feeding	2.20	Lost weight. Spastic paralysis.
2	Casein treated with liq. NH_3	Placed in vacuum oven 100°C. 24 hr. Fed mixed	0.40	Gained weight.
3	Casein treated with liq. NH_3	This casein was fed in a separate cup	2.20	Gained weight.
4	Casein treated with liq. NH_3	Casein fed mixed. Moist yeast, separate cup	2.20	Gained weight.
5	Casein treated with liq. NH_3	Casein fed mixed. Dry yeast, separate cup	2.20	Gained weight.
6	Starch treated with liq. NH_3	Mixed with rest of diet before feeding	0.75	Lost weight. Spastic paralysis.
7	Starch treated with liq. NH_3	Placed in vacuum oven 100°C. 24 hr. Fed mixed	0.31	Gained weight.
8	Starch treated with liq. NH_3	This starch was fed in a separate cup	0.75	Gained weight.
9	Starch treated with liq. NH_3	Starch fed mixed. Moist yeast, separate cup	0.75	Gained weight.
10	Starch treated with liq. NH_3	Starch fed mixed. Dry yeast, separate cup	0.75	Gained weight.
11	Dry yeast treated with liq. NH_3	This yeast was fed in a separate cup	2.00	Lost weight.
12	Moist yeast treated with liq. NH_3	This yeast was fed in a separate cup	2.00	Gained weight.
13	Dry yeast treated with NH_4OH	This yeast was fed in a separate cup	2.00	Gained weight.
14	Ammonium carbonate	Mixed with rest of diet before feeding	0.75	Lost weight. Spastic paralysis.
15	Ammonium carbonate	Mixed with moist yeast, fed in separate cup	0.75	Gained weight.
16	Ammonium citrate	Mixed with rest of diet before feeding	0.75	Gained weight.

In groups 14, 15 and 16 the percent of nitrogen increase does not refer to the compounds themselves, but to mixtures of them and starch, the excess nitrogen 0.75% being the same as for group 6.

has been increased 0.75%, from 0.21% to 0.96%, by treatment with liquid ammonia, and that after heating as described it still contained 0.52% nitrogen or an excess of 0.31% nitrogen (group 7). With casein (table I, and group 1) the excess nitrogen after treatment is even greater. Ammonia that is held by absorption only can be removed by the process mentioned. Moist yeast when treated with ammonia does not form a hard, translucent mass but instead a soft opaque dough.

Control animals were fed in a manner similar to the experimental animals. For example, when casein (group 3) which had been treated with liquid ammonia was fed in a separate container, untreated casein was also fed in a separate container to the control animals. This is done so that the feeding conditions are similar in each case, and one can watch the amounts of food eaten both treated and untreated. Litter mates were used and also an equal number of males and females. Each animal was kept in a separate cage. At least 4 rats were used as experimental animals and an equal number for control animals. In all about 200 rats were used. The results are uniform in every member of each group in regard to loss or gain in weight and the development of spastic paralysis. The control animals remained in good health, and continued to gain weight in every case. The food was given ad libitum, and the animals ate the treated foods as readily or even more so than the untreated food. Due to the kind of feeding cups used very little food was wasted. Harris vitamin free casein and starch were used. Fleischman's bakers moist yeast and Northwestern's powdered yeast were used. The yeast when fed in separate containers was weighed each day since it is known that vitamin B in excess will accelerate the growth of young rats.

The excess amount of nitrogen received per day by an experimental rat as compared to a control rat amounted on the average to be 0.066 gm. In general 4 rats eat 500 gm. of food per week or 17.8 gm. per rat per day. On a diet containing 46% starch with an increase of 0.75% nitrogen due to the liquid ammonia (table I, group 6) each experimental rat received an excess of 0.0615 gm. of nitrogen per day. For a treated 18% casein diet (table I, group 1) each experimental rat received 0.0704 gm. of excess nitrogen per day. This represents an average increase of 13.8% in the protein nitrogen. The amount of ammonium carbonate and ammonium citrate to be used was calculated from a Kjeldahl determination of the ammonolyzed starch which showed an increase of 0.75% nitrogen and was a sample that caused paralysis (table I, group 6). Therefore 16 gm. of ammonium carbonate or 23.2 gm. of ammonium citrate were added to each 500 gm. of the food which is made up to contain 230 gm. of starch in 500 gm. of the diet. Therefore, groups 14, 15 and 16 have the same nitrogen increase in their diets as those in group 6, or 0.0615 gm. of nitrogen per rat per day.

The results are summarized in Table I. They prove that the deleterious effect of liquid ammonia and ammonia gas is due to the action of the ammonia on the vitamin B complex, when the latter is in a fairly dry state. It has been shown (6) that liquid ammonia tends to form addition compounds under such circumstances and Williams has shown that liquid ammonia acts on vitamin B_1 (7). That the effect is not due to a basic action is indicated by the negative results or growth obtained with ammonium hydroxide. (Group 13). That sodium hydroxide however, partially inactivates vitamin B has been shown by others (8). The negative results with ammonium citrate (Group 16) would rule out the ammonium ion as such. The results also show that the ammonia-vitamin B derivative is easily hydrolyzed giving negative results with wet yeast, (group 12) but positive results or paralysis and loss of weight with dry yeast (group 11). Further, it is shown that the compounds formed with casein and starch are not entirely stable in a vacuum oven at 100° C. (Groups 2 and 7), but evolve a considerable amount of ammonia. However, a certain amount of ammonia remains fixed: 0.4% as nitrogen in the case of the casein and 0.31% as nitrogen in the case of the starch, and this fixed ammonia seems harmless since growth was obtained in groups 2 and 7.

The failure of the rats to gain weight on ammonolyzed casein referred to in the introduction was not due to any kind of toxicity caused by the action of ammonia on the protein, but to inactivation of the vitamin B present. Ammonolyzed food has less tendency to spoil and become mouldy than untreated food (Mould is found on untreated food within 2 weeks; no mould on treated food in 5 weeks), and it caused a more rapid growth in albino rats, (Groups on treated foods gain weight twice as fast as controls for two month periods), providing an additional source of vitamin B is available.

The preponderance of opinion as indicated in the literature favors the use of ammonium salts as dietary nitrogen supplements. Liquid ammonia as compared to non-volatile ammonium salts has certain advantages and certain disadvantages. One disadvantage is its tendency to inactivate vitamin B. Another is that it cannot be used to increase the protein nitrogen more than about 20% and still be edible. On the other hand it is comparatively cheap, acts as a preservative against moulds and possibly plays a dual role in nitrogen assimilation; first by increasing the nitrogen content of foods by forming addition products, and second by increasing the digestibility of the original protein. McChesney and Roberts (9) have shown recently that ammonolysis increases the digestibility of some proteins to the action of trypsin in vitro. It has been assumed that in ruminants bacteria of the digestive tract play an intermediate part in the assimilation of non-protein nitrogen. Whether such an argument can be used in favor of non-ruminants is not known, but the more efficient digestion and absorption of the protein nitrogen of ammonolyzed proteins should apply as well to non-ruminants including humans. Mitchell and Hamilton (10) in reviewing the literature of the use of non-protein nitrogenous compounds, such as urea, for protein supplements in the diet, find that the evidence is inconclusive although it is sometimes indicated that urea increases the digestibility of proteins. Recently, Schoenheimer (11) has made use of the nitrogen isotope N^{15} and the mass spectrograph for detecting it, to follow the metabolism of such salts as ammonium citrate in albino rats. He finds that some of the N^{15} of the ammonium citrate fed can be located later as alpha amino nitrogen $N.^{15}$ From our own work we conclude that liquid ammonia properly used can serve as a dietary protein supplement.

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A NEW APPROACH TO FIRST YEAR CHEMISTRY

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ABSTRACT

Amplification of the paper of the above title consisted in listing the experimental, factual basis and the application. A fresh presentation of first year chemistry is sought to avoid confusion in the mind of the beginner.

Chemistry relates the prescription, testing and production of materials to their properties and these in turn to their structure. The properties exhibited by a statistical aggregate of even very similar particles are not always the properties exhibited by an individual particle of the aggregate. Interest in physical properties can be stimulated by studying them in connection with the instruments used in their measurement.

In the discussion of structure and its relation to properties distinction must be made between the electron considered as a unit of measure and as a structure. The same distinction can be applied to the word atom. We must also distinguish between a structure and our model of it.

Some of our present knowledge of the structure of materials may be stated as follows. Material structure is the result of an interplay of electric, magnetic and geometric fields. Centers of wave interference exhibit the properties of particles. One such particle is the nucleus, positively charged, surrounded by a negative charge distributed in concentric, hollow, more or less spherical shells. The density of the shell diminishes gradually but rapidly both toward and away from the center. The shell nearest the nucleus may contain as a maximum enough material to furnish two electrons. The shell nearest the nucleus may contain as a maximum enough material to furnish eight electrons, two from one sub shell and six from another. The shell third from the nucleus may contain as a maximum material enough to furnish eighteen electrons, two from its first sub shell, six from the second and ten from the third. The shell fourth from the nucleus may contain as a maximum material enough to furnish thirty two electrons, two from the first sub shell, six from the second, ten from the third and fourteen from the fourth.

The variables associated with the nucleus are: charge, always positive and quantized; mass, quantized; and energy content, quantized. The variables associated with the negative charge about the nucleus are: charge, always negative and quantized; mass, negligible for many purposes; energy content, quantized; and distribution in shells and sub shells.

If the positive charge on the nucleus is equal to the negative charge around the nucleus we call the resulting structure an atom; by taking account of the variables of nucleus and of surrounding negative charge the number of kinds of atoms may be found. If the nuclei of two atoms have quantitatively the same positive charge but differ in mass the one atom is said to be an isotope of the other, whereas if the nuclei have the same mass but differ in charge the one atom is said to be an isobar of the other. If marked stability is a characteristic of the structure we call it a mononuclear molecule.

If the structure exhibits more than one nucleus all of them surrounded by and inbedded in the same negatively charged field in which the interpenetration of contributing negative fields produces a volume or volumes of denser negative charge holding together the positively charged nuclei, we must distinguish several cases.

If the nuclei are all of one kind and if the sum of the positive charges on the nuclei equals the surrounding negative charge we have a polynuclear molecule of an elementary substance; if the sum of the positive charges on the nuclei is greater than the surrounding negative charge we have a poly-homonuclear cation; if the sum of the positive charges on the nuclei is less than the surrounding negative charge we have a poly-homonuclear anion.

If the nuclei are not all of one kind and if the sum of the positive charges equals the negative we have a poly-heteronuclear molecule of a compound

TABULATION

1 nucleus
- $+ = -$; atom.
  - masses $=$, charges $\neq$; isobars.
  - “ $\neq$, “ $=$; isotopes.
  - very stable; mononuclear molecule, He.
- $+ > -$; mononuclear cation, Na^+.
- $+ < -$; “ anion, Cl^-.

more than 1 nucleus
- all of 1 kind
  - $+ = -$; poly-homonuclear molecule of an elementary substance, O_2.
  - $+ > -$; “ “ cation
  - $+ < -$; “ “ anion, I_3^-
- not all of 1 kind
  - $+ = -$; poly-heteronuclear molecule of a compound substance, CH_4.
    - center of charge $=$ center of gravity; non polar, CH_4.
    - “ “ “ $\neq$ “ “ “ ; polar, H_2O.
  - $+ > -$; poly-heteronuclear cation, NH_4^+.
  - $+ < -$; “ “ anion, $SO_4^{=}$.

substance; if the centers of positive and of negative charge and the center of gravity are coincident the molecule is nonpolar; if these centers are not coincident the molecule is polar; if the sum of the positive charges is greater than the surrounding negative charge we have a poly-heteronuclear cation; if the sum of the positive charges is less than the surrounding negative charge we have a poly-heteronuclear anion.

By continuing this enumeration of combinations, descriptions in terms of structure are supplied for the various kinds of ion sets, solutions, alloys and mixtures. The result is a univalued terminology structurally related to the properties exhibited by the materials so classified.

AN ABSORPTION BULB FOR DETECTING VARIOUS GASES

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Measured by modern standards, some of the older tests in analytical chemistry are very low in sensitiveness. For example, the test for CO_3^{--} ions, in which CO_2 is detected by a drop of $Ca(OH)_2$ solution on a stirring rod, is satisfactory only in cases of high concentrations. Even when the CO_2 is evolved in a closed system and the gas bubbled through $Ca(OH)_2$, the sensitiveness varies, depending upon conditions. The capacity of the system, the rate of bubbling, the temperature,—a number of circumstances affect the sensitiveness of the test. In order to provide an apparatus as compact as possible, an absorption trap (Fig. 1) has been devised, using the principle of the Liebig bulb. The speed of the reaction may be increased by direct heating or by placing the test tube in a beaker of hot water. This apparatus has been found to be very efficient, and concentrations of CO_3^{--} as low as 0.03 milligram per milliliter may be detected.

In increasing the sensitiveness of the test, interferences by other anions are magnified. The interference of SO_2 from sulfites and thiosulfates was to be expected, and was obviated by adding $KMnO_4$ to the reaction vessel. But borates were also found to interfere, and even oxalates when present in high concentrations. The complication by borates is due to the volatility of boric acid in steam. Oxalic acid, on the other hand, is generally assumed to be nonvolatile. There is a loss when oxalic acid solutions are evaporated to dryness, but it has been assumed that it is due to sublimation of the solid, and not to distillation of the solution. The present work shows very definitely that solutions of oxalic acid of concentrations greater than 0.75 molar can be made to give off white

TABLE I—SENSITIVITY TESTS WITH ABSORPTION BULB

Ion	Reagent	Gas System	Absorbent	Sensitivity (mg./cc.)
CO_3^{--}	H_2SO_4	$Zn + H_2SO_4$	$Ca(OH)_2$	0.03
$C_2O_4^{--}$	$KMnO_4 + H^+$	$Zn + H_2SO_4$	$Ca(OH)_2$	.01
SO_3^{--}	H_2SO_4	$Zn + H_2SO_4$	$BaCl_2$-$KMnO_4$	.1
S^{--}	HCl	Zn + HCl	$Pb(C_2H_3O_2)_2$	.1
I^-	Fe^{+++}	$CaCO_3.MgCO_3$	Starch	.01
Br^-	$KMnO_4 + H^+$	$CaCO_3.MgCO_3$	CCl_4	.1
BO_3^{---}	H_2SO_4	$CaCO_3.MgCO_3$	Turmeric	low
As	$Zn + H_2SO_4$	Zn + HCl	$HgCl_2$	.01

fumes of $H_2C_2O_4$ at slightly above 100°, especially if they are boiled vigorously. As an extreme case, arsenious acid may interfere with the carbonate test if the boiling of the solution is prolonged.

These interferences can be obviated by a low temperature distillation of CO_2, since the vapor pressures of boric and oxalic acids are negligible at room temperatures. This low temperature distillation can be accomplished by sweeping the CO_2 out of the reaction mixture by means of an inert gas. For example, CO_2-free air may be passed through the reaction vessel. But a simpler method is to introduce a small piece of metallic zinc, and let the hydrogen formed sweep out the CO_2. This removal may be hastened by placing the tube in a beaker of hot water. As long as the contents of the tube do not boil, none of the interfering acids seem to come over.

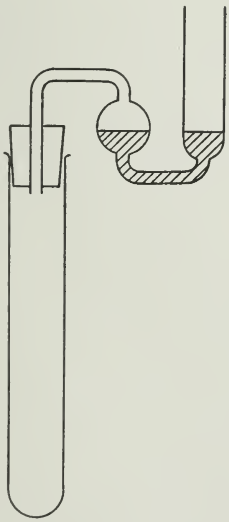

Fig. 1.—Absorption bulb for gases.

In view of the utility of the absorption tube in detecting CO_2, it seemed that its use might be extended to other tests (Table I). The SO_2 from sulfites and thiosulfates may be absorbed in an acid solution containing $KMnO_4$ and $BaCl_2$, bleaching the permanganate and precipitating white $BaSO_4$. The tube may also be used for the detection of sulfides, using Zn + HCl as the solvent for the material and $Pb(C_2H_3O_2)_2$ as an absorbent for the H_2S evolved. This test is sensitive, but does not seem to have any advantage over the usual procedure with $Pb(C_2H_3O_2)_2$ paper. Tests for iodide, bromide and chloride may be made by treating the solution with suitable oxidizing agents and dissolving the liberated halogen in carbon tetrachloride or iodide-starch mixture. Calcite, or dolomite, or other slowly-dissolving carbonate is introduced into the tube to furnish the inert gas required in the distillation. As seen in Table I, these tests have no advantage in sensitiveness over the usual procedures. Borates in HCl solution may be distilled and absorbed in turmeric solution, but again the test has nothing to recommend it. On the other hand, the new apparatus is wonderfully suited for the modified Gutzeit test for arsenic, in which a strip of paper impregnated with murcuric chloride is placed in the open arm.

QUANTITATIVE ESTIMATIONS IN THE QUALITATIVE COURSE

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Whatever the primary objectives of a course in qualitative analysis may be, one of its most important functions is to train the student in the use of laboratory tools and methods. A thorough grounding in laboratory technique should be one of the important results attained by the course; and by laboratory technique is meant not just a certain manipulative skill, but a thorough understanding of the various chemical and physical processes involved in laboratory work. At the same time a careful and painstaking attitude towards details of the laboratory work must be developed.

A method of attaining this objective, which is neither new nor original, consists in the requirement of a moderately precise quantitative estimation of the quantities of the various ions present, each ion being reported in terms of the number of milligrams in the sample analyzed. This system has the advantage of requiring a minimum amount of change in the standard qualitative procedure. It gives the student an excellent idea of the actual weights of material he is handling, and thus of the sensitivity of the tests, a thing which the classification into "large" and "small" quantities fails to do. It also leads directly to the intelligent use of control and blank tests, where the amount of contaminating material is compared directly to the unknown sample. From a practical standpoint, the conditions of analysis correspond more closely to industrial requirements, where the amount of a constituent present is often as important as its identification.

The procedure used in making estimations differs but little from standard laboratory procedure. Each student first runs an analysis on a known solution containing 50 milligrams of each ion in the group being studied, saving each final test in a labelled test tube. After the completion of the known analysis, an unknown solution containing varying amounts of one or more ions in the same group is analyzed in exactly the same manner as the known, each final test being saved for comparison with the known quantities. After the precipitates have completely settled, the student estimates the quantity of each ion by comparison with the known amount, the bulk of the precipitate being assumed to be proportional to the amount of ion originally present. In carrying the unknown solution through the same process as the known, errors due to mechanical losses tend to cancel out. By suitable modifications of the analytical scheme, usually quite minor and readily made, it is easy to obtain an analytical scheme which is satisfactory for this method of analysis.

The precision which the average student is able to attain in quantitative estimations of this sort cannot be judged by any practical analytical standard, but in order to set up a valid system of grading for a class, it is necessary to have a good idea of the precision which is to be expected. A requirement which is not very stringent is to demand that the result lie within limits of 50 and 150 per cent of the amount of material actually present. However, only 56 per cent of the 300-odd ions reported by the class at Knox this year fell within these limits. If the allowable limits of error are increased to 50 and 200 per cent of the amount given, then 67 per cent of the ions given out were reported correctly, so these limits are probably more nearly representative of the ability of the average student. That we can expect better resuls than this from the more skilful members of the class is shown by the fact that the top third of the class reported 82 per cent of their assigned quantities correctly.

It is of some interest to study the effect of the modified procedure on the student. The average student in the qualitative course is apt to be a rather sloppy worker, as he feels that it is possible to obtain a positive test in most cases even if a large proportion of the solution is spilled or otherwise lost. If, however, he is impressed with the fact that to lose a fraction of his precipitate is to ruin his chances of making a good quantitative estimation, he is going to be much more discreet in handling his materials. There is thus much more incentive for careful and painstaking work, and the results in this direction are distinctly encouraging. Granted that the results of analyses are not so rapidly forthcoming, nevertheless each student, feeling the necessity of recovering every scrap of precipitate, of thorough washing, etc., is much more careful and thorough in his work.

Whether there is a gain in the understanding of the processes comparable to the betterment of the laboratory attitude is perhaps questionable. However, it is doubtless true that the reasons behind the various processes have at least a better chance of being understood, since a little more time is spent on each step of the analysis, and the student has the opportunity to examine each process a little more closely.

In conclusion, it is perhaps fair to state that the results which the student can obtain by a scheme of this sort are not remarkable for their precision, but that they make up for their lack of practical value by their pedagogical value. The extra time and care necessary pay real dividends to the student in increased skill, a sounder attitude towards his laboratory work and a better understanding of the analytical scheme. He is laying a foundation of careful, painstaking laboratory technique which will stand him in good stead no matter where he may go.

A pH EXPERIMENT FOR THE FIRST COURSE IN CHEMISTRY

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An experiment in the conduct of first-year laboratory work in college chemistry is being carried out in Monmouth College. In this plan, every project requires each student to solve a problem, employing about the same techniques as his neighbor does, but getting a different answer, in general. Thus the determination of the percentage of chlorine in a sand-and-salt mixture occurs as an early exercise in weighing: five oxides are identified, partly by their behavior in hot hydrogen; unknown metallic elements are studied before an oxygen-blown blowpipe flame, etc. Experiments involving unknowns quite different in type from the conventional qualitative and quantitative problems of the sophomore year have been sought. Varying degrees of success have attended different projects thus offered. One experiment resulting quite satisfactorily was that herein reported.

A set of salts (five for two laboratory periods) are provided, freely soluble in water, and nearly pure; the cations being restricted to sodium and potassium; the anions to sulfate and bisulfate, sulfide sulfite, bisulfite, tertiary orthophosphates, secondary orthophosphates, primary orthophosphates, carbonate, and bicarbonate. One hydrated form, if common, and the unhydrated form are possible. All possibilities are definitely stated.

In identifying these, the cations are determined by flame tests; hydrate water by heating in 3 x ⅜-inch test tubes; and the anion type by tests with barium chloride, cadmium chloride, silver nitrate, and acidified potassium permanganate. The extent to which proton is present in the anion is inferred from the rough measurement of the pH of a molar solution of the unknown and comparison with a recorded value for the anion in question; or, alternatively, by comparing the pH of a 10 per cent solution of the unknown with 10 per cent solutions of all possible knowns. 10 ml. are ordinarily prepared. In the present plan, the solution is made 1 molar on the assumption of the lowest possible molecular weight of the unknown, and increments of salt subsequently added to suit successive assumptions of higher molar weights, the pH being noted at each stage. Any matching a recorded possible value is taken as determining the formula of the salt.

The pH is found by using the wide-range or universal indicator furnished by the Hartman-Leddon Company, of Philadelphia, Pennsylvania, and the color chart to accompany this indicator also sold by them. The chart may be dispensed with if the scheme of knowns is used.

The following are experimentally-determined pH's of 1-molar solutions of anions to be distinguished in this project:

$PO_4^{\equiv}$	$HPO_4^{=}$	$T_2PO_4^{-}$	$CO_3^{=}$	HCO_3^{-}
9.5	8	3	9	8

$SO_3^{=}$	HSO_3^{-}	$SO_4^{=}$	HSO_4^{-}
9.5	4.5	7	1

Sulfides are ordinarily highly colored by polysulfides incidentally present. This hopelessly falsifies the indicator reading. Therefore, disulfides are ruled out in this project.

To have the first-year student calculate the pH of the molar solution has not worked well. The arithmetic and algebra of the ionization and hydrolysis constants is beyond the average first-year student. For the reactions involving transfer of protons from water to anions of the unknown, an empirical (for the student) equation was worked out by means of which the pH could be calculated, but the working of the calculation was meaningless to the users, and the results in a most unsatisfactory relation to the observed value; so the formula was abandoned in favor of the table, which has a uniform record of satisfactory performance.

THE CHEMISTRY OF EUROPIUM

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Although discovered over forty years ago, the chemistry of europium developed very slowly. Europium is one of the rarest members of the rare earth group. Prior to ten years ago, europium material could be obtained only after long continued fractionation of a large quantity of rare earth compounds. Yntema[1] in 1930 discovered a method whereby europium could be separated rapidly from rare earth mixtures. This discovery not only enabled the rare earth chemist to separate europium quite easily from the rare earths but provided a means whereby sufficient material could be accumulated for extensive research.

Europium is capable of existing in two valence states, the trivalent and the divalent. Trivalent europium exhibits properties which are similar to those displayed by other trivalent rare earths. In addition to these properties trivalent europium may be easily reduced to the divalent state by such reducing agents as aluminum, zinc, or iron. Europium is more easily reduced than any other reducible rare earth.

Divalent europium was discovered by Urbain and Bourion[2] in 1911. They were endeavoring to prepare anhydrous europic chloride by the metathetical reaction between sulfur monochloride and europium oxide. The compound obtained possessed a smaller europium content than that required by the formula $EuCl_3$. This fact led them to investigate the reduction of anhydrous europic chloride by means of hydrogen.

No further work was reported on europous compounds until 1929 when Jantsch and co-workers[3] prepared europous chloride by the reduction of the hydrated europic chloride in an atmosphere of hydrogen chloride and hydrogen. They prepared the sulfate by treating a solution of the dichloride with sodium sulfate. They commend on the insoluble nature of the sulfate. This characteristic together with the stability of the di-iodide led them to postulate the similarity between the divalent rare earth ions and the alkaline earth ions.

Yntema[1] conceived the idea of using these facts in separating europium from other rare earths. He prepared the slightly soluble europous sulfate by electrolyzing a solution of the rare earth chlorides in the presence of dilute sulfuric acid. Practically pure europium was obtained by a single electrolysis. Complete removal however could not be effected. Selwood[4] suggested that divalent europium should possess an ionic radius approximating that of the barium ion and consequently practically quantitative removal could be obtained by a single electrolysis if europous sulfate was co-precipitated with barium sulfate. Brukl[5] found that strontium sulfate was the more efficient co-precipitating agent since the strontium ion and europous ion were practically equal in ionic radii.

McCoy[6] found that an efficient separation could be effected by means of the Jones reductor using amalgamated zinc as the reducing agent. In our laboratory we have studied the optimum conditions for the removal of europium together with some of the properties of europous europium.

The properties of the europous ion are quite different from those of the europic ion. Very dilute solutions of europous ions are colorless. At a concentration of 10mg. per ml. or greater the solutions possess a greenish-yellow color similar to that of chlorine watér. Europic solutions are practically colorless. Solid europic compounds possess a faint rose color whereas the europous compounds are generally white. Solutions of europous ions are powerful reducing agents. The reduction potential of the europous-europic ion is approximately 0.4 volts. It is thus one of the highest reducing potentials recorded for an ionic change involving the transfer of one electron. Europous ion is slowly oxidized by dissolved oxygen. If oxygen is absent the europous ion reacts slowly with the water. Hydrogen is discharged and basic salts are precipitated. Similarly to other reducing agents the europous ion is more stable in acid solution than it is in neutral solution. Moderate or strong oxidizing agents oxidize europous ion rapidly to the europic state. Iodine may be used to determine the europous europium content of a solution. Europous europium is capable of reducing ionic silver, copper, mercury, and lead to the metallic state. Ferric iron is reduced to the ferrous state. Sulfite ion is reduced to hyposulfite. Concentrated hydrochloric acid precipitates europous chloride containing two molecules of water from europous solutions. This enables one to obtain very pure europium material. If a sulfate is added to europous solutions, an insoluble precipitate of europous sulfate is obtained. This precipitate is very stable, resisting to a high degree the effect of strong oxidizing agents. Nitric acid however decomposes it rapidly. The sulfate is precipitated in two crystalline modifications depending upon the conditions. The sulfate appears to be the least soluble of the europous compounds. Digestion with sodium carbonate converts the sulfate into the carbonate.

A consideration of the atomic structure of europium enables one to understand more clearly the chemical and physical properties of this element as well as the relationship between it and its neighbors in the rare earth group. In general the addition of an electron takes place in either the outer or next to the outer shell. When we come to the rare earths we find that the electrons are added successively not to the outer shells but to deeper ones. Thus we find that when we come to europium, possessing an atomic number of 63, there are the same number of electrons in the two outermost orbits as there are in the other rare earths but that the 4_4 level has built up to six electrons. These additional electrons are thus shielded from activity and explain why europium possesses certain properties which are characteristic of the rare earths. The electrons in the 4_4 level however would be expected to exert some influence on the properties of the rare earths. After a certain number of electrons have been added to this level, they exert a stabilizing effect enabling one to obtain divalent ions under certain conditions.

Divalent europium possesses 61 electrons in its outer orbits. Trivalent gadolinium and tetravalent terbium also possess 61 electrons. We would thus expect certain properties of these elements in the valences mentioned to be similar and this is found to be the case. Magnetic and optical properties have been shown to be similar.[7] Trivalent europium possesses 60 electrons. Divalent samarium likewise possesses 60 electrons. Consequently we can postulate a similarity between trivalent europium and divalent samarium.

Numerous experiments are still being conducted in order to extend our knowledge of the chemistry of europium. No doubt this information will prove to be not only interesting but also illuminating with respect to the chemistry of the entire rare earth group.

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PREPARATION OF HUMIC ACIDS FROM ILLINOIS COAL

G. R. Yohe and C. A. Harman*

Humic acids are complex, high molecular weight colloidal substances. They form dark brown solutions in aqueous alkalis, from which they separate as highly hydrated, brown flocculent precipitates upon acidification. They are products of certain types of plant decomposition, and may be obtained from such materials as decayed wood, peat, and brown coals by alkali extraction. Bituminous coals, which do not yield these alkali soluble materials directly, may become good sources of humic acids after being subjected to partial oxidation.

Humic acids have been recognized by many investigators[1, 2, 3, 4] as a rich source of information concerning the constitution of coal. Various methods have been utilized for preparing them by partial oxidations of coal. Those reported have included oxidation with nitric acid,[5, 6, 9] sulfuric acid,[7, 8] potassium permanganate,[9, 10] hydrogen peroxide,[9] and atmospheric oxygen.[11] Pure oxygen has been used on coals suspended in aqueous alkalis,[12] and electrolytic oxidation[13, 14] has been reported. The oxidations using air appear to be the most convenient for the production of humic acids in large quantities.

The problem of preparing a quantity of humic acids from vitrain, the brilliant, jet-black portion of coal, arose in connection with another investigation. For purposes of comparison, the methods used have been applied also to the other banded ingredients of coal, which have been described[15] as follows: clarain is glossy and finely laminated, durain (commonly called "splint") is dull gray and laminated, and fusain is the very friable mineral charcoal. The coal used in the present work was obtained from the Herrin No. 6 seam in Franklin County, Illinois. Vitrain was isolated by subjecting —4, +8 mesh coal to float-sink separation in a benzene-carbontetrachloride mixture of sp. gr. 1.30. The floating portion was again treated with a mixture of sp. gr. 1.28; giving a "sink" fraction (C-2108) and a "float" fraction, which was handpicked to remove dull pieces (C-2092). The clarain, durain and fusain were hand-selected at the mine. Analyses of the vitrain samples are given in table 3.

Oxidation of citrain with *N* nitric acid gave a 70 per cent yield of humic acids, but the method was abandoned because it introduces nitrogen into the product.[9, 16, 17]

Dry Air Oxidation of Coal.—An experiment with air oxidation, in which the powdered coal was placed in a well-ventilated electric oven at 150° C., showed that the coal "heated" spontaneously. The following procedure eliminated this difficulty. One hundred grams of vitrain (C-2092), 30 gm. each of durain and clarain, all ground to pass a 200-mesh sieve, were placed in separate shallow pans in an electric oven at 110° C. The temperature was raised gradually (ca. 5° per day), and at the end of one week it was set at 150° C. and kept there for 3 weeks. The coal samples were stirred daily, and at the end of the oxidation period two 10 gm. samples of each coal were digested for 15 minutes with 500 cc. of boiling 5 per cent sodium hydroxide. The coal residues were washed free of alkali-soluble humates by decantation; the residues were recovered and the solutions clarified by centrifuging, first with a type 1-C International centrifuge (1,750 r.p.m., centrifugal force about 600 times gravity), then with a Sharples supercentrifuge (50,000 r.p.m., centrifugal force about 63,000 times gravity). The sodium humate solutions were acidified with hydrochloric acid and the precipitated humic acids washed several times by stirring with water, centrifuging and decanting. Both the coal residues and the humic acids were finally transferred to filter papers and air-dried. The amounts of coal residue and the yields of humic acid obtained are given in table 1.

Air Oxidation of Coal Suspended in Hot Aqueous Alkali.—The powdered coal samples were suspended in dilute sodium hydroxide (50 cc. per gm. of coal) in 1 liter round-bottomed flasks fitted with reflux condensers. A moderate stream of air was bubbled into the bottom of each

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Table 1—Dry Air Oxidation of Coal

Description of Sample	Products from 10 g oxidized coal (grams)		Yield of Humic acid (Per cent)
	Coal residue	Humic acids	
1. Durain	3.7	6.3	63
2. Durain	3.8	5.9	59
3. Clarain	1.4	8.2	82
4. Clarain	1.4	8.3	83
5. Vitrain (C-2092)	0.5	9.6	96
6. Vitrain (C-2092)	0.6	9.6	96
7. Vitrain (C-2092)	0.5	9.5*	95

* A 30-minute NaOH digestion was used in isolating this yield.

Table 2—Oxidation of Coal in Alkaline Suspension

Type of Sample	Period of Oxidation (Days)	Yield of Humic Acid		
		As rec'd. basis		Dry-ash free basis (Per cent)
		Grams	Per cent	
1.[a] Vitrain (C-2108	6[d]	1.1	11	11
2.[a] Vitrain (C-2108)	8[e]	6.0	60	61
3.[a] Vitrain (C-2108)	24[f]	7.2	72	73
4.[b] Vitrain (C-2108)	7	0.3	2	2
5.[b] Vitrain (C-2108)	14	2.6	17	17
6.[b] Vitrain (C-2108)	21	12.5	83	84
7.[c] Vitrain (C-2108)	7	0.3	3	3
8.[c] Vitrain (C-2108)	21	6.8	68	69
9. Fusain	21	<0.1	<1	----------
10. Fusain	21	<0.1	<1	----------
11. Durain	21	0.7	7	----------
12. Durain	21	1.6	16	----------
13. Clarain	21	1.6	16	----------
14. Clarain	21	3.3	33	----------

[a] 60 mesh samples used; all others were 200 mesh.
[b] 15 g samples were used; all others were 10 g.
[c] 10% NaOH used; all others were 5% NaOH.
[d] Three 2-day periods; new NaOH for each period.
[e] Two 4-day periods; new NaOH for each period.
[f] Three 8-day periods; new NaOH for each period.

Table 3—Analytical Data

Type of Sample	Moisture	Ash	Dry-ash free basis					
			C	H	O	N	S	B. t. u.
1. Vitrain	5.4	2.2	81.96	4.98	10.23	1.65	1.18	14,444
2. Vitrain	8.1	2.1	81.74	5.10	10.23	1.98	0.95	14,270
3. Oxidized vitrain	3.9	1.4	68.99	2.98	25.18	1.77	1.08	10,548
4. Humic acid	8.4	1.0	71.27	3.60	22.86	1.56	0.71	11,387
5. Humic acid	8.3	0.8	----------	----------	----------	----------	----------	----------
6. Humic acid	7.0	2.5	----------	----------	----------	----------	----------	----------

Description of samples:
1. Vitrain from No. 6 coal, Franklin Co., sp. gr. < 1.28; Lab. No. C-2092.
2. Vitrain from No. 6 coal, Franklin Co., 1.28 < sp. gr. < 1.30; Lab. No. C-2108.
3. Sample (1) air oxidized 3 weeks at 150° C; Lab. No. C-2117.
4. Combined sample of crude, air-dried humic acids, obtained from experiments 1-8, table 2; Lab. No. C-2110.
5. Combined sample of humic acids, obtained from experiments 9-14, table 2.
6. Combined sample of humic acids, obtained from experiments 1, 3 and 5, table 1.

flask and the temperature maintained at 95° + 5° C. At the end of the oxidation period the reaction mixtures were diluted and the residual coal removed as in the dry air oxidations. The humic acids were precipitated with hydrochloric acid, recovered by centrifuging and filtering and air-dried. The yields are shown in table 2.

Discussion. — The inconsistent results obtained by the oxidations in sodium hydroxide suspension may be due in part to differences in effectiveness of agitation by the air streams introduced into the reaction mixtures. The use of hot alkaline solutions for the prolonged periods of time resulted in pronounced etching of the pyrex flasks used.

In all cases except fusain, the separation and washing of the alkali insoluble residue was difficult. This residual matter settled slowly, even in the International centrifuge, and upon attempted filtration either went through the filter or clogged the paper to such an extent that filtration was impossible. The difficulty of this separation was greater with the samples oxidized in sodium hydroxide suspension, and may have contributed to the variations in the yields of humic acids obtained.

The alkaline humate solutions were apparently colloidal; they showed the Tyndall effect even after being put through the Sharples supercentrifuge.

The humic acids formed bulky, flocculent precipitates. Effective washing was difficult because of their tendency to disperse colloidally in pure water; it was necessary to acidify the final portions of wash water with a few drops of hydrochloric acid to prevent this dispersion. After centrifugal settling humic acids had a dark brown to black color and a jelly-like consistency. They dried to jet black, friable solids resembling vitrain.

Summary and Conclusions. — Humic acids have been prepared from the banded ingredients of Illinois coal by dry air oxidation at 150° C., and by bubbling air through a sodium hydroxide suspension of the coal at 95° C.

The dry air oxidation has proved more satisfactory from the standpoint of yields obtained and reproducibility of results. It is decidedly more convenient to carry out, and minimizes the possibility of contaminating the products with silicates removed from glass vessels by prolonged hot alkali treatment.

Vitrain can be converted almost completely to humic acids, clarain and durain yield smaller amounts, while fusain is resistant to this oxidation under the conditions used.

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PAPERS IN GEOGRAPHY

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

The Geography Section carried twelve papers, eleven of which are herewith published. The other was entitled as follows:

Reading geographic symbols, by Otis McMahon, Carterville.

Variations in the frost-free season in Coles County, Illinois, by G. D. Koch, Eastern Illinois State Teachers College, Charleston.

Average attendance was 70.

Those present elected as chairman for the 1940 meeting *Clare Symonds,* Quincy, Illinois.

(Signed) THOMAS F. BARTON, *Chairman*

WANTED—MORE VARIETY IN THE GEOGRAPHIC MENU!

W. O. Blanchard

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In one of Mrs. Dwight Morrow's delightful letters describing life in Mexico's capital, she relates an incident which, in this age of mechanization and standardization, furnishes much food for thought.

Needing some chairs for her summer home, Mrs. Morrow had sought out the local carpenter and showed him a sample of a chair she had admired. He agreed to make a duplicate for a certain sum. When, however, she asked him to name a price for a dozen such chairs—all like the sample—he seemed quite dismayed. Finally, after much urging, he named a figure for the entire order, but it was much more than twelve times the price formerly suggested for one! "How is this?" said Mrs. Morrow. "In our country when we order a large number of the same thing, we usually get it at a cheaper rate. You are actually asking me more." "But," said the perplexed craftsman, "just think of the awful monotony of making twelve of them—all just alike!"

We all crave variety. Men and women, and especially children, seek change and are bored by monotonous repetition. This desire extends to our work and to our play; to our dress and our diet; to the environment we work in and to the entertainment we seek.

Doesn't it seem like good sense to recognize that deep-seated natural desire and to plan our school work accordingly?

Too often, however, the recitation is a daily rehashing of a text assignment following the same outline. Today, it is the "climate, topography, occupations, products, and foreign trade" of Argentina. Tomorrow, it will be the same procedure for Brazil. And so on, ad nauseum. It is like serving boiled potatoes and roast beef to the same group of boarders day after day for eight or nine months!

But a good cook doesn't do this! He may have a limited supply of raw materials, but by varying the preparation and seasoning, he makes a formidable array of tempting dishes. We also can change the recipe, vary the form of our materials and the avenue of approach, thus providing the variety which stimulates interest and thoughtful effort.

The "geographic cook book" has suggestions galore for varying our daily offerings. The possible suggestions are not new. All of you have known of some of them. Some of you are familiar with all of them. Better still, some of you use them. It is one thing to know what to do, but quite another to do it. The late Dean Mumford of the University of Illinois College of Agriculture once remarked that he was not so much concerned with the need for further research activities which might point the way to better agricultural practice as he was with the problem of making farmers actually apply the knowledge they already possess. I suspect the same situation is true among teachers.

So from the many possible variations in the geographic program let me urge the more extended use of two devices in particular which though old, are valuable in practically any grade of work:

(1) *The larger use of important current events and the placing of them in their proper geographic setting.* Properly used this is a most valuable exercise in applied geography. This requires care in selecting worthwhile items and in bringing out the geographical relations. Without such precautions the work degenerates into a rehashing of unimportant happenings of transient interest. Two or three items well done are worth a score of doubtful value. Thus, the accounts of the Chilean earthquake will not only furnish details of the character of such a disturbance but should also recall that Chile is a part of the earthquake belt which encircles the Pacific. The recent inauguration of regular trans-Atlantic air service via the Azores furnishes much material for thoughtful discussion as to Atlantic winds, storms, distances between land bodies, etc. A bulletin board may be used to supplement this work with mounted clippings and pictures of geographic interest. It becomes especially interesting if a large world map is mounted in the center and the location of the

event shown by a thread or string which runs from the item to the proper point on the map where it occurred. A further adaptation of the same general idea is to be found in the geographical scrap book. The pupil's book may be divided up according to continents, and the clippings and pictures mounted in their proper sections with appropriate comments and explanations.

(2) *The more liberal use of maps and graphs.* Desk outline maps upon which distribution data may be shown, and graphs showing trends, are valuable supplements to the textbook. Too often the exercise ends when the pupil has shown the distribution on the map or the trend in production by a graph. Often interesting correlations may be suggested by studying graphs of related figures placed side by side. Thus, the rise in automobile use is paralleled by a corresponding decline in carriages; the decrease in Chilean nitrate output, by a corresponding rise in artificially fixed nitrogen; the rise in rayon, by a fall in silk prices, etc. In lieu of individual maps and graphs, large ones may be drawn on the board and groups assigned and made responsible for certain parts. Large outline maps printed on newsprint may now be purchased in quantity for about 6c each. Mounted on cardboard they serve the purpose admirably.

There are dozens of other variations in the presenting of material and if one has in mind the basic relations to be taught, the recipe for their preparation may be varied almost indefinitely.

ECOLOGICAL AND HISTORICAL ASPECTS OF LEADVILLE, COLORADO, AS TYPIFYING THE PURE SAXICULTURAL ADJUSTMENT

E. Mitchell Gunnell

Galesburg, Illinois

The author suggests that of the pioneer mining camps of the west which are still active down to the present day, Leadville, Colorado, perhaps better than any other, best typifies the characteristic sequence of cultural aspects of the pure saxicultural adjustment. In order to prove the validity of this suggestion, he presents a brief discussion of certain basic relationships and responses of diversified geographic kind discernible in the history of Leadville.

The location and site of Leadville are described and shown to be truly alpine. The city is located in the Upper Arkansas Valley, and situated on a pediment bench some miles east of that river and at an elevation of over 10,000 feet. It is surrounded on east, north, and west by the snow-covered summits of the Mosquito Mountains, Tennessee Pass, and the Sawatch Mountains respectively.

The Leadville fundament is described in some detail in such a way as to emphasize its economic barrenness to all profitable mass-endeavor except the mining of metalliferous ores. Leadville dominates population-distribution of its alpine region, containing in 1930 some 77 per cent of the people of Lake County. According to county assessment figures for 1937, only 27 per cent of the area of the county was privately-owned land, and utilization of this land was solely for the purposes of grazing (transhumance) and metalliferous mining. Various economic bases leading to successful adjustments in mountains are described with application to Leadville: agriculture has never been possible; timbering was limited to the sawing of rough lumber for building and for fuel (cordwood and charcoal for smelters) during the early boom period; smelting was once an important industry but declined sharply by 1885; railroading has contributed little except to the mining industry; retail trade in Leadville has always been of local character despite strategic position because of the scant population-density of the alpine trade area.

The writer then divides the seventy-eight years of Leadville's existence into the three periods he believes inherently involved in the life of any saxicultural community; viz., periods of discovery of minerals, development of mining (or other form of extraction), and decline of mining to final extinction. Opposite each of these periods he puts the discernible status of urban and cultural development in the Leadville settlement, thus deriving a sequence of cultural aspects. He then describes each of these cultural periods in some detail, with the exception of the last which must await field study in the Leadville region before he feels willing to make a report upon it.

The period of discovery was marked by what the author terms the "shantytown level of culture" of Oro City, the first settlement in the Leadville district. This sprung up in direct response to the basic physical needs of thousands of gold miners in California Gulch for shelter, food, and diversion. It was unorganized, impermanent, crude and ugly beyond description, yet adequate. By the end of the year, the Gulch was believed worked out, the population of Oro City largely departed, and the settlement quickly assumed the aspect of a ghost town.

The period of development came about as a response to the discovery of rich silver-lead ores in 1875. A second rush slowly got under way to overflow the Gulch by 1878. A new city was laid out some miles away from old Oro: this was Leadville. Within a year it had grown to a city of some 15,000 people and modern aspect: a list of adjuncts by which its relatively high plane of municipal and cultural achievement may be judged is given. The early smelting industry, because it is an interesting historical instance of conjunctive industrial symbiosis, is considered in some detail; that it had withdrawn almost entirely from Leadville by 1885 was in response to the cumulative effect of several factors which rendered it uneconomic to remain in Leadville.

Attention is drawn to the fact that no one year naturally marks the beginning of the period of decline at Leadville: arbitrary choice must be exercised because of the overlap of years depending upon one's particular point of view. Certain general evidences of municipal and cultural decline are noted, as is the inevitable conclusion that Leadville is fast approaching the ghost town stage.

GEOGRAPHY OF THE MISSISSIPPI GULF COAST

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AN ABSTRACT

The Coastal Plain of Mississippi, underlain with sand, clay and loam sediments of Pleistocene and recent age, descends gradually from the low hills of the Pine Hills Physiographic region to the Gulf, and continues beyond to form the Continental Shelf. Several low sand ridges have emerged and become fixed with vegetation, thus breaking the monotonous plain. Swamps and marshes are common near the coast and along the stream valleys. The mixture of pine forests and grassland vegetation has often caused this region to be called the Coastal Pine Meadows; however it is more preferably called the "Coastal Terraces." The terrace character of the topography is noticed only after more careful study and mapping.

The Mississippi Gulf Coast is well known as a healthful resort. Harrison County, in which Gulfport is located, has been declared by the United States Public Health Service as one of the healthiest counties in the United States. The formation of the rocks has made possible numerous artesian wells from which the cities are supplied with the purest artesian water, delicious to drink and so soft that the mildest soaps foam into rich suds. Other health producing factors are the long hours of sunshine, and temperatures that make outdoor activities possible all the year. The mean average annual temperature of the coast is approximately 68° F. The average annual precipitation is approximately 62 inches.

After two years under the administration of the Mississippi "balance agriculture with industry" program, the state has the promise of added industrial payrolls approaching two million dollars to

be paid to nearly three thousand new workers in nine new enterprises. Two of these, a woolen mill and a plywood factory, are in Jackson county. These and previous garment factories and other plants begun under this program have given employment to a large number of the people, and have also utilized large amounts of the raw materials of the region.

None of the cities of the Coast are so very large, but they are all important as shipping and fishing centers, and especially as resorts. Gulfport, the largest, has a splendid new $425,000 small craft harbor, a ship canal, a deep water harbor, a recently completed $1,250,000 municipal dock and ware houses, the latest equipment for loading and unloading ocean-going steamers plying to all foreign ports, and numerous smaller factories and canning plants. Biloxi, the first permanent white settlement in the Mississippi Valley, was once capital of the region that stretched from what is now Yellowstone Park to the present site of Pittsburg—the American domain of Louis XIV of France. Today the Old Historic Lighthouse, over which seven different flags have flown, still watches over the five hundred fishing craft which supply the seafood canning plants of Biloxi. Pascagoula, another important fishing and lumbering city, has recently accepted a shipbuilding contract with the government. Moss Point, the easternmost city on the Mississippi Coast, was the site of one of the south's first paper mills. The Moss Point Paper Mill is at present an important producer of paper which is made from local pine timber. It is also of interest to note that even though little, if any, oil has been found on the Mississippi Gulf Coast as yet, oil companies have recently leased much of the land. They have good prospects of finding oil in the region.

The Gulf Highway follows the Old Spanish Trail and is sometimes called the seawall boulevard because for miles on either side of Gulfport the world's longest seawall, 40 miles in length, protects the highway from the Gulf. By the end of March the waters of the Mississippi Sound are warm enough for swimming and this seawall becomes a playground for sunbathers. Spring comes early in Mississippi. On the coast the camelia japonica and wisteria bloom in February. The wooded hills, where pine and live oaks are green the year round, usher in spring with dogwood, redbud, and yellow jessamine. Traveling the Coast's "Azalea Trail" is really an unforgettable experience. The azaleas are in bloom by the latter part of February, and the "Trail" extends from New Orleans, through Gulfport, and on to Mobile. Thus one can see why the tourist trade begins so early in these ciites.

Thus we might summarize the Coastal Terraces as a whole as a region of forest and forest industry, since only scattered areas have been cleared for part time and subsistence agriculture. On the higher and better drained portions, particularly near the northern border, conditions favor the expansion of subtropical plantation crops. Notable beginnings have already been made in the production of pecans, satsumas, oranges, and tung oil. South Mississippi is now recognized as the ideal place in the United States for the production of this oil which until only recently was almost exclusively imported from China. The coast cities depend largely upon the tourist industry, fishing, and shipping. In addition the region is rapidly changing toward the "balance industry with agriculture" program. Thus we conclude that in the near future these cities will also depend more largely upon manufacturing.

ILLINOIS RAINFALL

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In presenting the subject of this paper, it seems proper to first lay the ground work on which the data is based, and later to touch briefly upon some of the influences that contribute to the wide variations in rainfall experienced.

Publication of Illinois climatological data was begun in 1887, with the organization of the Illinois Section of the U. S. Weather Bureau's climatological service, with some 60 reporting stations. Equipment of stations, proper exposure of equipment, and a reasonably adequate distribution of stations was advanced as rapidly as practicable to bring the recordings up to an acceptable plane. At present we have 112 well distributed stations in this State, all equipped with standard rain gages, and manned in the great majority of cases by Cooperative Observers who have carefully been selected for their dependability and fitness for the work, as well as their individual interest therein. Expectations are that the number of rainfall stations will be materially increased during the next year or so, with the addition of a considerable number of rate-recording gages, this to particularly meet the needs of engineers concerned in water run-off problems. A material increase in the number of recording stations while not

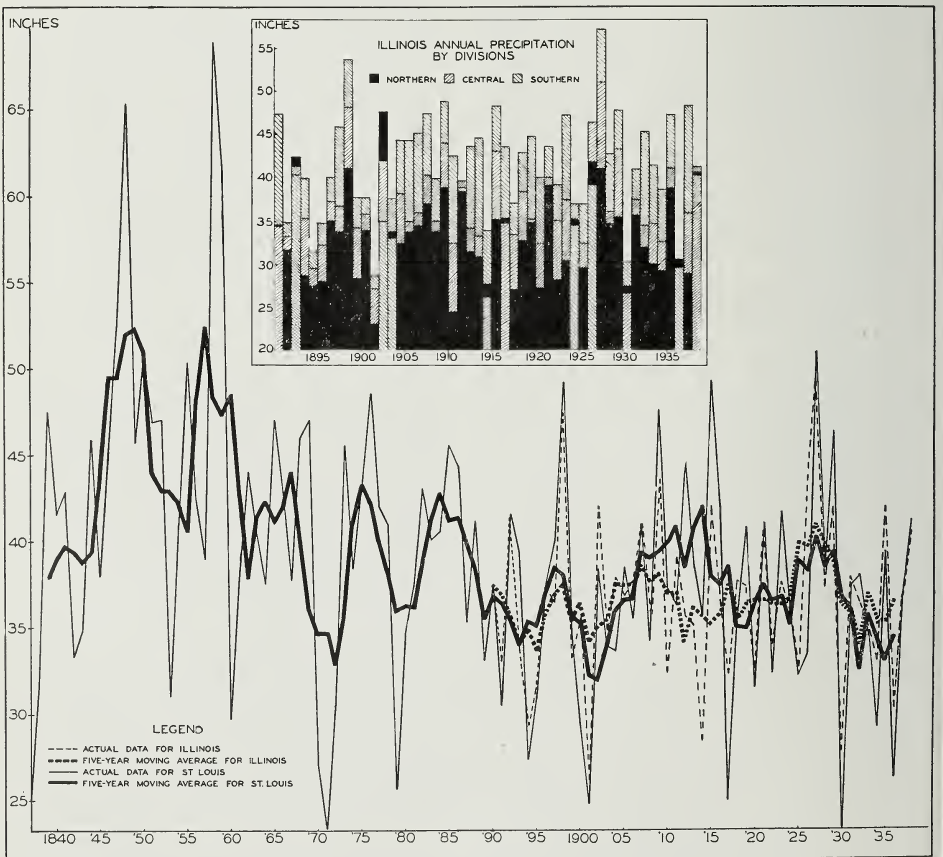

Fig. 1.—Annual precipitation. State of Illinois compared with St. Louis, Mo.

particularly important from the standpoint of computing State and division averages from year to year, is very desirable from many other viewpoints, and especially are more automatic records of rainfall needed.

At this point it seems desirable to emphasize the fine public service our Cooperative Observers are performing. Their careful daily observations throughout the year, Sundays and holidays included, is a remarkable contribution to science when it is considered that they receive no compensation for their work. Their fine calibre of service can not be too highly commended, and among the many cooperative observers we have a few who have made these observations for more than 25 years, 30 who have served for more than 15 years, and one, Mr. O. C. Nussle, of Walnut, who has maintained a continuous and excellent record since 1892. In the United States as a whole there are more than 5,000 of these cooperative observers rendering this day-in and day-out service to their community and the U. S. Weather Bureau; certainly they derive much satisfaction in doing a very useful job extremely well.

Illinois precipitation, based upon a 49-year record, averages 36.67 inches, with the southern division receiving 23 per cent more precipitation annually on the average than the northern division. Annual averages during this period have ranged from 49.39 inches in 1927, to 26.25 inches in 1901. At individual stations annual totals vary from 71.24 inches at Golconda in 1882, to 16.15 inches at Pontiac in 1887. In order to project our State averages backward over a longer period, Illinois average rainfall has been superimposed on a graph over the Saint Louis record. The close relationship in trend will be noted between the two records. In the graph actual records are shown; also the data has been smoothed out somewhat by means of charting a 5-year moving average. It will be noted that during the past 49 years Illinois has experienced about as severe drouths as is indicated by the Saint Louis record of 100 years, and that these severe drouths have occurred with greater frequency during the past 50 years than in the preceding like period. Illinois has had six major drouths since 1890, while only 3 are indicated by the Saint Louis record for the more than 50 years preceding. The five-year moving average quite definitely brings out that the past half-century was not nearly so wet as the half-century preceding, and the Saint Louis record shows by its five-year moving average a timing of about 30 years between its extreme dry periods, with the intervening period of maximum rainfall not so well defined. Unfortunately years of Saint Louis heavy rainfall, 1848 and 1858 precede by a number of years inception of state-wide records in Illinois; however, the few records that are available for this State for 1858 well bear out the Saint Louis inference that 1858 represents the year of maximum precipitation for Illinois in the past 100 years. Based upon 49 years of record the northern division of Illinois receives 28 per cent of its annual rainfall in the spring months, 32 per cent in the summer months, and 26 per cent in the autumn months, the central division 30 per cent in the spring, 29 per cent in the summer, and 24 per cent in the autumn, and the southern division 30 per cent in the spring, 26 per cent in the summer, and 23 per cent in the autumn, showing that on the average for the crop season rainfall is progressively less from north to south across the State; however, while the northern division averages 86 per cent of its annual rainfall during the nine warmer months in comparison with 83 per cent in the central division and 79 per cent in the southern division, the actual average amounts for that period vary by only a few inches because of the usually larger average rainfall values with advance southward. Further comparison between the three divisions of the State shows that the north is less subject to wide variations from normal than the south. Blocks on the graph represent annual precipitation for the three divisions.

There are possibilities of monthly amounts ranging from nearly 10 inches to about 20 inches, available records for individual stations giving maximum totals exceeding 11 inches in every month except December, and December has a record of 9.53 inches. Monmouth recorded 20.03 inches in September, 1911, Shawneetown 19.04 inches in January, 1937, and Anna 18.21 inches in June, 1928. Several stations on the Illinois side of the Ohio River during the great flood of January, 1937, recorded from about 17 to 19 inches during a 25-day period. The greatest amount within the State for a 24-hour period for which we have a record is 10.25 inches at LaHarpe on June 10, 1905. Several other stations in various parts of the State have recorded from 7 to 9 inches within a similar period of time.

The natural question arises as to the meteorological causes for these large variations in amount of precipitation, and the source of the moisture that on the average provides Illinois with roughly 150 billion tons of water annually. Evaporation of water within the State, from the Great Lakes, and to the areas to our westward and southwestward do of course contribute a small part of this enormous volume of water; however, our main source of supply is the Gulf of Mexico from which warm, moisture laden air is brought by the southerly winds devedoped in front of low pressure areas advancing in our direction from the west and southwest. These northerly moving masses of warm, moist tropical air moving up in front of a "Low" meet masses of cool polar air associated with the rear section of the "Low", and as the lighter and warmer tropical air glides upward over the denser polar air, the gain in altitude of the tropical air forces cooling and condensation of its vapor. The frequency and development of these low pressure processes, the period of time they function over a given area, and the favorableness of conditions for the moving northward of moist tropical air together with the contrasting presence of cool polar air are factors that largely determine abundance or deficiency of precipitation.

NATURAL REGIONS OF THE OZARK PROVINCE

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Because of the great interest in cultural studies, there is some danger that the physical studies, which furnish much of the basic explanatory material for them, will be neglected. Before any significant advance can be made in understanding man's activities, it is necessary to analyze and describe the physical environment which is their setting.

Many important areas in the United States have not been adequately treated in published maps and descriptions. Such an area is the Ozark Province of Missouri, Arkansas, Oklahoma, and Illinois. Despite increasing interest in the Ozarks, relatively little is known of their physical features and aspects. Even the more recent maps present inaccurate ideas of their boundaries and characteristics.

For several years studies have been in progress aiming at a thorough quantitative analysis of both the physical and cultural aspects of the province. The present paper deals with some of the principal results already attained. Maps have been prepared to show the geology, local relief, angles of slope, native vegetation, and natural regions of the Ozarks, employing techniques described in an issue of the Transactions of the St. Louis Academy of Science now in press. Other maps will be prepared when the analyses of the factors concerned have been completed.

One fact of especial interest to residents of Illinois is brought out by the maps. These show that most of the hill country commonly called the Illinois Ozarks is distinctly unlike the true Ozarks in the greater part of its physical characteristics.

Because of the difficulty of coordinating the data presented on different maps, generalized physical profiles have been prepared to show regional characteristics and to emphasize relationships among the various physical factors. Descriptions of some of these profiles illustrate the results obtained by regional analysis. The first example, the St. Francis Forested Knob Region, is the structural center of the Ozark dome. Ancient igneous mountains, formerly buried by sediments, have been partly uncovered by erosion. The high differential resistance of the rocks has resulted in the strong local relief of 500 to 900 feet, the resistant igneous masses standing out above the surrounding sedimentary areas. In the lowlands differential resistance is low, except where isolated masses of cherty dolomite cap the weaker sediments and preserve them from erosion.

Each rock type of this region has characteristic soil and vegetational expressions. On the igneous knobs the mantle rock is shallow clay which has developed a poor, immature forest soil. Because of the shallow mantle rock, flooding and baking alternate. The soil conditions are reflected in a scrubby forest in which shag bark hickory, post, and red oaks constitute more than half of the timber. The sandstone areas of the lowlands have deep sandy mantle rock, poor forest soil, and low water tables. Part of the area has been cleared and the remainder supports a second growth forest in which pine, post, black and white oaks, are dominant. On the non-cherty dolomite the mantle rock is clay, the forest soil relatively fertile, and most of the land cleared for agriculture. Along the streams there are strips of timber with sugar maple, sweet gum, sycamore, and white oak predominating. The limited areas of cherty dolomite which erosion has left as caps on the higher hills have deep, pervious, siliceous mantle rock, low water tables, and poor forest soils. High percentages of pine and post oak reflect the unfavorable conditions.

The St. Francis Forested Knob Region formerly was noted for its iron mines which furnished ore for the furnaces of eastern Missouri and adjacent parts of Illinois. In the region, also, are limited deposits of disseminated galena with which is associated some nickel and cobalt. None of the metallic minerals are being worked at present.

North of the St. Francis Forested Knob Region is the St. Francis-Big River Cleared Lowland. This region differs markedly from the preceding one. Igneous rocks are exposed only in the deepest valleys, and dolomites, sandstones, and limestone of low resistance occur over most of the area. Because of the ease with which erosion acts on these rocks, the region has been degraded below the level of the adjacent areas of resistant strata. Among the weak rocks, however, the differential resistance is high, the dolomite forming caps for the softer sandstone. The result is rolling topography with a local relief of 200 to 300 feet and concave slopes below the cap layers. If stream cutting were not limited by the depressed character of the region, the differential resistance is adequate to give rise to high local relief and steep slopes.

The mantle rock of the region is deep and non-cherty. On the dolomite and limestone it is clay, which has a high water table and good forest soil. These areas are cultivated, except along stream margins which are timbered with sugar maple, sweet gum, sycamore and white oak. On the sandstone, however, the mantle rock is sand, the water table low, and the soil poor. Pines, post, black, and white oaks make up more than 50 per cent of the timber. The St. Francis-Big River Cleared Lowland Region includes the rich disseminated galena deposits of southeast Missouri which furnish an important part of the nation's production of lead.

The other natural regions of the Ozark Province differ from those discussed in numerous respects. Difference in rock type, structure, and amount of entrenchment of streams is expressed in variations of local relief, angles of slope, average width of hills, soils, and native vegetation. Descriptions of the eight natural regions of the Ozarks are included in an article now nearing completion, in which generalized physical profiles are used to express regional characteristics.

THE GUATEMALA HIGHLAND

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Two things that are perhaps most interesting to a traveller in the Guatemala Plateau are the native inhabitants and the striking beauty of the country. Some four hundred years ago, Pedro de Alverado, one of Cortez's lieutenants placed in charge of the first expedition sent to Central America from Mexico, wrote as follows describing the Guatemala Plateau, "I would your Grace to know that the country is healthy and the climate temperate and well populated, with many strong towns." This first brief description is still very true.

The date of the first inhabitants is still largely a matter of conjecture. Guatemala quite definitely was the scene of one of the oldest, if not the oldest, civilizations in North or South America. A conservative estimate puts the date several centuries B. C. From what little we do know of these early people, it is clear that they had a very high civilization and culture. Their knowledge of astronomy, time recording, architecture, and many other things were on a very high plane. In fact some of these early lines of progress have never been surpassed.

A knowledge of this early history is a very fitting background for an understanding of the Guatemalan Highland, whose population is predominantly Indian, tracing their culture directly to these people of centuries ago from whom they are descended.

This first civilization, though it covers many centuries, peaks and valleys of advancement, migrations and movements that have left only scattered stone ruins to tell briefly and incompletely of various steps and stages of progress, might be referred to as the first stage in the historical development. The second stage is that of Spanish domination. During this period from 1524 to 1823 there were three different capitals of Central America. The first two were destroyed by earthquakes. Spanish control was overthrown in 1823 with the beginning of the third stage. The Federation of Central American Republics took form then as a republic. This venture failed and in 1839 the start of the most recent period began with the forming of independent republics. Until quite recently the only part of Guatemala that had been inhabited by white people was the plateau country.

There are four natural geographic regions in Guatemala. The Eastern Coastal region has only about twenty miles of coast line on which the principal port of the country is located. The West Coast zone with two hundred miles along the Pacific stretches between Mexico and El Salvador. It extends inland only about fifty miles to the foot of the mountain slopes. The Plains of Peten are the third and least important region although they occupy about one-third of the country. In character they are much like Yucatan, a low undulating expanse with poor soil and extreme drought during much of the year, and less than two people per square mile. The fourth and most important region is the Highland.

The Guatemala Highland consists of about one-third of the country's 48,200 square miles. The land ranges from 3,000 to 13,814 feet in altitude, Tajumulco being the highest peak in all Central America. There is a definite massing in the western part of the country fifty to one hundred miles inland from the Pacific, where the mountains reach their greatest heights and are extremely rugged. In this region where the mountains have a general northwest to southeast trend there are many volcanic peaks. Although the mountains do take a definite direction trend, there are several spurs that run off in an easterly and northeasterly direction.

The lakes Atitlan and Amatitlan are the only ones of any size in the highlands. Their chief value at present is their great beauty which definitely is an attraction to the tourists, who are just beginning to discover this charming little country. As one looks from a promontory some two or three thousand feet above at the azure blue waters of Atitlan, sheer mountains dropping into it and cutting its outline into many irregularities, volcanic craters rising in symmetrical outline, and overhead a sky of deep blue with a few drifting clouds, it is truly a sight worth traveling many miles to see.

The soil on the plateau is chiefly of volcanic origin and quite fertile. A number of years ago a survey was made. It stated that there were twenty-five million acres in the whole country of which about five million were good for cultivation. A reasonable estimate places a little more than half of the tillable land in the highlands. As a person from the United States goes through the country, he will undoubtedly wonder just what tillable land is. Certainly in the United States land that reclines at a forty-five degree angle would not be included in this classification. Yet nearly all slopes in the more densely populated regions of the highlands have some corn growing on them.

One of the chief contrasts in Guatemala is in the climate. The eastern coastal climate is the tropical jungle type. There is rain throughout the year. As one gets into the highlands, the vegetation shows quite conclusively the change in climate. From the tropical lowland to a semi-arid almost desert region along the upper reaches of the Motagua River, to the plateau country with its wooded slopes and grass covered valleys, is but a few hours train trip. The rainfall in the highlands is seasonal and averages fifty-two inches a year. The temperature is refreshing the whole year, the average being 65 degrees.

A study of the people of Guatemala is the most accurate way of obtaining a picture of the country. The 1930 census gave the population of the country as a whole as 2,426,000 or forty-six people per square mile. About three quarters of the population are in the highlands, which naturally makes the density greater. The important factor in considering statistical figures is that of the total population: 65 per cent are pure Indian and over 20 per cent are mestizos or ladiños, as they are known there; nearly all of these are strictly highland dwellers.

A large number of the Indians are living back in the highlands where they never come in contact with modern civilization. They have been living in much the same fashion for centuries. H. J. Spinden wrote in an article, "Population of Ancient America," (1928), "A missionary living in the populous Guatemala highlands estimates that there are at present 700,000 Indians speaking native languages and maintaining parts at least of the ancient culture." It has been reported on very good authority that there are many Indians living under their ancient tribal governments, and many of these people do not know that there is a central government ruled by white men and having its capital at Guatemala City.

Several years ago one of the government's statistical bureaus issued figures stating there were 14,067 land owners in Guatemala, or about one person in every hundred and seventy-five that was a land owner. This ratio on the surface seems quite alarming. These figures, however, are of little value because of the large number of Indians living in a tribal fashion and cultivating land that has been theirs for centuries, before any white man came and issued land deeds. There have been recent attempts to classify the land and include all the Indians in the system of national economy, and in so doing to collect taxes from them. In many cases where the Indians inhabit the more accessible lands and are unable to pay these taxes in currency, they are required to make up for this by working for the government a certain amount of time each year. The traveller will often see evidence of this in the numerous road gangs that infest the roads certain times of the year.

The economic situation of Guatemala is again the reflection of its people, the Indians. What little industrial development and commercial agriculture there is, is due to the white people and the influx of some foreign capital. The railroad that runs from coast to coast by way of Guatemala City is foreign-owned, as are most of the public utilities.

Agriculture is naturally the keynote of Guatemalan life. The majority of the people of the highlands are engaged in subsistence agriculture. The only accurate figures that are available are on those crops that enter commerce. Coffee is by far the chief export crop of the country, though of recent years the banana has increased greatly. The chief coffee region which produces eighty-five per cent of the total annual crop (average crop being 130 million pounds) is located on the southern slope of the Pacific highland region. A second area of production, known as Coban, is on the slopes of the northern mountains. This produces about 10 per cent of the total. The third area is situated in the central highlands around Antigua, and raises six per cent. Coffee fincas are the chief source of coffee production. The larger ones are set up as commercial enterprises designed for efficient production, processing and marketing. There are some 2,000 coffee plantations in the country which vary in size from quite small to many thousands of acres. The Guatemalans, like other Central Americans, claim their highland coffee to be the best coffee in the world. In recent years the export of this commodity has been a little less than one-half to Germany and almost a quarter to the United States.

While coffee is the chief and almost the only export crop of the highlands, there are several others that enter local commerce. Wheat can be grown on much the same land as coffee, and as a result wheat production has suffered, for much of the good wheat land is now planted in coffee groves. About a million dollars worth of flour is imported from the United States each year.

Corn, the chief food staple, occupies more land than any other crop. The Bureau of Foreign and Domestic Commerce issued a report in 1927 which stated that there were 526,000 acres planted in corn. (This was for the whole country, but fully 90 per cent was in the highlands.) A report of this kind in a primitive country is naturally an estimate, and in this case probably a low one. Every little Indian hut has its patch of corn. In most localities two crops a year are possible.

Among other crops of importance are sugar, grown chiefly on the Pacific coastal plain; cacao, grown on the slopes of the Pacific range; cotton, rice, vegetables and other crops of purely domestic importance. All these are consumed within the country. The principal live stock region is around Quezaltenango. There have been a number of difficulties characteristic of the tropics that have had to be overcome before good livestock could be raised. This has been done to a large extent. In fact in 1915 a group of Guatemalans thought they could start a cattle export business to the Gulf states of the United States. Over 2,000 head were shipped to New Orleans. A series of difficulties arose due chiefly to lack of proper inspection of the cattle before leaving Guatemala and no more shipments were made, nor have there been any further attempts to revive this venture. Hides, however, do enter foreign trade, and usually add one to two hundred thousand dollars to the annual export total.

Local open air markets are the principal means for the Indian population to market goods. The barter system of payment is often used. Markets are held at regular intervals in the various centers. Indians often travel several weeks with tremendous loads on their backs or heads to reach a certain market and sell their wares, which may not exceed several dollars in worth.

To make reference to Guatemala's industry in the modern sense is really impossible. Guatemala City, the largest city in Central America, is the center of what industry and manufacturing there is. Most of this is carried on in semi-hand mechanical fashion, and exists to meet local needs. Electric light plants, sugar mills, tanneries, distilleries, and such are the principle industrial enterprises. Weaving, pottery, cloth making, are done chiefly by hand. Quezaltenango, the second city in size, also on the plateau, is of small industrial importance. The reason for the lack of industrial development is largely due to the small, almost non-existent, demand and purchasing power of the primitive Indians.

In considering the future of this country there are many things that lead to questions that can only be answered in a problematic way. Central American politics, like most Latin American, have been turbulent and fluctuating. Public opinion because of geographic remoteness has had little influence. Dishonest motives, corruption, and exploitation have played a large part in putting these countries where they are now. Recent trends are changing this. Guatemala's neighbor to the north, Mexico, has taken the most radical stand. Guatemala herself has in the past few years made many reforms and attempts to unify and improve the country. New roads are being pushed out from the capital from all sides. These steps, generally considered forward steps, will naturally bring the highland Indians into touch with modern civilization. What will be the result? One has only to look at other primitive peoples, such as those in parts of Mexico, to see the new problem that arises when they are thrown suddenly into a modern complex form of civilization.

RECREATION POSSIBILITIES OF THE SHAWNEE NATIONAL FOREST PURCHASE UNITS

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Recreation is one of the most important multiple uses which will be made of the Shawnee National Forest Purchase Units (See figure). In spite of the natural handicaps cramping development of recreation and tourist industry in southern Illinois, there are many distinct advantages favoring it. Most of the handicaps, moreover, may be mitigated or completely removed.

Disadvantages to Recreational Development.—Six of the greatest handicaps to the development of recreation and tourist industry in the Shawnee National Forest Purchase Units are: 1, dearth of natural recreational lakes; 2, hot summers; 3, limited extent of the units; 4, mosquitoes and malaria; 5, unhealthful drinking water; and 6, poisonous snakes.

1. Dearth of natural recreational lakes. Because the forest purchase units are located in the mature topography of the "Little Ozarks" and in the floodplains of the Ohio and Mississippi rivers, there is not only a paucity of lakes, but the existing ones offer few if any possibilities for recreational development.

The abandoned channel and ox-bow lakes such as Wolf Lake and Mud Lake are undesirable for certain types of recreation. They are shallow and the water in summer gets very warm. The shorelines and bottoms are muddy and slimy, and along the edges and extending long distances into the water is usually found a heavy growth of vegetation. Most of the lakes are also infested by mosquitoes. Moreover, being small, they are rapidly being destroyed by silting and vegetation. Such lakes are inadequate and undesirable for swimming, boating, and fishing.

One must admit, however, that abandoned channel and ox-bow lakes are better than no lakes, and do contain some

fish and that they are good "feeding stations" for migratory birds, especially waterfowl. These lakes also act as a yearly habitat for some animals and birds.

The karst lakes are mostly small and undependable. Some of them are seasonally intermittent while others may contain water for several years before they are drained by the loosening of the bottom "plugs".

Although mature topography means the extinction of lakes, fine sites for dams and artificial lakes exist. Two dams are now under construction. These will provide lakes for recreational purposes. They are the Crab Orchard dam and the Pounds Hollow dam. A number of other sites have been selected, and plans are being made for more artificial lakes.

2. Hot summers. It is true that summers are hot and the relative humidity in southern Illinois is high. For example, the average summer temperature for Carbondale is 76.9, for Harrisburg 77.4, and for Cairo 77.4 degrees F. Maximum daily temperatures of over 100° F. are common.

Now, since millions of people live within a hundred-mile radius of the Shawnee National Purchase Units, and since on a hot day it is naturally more comfortable swimming, or driving through a wooded area than sitting in an urban house not "weather-conditioned" for local use, most of these people will rely upon whatever recreation the local area has to offer. Trips to the purchase units can easily be made after working hours, evenings, or week-ends.

Accessibility and cost of transportation to recreational points are often a more determining factor than weather. Most of the people within a hundred-mile radius of the national forest do not have the time to go for long extended trips, but they can afford to drive one hundred miles for attractive out-door life.

For example, the Lake of the Ozarks in Missouri is not as cool or desirable as the "Lakes Area" in northern Wisconsin, but the former is frequented by a lot of people living within a radius of one to two hundred miles because they lack the time or means for longer trips.

Although in southern Illinois the summers are hot, spring comes earlier and fall lasts longer than in northern Wisconsin. Therefore, the possible ideal recreational weather is longer in southern Illinois than in Wisconsin—even excluding July and August. It is expected that even during those two months the recreational use of the purchase units will be high.

3. Limited extent of the units. It is true that one can drive from one end of the Shawnee National Forest Purchase Unit to the other in a day. But, if one were to appreciate the scenic beauty, visit the unique physical phenomena of the area, or delve into the storehouse of knowledge the regions offer in archaeology, botany, geography, geology, history, or zoology, it would take one days and weeks to cover the region.

4. Mosquitoes and malaria. In the past, southern Illinois was greatly menaced by malaria-carrying mosquitoes. During the last ten years, however, the drainage of swamp land and the better methods of control have greatly reduced the number of these insects.

A factor considered in selecting sites for artificial lakes is mosquito control. A lake with a high location and with prevailing winds together with a partly rock shoreline will permit water to dash malaria-carrying mosquito larvae against the rock walls thus destroying them. In sheltered and protected areas or embayments, larvae-eating fish, with which the lake will be stocked, will help control the mosquito.

A few mosquitoes, however, will not hamper the recreational use of an area. Anyone who has visited Atlantic City or Lake Champlain in New York, know that these insects are large and numerous, yet both these areas are recreationally famous.

5. Unhealthful drinking water. Many of the shallow wells and springs in southern Illinois contain unsanitary drinking water. Consequently, the federal government does not encourage its use. The government will not provide facilities whereby spring water may be tapped. Deep wells are being drilled and the only drinking water to be had must meet the state health tests and standards.

6. Poisonous snakes. Although formerly numerous, through ruthless and thoughtless extermination poisonous snakes are fast disappearing. They are now found only in the more inaccessible places.

Advantages Favoring Recreational Development.—Six important assets to recreational development and tourist industry in southern Illinois are: 1, existing recreational needs; 2, a great variety of hunting; 3, educational phenomena and projects; 4, scenic beauty; 5, inaccessible areas; and 6, location on Highway 51.

1. Existing recreational needs. Within a 100 to 150 mile radius of the Shawnee National Forest Purchase Units live 15 million people with a few if any recreational opportunities. These people live within a three to four hour ride of this national forest offering present and future recreational opportunities. For example, St. Louis and the Belleville-East St. Louis-Alton Industrial Areas lie within a few hours drive of these purchase units. The metropolitan area of St. Louis is nearer the Shawnee National Forest Purchase Units than it is to the Lake of the Ozark region. People from here now come to southern Illinois to hunt, or to enjoy the natural beauty of the scenery, particularly during the peach-blossom time or when the fruit is ripe. Evansville, Indiana is within a few hours drive to the northeast, and Paducah, Kentucky is just across the Ohio river south of the units.

In Illinois, there are no large recreational centers south of Pana. That people in southern Illinois would take advantage of proposed recreational facilities is indicated by the use they now make of the abandoned channel and ox-bow lakes. On week-ends and holidays these second-class lakes are overcrowded.

2. Great variety of hunting. Hunters, here, will find a great variety of game. There is more quail, rabbit, and squirrel here than in any other part of the state. Opossum and raccoon are still numerous. And not only is it possible to follow the dogs as they chase the "'possum and the coon" on moonlight nights, but here one may still hold fox hunts. Restoration of deer in the forest units is expected to furnish deer hunting. One of the principal north-south migratory waterfowl flylanes covers the area. Although waterfowl-hunting may not be permitted in some parts of the purchase units, camera shooting and sight-seeing are welcome.

3. Educational phenomena and projects. The educational value of the physical phenomena, points of historic interest, and conservation projects for educational-recreational groups (such as boy scouts, girl scouts, religious groups, etc.) is unusually large for such a small area.

Many important historical events connected with our State's history took place here. Evidence reveals that early man probably lived in rock shelters long before he learned to make mounds. Biological southern and northern species are found here, as well as combinations due to interbreeding. From the standpoint of physical geography and geology there are more features in juxtaposition than in any other part of the state. In connection with conservation, one may see examples of how forests, soil, and wildlife are being restored and conserved.

4. Scenic beauty. Those who have viewed the forest-clad escarpments of the cuesta topography in Johnson County, the rugged hill topography along Skyline Drive above Pine Hills, the enchanting beauty of the Mississippi floodplain, the scenery around Pounds Hollow, or the karst topography of Bell Smith Springs, will not deny the scenic beauty of the "Little Ozarks". Space will not permit mentioning other places of equal beauty.

5. Inaccessible area. Natural, small inaccessible areas will not be opened and cluttered with cultural features. They will remain as natural areas to be viewed only by those willing "to take the climb".

6. Location on National Highway 51. The Shawnee National Forest Purchase Units rest astride the main north and south route of tourist travel—from Chicago to New Orleans. It is only natural then, to expect some tourists to stop over in southern Illinois.

Recreational Objectives. — To provide varied healthful recreational facilities blending with the physical environment, and within the means of the $1,000- to $3,000-a-year class of people, is the general goal of the Shawnee National Forest Purchase Units.[1] Expensive resort hotels such as we have in Yellowstone Park will not be found. Present plans do not even cover tourist camps — a number exist outside the area. A few trailer

[1] Interview with J. B. Gray, Recreation Specialist of the Shawnee National Forest Purchase Units, Jan. 22, 1939.

camps may be constructed, but not elaborate ones.

To fit in with the physical environment there will be rock shelter camps for small outing groups. The facilities of these camps will chiefly meet the needs of the hiker wanting to "rough it". Here one can unroll his pack and sleep under the rock shelter protected from weather elements.

Seven types of recreation will predominate, namely: scenic drives, improved picnic grounds, hiking trails, fishing and hunting, specialized wildlife habitat areas, artificial lakes with associated recreational facilities and specialized recreational areas. In some places a number of these types will be associated together.

Many superior scenic drives will cover the area. Short ones will be linked, making possible long continuous routes. The Pine Hills Skyline Drive has been recently constructed. The Skyline Drive to Bald Knob (the highest elevation in southwestern Illinois) is now being paved with macadam, and Karber's Ridge Skyline Drive at the southern edge of the Eagle Creek syncline of gravel.

Improved picnic grounds will be provided. In 1938, a small map of the Shawnee National Forest Purchase Units was issued showing seven of these places. There will be hiking trails and "hosteling", and these should become a very important part of the recreational use of the area.

After fish and game have been restored, fishing and hunting in some parts of the forest will be regulated. Artificial lakes will be stocked. Breeding stocks of birds and animals are also being released,[2] and wise use of wildlife and tree protection will be stressed. If part of the annual increase of some wildlife were not removed by hunting and fishing, the wildlife would be harmed by natural "overproduction".

In specialized wildlife habitat areas, no hunting will be permitted. Such an area is being considered on the upper end of the Crab Orchard Lake. Hunting on small recreational lake areas would be dangerous to man and would also frighten the animals. One of the greatest pleasures of man is to watch the activities of wildlife in its natural environment.

Several artificial lakes with associated recreational facilities such as swimming, boating, fishing, etc., will be made available. The Crab Orchard Lake[3] and the Pounds Hollow lake should be completed in 1939. The dam for the Little Grassy Creek Lake will be started in 1939.

Although picnic grounds are widely dispersed over the purchase units and scenic drives and hiking trails will interlace the forest areas, there will be some specialized recreation areas. Some of these are partly finished and now in use, while others are under construction or still in the "planning stage".

Some of these specialized recreational areas are: Pounds Hollow, Bell Smith Springs, Crab Orchard Lake, Little Grassy Creek Lake, Big Grassy Creek Lake, Bear Creek, Pine Hills and La Rue Botanic, Fountain Bluff, and Lusk Creek.

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[2] For additional information, see Barton, Thomas F., Reforestation in Southern Illinois: The Shawnee National Forest Purchase Units, *Transactions of the Illinois Academy of Science,* Vol. 30, pp. 201-205.

[3] The Crab Orchard Creek Project is to become a part of the Shawnee National Forest Purchase Units when completed.

A DAY OF TORNADOES IN THE MIDDLE WEST

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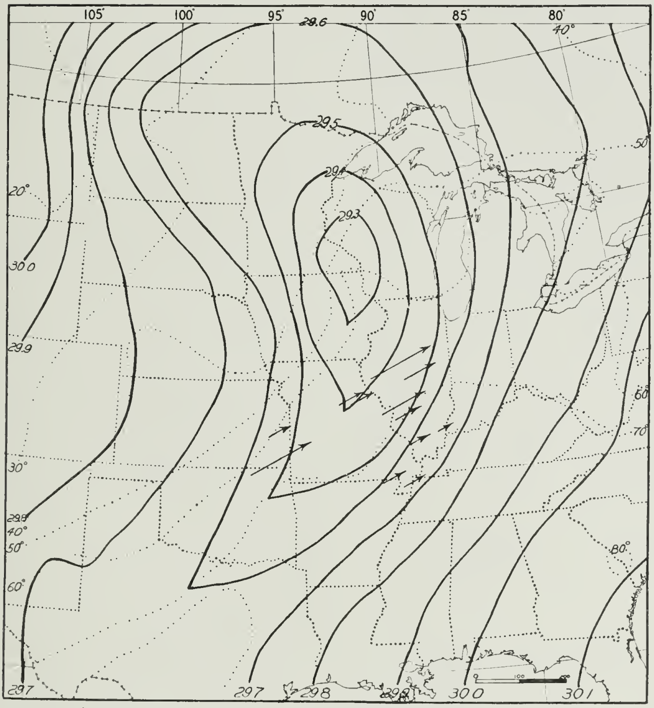

Fig. 1. Section of the United States Weather Bureau Map for 7:30 p. m. March 30, 1938. The arrows show location, extent, and general direction of the various tornadoes.

March 30, 1938 was a day of wind, rain, hail, and tornadoes in the middle west. Five states felt the destructive violence of these storms. At least 12 tornadoes were noted, and a half-dozen other storms with funnel-shaped clouds reached destructive proportions, but do not appear to have been full-fledged tornadoes. (Fig. 1) In addition to the tornado type of storms, large areas in Oklahoma, Arkansas, Kansas, Missouri, and Illinois were swept by strong winds accompanied by heavy rain, with hail in some instances. Twenty-nine people were killed and hundreds injured during the day. The estimated property damage was about $2,500,000, of which approximately $1,500,000 occurred in Illinois, $800,000 in Kansas, and $225,000 in Missouri.

Minor Tornadoes.—The first tornado of the day developed in Anderson County, Kansas about 9:45 a. m. It was a small storm and did little property damage, although one person was killed. Throughout the remainder of the day five small, widely separated tornadoes occurred at various places in Missouri. These were only moderately destructive of property, but five persons were killed and 49 injured. One of these storms originated in Arkansas near the Missouri boundary and travelled in a northeasterly direction across the state line and blew itself out near Poplar Bluff, Missouri. In general the tornadoes appeared later in the afternoon in the central and eastern portions of the state, the one near New Madrid occurring about 9:30 p. m.

One of the tornadoes developed in eastern Missouri and entered Illinois near Alton in northwest Madison County about 6:15 p. m., and dissipated in the vicinity of Litchfield about 6:45 p. m. This storm was 500 feet to one-fourth mile in diameter and did damage over a strip of territory approximately 30 miles in length. No one was killed, but more than 100 residences and several public buildings were damaged, mainly in Alton and Bunker Hill. The total damage of the storm was estimated at about $315,000.[1]

Another small tornado made its appearance near Glen Carbon, Illinois about five miles south of Edwardsville at 6:45 p. m., and moved northeast about six and one-half miles before dissipating. Its path was 600 feet to one-half mile in width. No one was killed but damages were approximately $75,000. While this storm covered only a small area, it did damage to orchards, live stock, rural buildings, and one grade school. Other isolated storms reported as having funnel-shaped clouds appeared in Sangamon, Christian, Macon, Champaign, Randolph, and Wabash Counties, Illinois. Several of these storms caused some damage, but their importance sinks to insignificance compared with the serious damage of the major storms.[2]

Major Tornadoes. *Columbus, Kansas.*—The first of the two major tornadoes of the day occurred shortly before noon. Originating in northern Oklahoma, it reached its most destructive violence at Columbus, Kansas and dissipated in the vicinity of Humansville, Polk County, Missouri about one o'clock in the afternoon. It covered a path about 35 miles long in Kansas and perhaps as great a distance in the other two states. The following quotation describes the damage of the storm: "One of the most destructive storms known in Kansas. Originated in Oklahoma, and ended in Missouri. Chief Kansas damage was at Columbus, where 10 persons were killed, 150 injured, and 180 residences demolished or greatly damaged, and 45 other buildings including Highland School damaged or demolished."[3] The average width of the storm was 400 feet, and property damage in Kansas was estimated at $575,000.

The Major Illinois Tornado.—The most destructive tornado of the day developed in Illinois southwest of Kellerville in eastern Adams County and moved northeastward, passing near Astoria and Havana, through South Pekin and south and east of Eureka. Figure 1 shows the path of this storm and the location of the other tornadoes. The following quotation gives in detail the location of the storm path, its approximate width, and rate of speed, as well as other interesting details.

"The tornado left a path of damage varying from one-eighth of a mile to more than one and one-half miles in width and extended approximately 115 miles almost due northeastward from point of apparent origin. It has been calculated its average progressive speed was about 48 miles per hour. The storm passed one-half mile north of Kellerville, going between Timewell and Mt. Sterling about 3:30 p. m., through the south portion of Rushville at 3:50 p. m., reached Astoria 4:10 p. m., thence passing about four miles north of Havana about 4:30 p. m., through South Pekin about 5:00 p. m., about three-fourths mile south of Eureka about 5:20 p. m., and lifting a few miles to the northeastward. The storm killed 13 persons, nine at South Pekin, two at Morton, and one each at Astoria and near Kellerville, and injured nearly 75. Property damage for the entire area is estimated to be about $1,000,000. A responsible party asserted he positively observed momentary separation of the base of the funnel cloud over Rushville, and the writer noted two definite and parallel paths of damage with a narrow strip between unaffected."[4] Mr. M. L. Fuller, the Weather Bureau Meteorologist at Peoria furnished the following: "The path of damage at South Pekin was more than one-fourth mile wide and probably approached one-half mile, but as it took in the whole town the edges were not distinctly marked. Numbers of trees were blown over; directions differed but without noticeable overlapping as from different directions in succession. About all the trees that remained standing showed violent whipping. Apparent violence was much less than that reported of some tornadoes. The east-west high line northeast of Pekin lost three towers, a spread of 1800 feet, and less damage to two adjacent towers, bringing the total damage width to about two-thirds mile. Some observers beyond South Pekin on either side of the path reported 'tails' of funnels hanging from main funnel or main cloud. An anemometer near Pekin, three miles from the path, recorded gusts of about 50 miles per hour from the northwest, and a barograph at that point recorded no unusual barometric effect."

The Width of the Illinois Storm.—Apparently the width of the storm varied considerably from place to place as shown in the quotation above from the Springfield office of the Weather Bureau. South Pekin is located east of the Illinois River on sand hills of the flood plain. The bluffs bordering the east side of the valley are about a mile distant and are well wooded. Where the tornado passed through the timber land on the bluffs the destructive path was from a mile and one-half to two miles in width. Near the southern margin of the storm path, (see Fig. 2) trees lay in a parallel direction pointing toward the northwest. A barn was completely destroyed across the road to the south. The center of the storm, however, passed as much as a mile to the northwest. The path of the storm was crossed at several other places and the width varied from one-fourth of a mile or even less to as much as a mile.

The storm apparently blew itself out or lifted at a point about midway between Eureka and El Paso. A small gas station standing on the concrete highway was partially unroofed, and this appeared to be the last destruction of the storm as it passed off in a northeasterly direction. The path of the storm at this point was narrow, probably not exceeding an eighth of a mile.

Destructiveness of the Tornado.—Many buildings were wrecked completely, while many others were unroofed, shifted on their foundations, or otherwise seriously damaged. In much of South Pekin all of the buildings were completely wrecked. Freight cars were overturned in the freight yards, and some live stock was killed in the adjacent rural districts. The storm does not appear to have been as severe nor the wind velocity so great as that of many other tornadoes. However, its destructiveness was severe over wide areas in both city and rural districts.

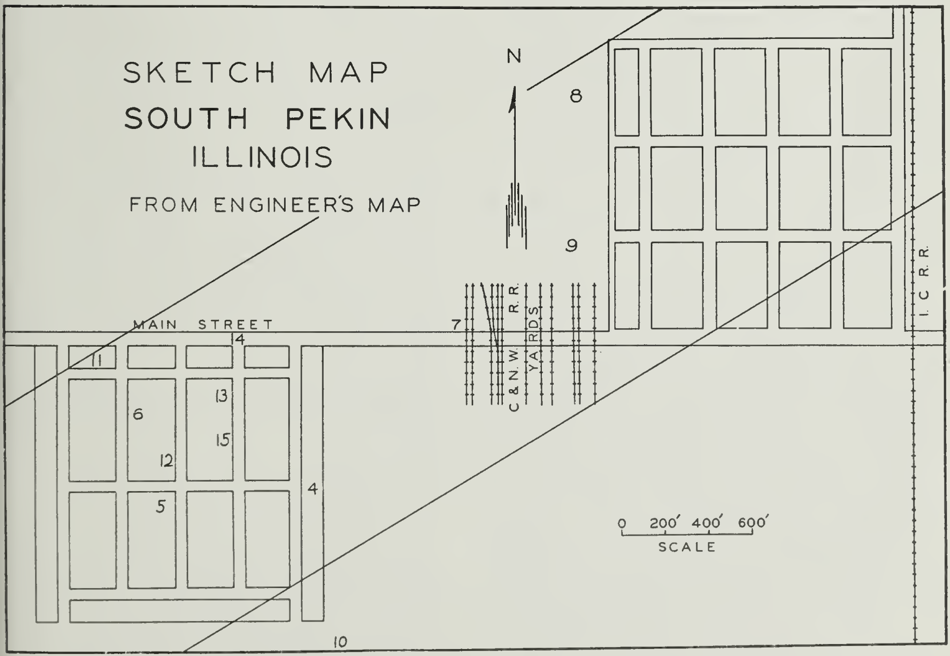

Fig. 2.—Sketch map of South Pekin, Illinois, showing path of the tornado between heavy parallel lines. Strong winds prevailed and some damage was done outside the parallel lines. Numbers on the map show the location of various places described in manuscript.

The accompanying map, Fig. 2, shows the general layout of South Pekin. It so happens that this railroad town was laid out with the section of the city west of the railroad lying in a southwesterly direction from the portion east of the railroad. The tornado struck the city almost centrally and passed over it from the southwest toward the northeast, completely demolishing almost the entire city. It is difficult to see how it could have been plotted mathematically to have wrought greater destruction, granting that the width of the storm remained the same. In the southeast and northwest portions of the west section of the city a few buildings remained which were damaged but not destroyed. These were apparently on the very margins of the storm, although people were killed within a short distance of these corners of the city. The southeast portion of the east section of the city was damaged less than other portions of that section. This corner apparently was on the southeast margin of the storm, although it had considerable force even to the south of the city, as evidenced by the effect in an adjacent cornfield across the road to the south, where the corn stalks had been almost completely blown from the field. From a distance one could lay a definite line marking the edge of the storm where it had picked up the corn stalks. This margin of the storm was not sufficiently destructive to blow down buildings because the houses on the north side of the road across from the corn field were not destroyed.

Stable structures in the city seemed to have been destroyed as badly as smaller buildings. The water tower supported upon a steel framework was blown down, and the brick school building was a complete wreck, no part of it standing more than 10 to 15 feet in height. (At Nos. 4 and 5, Fig. 2.) A large brick church, the brick railroad station, and the brick buildings of the railroad repair shops were completely or partially demolished (at Nos. 6, 7 and 8, Fig. 2). One of the interesting sights was the ice house, in which the building was completely blown away leaving the blocks of ice exposed (at No. 9, Fig. 2). Apparently the blocks of ice were frozen together in a solid mass and none of it was moved. Even much of the sawdust remained on the ice because it had been frozen to it.

Extensive search was made in different parts of the storm path to determine if the debris along the margins of the path of the storm pointed in toward the center, thus indicating the twisting character of the storm. The evidence was unmistakable all along the course of the storm showing that this was true.

Careful study was made of the location of the debris in demolished buildings. In most instances the debris was shifted toward the east and north sides of the foundations and in many cases the southwest part of the basement had little or no debris in it (at No. 12, Fig. 2). There was little debris in the southwest corner while most of the remainder of the basement was filled with wreckage. This may well be considered evidence that the southwest corner of the basement is probably the safest place in the house if the storm comes from the southwest, as most tornadoes do.

Weather Map.—The weather maps studied show an interesting succession of changes of pressure and temperature conditions throughout the day of March 30. At 7:30 a. m. the map shows an elongated low pressure area which was central over the Texas Panhandle with the long axis extending from the northeast toward the southwest. The lowest barometer reading on the morning map was 29.40 inches. Lying to the south of the wind shift line was a mass of Transitional Polar Pacific air (NPP) while to the east and to the south of the wind shift line was a mass of Tropical Atlantic air (TA). On the southern margin of the NPP air mass was an area of Upper-Air Subsidence (S).

A second low pressure area was central over North Dakota and the Canadian border, which was characterized by Polar Continental air (PC) while in the east and northeast margins there were areas of Transitional Polar Pacific air (NPP).

By 1:30 p. m. the low pressure area over the Canadian border had remained stationary while the one over the Texas Panhandle had moved rapidly toward the northeast and centered over northeastern Kansas, northwestern Missouri, and southern Iowa, and showed a minimum pressure of 29.30. It had developed a well marked wind shift line extending from the Great Lakes region southwestward to New Mexico. The winds on the south side of the wind shift line were fresh to strong winds from the south and southeast, while the winds on the northwest of the wind shift line were moderate winds from the northwest.

By 7:30 p. m. the low pressure area had developed a marked pear-shaped or "frying-pan" configuration with the handle portion extending from the northeast toward the southwest and running from near the Mississippi River along the western boundary of Illinois, southwestward through the Texas Panhandle. On the 7:30 p. m. map a temperature of 70° existed to the south side of the wind shift line, while temperatures of 50° ran through the center of the low and 40° ran just to the west of the center.

Thus, on the afternoon of March 30 there were large masses of warm, moist air partly of tropical origin on the southeast side of the wind shift line. To the north and west of the wind shift line temperatures were 20 to 30° below those one to two hundred miles to the south, and these air masses were of Polar Pacific or Polar Continental origin. By the afternoon of March 30 the unstable air conditions favored the formation of severe wind storms of a tornado nature in the vicinity of the squall line of the low pressure area.

On the succeeding day the weather map showed a strong low pressure with a minimum reading of 28.90 located over the Lakes region accompanied by heavy precipitation. The frying-pan configuration had entirely disappeared and the cyclone was circular in shape. High pressure areas bringing colder weather with snow in the north portion of the Great Plains spread westward from the Mississippi River and reached to the Pacific.

Freaks of the Storm in Pekin. — The portions of the destructive path of the South Pekin tornado visited by the writer did not have any outstanding freaks, such as sometimes attend these storms. There were, however, some things of an unusual nature. The pile of ice without any building has already been described. The buildings about a small bird house (at No. 13 on map) were more or less demolished and the trees were blown down or badly whipped. However, the bird house stood without any apparent damage, and the birds were occupying it as usual. In the southeastern part of the city a small wooden garage was not destroyed, and the car within was not scratched, but a cement-block garage in the same block was completely wrecked. At No. 15 on map, timbers were driven into the sides of a stucco house located north of Main Street on the margin of the storm, while a large residence nearby standing directly in the path of the storm, was little damaged. An unusual characteristic was noted in the country southeast of Eureka where two sets of farm buildings were completely destroyed with the exception of the corn cribs. In each instance the corn crib, filled with corn, stood close by the barn and other outbuildings, but showed no evidence of destruction. Whether it was the weight of the corn which held the building down or whether the slatted siding permitted equalization of pressure within and without, thereby preventing destruction, is impossible to say.

Conclusion. — The numerous tornadoes and other types of storms that occurred on March 30 accompanied a "frying-pan" low as it moved eastward during the day. Most of the storms appear to have occurred slightly in advance of the wind shift line, although some of them developed west of this line. While some of the storms may have lifted over long distances and descended to the earth farther to the northeast, it appears that most of the tornadoes had an individual origin and existence. A combination of pressure conditions, wide variations of temperature in short distances, and contrasting air masses with accompanying winds seem to be the conditions favoring the development of the tornadic type of storms. When such a combination of conditions prevail, numerous such storms may develop.

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[1] Holcomb, E. W., Meteorologist, U. S. Weather Bureau, Springfield, Illinois, Climatological Data, Illinois Section, March, 1938, p. 12a.
[2] Ibid, p. 12a.
[3] Flora, S. D., Meteorologist, U. S. Weather Bureau, Topeka, Kansas. Climatological Data, Kansas Section, March, 1938, p. 24.
[4] Holcomb, E. W. op cit, 12a.

GEOGRAPHIC ASPECTS OF INTER-AREAL TRANSITION[1]

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ABSTRACT

Although studies of geographic regions are well known, many of us may be much less familiar with the boundaries which separate such regions or areas. For the sake of convenience man draws a boundary in the form of a line. Such a boundary, however, is technically incorrect because nature does not delimit her regions sharply. In effect, the boundary is always a zone—a belt of inter-areal transition partaking of the characteristics of the two areas which it separates.

Such an inter-areal transition zone exists in Southeastern Missouri and separates the Corn and Winter Wheat Region to the north from the Cotton Belt to the south. A north-south strip of land cutting across this zone and also across the boundary line drawn by O. E. Baker brings out many aspects of transition. Included in the strip are Perry, Bollinger, Cape Girardeau, Scott, Stoddard, Mississippi, New Madrid, Pemiscott, and Dunklin Counties.

Two important features of transition are manifest after some study. In the first place, the characteristics of each crop region prescribe an order of decrease across the counties of the transition zone and the boundary line. Those features which characterize the Corn and Winter Wheat Region present a trend-of-decrease southward across the transition zone and the boundary line. The features are (1) the acreage of wheat; (2) the acreage of hay; (3) the size of the farm unit; and (4) the number of owner-operated farms. Antithetically, those features which characterize the cotton belt form a trend-of-decrease northward across the transition zone and the boundary line. These features are (1) the acreage of cotton, (2) the acreage of corn, (3) the number of tenant-operated farms, and (4) the number of mules. All of these decreasing phenomena are actually fringes projecting from the respective crop regions. The fringes are irregular in nature, of unequal lengths, and are associated together in overlapping fashion. Cotton, corn, and wheat are all important crops in the same counties in the middle of the transition zone. The second important feature of transition is that a new regional entity of local dimensions is perceivable in the middle of the transition zone where certain of the associated fringes from the two great crop regions become of nearly equal value. Wheat, corn, and hay from the north and cotton from the south occupy important acreages. This new region has an east-west extent following Baker's boundary line. This small region is truly an area of struggle, for corn and wheat grown as cash crops together with livestock farming attempt to expand southward; but they must compete with cotton which attempts to move northward. Being a peripheral zone, variations in climate, labor, and market conditions cause readjustments in the land-use pattern. Thus, this Corn, Cotton, and Wheat Region has a dynamic nature and its boundaries may shift.

The general agricultural utilization of the great crop regions is based primarily on climate and particularly on the two elements, temperature and precipitation. Precipitation does not vary enough between the Cotton Belt and the Corn and Winter Wheat Region to be a deciding factor in the land use. Temperature or latitude, however, is a deciding factor in the land use. It sets the northern growth-limit of cotton at approximately the line of the 200-day growing season. Cotton growth north of this line is hazardous. In this strip Caruthersville in the south has an average growing season of 211 days, Sikeston in the middle has 190 days, and Jackson in the north has 183 days. Corn and wheat in their southward drive are limited not so much by climate as by inability to compete economically with cotton. Thus, climate is the basis of general land use; however, other factors provide bases for local land use.

[1] Six illustrations accompanied the original paper, but it is impossible to print them with this abstract.

The best utilization for a particular piece of land is based, largely, on edaphic conditions of (1) soils and (2) topography. These edaphic boundaries, in contrast to climatic ones, are frequently of an abrupt nature. To these are due many of the local irregularities in the land-use pattern and in the pattern of transition.

The soils occur in general north-south patterns with land utilization adjusted to soil types. In the north commercial wheat farming occupies most of the fertile, loamy, upland soils which are rich in lime, while farming based on corn is concentrated on the valley bottom soils and poorer upland soils. In the southern part of the province cotton holds sway on the light soils of the uplands and terraces while corn is most important on the heavier, bottom soils.

Topography is a factor of considerable importance in local land use. An obvious influence is through development of soils and erosion of soils. Soils developed on undulating to slightly rolling topography reach greater degrees of maturity than do those developed on steep slopes or flat topography. Those soils developed on the steepest slopes are thin, stony, infertile, and subject to great erosion. As a result of this plus the difficulty of using farm machinery, the steepest slopes are relegated to pasturelands and woodlands or eventually abandoned to sassafras and persimmon bushlands if cleanly cultivated. Oftentimes, the next steepest slopes are given to wheat and other small grain, while the slopes of smallest degree are devoted to cotton or corn, which are cleanly-plowed crops and promote the greatest amounts of erosion. Throughout much of the flat bottomlands in the southern part of the strip, erosion is inoperative, but poor drainage becomes the paramount problem. Thus, topography influences local land use through erosion, drainage, development of soils, and effect on use of farm machinery.

Other factors of a historic-geographic nature have some influence on the local land use. The farming systems of certain immigrant peoples reflect their imported cultures.

In conclusion, certain pertinent aspects of inter-areal transition are manifest. In the first place, the two crop regions actually are separated by a zone partaking of the characteristics of the adjacent regions; however, for convenience sake, man utilizes a lineal boundary-of-separation. Secondly, the features typical of each region occur as fringes or trends-of-decrease across the transitional zone. Edaphic factors offer partial explanation for irregularities in this pattern. Thirdly, a regional entity of local dimensions is discernible between the two great crop regions. This is formed near the middle of the transitional zone where the associated fringes are all of great importance. Corn, cotton, and wheat are widely grown and are in constant competition. Thus, the true unit of transition is dynamic. Several factors operate to determine its character and boundaries at any given time.

DISTRIBUTION OF JAPANESE CITIES

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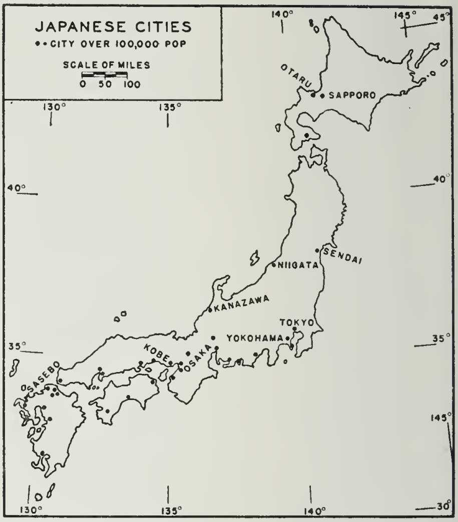
The value of the study of cities as a culminating topic in regional and economic geography has already been brought to the attention of geographers by Whitaker[1] who points out that both review and summary may be secured by such a procedure. Another method of attaining a similar climatic epitomization of a large region is by a study of its cities and their areal relationships. To exemplify this method of procedure, a brief description and explanation of the distribution of Japanese cities might well be used.

There are thirty-six cities in Japan with a population of over 100,000, the figure commonly accepted as truly defining urban agglomerations. (See figure.) Thirty of these cities are located south of the 36th parallel where the trend of the main mountains of Japan is east and west. Within this most urbanized portion of Japan occurs one of the most remarkable city alignments of the world. If a straight line be drawn from Tokyo to Sasebo, a distance of 600 miles, and if two lines be drawn parallel to this line, each 30 miles distant from it, the area bounded by the two outer lines would include, not only twenty-six of the thirty-six cities of Japan, but also its nine largest cities, two of which, Tokyo and Osaka, have a population in excess of two million. This alignment of cities might be termed a corridor, a structural, or a trunk route alignment, but in a larger sense it is a regional alignment, lying as it does along the major axis of a region. Within this regional alignment there are four city groups or urban nodes. These are (1) the Kwanto Plain grouping, including Tokyo the capitol, and Yokohama its port; (2) the Kinki grouping, including Osaka, Kyoto, Kobe and others; (3) the Hiroshima-Kure group; and (4) the grouping in Northern Kyushu. Between these groups of cities and the cities interspersed between them is a surprisingly regular interval of from sixty to seventy-five miles.



The ten cities not included within this alignment are scattered throughout the remainder of Japan, with only one other grouping existing, that of Otaru and Sapporo in the fertile Ishikari Plain. This Sapporo-Otaru grouping also points to a minor urban pattern very common in Japan, that of a large city with a satellite port city. Other examples are Osaka and Kobe, and Tokyo and Yokohama. Though from a map there appears to be an alignment of the three cities of Kanazawa, Niigata, and Sendai, it is perhaps accidental, since there seems to be no evidence to support any reason for such a pattern.

The most favorable physical environment for the development of Japanese culture seems to be that of Southwestern Japan where that same Japanese culture originated. And within Southwestern Japan the most favorable combination of both site and situational factors is found in that east-west belt where the great city alignment is located.

Japanese culture is associated with flat alluvial plains, the only areas in such a humid, rugged land where intensive

[1] Whitaker, J. R., "The Study of Cities as a Concluding Unit in Economic Geography", *Journal of Geography,* vol. 36, pp. 50-54.

rice agriculture is possible. This belt contains the largest, as well as several of the larger, alluvial plains of Nippon. These include the Kwanto Plain, the Nobi Plain, the Kinki Plain, and the Plains of Northern Kyushu. In addition to these, there are a number of other plains of lesser extent, all of which, however, add to the sum total of flat, rich land available to the inhabitants of the zone of cities. All of these plains are situated on tidewater, a factor of great historical importance, since it enabled easy communication between them in a day when their encircling mountains were almost insurmountable barriers to trade. Increasing the effectiveness of this internal means of transportation was the Inland Sea which furnished a well-protected route between east and west. Later, when Japan became westernized, this same route also became significant in foreign trade since it lies astride the Great Circle route from Western United States to Shanghai. The present great axis of Japanese land transportation parallels this sea route all the way from Tokyo to Nagasaki, though it is to a certain extent an outgrowth of the imperial road system which tied the larger plains together.

The climate of this belt of cities is rather more favorable than that found in the remainder of Japan, for several reasons. Most of this belt is within the great structural valley or basin lying between the two main mountain ranges of Japan and thus is protected to the north and west from the severe winter monsoons blowing out of Asia and to the south from the destructive typhoons moving northward from tropical waters. Everywhere within this zone of city concentration temperatures permit two crops of rice annually, a very important consideration in the densely populated Orient. Temperatures are also suitable to the production of mulberry, the basis of much of Japan's export trade. As in all of Japan, precipitation is everywhere adequate for agriculture.

In addition to the large areas of flat plains, the natural and well-situated transportation route, and its favorable climate, this belt also contains other important natural resources. These include the extensive coal fields of Northern Kyushu, the basis of the Japanese iron and steel industry, the copper mines of Northern Shikoku, and the resources of the Inland Sea, salt, tatami reeds, and fish.

Papers In Geology

Extract From the Report of the Section Chairman

There were thirteen papers given in the Geology Section, of which seven are printed herewith. The others were:

Pennsylvanian correlation studies between Carlinville and Neoga, Cumberland County, Illinois, by E. F. Taylor and Gordon Prescott, State Geological Survey, Urbana, Illinois.

Sampling the ocean floor, by K. O. Emery and R. S. Deitz, University of Illinois, Urbana, Illinois.

Periglacial features in Grundy County, Illinois, by R. P. Sharp, University of Illinois, Urbana, Illinois.

An unusual feature of brachiopod shell, by A. H. Sutton, University of Illinois, Urbana, Illinois.

Structural control of topography in the Appalachian Mountains near Harrisburg, Pennsylvania, by Harley Barnes, Northwestern University, Evanston, Illinois.

Some applications of petrofabric analysis in the study of sediments, by R. A. Rowland, Illinois State Geological Survey, Urbana, Illinois.

Attendance at the meeting was 40.

David M. Delo, 135 West Thompkins, Galesburg, Illinois, was elected chairman of the 1940 meeting.

(Signed) J. T. Stark, *Chairman*

SILURIAN ROCKS OF SOUTHERN ILLINOIS

John R. Ball

Northwestern University, Evanston, Illinois

E. O. Ulrich gave the Bainbridge formation in Missouri its name in 1904, and at that time mentioned its occurrence in localities north and south of Thebes, Illinois.[1] The original application of the term apparently included strata of both the Alexandrian and Niagaran series in Missouri and Illinois. T. E. Savage in subsequent studies differentiated the two series and discussed the lithology and paleontology of the Alexandrian series.[2] Josiah Bridge and others, including Flint and Ball, have differentiated the Niagaran and Alexandrian series in southeastern Missouri.[3]

The writer has undertaken a restudy of the Niagaran strata in southeastern Missouri and in southern Illinois in order to delimit more exactly, if possible, the correlation of the Missouri and Illinois rocks with the Niagaran of western Tennessee. This correlation has been suggested previously by Ulrich, Foerste and others and it seems desirable to carry to some further extent the studies once initiated along this line.

In connection with this project some reconnaissance work has been done in Illinois, and this brief report presents the distribution of the Bainbridge formation in Alexander and Union Counties known to the writer. The following locations have been visited:

1. Outcrop in water of Orchard Creek, under bridge in SW¼, NW¼, sec. 21, T. 15 S., R. 3 W., nearly 1¾ miles south of Thebes.
2. Farmyard of Gerald Clutts, NE¼ sec. 21, T. 15 S., R. 3 W.
3. In tributary to Orchard Creek, SW¼, SE¼, sec. 21, T. 15 S., R. 3 W.
4. Railroad cut near location 1, in the NW¼, SW¼, sec. 21, T. 15 S., R. 3 W.
5. Bed of Orchard Creek, SE¼, SE¼, sec. 21, T. 15 S., R. 3 W.
6. Cut along gravel road, south line of sec. 21, SW¼, T. 15 S., R. 3 W.
7. Gully north of "Powder Mill Hollow," near center SE¼, sec. 28, T. 15 S., R. 3 W., fork of tributaries near head of main gully.
8. In fault block, Railroad cut, SE¼, SE¼, sec. 28, T. 15 S., R. 3 W.
9. Fault zone, "Powder Mill Hollow," SE¼, SE¼, sec. 28, T. 15 S., R. 3 W.
10. On south fork of Salaman Creek, SW¼ and SE¼, sec. 2, T. 15 S., R. 3 W.
11. On north fork of Salaman Creek, NE¼, SW¼, sec. 2, T. 15 S., R. 3 W.
12. In farm yard of Nathaniel King, NW¼, NE¼, sec. 28, T. 13 S., R. 2 W., Union County, Illinois.

The lithology of the Bainbridge formation is well described by the term once used for its Tennessee counterparts, the "variegated beds." In places it is a pure, compact limestone, with a large admixture of reddish coloring material. Elsewhere, possibly in the same exposure, it is a very impure, argillaceous limestone, or a red or purple shale. A mottled aspect of the rock is its common aspect, with areas of grayish green in a red matrix, or, areas of red in a gray background. Extended streaks of grayish-green coloring follow along a joint for many yards in some stream beds or in vertical sections.

In its basal strata the rock is massive and resistant, and commonly quite dense in texture. Above the basal portion a shaly phase of the limestone, or a thinly banded shale may occur. About midway in the type section some massive beds occur and above these is a 10-foot horizon of dark *Cyrtograptus*-bearing shale. This shale is observed in the nearby outcrops but apparently is not of wide distribu-

[1] Personal communication, E. O. Ulrich, The Quarrying Industry of Missouri, Missouri Bureau of Mines, Vol. II, 2nd Series, pp. 110-111, 1904.
[2] Savage, T. E., Pre-Devonian of Southern Illinois, Bull. Ill. Geol. Surv., 16, p. 336, 1910.
[3] Flint, R. F., and Ball, J. R., Revision of the Silurian in Southeastern Missouri, Jour. Geol., Vol. XXXIV, pp. 248-256, 1926.

tion. Above the shale an impure earthly limestone and shale occurs, commonly green in color. And, at the top, are a few strata of well-bedded red or purple limestone.

The green limestone and shales are exposed in several outcrops in southern Illinois and seem to be more widely distributed there than in southeastern Missouri. The green limestones are apparently intergradational with the overlying Bailey and a sharp contact between the two formations has not been observed in this locality.

Distribution and Extent.—The scattered outcrops of the Bainbridge range from the south half of section 28 in T. 15 S., R. 3 W. to the north part of section 28 in T. 13 S., R. 2 W., a distance of about 13 miles. A distance of about 8 miles separates the one exposure thus far known in Union County from the ones in Alexander County, southeast of Gale. A further somewhat unique occurrence of the formation is known to be in the bed of the Mississippi River. Dredging operations in December of 1938 were bringing the Bainbridge in massive blocks from the bed of the River. The stone is used in a wing dam on the Missouri side. The place of the dredging operations is approximately in the center of section 28, T. 15 S., R. 3 W., assuming that that section were projected into the river bed. This midstream occurrence evidently is incorporated in some of the fault blocks of the region.

The author is indebted to L. E. Workman of the Illinois State Geological Survey for information concerning the subsurface extent of the Bainbridge formation in the state. He writes that the shaly, fine-grained red Bainbridge limestone is found as far north in Illinois as the northern part of Bond and Lawrence Counties and through the center of Effingham County. This extends the formation northerly for about 100 miles from the Alexander-Union County line, and northeasterly for about 150 miles. Workman states further that north of these limits, as in Clark County, traces of the reddish rock appear in the samples, but that there is no appreciable thickness. This report points to the reddish Bainbridge as far north on the east side of the state as the gray dolomites in the vicinity of Grafton are on the west side.

The Bainbridge occurs in association with the Alexandrian Brassfield or Sexton Creek formation in half the number of out-crops cited in this discussion. The Brassfield occurs in isolated, boulder-like masses along creek beds and near fault traces. Weathering and erosion have attacked the Brassfield very effectively and it is not as extensive in this part of Alexander County as is the Bainbridge. In the Union County vicinity, the Brassfield apparently is of considerable thickness in the slopes west of the Bainbridge occurrence.

The average thickness of the formation, which in Missouri is about 130 feet, is not shown in the Alexander County outcrops. A section of only 9 feet is seen at low water in Orchard Creek.[4] This outcrop evidently is near the top of the formation. Greater thicknesses are displayed in "Powder Mill Hollow," where the rock is disturbed by faulting, and in the gully north of the "Hollow." A possible thickness of about 50 feet may be estimated in "Powder Mill Hollow", based on plane table readings and with no allowance for dips. About the same thickness seems evident in the gully north of the "Hollow" and in this gully the waterfall descent of the stream bares a cliff of something more than 15 feet in height. About 3 miles northeast of these occurrences the Bainbridge, exposed at the stream level of Salaman Creek, rises for apparently 40 feet or more into the slopes of the valley wall. Probably it is of considerable thickness also in Union County but is concealed by undergrowth.

The Bainbridge is among the calcareous rocks which have been tested for rock wool possibilities by local interests. A number of citizens of Thebes are interested in its commercial possibilities, and the author in his inquiries has received much help from Mr. E. L. Holliday, Mr. J. E. Rimer, and Mr. Clutts, of Thebes, Illinois.

[4] Ball, J. R., Type section of Bainbridge formation of southeastern Missouri, Bull. A. A. P. G., vol. 23, p. 598, 1939.

RECOVERY AND PRESERVATION OF MARCASITIZED AND PYRITIZED MICROFOSSILS

Harvey Borger

University of Illinois, Urbana, Illinois

In order to obtain complete specimens without the loss of surface ornamentation extreme care must be exercised in removing pyritized and marcasitized microfossils from limestone. The following procedure was found to be the most satisfactory: break sample into several small pieces; place broken sample in 500 c. c. beaker; fill beaker two-thirds full of water; add dilute HCl by means of burette tube at the rate of one drop per thirty seconds; drain off the water and remove silt and clay by repeated washings, using extreme care during washing so that fragile specimens are not destroyed; for final washing use saturated solution of tartaric acid which removes iron oxide and iron sulfates that have formed on pyritized or marcasitized fossils; place washed material in oven to dry and examine material in usual manner.

The fossil material which is picked out for future use should be washed with saturated tartaric acid solution in order to remove all products of oxidation; when solution has evaporated, wash specimen in strong ammonia solution, so that a basic condition exists upon the surface of the specimen; wash in absolute alcohol to dry specimen thoroughly; orient fossils and place on slide using celloiden which coats and attaches specimen to slide. The celloiden coating prevents oxidation,[1] but can be removed with absolute alcohol.

The important rule to be observed throughout is: never coat a specimen with celloiden if the surface is acidic, because an acidic condition favors oxidation of specimens even though the specimen is coated with celloiden.

[1] Celloiden is a mixture of ¾ gram celloiden (air dry), 50 cc. absolute alcohol, and 50 cc. of ether.

The author wishes to acknowledge the helpful suggestions of Harry Kimple, University of Illinois, concerning the proper mixture for the celloiden solution.

STRUCTURAL TRENDS IN THE ILLINOIS BASIN*

George V. Cohee and Charles W. Carter

State Geological Survey, Urbana, Illinois

The Illinois basin is here defined as that area between the Ozark uplift to the south and southwest, the Mississippi arch to the west, the Wisconsin uplift to the north, and the LaSalle anticline to the east. The basin, which has been notably an area of depression and sedimentation since pre-Cambrian time, has experienced repeated uplifts and downwarpings with associated folding. Many structural features have resulted from these diastrophic movements. Of these the LaSalle anticline is the most pronounced.

Information regarding some of these structures has been made available from studies of outcrops, well borings, and coal tests in the shallow parts of the basin. Until the recent oil development, which began in 1937, very few data were available for the central part of the Illinois basin which lies in the southern half of the State between the DuQuoin anticline on the west, the LaSalle anticline on the east, and the Ozark uplift in the extreme south. Geologic information from the many wildcat wells and wells drilled in the new oil fields has contributed much to knowledge of the details of structure in the deep part of the basin. These recent data show that this part of the basin is by no means a simple down-

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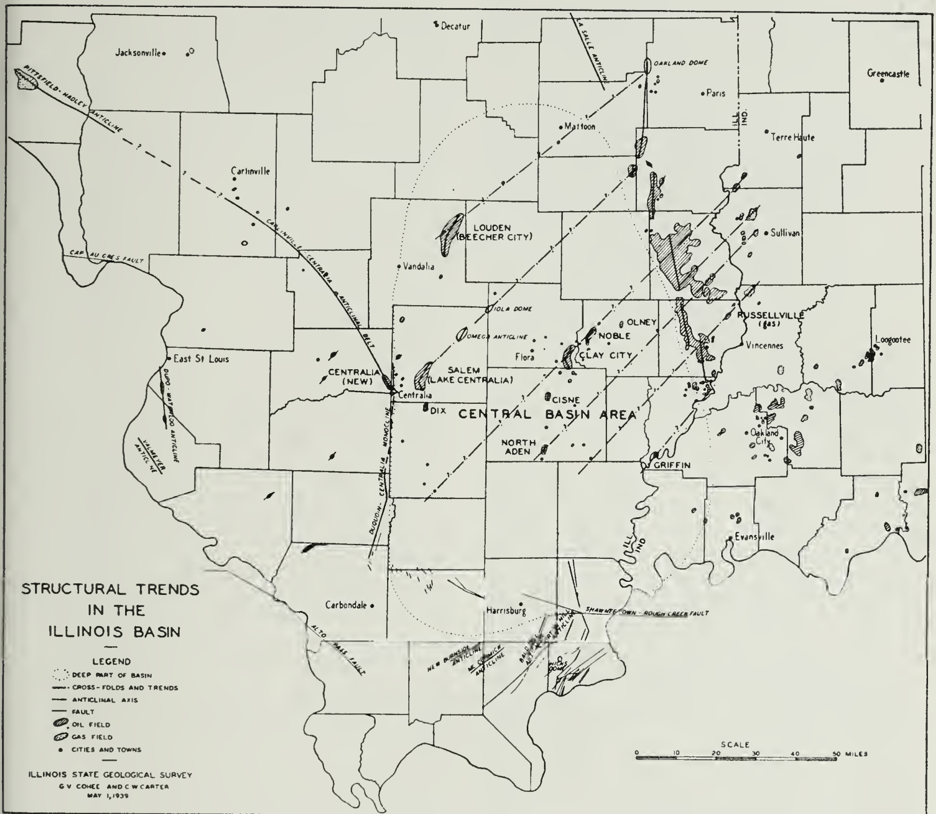

Fig. 1

warped area, but is crossed by numerous folds with various trends. There are now several oil fields located on the structures within the central basin area.

The largest fields developed so far in this area are Clay City and Noble. Both fields are located on separate closed structures on a regional "high". There is a closure of 100 feet on the Ste. Genevieve limestone in both fields. Each structure is an elongated anticline with a northeast-southwest trend and at the southwestern end of each there is a nose extending to the southeast. This southeastern nose in both fields extends toward a small producing area which is apparently a small dome with little closure. The Olney field, which was discovered more recently than the Clay City and Noble fields, is of the same regional "high". The McClosky "sand" of the Ste. Genevieve limestone is the principal producing formation in the central basin fields. The Cypress sandstone is also productive in the north Noble field.

The Salem (Lake Centralia) field in Marion County and the Louden (Beecher City) field in Fayette County are the major fields on the west edge of the deep part of the Illinois basin. Both fields are elongated anticlines with more than 200 feet of closure on the producing formations.

The Salem (Lake Centralia) structure is elongated northeast-southwest and at the southwestern end there is an anticlinal nose extending southeastward toward the Dix field in central north Jefferson County. From the axis of the anticline the formations dip steeply westward and northwestward as much as 200 feet per mile into the syncline between the field and the DuQuoin monocline. The formations dip more gradually toward the east. The Bethel and Aux Vases sandstones and the McClosky "sand" are productive in the field.

The Louden (Beecher City) field is likewise on a northeast-southwest trending anticline. The formations dip steeply to the west and northwest at a rate of approximately 200 feet per mile and more gradually to the east into the deep part of the basin. Unlike the other fields in the deep part of the basin there is a north-south extension of the structure instead of the common southeastward extension. The Cypress and Bethel sandstones are the principal producing formations in the field. Production has also been obtained in the sandstone of the Paint Creek formation.

Mylius[1] in his detailed study of structural conditions in the north part of the southeastern fields found that the structural irregularities along the LaSalle anticline suggest that closed structures on the uplift are related to a series of cross-folds which trend east of north and west of south. He stated that "If such a system of cross-folds of definite trend exists, as suggested, the knowledge would be of vital importance to future prospecting in the way of guidance of the search for new closed structures." Weller and Bell[2] showed cross-folds extending northeastward from the producing area on the LaSalle anticline in Crawford County to anticlinal structures in Indiana which are productive.

Cross-folds are also present in Lawrence and Wabash counties. The Russellville gas field in northeastern Lawrence County, discovered in 1937, is located on a northeast-southwest dome on the cross-fold that extends northeast from the producing area southwest of Lawrenceville, Illinois, to the Oaktown gas field in northwestern Knox County, Indiana. Contours on the Biehl sand[3] in Wabash County show a southwest trend from the Allendale field toward the Griffin pool which was recently discovered near the Wabash River in Gibson County, Indiana.

The influence of the cross-folds is shown by the structural irregularities of the LaSalle anticline and there is a corresponding irregularity of the producing areas. The cross-fold in northern Crawford County along which there is a considerable eastward extension of the producing area is in a northeast-southwest line with the Clay City and Noble fields in the central basin area and there is a suggestion that the influence of the cross-fold was extended into this area. A similar condition is suggested for the Salem and Louden fields. The north part of the Salem field is in a northeast-southwest line with the Omega anticline, Iola dome, the recent Iola field in northwestern Clay County, and the Siggins pool in the southeastern fields. The latter is located on a cross-fold described by Mylius and indicates a definite break in the LaSalle anticline. The north part of the Louden field is in line with similar trend extending through the new Stewardson field in Shelby County, the recent Mattoon field in Coles County, and the Oakland dome in Edgar County.

The principal axes of folds upon which the new fields in the basin are located are more north-south than the trends, suggesting an *en echelon* arrangement of the structures along the trends.

The southeast extensions of these new fields may reflect northwest-southeast trends which parallel the axis of the LaSalle anticline. These trends are suggested by the Centralia field in which the axis is northwest-southeast and by the southeast extension of the Salem field toward the Dix field.

Important folding occurred at the close of the Mississippian period when all of the borders of the Illinois basin were raised. The LaSalle anticline was the most important structure formed at this time,[4] and preexisting structures such as the Valmeyer and Waterloo anticlines were accentuated. It is also possible that the Pittsfield-Hadley anticline was formed then. Studies of the thickness of the Chester series and the Lower

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[1] Mylius, L. A. Oil and Gas Development and Possibilities in East-Central Illinois. Ill. Geol. Survey Bull. 54 (1927), pp. 167-168.

[2] Weller, J. Marvin and Bell, Alfred H. Illinois Basin. Ill. Geol. Survey Illinois Petroleum 30 (1937), fig. 4.

[3] Moulton, G. F. Further Contributions to the Geology of the Allendale Oil Field, with a revised structure map. Ill. Geol. Survey Report of Investigations 7 (1925), Plate I.

[4] Cady, G. H. Structure of the LaSalle Anticline. Ill. Geol. Survey Bull. 36 (1920).

Mississippian by L. E. Workman and J. N. Payne show a region of thinning from Carlinville to Centralia which they designated the Carlinville-Centralia anticlinal belt. This region was likewise accentuated at the end of Mississippian time. It is suggested that the Pittsfield-Hadley anticline may connect with this structural axis. Faulting in Union County occurred at this time; also renewed movement along the Alto Pass fault which is thought to have existed previously.[5] Studies of well data in the deep basin area show upper Chester beds eroded from the tops of the structures,[6] which suggests that there was considerable folding of these structures then. Folding occurred during Pennsylvanian time in the Illinois basin and approximately 2,500 feet of Pennsylvanian sediments were deposited. The last important folding took place at the end of Pennsylvanian time. Preexisting structures in the Illinois basin were accentuated. The extreme southern part of the State was folded into a complexly faulted northeastward dipping monocline which cut off the Illinois basin from its southward extension. The Shawneetown-Rough Creek fault area, which is apparently a thrust fault with the upthrow side to the south, was formed at the same time. It has been suggested by various authors[7] that this fault may connect with faults and folds farther east in Kentucky and West Virginia. Small anticlines in the southern part of the State having northeast-southwest axes were formed at this time.

Acknowledgements

The writers wish to express their appreciation to Dr. A. H. Bell, Head of the Oil and Gas Division of the State Geological Survey for his helpful suggestions and criticism of the paper. Valuable information and suggestions were also contributed by Dr. J. Marvin Weller, Mr. L. E. Workman, Dr. J. N. Payne, Mr. F. Squires, and Dr. G. E. Ekblaw of the Survey staff.

[5] Weller, J. Marvin. Personal communication.
[6] Workman, L. E. Unpublished manuscript on the Subsurface Stratigraphy of the Chester Series.
[7] Weller, J. Marvin and Bell, Alfred H. op. cit.
Russell, W. L. Relation of Rough Creek Fault of Kentucky to Ouachita Deformation. Bull. Am. Assoc. Petr. Geol., vol. 22 (1938), pp. 1682-1686.

SOME GEOLOGICAL FACTORS IN THE LOCATION AND CONSTRUCTION OF THE LAKE SPRINGFIELD DAM*

George E. Ekblaw

State Geological Survey, Urbana, Illinois

Geology entered into the choice of location and the construction of the Lake Springfield dam at four separate stages in the development of the project. It was a factor in the selection of one of three valleys considered as possible reservoirs; it was one of the factors that determined the best site for a dam across the chosen valley; it had its place in guiding the design of the dam and spillway; and it was of prime importance in indicating the nearest sources of desirable material for the dam.

A surface water supply for the City of Springfield had been discussed for some years before the project was begun in 1928. The three valleys that were considered as potential reservoirs were the Sangamon, with a damsite at Peabody, five miles north and three miles east of Springfield; the South Fork, with a damsite west of Rochester, five miles east and three miles south of Springfield; and Sugar Creek, with a damsite about three miles south and three miles east of Springfield. Preliminary borings were made at all three locations.

The three sites were alike in that they are flat-bottomed valleys. The lower part of the valleywalls consists of bedrock belonging to the Pennsylvanian system, and the bedrock is covered by glacial drift mantled by weathered loess. The sites differed in that the bedrock is not the

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same at all three localities nor is the material comprising the valleybottoms the same.

In Sangamon valley, the valleybottom material is mainly sand and gravel, a fact already fairly well known; in South Fork valley it consists of as much as 40 feet of clay and sand in discontinuous lenses; and in Sugar Creek valley it consists of a downward succession of consistent layers of (1) black loam, 5 to 6 feet thick, (2) noncalcareous yellowish silt averaging 14 feet thick, (3) calcareous, bluish-gray silt averaging 18 feet thick, and (4) ½ to 4½ feet of gravel lying on sandstone bedrock. Along the east side of the valley the upper part of the bluish-gray silt is replaced by 8 to 10 feet of black clay and marl. The more favorable condition of the valleybottom in Sugar Creek valley was one of the factors that determined its eventual selection as the reservoir site.

After Sugar Creek valley had been chosen, it became necessary to ascertain the most favorable damsite. For this purpose numerous additional test-borings were made across the valley at possible sites for the principal dam and also at the low narrow divide between South Fork and Sugar Creek valleys, where another dam was required to complete the reservoir. Still more borings were made to ascertain the character of the material available for constructing the dams, especially that which would be excavated from the spillway for the main dam. These borings confirmed details about the valleybottom material and also revealed the character and the precise elevations of the bedrock at the various points in the valleybottom and in the valleywalls.

Outcrops and the borings showed the following succession of materials in the valleywalls at the main damsite:—(1) ½ to 1½ feet of loessial loam, (2) 1½ to 15 feet of loess, (3) 2 to 16 feet of glacial till, (4) an irregular bed of limestone, (5) calcareous shale with lenticular concretions, (6) coal up to 2½ feet thick, (7) underclay up to 2½ feet thick, (8) calcareous shale 1½ to 4 feet thick with limestone lenses, and (9) shaly sandstone. The elevations of the coal bed indicated a slight northward dip of the beds. The coal, the underclay, and the underlying calcareous shale were not reported in all of the borings in which they would be expected. The test-borings at the site of the dividing dam showed a succession of soil, loess, till, and bedrock essentially the same as at the main damsite.

The data revealed by the test-borings not only served to determine the best position and alignment for the dams, but they also provided fundamental information for their design. The valleybottom material was satisfactory for a foundation so far as its bearing power was concerned, and so the only question of design was to make the base of the dam sufficiently wide to distribute its weight properly. Sheet piling was driven through the yellow silt to the bluish-gray silt at the main dam and to bedrock at the dividing dam to cut off subdam seepage. The spillway was designed to discharge its waters on the sandstone formation.

Samples from the borings made to ascertain the character of the source materials were carefully analyzed and on the basis of the results of analyses, selected material was excavated and combined in the dam in the approximate proportions that had been determined would be most stable.

Thus all the investigation and research necessary to insure the geological sufficiency of the damsites and the dam materials were undertaken. All other factors were similarly investigated and analyzed, and certainly in this respect the project was as complete and thorough as could be desired.

THE AGE OF THE LASALLE ANTICLINE*

J. Norman Payne

Illinois State Geological Survey, Urbana, Illinois

The LaSalle anticline has been described in various papers throughout the last century, but the most thorough and comprehensive investigation was made by G. H. Cady whose results were published in Bulletin 36 of the Illinois State Geological Survey in 1920. The more recent study of numerous sets of additional well cuttings has added a great deal to our information on the age of folding of the LaSalle anticline.

Cady gives the history of the deformation in LaSalle County as follows:[1]

1. Deformation during or after "Lower Magnesian" time, the nature and extent of which is not fully understood.
2. Slight deformation during or after St. Peter time, along the axis of the anticline causing an unconformity between it and the overlying Platteville dolomite.
3. Deformation some time after Silurian and probably after Devonian deposition.
4. Deformation during and after Pennsylvanian time.

The "Lower Magnesian" consists of the Shakopee, New Richmond, and Oneota formations. A study of the thickness of the Shakopee and New Richmond formations shows no thinning over the crest of the LaSalle anticline, but there is a thinning over a cross-fold that extends in a northeasterly direction from a point south of Peru through Ottawa. There is also thinning and complete removal of the Shakopee and New Richmond formations over the Kankakee Arch. Consequently, it appears that the LaSalle anticline was not present in pre-St. Peter time.

The cross-fold appears to have moved recurrently during Maquoketa and Silurian time, and possibly during or at the close of St. Peter time. If such post-St. Peter pre-Platteville movement took place, the Glenwood and lower Platteville beds might be absent from this zone and would be related to this structure rather than to the LaSalle anticline. This would better explain the fact that Glenwood beds are found in considerable thicknesses to the north and south of the Ottawa area.

The conclusion that the LaSalle anticline was not formed in Ordovician time is supported by the fact that there is no thinning of the Galena-Platteville formations toward the anticline, except where they have been affected by post-Silurian pre-Pennsylvanian and later erosion (Fig. 1). The distribution and thickness of the Glenwood formation is not related to the LaSalle anticline. Also, shoreline facies along the flanks of the structure have not been noted in formations below the Pennsylvanian in the LaSalle County area.

The question may be raised as to the possible Silurian or Devonian age of the structure. This possibility, however, is discounted by the fact that well records show the Devonian and Silurian strata to be thicker on the crest of the anticline in Crawford County than west of the anticline in southern Effingham County.

Lower Mississippian and Chester strata, where unaffected by post-Chester pre-Pennsylvanian erosion, bear no relation to the anticline but instead show a progressive thinning toward the eastern edge of the Illinois basin.

The cross-section AA' is drawn from Depue eastward to Wilmington. The divergence in dip between the Pennsylvanian and the older formations and the overlap of the Silurian by the Pennsylvanian strata show that the first major deformation was certainly post-Silurian. As a result of the first movement the minimum differential elevation in this area was 900 feet.

In the vicinity of Tuscola in Douglas County the minimum differential elevation caused by the first movement was about 1400 feet for here the Pennsylvanian sediments overlap Mississippian formations from the Chester down to the lower Osage.

[1] Cady, G. H. The Structure of the LaSalle Anticline, Ill. Geol. Survey Bull. 36, pp. 171-177 (1920).

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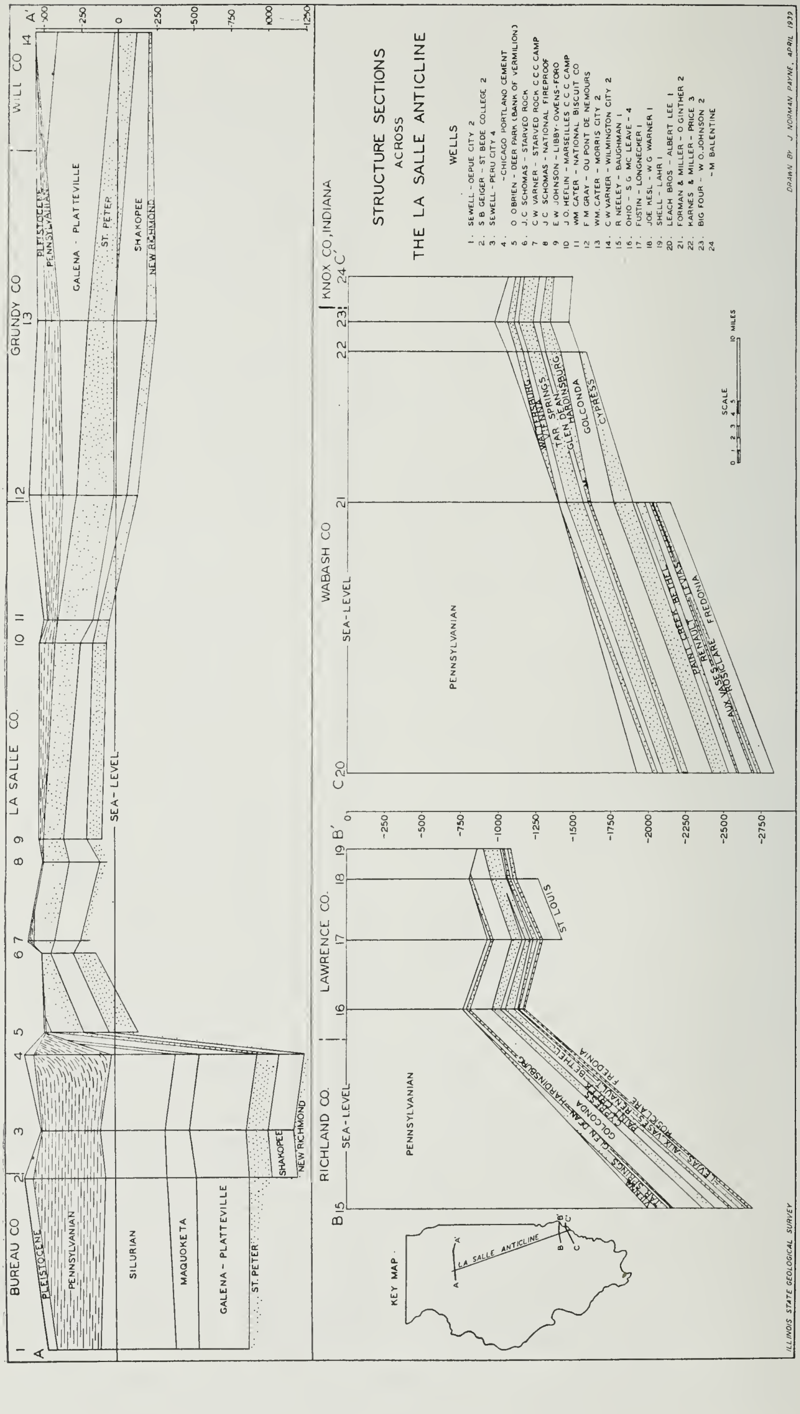
STRUCTURE SECTIONS
ACROSS
THE LA SALLE ANTICLINE
WELLS
1. SEWELL - DEPUE CITY 2
2. S B GEIGER - ST BEDE COLLEGE 2
3. SEWELL - PERU CITY 4
4. - CHICAGO PORTLAND CEMENT
5. O OBRIEN - DEER PARK (BANK OF VERMILION)
6. J.C SCHOMAS - STARVED ROCK
7. C W VARNER - STARVED ROCK C C C CAMP
8. J C SCHOMAS - NATIONAL FIREPROOF
9. E W JOHNSON - LIBBY-OWENS-FORD
10. J.O. HEFLIN - MARSEILLES C C C CAMP
11. WM CATER - NATIONAL BISCUIT CO
12. F M GRAY - DU PONT DE NEMOURS
13. WM. CATER - MORRIS CITY 2
14. C W VARNER - WILMINGTON CITY 2
15. R NEELEY - BAUGHMAN 1
16. OHIO - S G MC LEAVE - 4
17. FUSTIN - LONGNECKER 1
18. JOE KESL - W G WARNER 1
19. SHELL - LAHR 1
20. LEACH BROS - ALBERT LEE 1
21. FORMAN & MILLER - O GINTHER 2
22. KARNES & MILLER - PRICE 3
23. BIG FOUR - W O JOHNSON 2
24. - M BALENTINE
BUREAU CO
LA SALLE CO.
GRUNDY CO
WILL CO
RICHLAND CO.
LAWRENCE CO.
WABASH CO
KNOX CO, INDIANA
SEA-LEVEL
PLEISTOCENE
PENNSYLVANIAN
SILURIAN
MAQUOKETA
GALENA - PLATTEVILLE
ST. PETER
SHAKOPEE
NEW RICHMOND
ST LOUIS
WALTERSBURG
VIENNA
TAR SPRINGS
GLEN DEAN
HARDINSBURG
GOLCONDA
CYPRESS
PAINT CREEK
BETHEL
RENAULT
AUX VASES
ROSICLARE
LEVIAS
FREDONIA
KEY MAP
LA SALLE ANTICLINE
SCALE
10 MILES
ILLINOIS STATE GEOLOGICAL SURVEY
DRAWN BY J. NORMAN PAYNE, APRIL 1939

PLATE I

Cross-section BB' taken from south of Olney eastward through Lawrence County shows definitely that the initial movement took place in post-Chester pre-Pennsylvanian time for 400 feet of strata were eroded from the crest of the structure and the Pennsylvanian sediments were deposited overlapping Chester beds from the Menard-Vienna to the Glen Dean.

Cross-section CC' from Edwards County, Illinois, to Knox County, Indiana, shows a distinct flattening of the western flank of the fold and a decrease in the magnitude of the initial deformation, the minimum differential elevation being about 250 feet.

Later deformation of the LaSalle anticline took place during and after Pennsylvanian time. Additional detailed work on Pennsylvanian stratigraphy will show whether the maximum deformation of the Pennsylvanian beds took place during or after the close of the period.

It is concluded that the initial deformation took place in post-Chester pre-Pennsylvanian time, and that the area of maximum deformation moved progressively southward from the LaSalle area, with the maximum differential elevation occurring in the first pre-Pennsylvanian movement in LaSalle and Douglas counties, and after Pennsylvanian deposition had begun in Lawrence and Wabash counties.

PROGRESS IN GEOLOGIC MAPPING OF ILLINOIS, 1839-1939*

J. Marvin Weller

State Geological Survey, Urbana, Illinois

It is interesting historically that the first discovery of coal in North America was made in Illinois by Father Hennepin in the latter part of the seventeenth century. This can hardly be considered the beginning of geology in our State, however, because geological science did not make its appearance until another two hundred years had passed.

In the early part of the nineteenth century several exploring expeditions mostly organized by various agencies of the Federal Government passed through Illinois. Some of these parties included naturalists, and more or less unrelated geological observations were included in the published reports of their findings. The first systematic study of the geology of any part of Illinois, however, was undertaken by David Dale Owen in 1839 for the Federal Land Office. His first report on the lead region centering around Galena, Illinois, and including adjacent parts of Wisconsin and Iowa was published in 1844. Included in this report was a map showing the extent of the Illinois Coal Field which was the first map showing with any accuracy any of the major geological features of the State.

In 1851 the first Geological Survey of Illinois was organized with Dr. J. G. Norwood as State Geologist. His studies covered the entire State and in 1858 he published a colored geological map at a scale of 50 miles to one inch. This map shows with a fair degree of accuracy the distribution of Silurian (including Ordovician =Lower Silurian), Devonian, Mountain Limestone (Middle Mississippian), Millstone Grit (Upper Mississippian or Chester), Coal Measures (Pennsylvanian), and Tertiary (including Cretaceous) rocks and was a very creditable piece of work for that time.

Norwood was succeeded by A. H. Worthen in 1858 and field work was continued until 1872. In 1875 Worthen published a geological map of the State at a scale of about 6 miles to one inch. The geological divisions recognized differed from Norwood's in that the St. Peter sandstone and Lower Magnesian limestone, Trenton Group (Galena-Platteville), Cincinnati Group (Maquoketa shale) and Upper Silurian-Niagara Group (Silurian) are differentiated, the Lower Carboniferous (Mississippian) is not subdivided and the Coal Measures (Pennsylvanian) is shown in two divisions.

The present Illinois State Geological Survey was organized in 1905 and in 1906

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a new geological map prepared by Professor Stuart Weller at a scale of 12 miles to one inch was published. This was quite similar to Worthen's map of 1875. A few errors in Worthen's map were in some measure corrected but in some respects this map was less accurate than the preceding one. This map, revised and republished in 1907, differed from the map of 1906 principally by the addition of important alluvial areas and the abandonment of a two-fold division of the Pennsylvanian. Corrections resulting from field studies were made in parts of Calhoun and Jersey counties and to a lesser extent in the vicinity of Rock Island.

A new geological map was prepared and published at a scale of 8 miles to one inch by the Survey in 1912. The changes made were of minor importance except for revisions of the Silurian and various Ordovician boundaries in the northwest corner of the State, the differentiation and separate mapping of the Upper Mississippian (Chester), the more accurate delineation of the Mississippian and Pennsylvanian boundary in southwestern Illinois and the inclusion of additional alluvial areas along the principal streams in the southern part of the State.

The last geological map appeared in 1917. It is principally distinguished from the last by revision of the Silurian and Ordovician boundaries in northeastern Illinois and the much more accurate representation of the distribution of Chester beds in southern Illinois which resulted from the extended field investigations of Professor Weller.

Since 1917 an extensive program of investigations has covered nearly the whole State. This has involved the detailed mapping of many quadrangles, reconnaissance field work elsewhere, and the careful study of many well records. Now, after more than 20 years, a new geological map has been prepared and preliminary copies will soon be ready for distribution. The new map shows the more important alluvial areas of Pleistocene and Recent age, Tertiary and Cretaceous beds of southern Illinois are distinguished separately, the Pennsylvanian system is subdivided into seven parts, and five divisions of the Mississippian are shown. As on the last map, the Devonian and Silurian systems are not subdivided and three units of the Ordovician are recognized. Finally, the small area of Cambrian outcrop now known to occur near Dixon is distinguished.

THE COVEL CONGLOMERATE, A GUIDE BED IN THE PENNSYLVANIAN OF NORTHERN ILLINOIS*

H. B. Willman

Illinois State Geological Survey, Urbana, Illinois

An important guide bed in the Pennsylvanian system in Northern Illinois is a thin but persistent limestone conglomerate for which the name Covel is proposed because of outcrops along Covel Creek south of Ottawa. The Covel conglomerate is exposed at many places along Illinois Valley and tributary streams between Morris and LaSalle. It also occurs near Cambridge, Galesburg, Peoria, and Danville but has not been found in the southern part of the State. A limestone conglomerate is reported to occur at this horizon in central Iowa.

Stratigraphy.—The Covel conglomerate occurs at the top of the Summum cyclothem and a short distance below No. 5 coal in the overlying St. David cyclothem. In the upper Illinois Valley the conglomerate is underlain by light greenish-gray calcareous clay of marine origin and is overlain by 4 to 6 inches of dark gray thin-bedded shale containing traces of plants and impressions of *Estheria* and is probably a brackish or fresh-water deposit. Farther west in the Peoria and Cambridge areas this shale is replaced by the underclay of No. 5 coal and the conglomerate is overlain by clay. No similar conglomerate has been found in the Pennsylvanian strata of northern Illinois and the distinctive character of the bed enabled its correlation from outcrops near Peoria and Cambridge across a 50-mile interval in which it is deeply buried to outcrops in the upper Illinois

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Valley near LaSalle. By reference to this bed the absence of No. 5 coal in the upper Illinois Valley was established, and this fact, together with others, showed that the "Second Vein" coal of that region, previously correlated with No. 5 coal of Western Illinois, should be correlated with the No. 6 coal.

Thickness. — The conglomerate varies from a trace to about 1 foot thick but is usually ½ inch to 2 inches thick. It is notably lenticular so that it is discontinuous in almost every outcrop but is entirely absent in few outcrops.

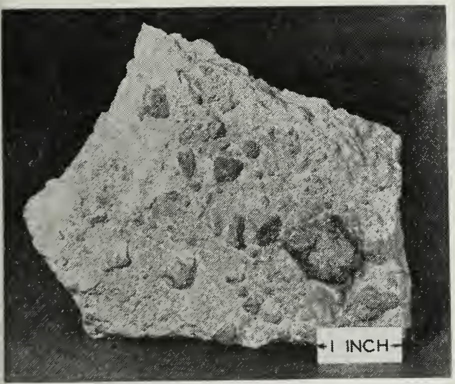


Fig. 1.—Typical specimen of Covel conglomerate.

Size of pebbles.—The largest pebbles in the conglomerate are usually 1 to 2 inches in diameter, but cobbles as large as 6 inches in diameter have been found. The conglomerate contains few fine sand grains and grains smaller than ¼ mm. in diameter are not common. At places the coarse sand grains predominate and the bed is a pebbly sandstone.

Composition.—Usually more than 75 per cent of the pebbles and sand grains are composed of very fine-grained dense limestone which contains few impurities. Pebbles of siliceous and argillaceous limestone are present at most places and fragments of calcareous silty clay occur locally. The limestone pebbles differ in color from very light gray to nearly black. Generally the dark gray limestone pebbles compose the greater part of the conglomerate, but a few light-colored pebbles occur at nearly every locality and locally they are abundant. Rounded and frosted grains of quartz as large as one-half millimeter in diameter are common at many places.

Shapes.—Most of the pebbles have irregular shapes and are marked by numerous nodular protrusions (See fig. 1). The surfaces are generally smooth and rounded. The smaller pebbles and most of the sand grains are well rounded and some are almost spherical. Sharply angular lath-shaped fragments are locally abundant and almost always present.

Sorting.—The conglomerate is poorly sorted although much coarser in some areas than others. Locally the sand grains show a lateral gradation in grain size.

Orientation.—Nearly all the pebbles have their long axes approximately parallel to the bedding. The lath-shaped pebbles frequently are tilted at various angles.

Matrix.—The spaces between the pebbles and sand grains are filled with finely crystalline pyrite, clear coarsely crystalline calcite, or fine-grained limestone. At some places the calcite forms a single crystal enclosing all the grains in sections an inch or more in diameter. Where limestone forms the matrix material the pebbles are often less closely packed and locally such areas grade into limestone containing scattered pebbles.

Fossils.—At a few places the conglomerate contains many brachiopods and crinoid stems. Gastropods, pelecypods, bryozoa, trilobites, and conodonts are also present. These fossils occur in the matrix and have not been found in the pebbles. At some places the upper surface of the conglomerate is covered by algal growths in irregular-shaped patches from a few inches to 2 feet or more in diameter. The algal growths consist of laminated calcite and are ¼ to 1 inch thick. They conform to the irregular surface of the conglomerate rising over the projecting pebbles without diminished thickness. The upper surface of the growths is about equally divided into intricately branching ridges and pits. The ridges are mostly 1 to 2 mm. wide and about 1 mm. high. This particular structure occurs at several localities and may be characteristic of the species of alga which produced it. Some of the pebbles in the conglomerate also show a fine network of cells and are probably algal growths. Many of the other pebbles have faint traces of banding and irregular wavy structures which suggest an organic origin and may also be algal.

Origin.—The presence of marine fossils in the matrix of the conglomerate indicates the deposition of the conglomerate in a marine environment. The source of the pebbles and sand grains is less evident. That most of the pebbles were not formed at the place where they now occur but were transported at least a short distance is suggested by (1) local sorting by grain size, (2) variation in the composition of the pebbles, (3) the presence of angular lath-shaped fragments oriented in various directions, (4) the presence locally of pebbles of calcareous clay derived from the underlying formation, and (5) the conglomeratic structure showing that most of the materials were consolidated when deposited.

That the pebbles were not transported any great distance is suggested by the fact that most of the pebbles have nodular surfaces, not water-worn shapes, and by the large size of the pebbles and their relative softness. In this connection the absence of dolomite and chert makes it improbable that the material was derived from areas to the north, while the absence of mica and quartz sand is evidence against the pebbles being derived from the areas which furnished the other clastic materials deposited during Pennsylvanian times.

The conclusion seems justified that the source of the pebbles was at no great distance from the place where they were deposited. The limestone nodules in the clay below the conglomerate are light greenish-gray and are not a possible source for the dark-colored pebbles which predominate in the conglomerate. It follows, therefore, that most of the pebbles must be derived from material deposited after the deposition of the underlying shale and immediately before or during the deposition of the conglomerate. With a few exceptions, however, the pebbles were formed of material which was consolidated so that no interpenetration of the pebbles occurred at their contacts when deposited.

Some of the pebbles are fragments broken from algal structures or from the limestone associated with the conglomerate. Many of them, however, appear to be nodules formed by algal growths. A few have a well-preserved cellular structure. Others have indistinct structures which may be of organic origin. In addition to the characters previously mentioned, an organic origin for most of the pebbles is suggested by (1) content of organic matter giving them a dark color, (2) freedom from argillaceous impurities, and (3) the rounded forms. The rounded forms might indicate a concretionary origin, but only a few of the pebbles have concentric or radial structures which might be concretionary.

The rounded grains of quartz sand which are scattered through the conglomerate may have been carried into the area by sand-eating animals. None of the Pennsylvanian sandstones of the area contains sand grains so large, and the animals must have carried them from distant areas.

Locally the pebbles were deposited in a fine-grained lime mud but more commonly they accumulated as a porous aggregate. Waters circulating through the conglomerate deposited pyrite and calcite filling most of the openings between the pebbles. Usually pyrite was deposited first, forming shells around the pebbles and the remaining spaces were filled with clear calcite. Less commonly pyrite entirely filled the spaces and locally it replaced the pebbles. At most places the conglomerate is so firmly cemented that it breaks across the grains.

The question may well be raised whether or not this bed should be called a conglomerate or a limestone. In chemical composition it is a limestone. Texturally it is a conglomerate, or in places a pebbly sandstone. From the viewpoint of origin it is perhaps a boundary-line case. However, as some of the pebbles are obviously broken fragments of rocks, and as the character of the deposits indicate some transportation for the pebbles, its designation as a conglomerate is more descriptive of both textural and genetic characters than if termed a limestone.

Papers in Physics

Extract From the Report of the Section Chairman

The Physics Section program carried eleven papers, nine of which are herewith published. The others were:

Demonstration of artificial radioactivity produced by neutron capture.—J. H. Manley, University of Illinois, Urbana, Illinois.
When are we going to have television as a public service and in our homes?—J. M. Synnerdahl, College of St. Teresa, Winona, Minnesota.

Forty-seven attended each of two sections.

C. N. Wall, North Central College, Naperville, Illinois. was elected chairman of the 1940 meeting.

(Signed) A. Frances Johnson, *Chairman*

EXPERIMENTAL PRODUCTION OF VORTEX RINGS

Lester I. Bockstahler

Northwestern University, Evanston, Illinois

One frequently finds references to the use of smoke rings in demonstrating the properties of vortex motion. Detailed methods for producing such rings on a scale for classroom use are rarely given. After trying boxes of many sizes and shapes it was found that a ply-wood box twelve inches square and three feet long closed at one end with a metal plate having a circular aperture in its center gave reliable and satisfactory performance. A piston with felt tacked around the edges was fitted snugly in the box and provided with a handle so that it could be pushed the entire length of the box. A circular aperture with a diameter of four inches was used. Other diameters were equally satisfactory, however. The smoke was produced by burning small pieces of camphor gum placed in a metal pan just back of the aperture. Rings were projected by forcing the piston forward in the box. The speed, stability and distance of projection depends on the rate and distance the piston is moved forward. In a room relatively free from air currents, rings were projected 30 feet from a four inch aperture by quickly moving the piston forward two inches at a time. A series of ten or a dozen rings can be projected in succession by this method.

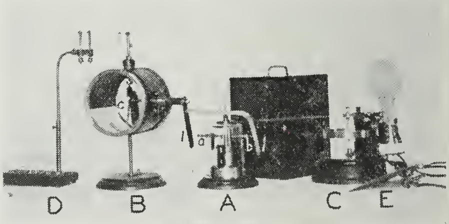
Camphor gum smoke rings were more stable and more "traceable" than those from sal-ammoniac or titanium tetrachloride vapors. The heavy particles of carbon are somewhat sooty, but seem less objectionable than the corrosive vapors.

A NOVEL HOMEMADE ELECTROSTATIC GENERATOR AND ZELENY ELECTROSCOPE ASSEMBLY

D. L. Eaton

Northern Illinois State Teachers College, DeKalb, Illinois

The apparatus used in the demonstration and illustrated in the accompanying cut was constructed by a friend of the author, Mr. Howard Daily, of Battle Creek, Michigan. Mr. Daily, recently deceased, was a skilled mechanic and an amateur scientist skilled in constructing apparatus for striking demonstrations of physical principles. The apparatus is presented in the view that it possesses some unusual features and merit in which others may be interested.



B is a modified Zeleny Electroscope. A is an electrostatic charger constructed on the principle of the Toepler-Holtz machine and housed in a glass tumbler. C, the motor for driving the charger, is a modified watt-hour meter. D is a stand on which is mounted a wire grid which may be heated to show the emission of therm-ions. E is a zinc plate which may be mounted on the electroscope when demonstrating the photo-electric effect.

The plate e of the electroscope may be charged either positively or negatively by moving the charger so that either terminal a or b is in contact with one of the flanges of the charger 1. Thus it may easily be shown whether positive or negative ions (or both) are present.

SATURATING REACTORS FOR CONTROL PURPOSES

Alan S. FitzGerald, *Haverford College, Pennsylvania*
and
L. J. Bulliet, *W. F. and John Barnes Co., Rockford, Illinois*

A universal complaint among users of automatic machinery is of the delays caused by maintenance work on switches. The trouble does not seem to be with particular switches but rather is inherent in the fundamental nature of the circuit breaking process. That is, opening a circuit must always produce more or less destructive arcing, and reclosing that circuit requires that foreign matter be absent from the contacting surfaces. True, many ingenuous ways have been found to mitigate these evils. Still, the machine builder wants something better for especially difficult applications. Our company decided to see if the essence of the switch could be replaced with something with more stamina.

We asked ourselves, how can we practically stop and start the flow of a current while leaving all connections intact. The physicist has some ready answers if we neglect the word "practical." He thinks immediately of electron tubes, resonant circuits, sliding iron core reactors, and reactors with variable D.C. saturating windings. We thought of all these but soon had to quit ignoring the catchword "practical." This word is all-important to the machine builder. Much as it hurts some of us to snub a lovable friend, electron tubes must, at least for the present, be ruled out of the general machine control field. The maintenance problem there seems to be worse than for switches. At any rate our customers think so and, commercially speaking, that settles that until such time as the customer's mind is changed.

Resonant circuits, in the ordinary sense, require much too bulky equipment to be practical at commercial frequencies and the provision of high frequency control power does not appeal if some other answer can be found. The non-linear or ferroresonant circuits have definitely appealing characteristics for the present purpose. We have done some experimental work with these circuits and propose to do more.

However, it is with variable inductance circuits that we have had our greatest success to date and it is to those that we now turn our attention. As is well known to those present, an alternating current can readily be varied between wide limits if an iron cored coil is included in the circuit and if that iron core is either moved in and out of the coil or if a variable direct current is sent through another winding on the core partially to saturate it. However, this way of varying the main current yields a proportional variation. That is, the A.C. varies gradually with the displacement of the core or the change in the D.C. saturation. Clearly this is not strictly comparable to switching where the current changes almost instantly from zero to maximum or vice versa.

Early in our investigation, I became acquainted with some discoveries of Mr. Alan S. FitzGerald,[1] a consulting electrical research engineer with laboratories at Haverford College. In his experiments with saturable core reactors, Mr. FitzGerald found that remarkable results could be obtained by adding another D.C. coil to the usual saturable core reactor. This new coil is connected in series with the A.C. winding but with an intervening full-wave rectifier so that the full main current flowed through the A.C. winding as A.C. and through the auxiliary winding as D.C.

This circuit has many properties interesting to physicists but for our purpose we shall discuss only those pertinent to problems of machinery control. It is found that a gradual variation of the regular saturating direct current will leave the main alternating current almost entirely unchanged until a critical value of D.C. is reached whereupon an abrupt and a very substantial change occurs in the main current. This effect is illustrated in fig. 1 where the load of alternating current is plotted as ordinates where the control or direct current is plotted as abscissae. For our purpose it is better to

[1] FitzGerald, Alan S., U. S. Patent No. 2,027,312.

replace the regular D.C. winding by two windings. By putting a constant D.C. through one of these, a normal working point or bias is established. Then the on and off may be effected by relatively slight variations in the D.C. through the third D.C. coil. Obviously, polarity effects are possible depending upon the value of the bias. For example, if the bias has the value I_7, then an additive increase in the other control current will reduce the A.C.

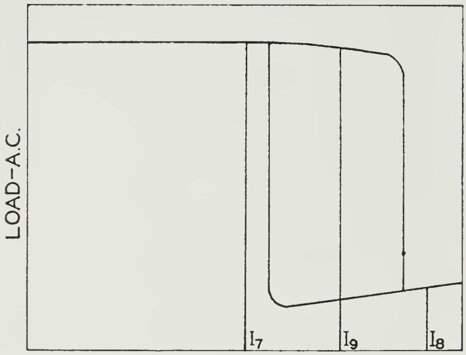


Fig. 1

If it is desired to have an increasing control current to increase the A.C., then the bias is set at I_8 and the control flux made to oppose the bias flux. Further the bias may be set at I_9 and the on and off function is accomplished by reversing polarity of the control current.

For specific application to machine operation, the D.C. is made to vary in response to motion of a machine member. Thus, the value of the D.C. is a function of that member's position and the A.C. will change abruptly when the pre-determined position is reached, just as though the machine member had mechanically tripped a snap switch. Someone will probably object at this time that D.C. is easily varied only by means of a wire wound rheostat so that the hated contact has reappeared as the slider on that rheostat. Thus we have chosen an elaborate path to get nowhere. This objection is met by using rectified A.C. as the control and varying this by means of an induction regulator or a simple sliding core reactor. The latter was not acceptable for direct control because of its proportional variation but it will do nicely in conjunction with the new circuit which has the discontinuous feature. Furthermore, the control reactor can be quite small because the circuit we have described is inherently an amplifier. That is, a given input power can be made to control a vastly greater output power as power amplification of 200 times is easily attained with one circuit while cascade connections can be made to develop amplication factors in the millions. Thus photocells can be made to control loads of several watts.

The apparatus is obviously extremely rugged and easy to build. We have only coils wound on iron cores and dry disk rectifiers. Such coils have proven themselves beyond all question as transformers and chokes. Dry disk rectifiers have given excellent accounts of themselves where they are applied with due regard for their potential and current limits. There are absolutely no moving parts beyond the original control inductor and that can be made rugged and free of all triggers and springs that give trouble in snap switches. The cost on a production basis has not been tried but careful estimates appear very satisfactory.

There is only one feature that we have found troublesome. While the load current changes abruptly and consistently when the critical control current is reached, it does not do so instantaneously. There is a definite time lag, which may be reduced by lowering the amplification but it cannot be eliminated. In some cases this is an objection although it is unimportant in many applications. The theory of this interesting circuit has not been fully explored. We have been too busy trying to put it to work. Essentially it seems to be something in the nature of a feedback effect. That is, the series D.C. flux conspires with the control flux to cause the action. The sudden change is related to the knee of the magnetization curve; that is, where the core begins to saturate.

FURTHER EXPERIMENTS WITH SINGING TUBES

Charles T. Knipp

University of Illinois, Urbana, Illinois

Two years ago at the Rockford meeting of the Academy of Science the writer listed 32 experiments as suitable for lecture table use, and also set down a short series styled "Sleight-of-hand in physics", centered around the singing tube.[1] Since only isolated demonstrations of the singing tube have been given before the Physics Section it was thought desirable to complete the series to date.

The results that may be obtained are surprising and rather mystifying. The energy that motivates these tubes comes from a difference in temperature of the air within two parts of the tube. At room temperature this difference, sufficient to make the tube sing, is obtained by heating the closed tip, Fig. 1, with a Bunsen burner (or an electric heater) to about 320° Centigrade. Just why the tube sings has not yet been completely or satisfactorily determined, though numerous physicists, including several theoretical workers, have given it attention. The most satisfactory experimental explanation, in the writer's opinion, is that by the late Professor Jakob Kunz[2].

The tip must always be warmer than the body of the tube. Two cases may be cited: **Case I.**—Heating the tip. The body is kept at room temperature, while the tip, to cause the tube to sing, must be heated to about 320° C. The essential requirement is to maintain a considerable temperature difference. The exact value of this difference in temperature depends on the physical dimensions of the tube, and these are quite critical.

Case II.—Cooling the body of the tube (with liquid air). From the statements made above it is reasonable to expect that a tone also should be emitted if we leave the tip at *room* temperature (20° C.) and cool the body of the tube to the temperature of liquid air (Figs. 4 and 5), i. e., to —180° C. With a carefully constructed tube this *temperature difference*, 200° C., was actually found to cause the tube to sing. The mechanism of the vibrating air is exactly the same as in the first case, except that the temperature difference is now between different limits. This is made

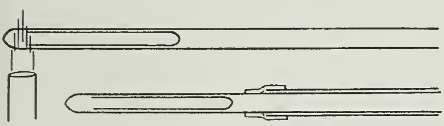


Fig. 1

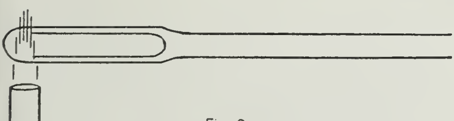


Fig. 2

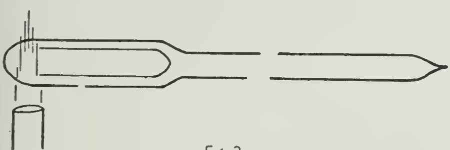


Fig. 3

Fig. 1.—Original of the straight form of the singing tube, styled the "Vest pocket" size. They are made in pairs. One tube has a sliding sleeve for tuning when the two are sounded simultaneously, (beats).

Fig. 2.—A larger form (but one shown). In addition to the sliding sleeve there are extensions for showing the relation of pitch to length, (low pitch, very loud, beats).

Fig. 3.—Large form with open end *closed*. This corresponds to a closed organ pipe, except that the tube is *entirely* closed. Vibrates but no sound is audible, (uncanny). May be made audible by setting the cold end of tube on a resonator—a table top, or against a wooden blackboard. Two such tubes simultaneously operated as above produce audible beats.

[1] *Trans.* Ill. State Acad. Science, XXX, p. 253, 1937.
[2] C. T. Knipp and Jakob Kunz, NATURE. CXX, p. 362, Sept. 10, 1927.

clear by the following tabular presentation:

	Temperature of tip		Temperature of body		Difference in temperature
Case I	+ 320°	—	(+ 20°)	=	300° C.
Case II	+ 20°	—	(— 180°)	=	200° C.

Further, the magnitude of the temperature difference in the two cases is less, as the tabulation shows, by about 100° C. And further still, the pitch is much reduced, however, this is what one should expect, since the pitch of an organ pipe is lowered with lowering temperature. In addition to the above the tube sings apparently on a less expenditure of energy. A burning match applied to the tip (Case II) makes the tube roar.

In case the tube is cooled with liquid nitrogen, which is colder than liquid air, the intensity of the tone emitted is increased, attended by a lowering of the pitch.

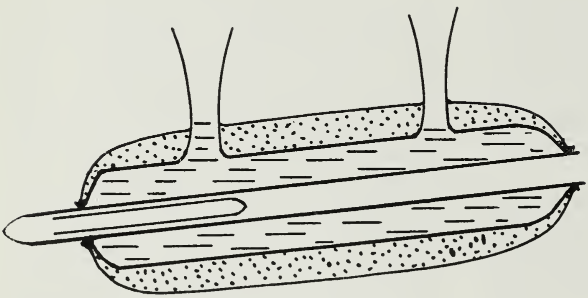


Fig. 4

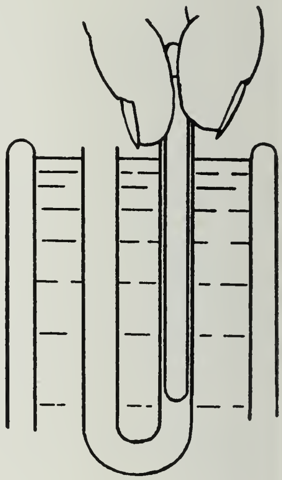


Fig. 5

Fig. 4.—Tubes in Figs. 1, 2, and 3 are made to sing by *heating* the tips, while the tube sketched here (Case II) will emit a musical note by leaving the tip at room temperature and *cooling* the body of the tube to the temperature of liquid air, as shown. Two tubes thus mounted and simultaneously cooled will produce beats, (effect surprising).

Fig. 5.—The straight tube of Fig. 1, or Fig. 4, is bent in the form of a U. The body of the tube (the U portion) is then cooled to the temperature of liquid air (Case II), while the tip is kept at room temperature. To operate grasp the tip by the right hand between the thumb, fore and middle fingers and lower into a Dewar ask filled to the brim with liquid air as shown. The tube will begin singing in about 45 seconds. Two such tubes lowered in liquid air simultaneously will produce beats.

A HIGH VOLTAGE NEUTRON SOURCE

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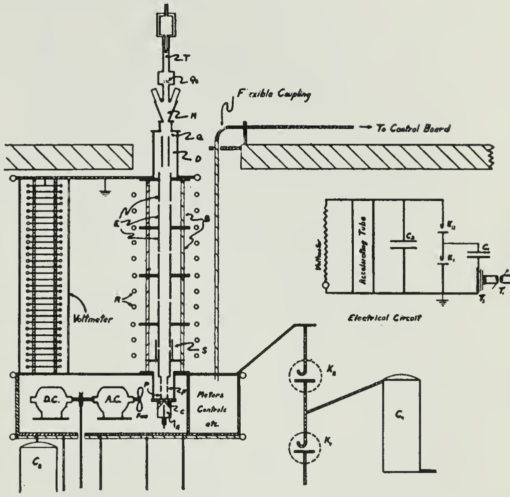
Of the several types of equipment which will give particles sufficient energy to penetrate the nucleus of any atom and thus provide information on its structure the most direct is a linear accelerator. The essential parts of this apparatus are a source of charged particles and a means of accelerating them through a difference of potential of several hundred kilovolts.

The details of the particular arrangement of the installation in the Physics Department of the University of Illinois are shown in Fig. 1. The ion source C, A at the lower end of the accelerating tube is a low voltage arc of the Zinn type.[1] The ions are extracted by a potential applied to the electrode P, focused by the electrode F and successively accelerated by the electrodes E. The total voltage across the tube is 250 kilovolts supplied by a voltage-doubler circuit, shown in the insert. The lower end of the tube is at high potential with respect to ground, and therefore all power for the ion source must be derived from the generators A. C., D. C. driven by an insulating belt. All equipment is remote-controlled from a room above that in which the high voltage equipment and tube are located.



One important provision of the apparatus is for securing modulated ion currents. This is accomplished by applying an oscillating potential to the deflecting plates, D, in the upper end of the tube, thus sweeping the beam across the target at the frequency of the potential applied to the deflection plates.

The chief application of this modulated ion beam is to secure neutrons of known velocity, using a beam of deuterons and a target T, of heavy water ice maintained by liquid air in the upper cylinder, each time the ion beam sweeps past the target a burst of neutrons will be ejected according to the reaction $_1H^2 + {}_1H^2 \rightarrow {}_2He^3 + {}_0n^1$. The ion current to the target triggers the sweep of a cathode-ray oscillograph whose vertical plates are connected to neutron recording equipment such that each neutron arriving at the recorder will produce a short voltage pulse on the oscillograph. The position of this pulse on the horizontal sweep or time scale thus records the time of arrival of the neutron at the recorder. Knowing the distance from the target to the recorder, the neutron velocity may be determined. This arrangement is the only satisfactory method so far devised for accurate measurement of neutron velocities.

From data on the neutron yield of the above reaction and the voltage and current available, the strength of the neutron source may be calculated. This is about 10^9 neutrons per sec. which is equivalent to the number of neutrons obtained from approximately 40,000 milligrams of radium mixed with beryllium $[_4Be^9 + {}_2He^4 \rightarrow {}_6C^{12} + {}_0n^1]$.

Although the apparatus has been designed primarily as a neutron source, provision has been made for study of other nuclear reactions. The fan-shaped chamber, H, is located in a magnetic field which can be used to deflect the ion beam to either side tube in which different targets can be placed. At the same time, a magnetic analysis of the beam may be made.

[1] *Zinn: Phys. Rev. 52,655,* (1937).

HOW ENGINEERS USE BASIC SCIENTIFIC FACTS—ILLUSTRATED BY A CONCRETE EXAMPLE

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ABSTRACT

There was a requirement for a small, sensitive electric switch, suitable for operation by slow motion, where small energy is available. Operation by thermal expansion is one example of such slow motion. The requirement was for a switch capable of controlling a ½ h.p. alternating current motor at full line voltage without the use of relays. It must also make positive contact and have low resistance on low energy switching, as in thermocouple circuits. It was apparent that to control a load of ½ h.p. at potentials up to 460 volts required snap action, yet the microscopically slow motion (on the order of 2.5×10^{-4} cm. per minute) and a total energy of only a few hundredths of a g. cm., ruled out the use of wide contact separation. Hence, the first consideration was the criteria of breaking an alternating current circuit without wide contact separation. It was impractical to consider working with a gap within the mean free path of an ion, but experience indicated that in contact openings on the order of .02 to .05 cm., ionization is less than with wider gaps, and that silver contacts separated by this distance, at suitable speed will satisfactorily interrupt circuits carrying 1200 watts at potentials up to 600 volts. The successful use of such short gaps for power switching had long been overlooked, although the general principles have been recognized in automotive ignition breakers for many years.

To meet commercial requirements, such a switch must provide a sharp, clean break to avoid radio interference, as well as to prevent contact destruction. The toggle mechanism to produce such a snap action break must also provide a velocity of contact separation on the order of 4 centimeters per second, as it has been learned that interrupting 60 cycle alternating current loads at lower velocity than this offers the probability of the rekindling of the arc if the zero phase is passed at the time the contacts are only minutely separated. On higher speeds, the probability is of an arc of higher voltage, due to greater mean length, and, consequently, greater wattage. Hence this critical speed produces the minimum mean energy dissipation in the arc. The mass of the moving parts and the air damping must also be considered from the standpoint of minimizing the bounce of contacts on the make, as the arcs occurring during the period of bounce are destructive to contacts and detract from the precision of the operation when switches are used as timing means where a few milli seconds tolerance is of consequence.

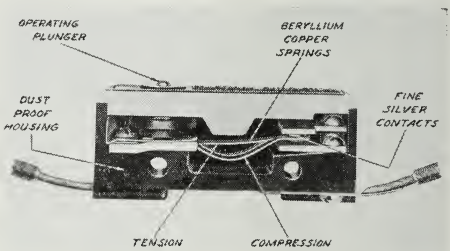

Fig. 1

Most of these elements may appear to be pure engineering problems, yet it was found helpful to review the theoretical physics of spring moduli and the criteria of stability in considering the relationship of parts of a toggle mechanism which will approach the performance specified.

In its commercial form, the switch is made from a single piece of heat treated beryllium copper .2 mm. thick. The spring is cut to have one central member 4 cm. long and two side members, joined to the central element at one end, each 2.2 cm. long, the whole being 1.3 cm. wide. The long central member is mounted in cantilever manner and the two short side legs seated in V's so placed as to give them a bow form. The free end carries a silver contact cooperating with fixed contacts. Fig. 1 illustrates such a switch mounted in a Bakelite block (shown cut open), with an operating plunger bearing against the long tension member at such a point as to produce a snap movement of the contact end. This type is self returning, but by use of wider separation of fixed contacts, it may be made of a sustained contact type. Such switches are made to operate with a plunger movement on the order of 2.5 x 10^{-4} cm. and a total energy of as little as .05 g. cm. Variations in design are made as it is apparent that a switch useful on the new 200 inch telescope in California will be specified in a different manner from one which must resist the vibration and centrifugal forces present in the hub of an aeroplane propeller, and an incubator thermostat switch will differ from one used on a ponderous machine tool.

The switch was designed primarily for use on alternating current, but by use of special circuits, several hundred watts D.C. may be switched.

The commercial success which this switching device has attained has fully justified the time and expense put into the careful scientific study of the basic principles involved.

A THEORY OF THE ACOUSTIC EFFICIENCY OF THE TELEPHONE RECEIVER

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This brief progress report combines the general procedure of two previous researches, the motional-impedance of the telephone receiver,[1] and sound absorption by the flue method.[2] The plan is as follows: I. To determine the total energy absorption of the telephone receiver diaphragm from the electrical input; II. Of this total absorption, to determine that part which is lost as heat; III. The difference between the energy absorption of I and II gives the acoustic output of the diaphragm.

I. The essential features of the telephone receiver, the vibrating plate and the magnet and coils, are shown at end A of the sound flue in Plate I, a. Closing the end of the flue is the plate or diaphragm, behind which are the polepieces, with coils connected to an impedance bridge for determining the motional-impedance of the receiver (that part of the impedance due entirely to the vibratory motion of the diaphragm). When the resistance and reactance components of the motional-impedance for frequencies in the resonance region of the diaphragm are plotted as coordinates, the resulting graph is the motional-impedance or velocity circle (plate I, b). Its principal diameter (through the origin) marks the natural frequency f_0 of the diaphragm, and the quadrantal points f_1 and f_2 mark the positions which divide the circle into quadrants.

The equation of motion of the diaphragm is

$$md^2x/dt^2 + rdx/dt + sx = F \sin \omega t \quad (1)$$

where m, r, and s are its inertia, resistance, and elastic constants respectively; F is the impressed force on it; t is the elapsed time; and $\omega = 2\pi f$. The solution of the equation for vibrational velocity is

$$dx/dt = (F \sin \omega t)/\sqrt{r^2 + (m\omega - s/\omega)^2}$$

Because of its vibratory motion, the diaphragm absorbs energy, the amount absorbed (omitting reactance) being $rdx/dt.^2$ The resistance constant r includes frictional heat in the material of the diaphragm (r_f), the eddy current loss (r_e), and absorption of energy as sound radiated into the flue (r_p) and into the receiver chamber (r_c). For a small, smooth chamber r_c may be neglected. Then the total energy absorbed by the diaphragm is given by:

$$rdx/dt^2 = (r_f + r_p + r_e)\ (dx/dt)^2 \quad (I)$$

II. At open end B of the sound flue is a loud speaker, connected to an electric

[1] The Motional-Impedance of the Telephone Receiver. A. E. Kennelly and G. W. Pierce. Proc. Am. Ac. of Arts and Sciences, 48, 1912.

[2] A Direct Method of Finding the Value of Materials as Sound Absorbers. H. O. Taylor. Phys. Rev. Oct., 1913.

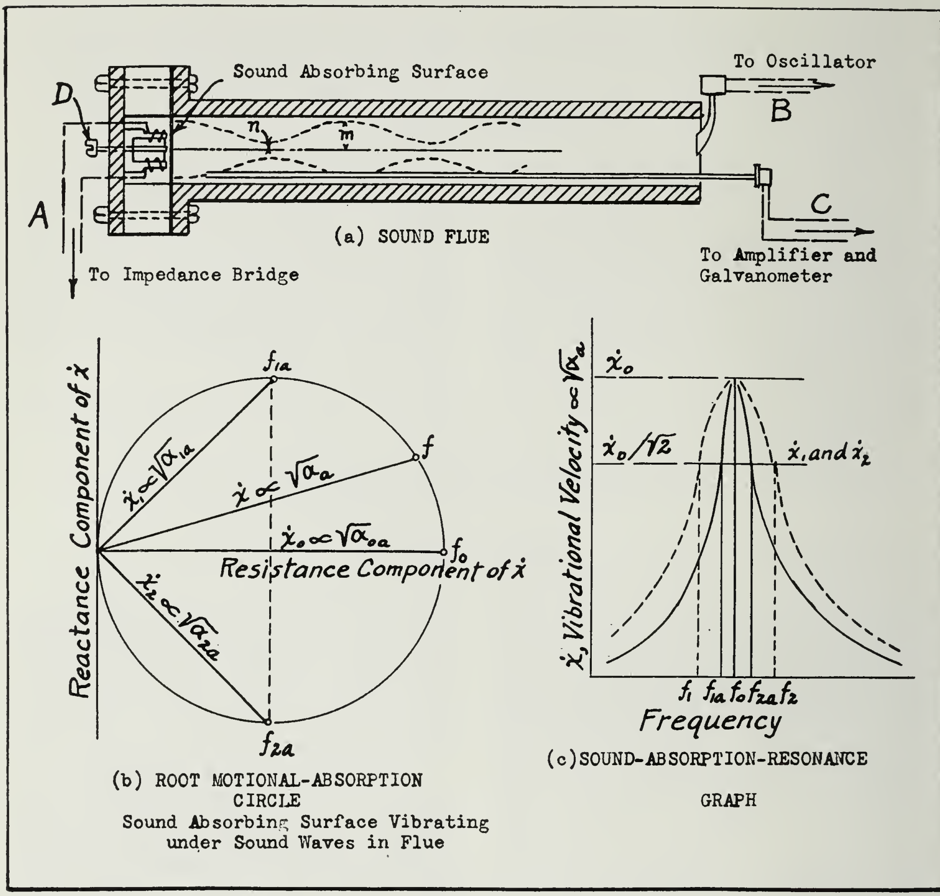

Fig. 1

oscillator, which delivers sound of pure sine-wave form to the flue. The progressive waves combine with those reflected from the plate at A to form a standing wave pattern. The sound intensities, m and n, at the maximum and minimum regions of this pattern are found by means of the exploring tube connected to telephone receiver C associated with an amplifier and galvanometer circuit. For a smooth interior flue surface, which absorbs practically no sound, the coefficient of absorption α of the diaphragm at end A is given by the relation:

$$\alpha = \frac{4}{(m/n)^{1/2} + (n/m)^{1/2} + 2} \qquad (2)$$

When the walls of the flue absorb sound appreciably, a formula for α is used which involves the attenuation of sound by the flue walls.[3]

When the diaphragm is excited by sound waves in the flue (rather than by the receiver coils) sound energy is absorbed by it because of both its porosity and its vibratory motion. The motional-absorption α_a of the diaphragm (that part of sound absorption due entirely to the motion of the diaphragm and not at all to porosity) is the difference between the free and damped coefficients of absorption, $\alpha - \alpha_d = \alpha_a$, where α is the free absorption, and the subscripts, d and a, refer to damped-absorption and motional-absorption, respectively. The

[3] Sound Absorption and Attenuation by the Flue Method. H. O. Taylor and C. W. Sherwin. Jour. Acoustical Soc. of Am., April, 1938.

damped-absorption is obtained when the motion of the diaphragm is damped by means of the contact screw D which, tipped with wax, is made to adhere to the center of the diaphragm. When these motional-absorption coefficients are determined for frequencies in the resonance region of the diaphgram, a sound-absorption-resonance graph may be plotted (diagram c) using dx/dt (proportional to $\sqrt{\alpha_a}$) as ordinates against frequency f as abscissas. dx/dt_1 and dx/dt_2 (each of which are equal to $dx/dt_0/\sqrt{2}$) are vibrational velocities corresponding to the quadrantal points. Thus a velocity circle similar to the motional-impedance circle may be constructed, which may be called the Root Motional-Absorption Circle (plate I, b).

The motional-absorption coefficient α_a corresponds to energy absorbed by the diaphragm from the standing waves in the flue given by $r_a x$,[2] where r_a is the resistance constant of the diaphragm for standing-wave excitation; therefore,

$$\alpha_a = r_a(dx/dt)^2$$

Then, when excited by the standing wave in the flue (with the telephone receiver coils on open circuit), the energy absorbed by the diaphragm is:

$$r_a(dx/dt)^2 = (r_f + r_e)\ (dx/dt)^2 \ldots \text{(II)}.$$

The term involving r_p does not appear because sound reflected from the diaphragm is not absorbed by it.

III. The difference between (I), and (II), is $r_p(dx/dt)^2$ the energy radiated from the diaphgram into the flue; and the fraction that this energy bears to the total energy absorbed by the diaphragm from the electrical input is the acoustic efficiency e of the telephone receiver; that is,

$$e = r_p/r \ldots\ldots\ldots\ldots\ldots \text{(III)}.$$

The value of e may be determined if the resistance constant r is evaluated in terms of the quadrantal points of the velocity circle, thus:[4]

$$r/(2m) = (\omega_2 - \omega_1)/2$$

from which $r = m\ (\omega_2 - \omega_1) = 2\pi m\ (f_2 - f_1)$, where m is the equivalent mass[5] of the diaphragm. Then from the motional-impedance circle, $r = 2\pi m\ (f_2 - f_1)$; and from the motional-absorption circle, $r_a = 2\pi m(f_{2a} - f_{1a})$. Combining these values of r and r_a with (III). gives:

$$r_p/r = (r - r_a)/r = 1 - r_a/r = 1 - (f_{2a} - f_{1a})/(f_2 - f_1) = e,$$

the efficiency of the telephone diaphragm as a radiator of sound waves.

The efficiency from electrical input to diaphragm absorption may be given as $(dx/dt)^2 r/i^2R = e'$, where i is the effective current in the coils and R is their electrical resistance. Then the overall acoustic efficiency E would be:

$$E = ee' = 2\pi m\ (dx/dt)^2\ (f_2 - f_{2a} - f_1 + f_{1a})/(i^2R)$$

Notes: This method (omitting the impedance bridge and receiver coils at end A of the flue) may be used to determine the coefficients of sound absorption over various frequency ranges for thin plates of metal or fabric used in the adjustment of the acoustics of rooms.

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[4] The Mechanics of Telephone Receiver Diaphragms, as Derived from their Motional-Impedance Circles. A. E. Kennelly and H. A. Affel, Proc. Am. Ac. of Arts and Sciences. Nov., 1915.

[5] Explorations over the Vibrating Surfaces of Telephonic Diaphragms under Simple Impressed Tones. A. E. Kennelly and H. O. Taylor. Proc. Am. Ac. of Arts and Sciences. April, 1915.

THE ONE HUNDRED TWENTY FOOT PENDULUM AT MUNDELEIN COLLEGE

SISTER MARY THERESE, B. V. M.

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From a point between the eighth and ninth floors in an unused elevator shaft of Mundelein College for Women, located on the north side of Chicago, a pendulum, the longest in existence, was suspended last June. It consists of a thirty-five pound chromium plated bob hung by piano wire, No. 35, from a bi-filar suspension known as the Longden suspension. It consists of two hard metal rollers about ¾ inches in diameter and about 4 inches long set at right angles to each other, one above the other. Separating the two rollers is a quartz plate ½ inch thick and optically plane to within a half wave-length of the D line of Sodium. Held upright by this plate is a counterpoise to compensate for the difference in length of the pendulum in the two directions. This counterpoise may be run up or down on the threaded rod. When the counterpoise is properly adjusted, the period of the pendulum is the same in east-west as in north-south direction. The wire forms two loops at the top, one over each end of the upper roller which has shallow grooves cut near the ends, travels down the shaft for over 100 feet as a single wire, and near the bottom again forms two loops which carry the bob.

While the pendulum is swinging it travels over a recording table. This consists of a hard rubber top about 12 inches in diameter with an inlaid metal ring about 8 inches in diameter. Graduations of 360° appear outside the metal ring. A platinum point projects from the lower surface of the bob and due to an electrical hook-up consisting of a high-voltage transformer and an interval timer, the circuit is closed every half hour. The circuit remains closed for 25 seconds during which time a spark travels from the platinum point through a sheet of sensitized paper to the ring in the top of the recording table, leaving several perforations in its path. The circuit is then broken for another half-hour period. The period of our pendulum is 12.258 seconds and its length about 123 feet.

While the pendulum is swinging the earth under it is rotating from west to east. To us it appears that the direction of the pendulum is changing. The rotation of the earth can be accurately measured by determining the displacement measured in degrees azimuth on the sensitized paper. Due to our latitude angle (Chicago, 42 degrees) the space swept through during consecutive half-hour intervals is 5 degrees. This angular velocity $\omega = 15°$ per hour $\times$ sin of the latitude angle, ϕ, and the time of one apparent complete revolution of the pendulum bob,

$$T, = \frac{24^{h}}{\sin \phi} = 35^{h}.75$$

MICROPHOTOGRAPHS OF SINGLE CRYSTALS OF ZINC CONTAINING SMALL KNOWN AMOUNTS OF IRON

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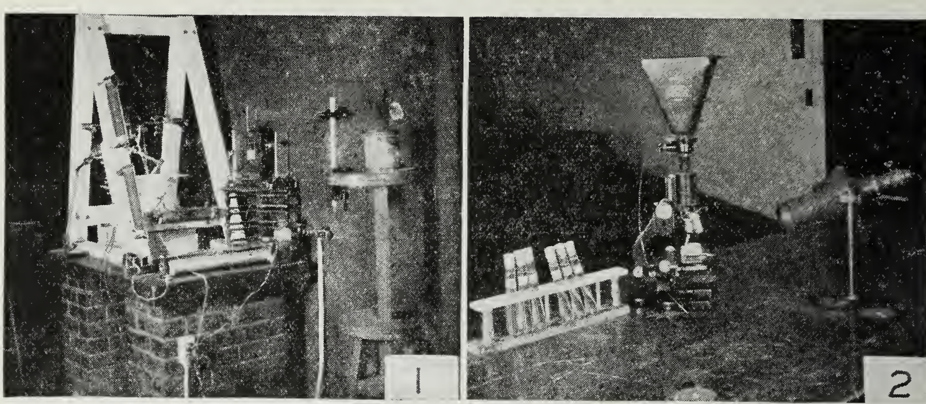
The authors of this paper presented at the 1937 meeting of the Academy a paper on Single Crystals of Zinc (1). This paper dealt with the effects on the zinc by the addition of small known amounts of several elements. The microphotographs showed some rather striking results in the case where iron had been the added impurity. Previous work (2) has shown that the addition of small amounts of iron to zinc in the form of a single crystal gives some very interesting results. The most unexpected effect is that it increases the electrical resistivity almost 50 times as much as the addition of any other impurity had done. When crystals were grown by means of a nucleus in a horizontal oven, the added iron seemed to widen the range of growth and in almost every case, a perfect zinc crystal was obtained. Whenever any of the others were added, mosaics invariably came in and only by very rigid temperature control could they be eliminated.

The growth conditions necessary for single crystals of pure zinc were at one time believed to have been worked out (3). Subsequent work showed that although the zinc had a purity of 99.8 per cent, the small percentage of impurity was an important factor in the successful growth of the crystals. In fact, it seemed necessary to have a small amount of Cadmium to grow single crystals by the Czochralski-Gomperz method. This suggested the possibility of using iron to help the growth conditions for single crystals by this method in preference to the cadmium.

The Czochralski-Gomperz method consists of drawing the crystals from the liquid metal. A glass tube (or copper wire) was immersed in the metal zinc and slowly but steadily pulled out. When the pulling was at a rate of about .5 centimeter per minute, the crystal was about 2 millimeters in diameter. Such a crystal had a so-called 90° orientation. With this as a nucleus for future pulling, any degree could be obtained by setting it at any desired angle when drawing the new crystal. The temperature was measured by means of a chromel-alumel thermocouple placed just under the surface of the liquid and read direct from a Leeds-Northrup manually operated indicator. The temperature of the liquid was controlled to within a degree by a series of heating units surrounding the crucible containing the zinc. The surface of the zinc oxidized rather readily, but could be skimmed off with a glass rod and the nucleus joining readily on the surface of the molten liquid if previously immersed in zinc chloride.

Crystals obtained by this method offered the possibility of studying not only the growth condition of various percentages of iron in the zinc, but also of getting some information of the structure by means of microphotographs. Because of the fact that iron has a very low solubility in zinc, it was necessary to use zinc extremely free of iron in order to measure the real effect. Bunker Hill zinc of extremely high purity was obtained. To check its purity, spectrograms were made on a 10-inch spectrograph and an analysis of its purity made by its comparison with standardized samples. Its resistivity was also measured as a recheck on the amount of iron present. It was found to contain no appreciable amount of iron and a very small amount of cadmium and lead. Because of the absence of iron, this zinc was found to be satisfactory.

To the pure zinc was added enough iron to make a .01 solution by weight. This was diluted down to make a .01 per cent sample; another, .0075 per cent; another, .005 per cent; and another .001 per cent. Spectrograms of each of these were made and growth effects on resistivity likewise made. A number of zinc crystals were grown by the Czochralski-Gomperz method for each concentration. The apparatus used in this is shown in the accompanying picture. Various temperature ranges were tried and limits of growth conditions determined. The crystals were placed in a 6-normal solution of hydrochloric acid for two minutes (other weaker solutions were tried but this proved the most satisfactory). They were maintained with the light falling on them at an angle of



Figs. 1 and 2.—Apparatus used in studying crystals.

about 30° with the horizontal. The microcamera used was a Zeiss mounted on a Spencer, No. 3 microscope with an apochromatic operation giving a magnification of ×80. Supersensitive panchromatic-cut films were found to be most satisfactory. For some of the work a Spencer metallurgical microscope with a direct illuminator and a short mount objective was used. This was found quite satisfactory primarily because the illumination was more uniform and the angle of illumination was constant.

The following table shows the growth conditions for the several percentages of iron used.

Table I

Per cent of Iron in zinc	Orientation (Degrees)	Range of growth (Degrees C above M. P.)
.0010	0 to 10 10 to 50 50 to 70 70 to 90	10 — 40 10 — 20 uncertain 10 — 40
.0050	0 to 10 10 to 50 50 to 70 70 to 90	10 — 35 10 — 20 10 — 15 10 — 40
.0075	0 to 10 70 to 90	10 — 30 10 — 30
.0100	0 to 10 70 to 90 75 to 90	10 — 20 10 — 20 10 — 20

The values given in table I are only approximate. Within these ranges over 50 per cent of the crystals attempted were successful. Outside of this range much less than 50 per cent were successful. In general, when .01 per cent iron was added to the zinc there was a wide range of growth conditions. For 0° to 10° orientation, the temperature range was extremely wide, being from 10 to 40 degrees above the melting point of the zinc. While this was also true of the 70° to 90° orientation, that is to be expected, for 90° are always easiest to grow. When crystals were started at an orientation of 50° to 70° they would grow only a short distance and then slip to a 0° crystal. This almost never happened when cadmium was used.

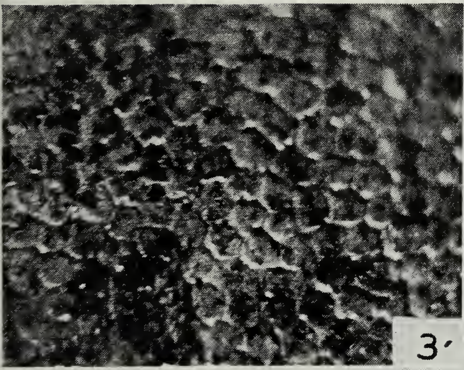
For .0050 per cent iron in zinc, the growth conditions were narrower (10° to 35° above the melting point for 0° to 10° orientation) but still retained a reasonably wide range at low and high orientations.

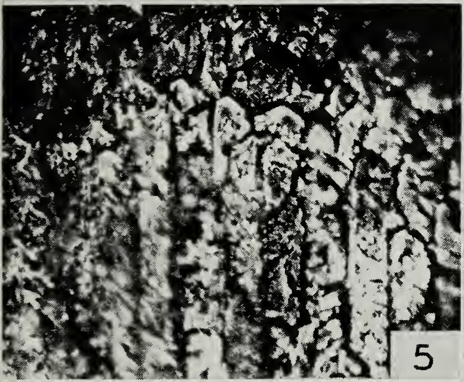
For .0075 per cent iron in zinc, the growth conditions narrow down considerably and not enough crystals were obtained between 10° and 70° to make a definite statement.

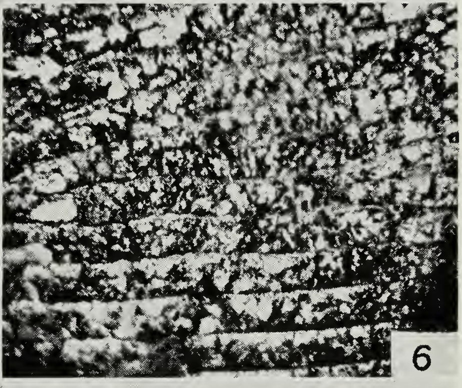
For .01 per cent iron in zinc, the conditions are extremely narrow and many mosaics were obtained.

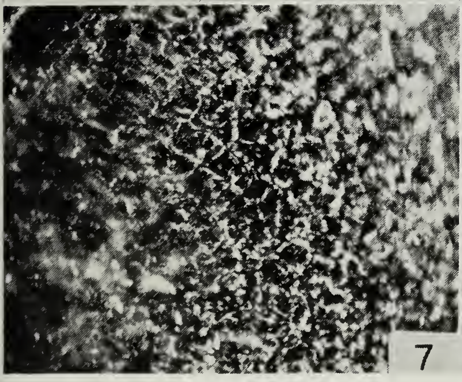
General Discussion

As the iron goes into the solid solution of zinc in the lattice of the single crystal, it might go in two ways. First, the crystal might throw out pure zinc until the concentration of the iron became sufficiently great to throw in a layer of pure iron, or second, the iron









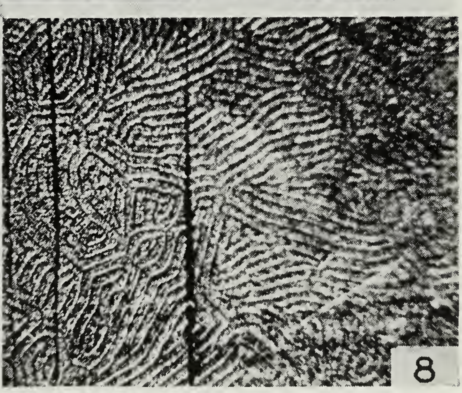


Fig. 3 shows a cross section of a single zinc crystal containing .0010 per cent iron in zinc. This microphotograph shows a hexagonal structure that is very definite.

Fig. 4 shows a cross section of a single zinc crystal containing .0075 per cent iron in zinc. While the hexagonal is observable in scattered places, it is not nearly so distinct as Fig. 3.

Fig. 5 shows a cross section of a single zinc crystal containing .0100 per cent. The hexagonal structure is definitely beginning to break down.

Fig. 6 also contains .0100 per cent iron, but is probably a mosaic instead of a single crystal.

Fig. 7 also contains .0100 per cent iron, but little or no definite structure is observable.

Fig. 8 also contains .0100 per cent iron, but is definitely not a single crystal.

might replace the zinc atoms in the lattice. Normally, the zinc crystal is of the close packed hexagonal type while the iron is the body centered cubic. If the iron tended to throw in a layer of different crystalline structure the crystal would probably not continue as a pure single beyond that point. This would explain why a higher concentration of iron makes it difficult to grow single crystals. It does not, however, explain why the presence of a small amount seems to be necessary for a single to start. It seems more reasonable to believe that up to a certain concentration (probably not more than .005 per cent) an iron atom replaces an occasional zinc atom in the lattice and the resultant crystal is of the close packed hexagonal type with some distortion.

Acknowledgment

The authors wish to acknowledge the considerable help given by Miss Marian Palmer in the growing of the crystals.

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Papers In Psychology And Education

Extract From the Report of the Section Chairman

This Section carried five papers, four of which are herewith published. The other was entitled:

Student activities in the Junior College, by Walter Wilkins, Springfield Junior College, Springfield.

Twenty persons attended the meeting and elected as chairman of the 1940 meeting *Jordan T. Cavan,* Rockford College, Rockford, Illinois.

(Signed) Harold S. Carlson, *Chairman*

SOCIAL FACTORS DETERMINING TRENDS IN WESTERN COLLEGES

Jordan T. Cavan

Rockford College, Rockford, Illinois

This report summarizes some of the points in a study of western colleges concerning the social conditions which account for their founding, their waxing and waning, their deaths. Begun in 1936, by an educationist trained in history and social science, and a research social psychologist, the materials so grow in bulk as to make analysis increasingly tedious and fascinating. Studies of social trends and attitudes had existed, studies of single colleges or single college problems; to put all this into meaningful patterns is the current task.

Why was each college founded, why did it die? (unable to find lists of defunct institutions, we had to begin to construct one *de novo*!) What patterns of colleges grow, what patterns decline, and what social trends dominate each decade of change? This is the task at which we are trying some preliminary spade-work. A few too-much-compressed instances follow:

Motivation in Personal and Corporate Ego-projection.—Colleges, our data indicate, primarily reflect ambitions for prestige, power, and growth; reflect beliefs so strongly held that one doubts not that all men must come to believe so too; reflect the faith that to get the mass of men to believe as you do or center their activity where you are, the best way is to train up the young (who will become leaders) to look up to your belief or your place. College foundations are the attempt to capture the future. Hence they are resistant to disaster and death beyond most human projects; they are super-kinetic with the vigor of sublime faith (or fanaticism). The ambitious man, the ambitious community, the proselytizing sect all find the college a way to indelibly mark the future through its leaders with their work, a way to gain deathlessness, ego-fulfilment. If modesty or sophistication should inhibit so bold a position, the same result follows—one must struggle to protect the future from capture by one's rivals—men, towns, or sects!

The *typical* college foundation combines the drive of a man, a place, *and* a belief, to a place in the sun; the summation of the three makes rashness and courage one, makes effort almost superhuman, makes for utter devotion like that to the state in wartime. Struggle and casualties, defeat and disaster result, but also victories and heroes for future generations to sing.

Social Trends and College Trends.—Why, from decade to decade of 1800-1920, does one type of college wax and another wane? What social changes occur alongside the change in higher education? Some examples: In urban-rural rivalry, the balance of power shifts, accordingly resources and leadership, accordingly those college patterns that are attached to each party. For 1830 and 1930 let us say then and now. Then young students, typically theological, must be kept away from the raw temptations of cities, then the rural college loudly boasted its advantage. Now, specific training for upper-level occupation is done (or overdone?) and enrollment piles up in mammoth urban giants. (For Presbyterians, little Franklin then, now metropolitan Western Reserve and Pittsburg.)

Land policy changes, thus changing the speed and type of settlement; patterns of college and academy follow. (Consider Oxford and Miami; Oberlin and Knox.) Land policy, as well as Andrew Jackson, can spread "democratic ways of feeling;" and a more democratic policy with widely diffused places of training follows. The Federalist officeholder in silk stockings (one of "the best people") is supplanted by the Jacksonian man-of-the-people, rotating in office. Soon public opinion emphasizes the spread of institutions rather than restriction to get higher standards; the denominational policy of one-college-to-a-state weakens, and every academy-with-ambitions calls itself college or university, every conference or synod considers founding an institution of its own. The Methodists, without colleges at 1830, in a decade or two (I quote) "spray colleges over the map," and most of them live.

With the spread of democratic feeling every occupational group, religious group, racial group, even that minority, women, demand their institutional chance at higher education, a place in the sun for their children. Manual-labor schemes make more possible education for sons of poor workingmen and small farmers, and old-line colleges training ministerial candidates fall in line; farmers' high schools and colleges, normal schools, mechanics' institutes, courses without classical language or with science multiply. New schools appear in sects, previously of the humble folk, who believe in a clergy "called of God, not made in factories," the expensive, long training in college and theological seminary.

Technology, Transportation, and Trade.—First the pack animal, then flat boat, Conestoga wagon, canal, steamboat, railroad, interurban, and now the motor vehicle move people and goods to the West. Study the map of college foundings. First on and near the rivers (Oxford, Marietta, Miami; Vincennes and Hanover, Alton and St. Louis); then along the staked-out lines that became the National Road (Ohio Wesleyan, DePauw, Illinois Wesleyan, Illinois Normal, Indiana, Ohio State—state capitals marched the same northward route); then the lake ports and their hinterlands (Western Reserve, Ann Arbor, Beloit, Northwestern); then the railroad routes (and the college which was earlier located a dozen miles off the route must die, move, or merge). Today intersections of main auto and rail routes seem best places for a college to grow—this includes the major cities automatically.

Dependent on this shift from Ohio River to Erie Canal and Great Lakes is the shift in dominance among groups of colleges. The earlier strong colleges tend to be on the river. Franklin yields to Reserve, Oberlin, Wooster; Hanover to Wabash; Blackburn to Chicago University; McKendree to Northwestern in enrollment and resources despite the prestige of age. The Episcopalians transfer from near Cincinnati northward to Gambier; Farmers' College, near Cincinnati, loses out to Columbus as the Land Grant location.

Dependent on changing best-routes-for-trade is the rise and fall of the commercial empire of the trading cities. Cincinnati falls behind Cleveland; Louisville, St. Louis and Alton behind Chicago; in countless lesser trading centers conflicting ambitions win, or lose. Where people no longer come to trade, they tend no longer to send their children to school. College expansion follows the wealth and prestige piled up at the victorious centers.

Changes in Control.—Early small educational units, largely dominated by a devoted or forceful man, yield to those controlled by small area, community, or sectarian groupings, finally to mammoth units representing the whole force of a state or a metropolis; the major leaders of commerce or government can say yea or nay to questions of basic policy, since they only can capture the huge sums required; internal control passes from a small faculty group (almost all ordained men who also sit in Council, Synod, or Conference) to imposing Boards of lay trustees, leaders of business in rising metropolitan centers. Presidents, first, are individuals and orators, and exemplify the virtues of the clergy; later, skilful administrators and harmonizers of complex institutions with the virtues of the captains of modern industry. In the same generations, the organization of business and government has changed in the same direction that college organization has.

Colleges conform to the principles controlling their constituencies. One pattern appears in the college of 1830 whose future depends on gifts (and wise men) from the East; another pattern in those rooted in the grass roots at home; high standards and permanence through endowments is the slogan of one party; democratic accessibility of opportunity and mushrooming enrollments of any sort of student is the slogan of the other. The debates of the Whigs and the Democrats are echoed in college history.

Other trends can be but mentioned. What divides the community splits and multiplies colleges. Denominations splitting into sects means a college in the area for each sub-group (from a Plan of Union college comes a Congregational *and* a Presbyterian institution; then an Old, a New, a United, a Cumberland, are all needed by Presbyterians. Free Will

Baptist college duplicates Baptist college, and so on. When theology becomes less divisive than slavery, pro-slavery and anti-slavery groups must each have a college. If this college will admit no women, found another that will, then the first group will start a woman's institution in self-protection. New social values, new occupations aspiring toward professional status, new sciences and arts and languages create widened college offerings, and also new colleges. As the community looks to new sources for its leadership new channels to train leaders are created too. As wealth (and hopes of wealth) wax, the volume and places of higher education follow upward. College trends and patterns seem to float on the tide of changing community values and trends.

THE EDUCATION OF DEAF CHILDREN BY THE ACOUSTIC METHOD

D. T. Cloud

Illinois School for the Deaf, Jacksonville, Illinois

The education of deaf children in the Illinois School for the Deaf by the Acoustic Method is not a recent innovation. Attempts or endeavors along these lines are recorded in the reports of the superintendents of the school as far back as 1894, when the first permanently organized class was formed. Encouraging results of these early efforts were recognized. No satisfactory reason is presented as to why this phase of our special educational work was not continued as a part of the definite policy of the school. I assume our predecessors found the equipment inadequate for the purpose and probably too cumbersome in construction for continued successful use. Recent advances in radio, acoustic and electrical engineering warrant, in our judgment, renewed efforts to re-establish confidence in this method of instruction.

There has been a good deal of loose talk and thinking about acoustic education—its aims and purposes. Sharp differences of opinion have been expressed as to its real merits and its place in an educational program designed for deaf children: a disagreement as to how intensively and how extensively this kind of education should be carried on in our schools. There ought to be an attempt made to reconcile these conflicting views. I am happy to have the opportunity of submitting the plan adopted and the policy followed for acoustic education in the Illinois school. We believe in acoustic education and wish to reiterate what we have said about it previously—i.e., "Schools for the deaf failing to provide such training are not doing all they should for their pupils."

Dr. Max A. Goldstein, Director of Central Institute for the Deaf, St. Louis, Missouri, defines the Acoustic Method as follows: Stimulation or education of the hearing mechanism and its associated sense-organs by sound vibration as applied either by voice or any sonorous instrument. This definition is, for our purposes, at least, wholly satisfactory and acceptable. A former superintendent of the Illinois school stated, many years ago, the purpose of acoustic education was "to secure for them (the pupils) such instruction as they would receive in the ordinary schools, were they able to receive it in the public schools." This principal objective holds good today; it is the end we are striving for in our own work.

Our present organization and program of acoustic education had its beginning in 1931. A class of eight young children was organized for the purpose of testing the practical usefulness of an instrument known as the Teletactor, devised and designed by Dr. Robert H. Gault of Northwestern University. This instrument consisted of a high fidelity microphone at the teacher's desk; a powerful amplifier; an electromagnetic receiver and vibrator for each child; a microphone fixed to each pupil's desk; and a set of ear-phones for each child. The progress and the results obtained from this experiment were from time to time reported upon in the professional literature. I shall not take time now to elaborate upon these reports. I do want to say, however, the opportunities to observe what might be done through hearing, through seeing and through feeling led to further study and experimentation. We thoroughly investigated and tested at least a dozen different makes and types of hearing aids. Every instrument had commendable features; none of them had all we desired. We accepted for use the type we believed would best serve our purposes. Extensive use of hearing aids began in the fall of 1936. The pupils were tested and classified. A year later a newly completed combination dormitory—school building was equipped for the purpose. We were traveling a road we knew had innumerable pitfalls; but one which we felt, none the less, led to a constructive educational program. We are succeeding.

Approximately 150 pupils are now under instruction in this department. Twenty-six of these children have come to us from schools for hearing children. There is a multiple hearing aid in each classroom and every pupil in the department has a set of air conduction earphones with the exception of eight, who prefer the bone conduction type. The pupil recorded as having the greatest amount of hearing has a thirty-five decibel loss in the speech range.

Thirty-four children in the group are not making satisfactory progress. They are considered to be "acoustic failures" and will be transferred to other classes next semester. We believe their places will be readily filled by other pupils now in school and from the new children entering next Fall. Thus approximately twenty per cent of the entire school population is being educationally benefited by the use of hearing aids.

You may logically ask: What types of deaf children in the school are receiving this kind of education? There are three general groupings, classified as follows:

(1) Hard of hearing children.......... Congenital and adventitious.

(2) Adventitiously deaf children....... Those in whom the loss of hearing is due to disease or accident. These children are totally deaf within the speech range.

(3) Children who had always been considered to be deaf or who had lost all apparent usable hearing before normal speech and language patterns were acquired.

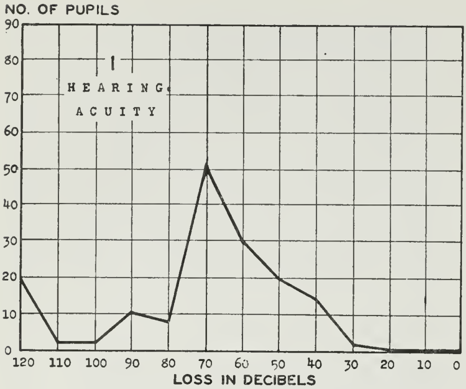
See graph 2 for distribution of types.

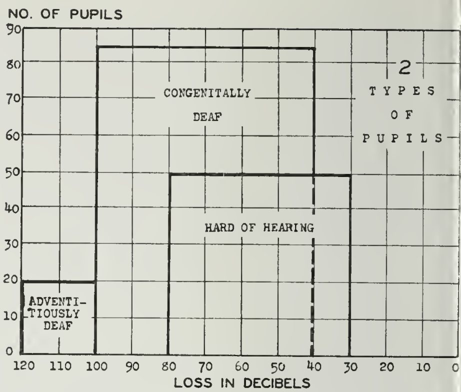
There are forty-nine children in the first group. Their hearing was partially trained. This had enabled them, before entering the department, to acquire some speech and some language, the quality of which, however, in many cases was poor. Nineteen children are in the second group. They acquired speech and language before loss of hearing. Their educational problems are very similar to those in the above group—especially the adventitiously hard of hearing. This type of deaf child is usually found to be living an isolated life in our schools for the deaf. Nothing can be done to train his hearing. He must get everything from sight and reading. Eighty-three children are in the third group. These pupils did not have the ability to understand speech through hearing when they came to the school. They were selected on the basis of their hearing acuity as disclosed by audiometric tests. See graph 1 for results of these tests.

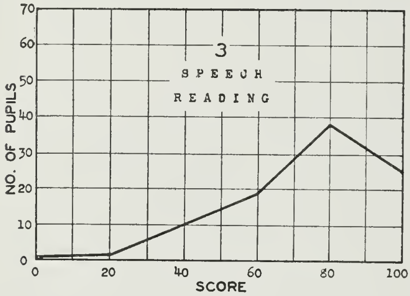
To determine the effectiveness and the efficiency of our policy, a five point testing program was set up. This program includes: (1) Drill vocabulary; (2) Speech intelligibility; (3) Acoustic understanding; (4) Acoustic understanding with speech reading; (5) Speech reading.

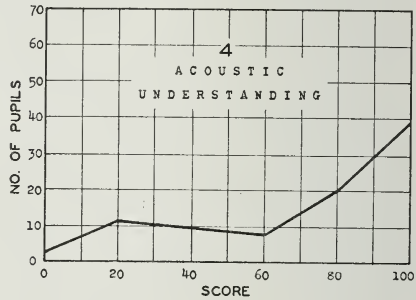
The drill vocabulary was developed through the use of several word lists. Horn's, as published in the 24th Yearbook, Dolch's, as found in the 36th volume of the Elementary School Journal (1936) and Thorndike's—First 2500 Words, were the most helpful.

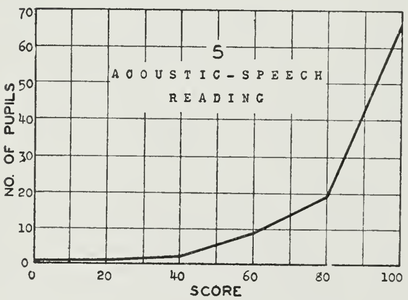
Speech intelligibility tests were administered by two members of the faculty, assisted by four auditors. The auditors wrote what they understood the children to say. Every child tested was given ten unrelated sentences to read aloud. Each sentence was read three times. Two of the auditors were permitted to look and listen. The other two auditors were permitted to listen only. The tests were scored on the basis of 100 per cent for the ten sentences. Ten points credit was allowed for each sentence read correctly the first time. Five points credit was allowed when the sentence was read correctly on second

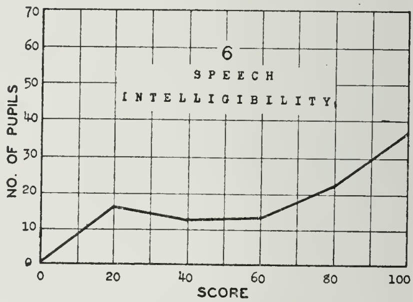












trial. Two points credit was allowed when the sentence was read correctly on the third trial. The following are some examples of the sentences used for this purpose:

(1) My folks will come for me in the car.
(2) Our dog sleeps all of the time.
(3) Everyone was frightened when the lights went out.
(4) What time will you be ready?
(5) Do you live on a farm?
(6) The girl saw her friend on the street yesterday.

Graph 6 shows the results of this test.

The test for acoustic understanding (hearing) was administered by two people, each of whom read ten sentences to the children. The pupils, in this test, put down on paper what they heard the examiners say. The examiners' faces were covered. The children had to depend entirely upon hearing. Graph 4 shows the results of this test.

The next test was given in a similar manner, excepting the pupils were permitted to look at the faces of the examiners as well as listen to them. You will find the results of this test interesting, as shown in graph 5.

The last test was given by the same examiners. This test was similar to that usually applied in determining the proficiency of pupils in speech reading. Graph 3 shows the results of this test.

As already stated, the principal objective is to develop a well-rounded program of instruction through the training of hearing. Nearly all formal classroom work is preceded by acoustic drills on the important vocabulary and language patterns involved. The pupils are receiving what we choose to call a "hearing vocabulary" for each subject studied. This is especially true in the primary and intermediate grades. Our program for the classes in the upper grades is not so well organized. Most of the pupils in these classes were in other divisions of the school for several years before the acoustic department was established.

EYE-MOVEMENTS IN READING MUSIC

O. Irving Jacobsen

Shurtleff College, Alton, Illinois

Abstract

So far as it has been possible to ascertain, there have been very few experiments made of the photographing of eye-movements in reading music. In fact, only two such studies have been found, one by a student at Leland Stanford University, and the author's own study at the University of Chicago. Since having made this particular study, however, the author has completed four other experiments in music-reading, one of reading rhythm; another of pitch; a third of reading vocal music; and a fourth, a combination of reading problems. The results of these five studies indicate the reading habits of the immature, average, and the mature readers and the development necessary for the immature reader for improvement and progress.

In describing how the eyes move while reading music, reference was made to the number of pauses made in reading a line or selection, and also to the length of these pauses (in 25ths of a second) or average length of pauses. Naturally, less time is required by the reader who can reduce the number of pauses or the length of pauses, or both. Also, regressive or backward movements of the eyes retard reading and indicate confusion in reading. The mature readers will therefore have fewer pauses, of short duration or length, few or no regressive movements, and the quality of reading will be indicated by few or no errors in reading. Both vocal and instrumental music were read by the subjects.

Chart I (not shown here) merely indicated the manner of recording the vertical and horizontal movements from the films, how they were synchronized, and how these results were transferred to the musical score. This selection consisted of instrumental material of whole notes.

Chart II (not shown here) indicated the eye-performance span (distance the eye preceded performance) for both mature and immature readers, and for one- and two-part selections. An attempt was made also, as shown in Chart II, to determine the width or extent of the span of recognition.

Four examples of reading shown in Chart III (fig. 1 of this article) are by the same subject, a mature adult reader. Example A shows the reading of the Latin syllables (do, re, mi). In this entire selection there were 40 notes, the reading of which required 27.68 seconds of time; 68 pauses; and in which two errors were made. In Example B, the same selection was again sung, but with the words, and the results were as follows: time, 15.84 seconds; 53 pauses; and no errors.

In the reading of Example C, the words were sung directly (excluding the Latin syllables first) and requirements for reading the selection of 38 notes were as follows: time, 16.92 seconds; 59 pauses; and no errors. Examples A and C contain almost the same rhythm, the same pitch intervals, and hence they can be

considered to be of the approximate same difficulty.

In the reading shown in Example D, the subject was permitted to read the printed words prior to performance of the singing. This selection contained 37 notes, the time required for reading was 14 seconds, with 52 pauses and no errors.

In general, all of the subjects tended to make nearly the same number of errors, when reading the words directly, and to require no more time or even less, with no more pauses, *than* when the Latin syllables had been sung prior to singing the words, as is the practice in school music to-day. Although fourth grade subjects were the youngest included in this experiment, it can be concluded that the Latin syllables, or some other form of pitch association, can be discarded, and need not serve as a crutch throughout the elementary school period; also, that it is a good plan to read the printed words prior to singing, as this reduces the number of errors as well as the amount of time required for reading. When the words were read prior to the singing, it is interesting to observe that less than one-third of the total time required for reading was given to the words and two-thirds to the notation, whereas otherwise it was about one-half of the time to each.

Chart IV illustrated the eye-movements of an immature and a mature reader in performing part of a four-part instrumental selection. Chart V also showed the type of reading of the mature and immature readers, for instrumental scale runs and arpeggios.

The conclusions drawn from the experiment can be summarized briefly. The number and length of the pauses, and the number of errors and regressive movements in reading, indicates the ability of the subject, and the aim for improved reading habits should be to read by phases or groups of notes and not to continue to read note-wise as beginners must necessarily do. The presentation and arrangement of the reading material is extremely important, a fact often overlooked in school music materials. Recognition and familiarity with the staff degrees, and with the instrumental keyboard or with pitch relationship in vocal performance are essential for improved reading. A good reader should also have a very fast reaction time since reading involves not only quick recognition but also quick response.

PSYCHOLOGICAL FUNCTIONING OF THE ENDOCRINE GLANDS

Ralph W. Pringle

Illinois State Normal University

ABSTRACT

1. Dr. Hoskins, Head of Endocrine Research at Harvard University, is authority for the statement, that "the endocrinologists have shied away from the intangibilities of psychology," the result being that the psychological aspects of endocrinology have received little attention; that is, little use has been made of "hormones as tools for the sympathetic exploration of human personality."[1] Moreover, the secondary or social effects of glandular disturbances are seldom even mentioned in the literature of internal secretions.

However, from the first, endocrine research has contributed abundant proof to the proposition that psychic life proceeds on a physical basis. No one doubts that the glands are living chemical laboratories, and that their cells "communicate," as Dr. Carrell asserts, "by chemical messengers—that is, by the agency of their secretions."[2] Thus it comes about that our body, which is a heterogeneous complex of many elements, is in fact psychically unified and simple.

Our problem concerns the relationship of hormones, on the one hand, and intelligence, instincts and emotions, on the other. In this relationship, we should be able to find much fundamental and practical knowledge relative to human personality.

2. By the method of indirect approach, it has been discovered that the normal functioning of the interstitial cells of the sex glands, acted upon by the sex-stimulating hormone of the anterior lobe of the pituitary, furnishes the physical basis for initiative, stamina, enthusiasm, vigorous mental, emotional, and social responses, courage, and general effectiveness. Early maturation and dynamic personality are the psychic effects of hypergondism. The most dominating characters in history and fiction are represented as vigorously masculine or feminine.

3. In its direct and indirect functioning, the pituitary gland is extremely versatile. It influences the emotions directly and indirectly, hence is a potent factor in determining personality. Through the pituitary's influence on the interstitial cells of the sex glands, the thyroid and the adrenals, it indirectly affects psychic life. Abnormalities in growth and development, due to improper functioning of the pituitary-growth hormone, produce pathetic results in mental and emotional reactions and in attitudes; personality effects of acromegaly furnish

a striking illustration. But the direct influence of acromegaly is not the whole story; the boney distortions, massive repulsive face, overgrown feet and hands, and gorilla-like appearance act as powerful disintegrating psychic influences. In the early stages of the disease, there may be absentmindedness, irritability, lack of concentration, and moroseness. During the overactive period, there may be hallucinations of taste and smell. In the transition period, there is likely to intervene sluggishness, failing memory, apathy, sometimes stupor. Entire change of temperament is a common characteristic of acromegaly.

4. The relative size of the thyroid gland and its correlation with the brain suggest its unique psychic functioning. The thyroid hormone acts as a fulminate to speed up oxidation, thus giving rise to increased physical and mental activity; that is, the thyroid may be thought of as a controller of short wave radiation, which means that the thyroid is often the basis of more intensive living.[3]

The results of hyperthyroidism are abnormal nervous tension, and a high degree of mental and emotional activity. The outward symptoms clearly betoken marked inner nervousness: meaningless tears and laughter, restlessness, continuous purposeless movements, dissociation, hallucinations, and extreme confusion of thought.

On the other hand, when thyroid secretions are seriously lacking, the mental reactions are listlessness, lack of instinctive drives, colorless emotional life; that is, essentially no personality. Personal adjustments are extremely difficult or impossible. The psychic effects of mixedema are forgetfulness, failing power of concentration, indecision, discontent, mental and emotional depression, various delusions, helpless mental and emotional confusion. The victim may become suspicious, untruthful, and abnormally self-centered.

5. Adrenine, the secretion of the medulla of the adrenal glands, is a powerful stimulant; in cases of complete collapse or shock, it is the only agency that will bring about resuscitation. According to Dr. Crile, "No other drug, no other hormone, no other stimulant, not even electricity, can effect the resuscitation of an apparently dead animal."[4]

Under conditions of quiet existence, adrenine plays only a small part in the processes of life, since ordinarily the blood stream contains little adrenine. Anger, pain, fear, and extreme emergencies are among the initial causes of medulla activity. Dr. Cannon's "emergency theory" furnishes an explanation of our ability to meet life's crises and to cope with situations demanding supreme physical and mental exertion. The psychology of this unique functioning is evident: repeated successes in dealing with unexpected difficulties builds an attitude of self-reliance and a feeling of security. Thus as Hoskins asserts, adrenine is "a factor in the maintenance of temperamental wholeness."

Under-activity of the adrenal cortex gives rise to a lack of energy, depression, irritability, lack of coöperation, and insomnia; these are the early symptoms of Addison's disease. As the disease advances, mental symptoms become marked; the victim finally goes into convulsions, followed by death. With the administration of cortin, the hormone of the adrenal cortex, all symptoms disappear, and the patient returns to normal physical and mental condition. Moreover, normal subjects suffering from tension due to overwork often receive prompt relief by using cortin; their irritability is reduced, their sleep is improved, and they experience a sense of physical and mental well-being. "Cortin would seem to be the ideal physiological cocktail." (Hoskins).

There have been numerous cases of enlarged cortex followed by accentuated virility; these cases may occur in either sex; hence the adrenals are frequently called "glands of masculinity."

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[1] "Physiological Factors in Personality," *Occupations, the Vocational Guidance Magazine*, May, 1936.

[2] *Man, the Unknown*, Alexis Carrell, pp. 102-104.

[3] Crile, G. W., *The Phenomena of Life*, pp. 138, 141.

[4] Crile, G. W., op. cit., p. 28.

PAPERS IN ZOOLOGY

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

This Section carried 26 papers, 12 of which are herewith published. The others were entitled:

Insect vectors of disease in Illinois, by C. L. Metcalf, University of Illinois, Urbana.

Life histories of ticks, by Philip C. Stone, University of Illinois, Urbana.

Rocky Mountain spotted fever in Illinois, by W. H. Tucker, Commissioner of Health, Evanston.

Animal tumors as test objects in cancer research, by Perry J. Melnick, Chicago.

Histamine and pepsin stimulation, by G. R. Bucher, Mundelein College, and A. C. Ivy, Northwestern University, Evanston.

Studies on the structure and biology of the pigeon mite Hypodectes, by Paul C. Beaver, Lawrence College, Appleton, Wisconsin.

Some aspects of atypical ovogenesis in Valvata, by C. L. Furrow, Knox College, Galesburg.

Notes on Illinois leeches, by Marvin C. Meyer, University of Illinois, Urbana.

Some nesting records for Ohio and Illinois birds, by W. V. Balduf, University of Illinois, Urbana.

An aberrant Cliff Swallow, by Kenneth L. Knight, University of Illinois, Urbana.

How common are mammals? by Carl O. Mohr, State Natural History Survey, Urbana.

Land use and wild life management. by Harry E. Gearhart, Department of Agricultural Soil Conservation Service, Edwardsville.

Some observations on Mosquito Fish, Gambusia affnis (Baird and Girard) in the Chicao area, by Louis A. Krumholz, University of Illinois, Urbana.

An experiment in conducting laboratory work in zoology classes, by W. M. Gersbacher and Charles Mayfield, Southern Illinois State Normal University, Carbondale.

Average attendance at each of the two Section meetings was 30.

Those present elected as chairman of the 1940 meeting *Wilbur M. Luce,* Department of Zoology, University of Illinois, Urbana, Illinois.

(Signed) M. T. TOWNSEND, *Chairman*

THE RELATIONSHIP OF BODY SIZE AND EGG SIZE IN DROSOPHILA

HAROLD J. EIGENBRODT, *North Central College, Naperville, Illinois*

and

PAUL A. ZAHL, *Haskins Laboratory, Schenectady, N. Y.*

Introduction.—This paper presents a study of the relationship of body size and egg size, and body size and rate of egg laying of a homozygous red, forked, bar stock of Drosophila.

Materials and Methods.—All flies were raised at a temperature of 27° C. The large flies were obtained by giving the developing larvae optimum conditions of space and food, while the larvae of the small flies had insufficient moisture, food and space.

The size of the flies was determined by measuring the length of the thorax. In a previous paper (Eigenbrodt, 1930) it was found that such measurements are reliable indices of the size of flies. Single pairs of these flies were placed in eight dram homeopathic vials. Glass rods which had previously been dipped in banana agar and afterwards inoculated with a solution of compressed yeast were inserted into these vials and these were changed daily. Daily egg counts for each female were made, and size determinations were made of those eggs which were in a horizontal position.

Experimental Data.—Table 1 gives the mean egg lengths of all of the flies used in these experiments. A total of 2619 eggs were measured.

TABLE I—COMBINED DATA SHOWING RELATIONSHIP BODY SIZE AND EGG SIZE IN DROSOPHILA (IN MICRONS)

Size of flies	Number of flies	Number of eggs	Mean egg length	Standard Deviation
1035	23	1390	506.5±0.2	11.6
659	20	1229	503.8±0.3	14.9

The data show that there is an average difference of 376 microns in the thoracic lengths of large and small flies, but there is only an average difference of 2.7 ± 0.4 microns in the egg lengths of large and small flies, the large flies having the slightly larger eggs. Although these mean differences in egg lengths are small, yet they are nearly seven times larger than the probable error of the mean differences, and so might be considered significant. Warren, 1923, while working on the problem of the inheritance of egg size in Drosophila, made some preliminary observations on the relationship of body size and egg size and he concluded that there is no correlation between the size of the female and the size of the egg she lays. Although one cannot positively say that the large flies lay larger eggs than the small flies, one can draw the conclusion that the small flies lay eggs which vary more in size than the eggs of the large flies, for the standard deviation (a measure of variability) of the eggs of the large flies is only 11.6 while that of the small flies is 14.9.

Table II, which shows the body size and egg size relationship of ten large and ten small flies taken at random from those flies which had the largest number of egg measurements, also indicates that the egg size of the small flies is more variable than that of the large flies. The egg lengths of the small flies varies from 492.4 to 508.5 microns, a difference of 16.1 microns, while the egg lengths of the large flies varies from 504.8 to 508.0, a difference of only 3 2 microns.

The relationship of body size and egg laying rate was also determined and results are shown in table III. The large flies laid an average of 24.5 eggs per day for each fly while the small flies laid an average of only 15.48 eggs per day, but unexpectedly, the small flies averaged 15.66 egg laying days, while the large flies averaged only 11.08 egg laying days.

TABLE II—BODY SIZE AND EGG SIZE RELATIONSHIPS OF INDIVIDUAL DROSOPHILA FLIES

Large Flies				Small Flies			
Size of flies	Number of eggs	Egg length	Standard deviation	Size of flies	Number of eggs	Egg length	Standard deviation
1010	134	504.8±0.8	13.2	687	102	492.4±1.2	18.1
1010	69	505.7±1.0	11.8	768	97	497.8±1.2	17.2
990	102	506.1±0.7	10.2	707	104	500.9±1.2	18.3
1030	91	506.7±0.8	11.5	687	121	503.0±0.7	11.7
1010	76	507.1±1.0	12.9	747	61	503.5±1.0	11.9
1151	39	507.1±1.1	10.3	606	67	504.9±0.8	9.2
990	94	507.2±0.8	11.4	687	70	505.6±0.8	10.1
1131	68	507.5±0.9	10.6	687	76	505.8±1.4	18.0
1010	112	507.7±0.8	12.7	586	64	507.4±0.7	8.5
970	64	508.0±0.7	8.5	727	140	508.5±0.8	14.5

TABLE III—RELATIONSHIP OF BODY SIZE AND EGG LAYING RATE IN DROSOPHILA

Average size of flies	Number of flies	Average number of eggs per fly	Average number of egg laying days	Average number of eggs per day
1010	24	271.5	11.08	24.50
719	15	242.5	15.66	15.48

Thus the small flies outlive the large flies. Alpatov, 1932, found similar results with the wild stock of Drosophila and he states that "a negative correlation was found between the duration of life and the average egg production (per day for the whole producing period)".

CONCLUSIONS

1. Large flies lay eggs which are slightly larger than the eggs of small flies. However, these differences may not be great enough to be significant.

2. The small flies lay eggs which show greater variability in size than the eggs of large flies.

3. The small flies lay fewer eggs than the large flies but they live longer than the large flies.

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EQUINE ENCEPHALOMYELITIS

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ABSTRACT

A widespread disease of horses and mules occurred in the San Joaquin Valley of California in 1930. The disease reappeared in 1931. Clinically, the malady presented a syndrome resembling many previously unidentified epizootics of horses recorded in the veterinary literature during the past 70 years. Clinicians commonly referred to these outbreaks as cerebrospinal meningitis and forage poisoning as well as Kansas horse plague. However, the etiologic agent was not identified until Meyer, Haring, and Howitt[1] of California recovered a filter-passing virus from the brain tissue of naturally affected horses in 1931. The California investigators also studied the pathology of the disease and suggested the name encephalomyelitis, in keeping with the inflammatory changes found in the brain and spinal cord.

In 1931 a similar outbreak occurred among the horses in Nevada where Records and Vawter[2] recovered a filter-passing

virus resembling the California strain. Two years later (1933) a virus equine encephalomyelitis was studied along the eastern seacoast by TenBroeck and Merrill[3] and by Giltner and Shahan.[4] Immunologically, the equine viruses encountered in the western and eastern seacoast states proved distinct entities and the geographical designation of the two diseases as eastern and western virus types of encephalomyelitis was adopted through common usage.

Western Type Virus in Illinois.—Two hundred and fifteen practicing veterinarians reported more than 6,000 cases of equine encephalomyelitis in 85 Illinois counties in 1938. In two counties clinical cases were observed during June and similar observations were reported in 19 counties during July. The disease spread rapidly and appeared in 51 counties during August and September. The mortality reported in 6,033 affected horses in Illinois was 25.44 per cent or 1,535 animals, representing a death loss of approximately $150,000. Cases were reported on 4,802 premises with an average of one plus cases per infected herd. The greatest number of horses affected on a single farm was six. More than 70,000 horses were vaccinated, with a mortality of less than two-tenths of one per cent. In some Illinois localities during the 1938 outbreak 28 per cent of the horse population was immunized. The Division of Animal Pathology and Hygiene, University of Illinois, in 1938 isolated and identified for the first time the western type virus in naturally affected horses from outbreaks in five different counties.

Summary. — An encephalomyelitis of horses associated with a filterable virus was first recognized in the United States (California) in 1931. Two years later a similar syndrome associated with an immunologically different virus occurred among horses on the eastern coast. These two virus types of the disease have now been reported in 39 states, and the incidence peak reached in 1938 was 184,662 cases in the 39 states.

The eastern type of the virus has not extended from the eastern seaboard states, though the western type of the virus has extended from California to the middle western and southwestern states. During the summer months of 1938 the western type virus appeared in 85 counties in Illinois with approximately 6,000 clinical cases. A mortality of approximately 25 per cent was noted. The economic aspects of this disease in agriculture are recognized as a serious menace to the horse industry, and in the light of recent knowledge equine encephalomyelitis has also become an important public health problem, as well as a disease of fowls.

An effective formalized chick embryo vaccine has been perfected for the immunization of horses. Employed as a prophylactic treatment by the veterinarian in 70,000 Illinois horses during the past year (1938), less than 0.2 per cent mortality occurred. On the basis of one year's results in the control of this disease in horses and mules, the outlook for the suppression of the disease by sanitary measures and immunization seems promising.

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VARIATION IN THE NUMBER OF SPINES AND RAYS IN THE FINS OF THE BROOK STICKLEBACK*

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The present study is based on counts of dorsal spines and fin rays in 10 collections of the brook stickleback, *Eucalia inconstans*. The fins examined included the left and right pectoral, the dorsal and anal. Counts also were made on the caudal fin in two collections. The spines and the rays in the fins all showed considerable variation as to number. In order to get a clear picture of this variation counts have been arranged in the form of frequency distributions.

The purposes of this paper are, (1) to show how the distributions in different collections differ from one another and (2) to point out, and then try to explain, the similarity of ray counts in the pectoral fins as a group and in the dorsal and anal fins as another group.

This study represents a side problem of the author's attempt to determine whether geographical races of sticklebacks might not be distinguished on the basis of statistical differences in number of spines and fin rays. That work had been suggested by the paper by Thompson (1931) who compared differences in mean ray number in the Johnny darter with varying water distances separating collections. The work of Hubbs (1922) and others who dealt with the effect of temperature of water during development on number of fin days was not considered at the time the earlier problem was being studied.

This study was carried on under the direction of Professor Charles Zeleny, to whom the author is much indebted for helpful suggestions. The author is also

* Contributions from the zoological laboratory of the University of Illinois, No. 529. This paper is based on the author's master's thesis. For a discussion of origin of fin rays the reader is referred to Goodrich (1930).

indebted to Dr. David H. Thompson, of the Natural History Survey, for suggesting the problem and for the loan of material from the Survey collections.

Variation in the Number of Dorsal Spines and a Description of an Abnormality in Spine Development

Frequency distributions for dorsal spines are shown in table 1. Thompson (1931), page 280, found a variation of from 3 to 7 spines in the stickleback. In the present study the number of spines was found to vary from 2 to 7 while the number most frequently counted was 5. Among the different collections the percentage of fish having 5 spines varied from 71 per cent in Series I to a maximum of 89 per cent in Series VIII.

In all individuals examined (about 2,200) a count of 2 spines was observed once, 3 spines four times and 7 spines five times. About 98 per cent of the individuals had counts of 4, 5 or 6. Usually 6's were several times more frequent than 4's but with the following exceptions. In Series I and II, no 4's at all were observed, while in Series VIII 4's and 6's were found in equal numbers.

A certain abnormality in dorsal spines was observed a number of times. The spines in the stickleback are not connected with one another by a webbing as in most of our other fishes, but they are nevertheless raised and lowered together. When the spines are lowered each of them fits into a depression and is about flush with the dorsal surface. The abnormality in question was that sometimes an individual spine, which at first appeared to be missing, could be found lying in a folded position covered over by a transparent layer of skin. When the covering was cut through, these spines could be lifted up, showing in some cases that the buried spines were of weaker build. A possible explanation of this abnormality is that the spines were developed in the folded position beneath the skin and remained in that position because the erector muscles possessed by these individual spines were too weak to push them through the skin. Another possible explanation is that they had been secondarily covered over by skin when the musculature was not strong enough to keep them in operation. Spines of this type were included in the counts.

Variation in the fins.—In the original description, Kirtland (1841), gives the number of rays in the dorsal and anal fins as varying between the limits of 9 and 12. In the present study, a still wider range of counts was observed. Rays varied in the dorsal fin from 6 to 12, in the anal fin from 5 to 13, in the pectorals from 4 to 13, and in the caudal from 8 to 14.

In table 2 is shown the frequency with which these different counts were observed. It will be noticed that 10 was the commonest number of rays found in the pectorals, the dorsal and the anal, while 12 was the commonest number found in the caudal.

Some Collection Differences in Frequency Distribution of the Fin Rays

The caudal fin.—Counts of the caudal rays were made on collections V and VI only. These collections were taken only a few rods apart, V in the Franklin Spring trout pond and VI in the stream immediately below the pond. The percentage of the catch having the modal count of 12 rays differed somewhat in these collections; 78 per cent of the pond fish had 12 rays while 88 per cent of the stream fish had 12 rays. In the pond fish, on the other hand, there was a much higher percentage of fish with 13 rays.

The pectoral fins.—In different collections the numbers of individuals with 9 rays and 10 rays were quite variable. The number of individuals with 11 rays also varied but within narrower limits. Among the 10 collections, the percentage of individuals with 9 rays varied from 4 per cent (X) to 31 per cent (VII); those with 10 rays varied from 62 per cent (VII) to 86 per cent (VIII); and those with 11 rays from 0 (II) to 16 per cent (X).

The distribution of low counts was far from uniform, some collections having no counts lower than 8 rays, other collections having rather numerous counts of 5, 6 and 7 rays (IV and V).

In all 10 collections it was found that 9's, 10's and 11's together comprised about 95 per cent of the counts. But the proportion of individuals with 9 rays to

TABLE 1—FREQUENCY DISTRIBUTIONS OF DORSAL SPINE COUNTS. THE TABLE SHOWS NUMBERS (IN PARENTHESES) AND PERCENTAGES OF INDIVIDUALS HAVING DIFFERENT NUMBERS OF DORSAL SPINES.

Collection number, location and date	Number of individuals	Number of Dorsal Spines					
		2	3	4	5	6	7
I. Spring 2 mi. N. of Evansville, Wis., Dec. 29, 1931	212				(151) 71.2	(59) 27.8	(2) 0.9
II. Allen's Creek 2 mi. N. W. of Evansville, Wis., Dec. 29, 1931	35		(1) 2.8		(29) 82.8	(5) 14.3	
III. Spring-fed creek at Evansville, Wis., June 17, 1932	59			(1) 1.7	(46) 77.7	(11) 18.6	(1) 1.7
IV. Franklin Spring Pond 9 mi. N. W. of Rockford, Illinois, Nov. 10 and Dec. 29, 1931	433			(10) 2.3	(370) 85.4	(52) 12.0	(1) 0.2
V. Franklin Spring Pond, Nov. 25, 1932	172			(5) 2.9	(140) 81.4	(26) 15.1	(1) 0.6
VI. Creek just below Franklin Spring Pond, Nov. 25, 1932	131			(2) 1.5	(110) 84.0	(19) 14.5	
VII. Spring connecting with south branch of Kent Creek 5 mi. W. of Rockford, Ill., Dec. 30, 1931	137	(1) 0.7	(2) 1.5	(7) 5.1	(105) 76.6	(22) 16.0	
VIII. Buffalo Creek 6 mi. N. of Sterling, Ill., Apr. 10, 1931	675			(36) 5.3	(602) 89.2	(37) 5.5	
IX. Oxbows along North Branch of Nippersink Creek, Richmond, Ill., May 22, 1932	352			(12) 3.4	(299) 84.9	(41) 11.6	
X. Dredge ditch 2 mi. S. of Harrison, May 3, 1927	81		(1) 1.2	(1) 1.2	(69) 84.9	(10) 12.3	

those with 11 rays was variable. Fins with 9 rays were 9 times as numerous as 11 rays in collection I, while 11 rays were more numerous than 9 rays in collection X.

For comparisons of distribution of pectoral counts in collections taken at points close together, the reader is referred to collections I and II, taken 2 miles apart on the same day at Evansville, Wis., and to collections V and VI, taken only a few rods apart on the same day at Franklin Spring. Differences of 10 per cent in the frequency with which counts of 9 and 10 appear will be noticed in these two comparisons.

Collections IV and V were made a year apart at Franklin Spring trout pond. The distribution of counts was considerably alike, although the collection made the second year had fewer pectorals with 10 rays, more with 9 rays, and many more with 8 rays.

The dorsal and anal fins.—These fins showed less variation in percentage of fish with 10 rays than were found in the pectoral fins. For the anal fins the smallest number counted with 10 rays was 47 per cent found in collection VII and the largest number was 63 per cent observed in collection VIII. A similar range was found in the dorsal fin.

As in the pectoral fins, the counts of 9 and 11 rays varied as to which number occurred most frequently. While in several collections 9's and 11's were found in nearly equal numbers, in collection VII, 11's were five times as numerous as 9's in the dorsal fin and 7 times as numerous as 9's in the anal fin.

Within the respective localities, the three collections from Evansville and the three collections from Franklin Spring show a number of fairly noticeable differences, particularly in numbers of individuals with 9, 10 and 11 rays. The two collections from the pond proper at Franklin Spring were not very much different, although rather large differences were found in the pectoral counts.

Comparison Between the Ray Counts of the Pectoral Fins as One Group, and the Dorsal and Anal Fins as Another Group

Examination of the frequency distributions in table 2 will show that counts of 10 rays were more common in the pectoral fins than in dorsal and anal. For

Table 2—Frequency Distributions of Fin Ray Counts. This Table Shows Numbers (in Parentheses) and Percentages of Individuals Having Different Numbers of Fin Rays. The Places and Dates of Collections are Supplied in Table 1

Collection	Fin	Number of individuals	Number of Rays										
			4	5	6	7	8	9	10	11	12	13	14
I	L. Pect.	212		(1) 0.5	(1) 0.5		(1) .5	(28) 13.1	(178) 83.9	(3) 1.4			
Evansville, Wisconsin	R. Pect.	212				(1) 0.5	(6) 2.8	(27) 12.7	(171) 80.6	(7) 3.3			
Spring	Dorsal	212					(1) .5	(35) 16.6	(138) 65.1	(36) 17.0	(2) 0.9		
Dec. 1931	Anal	212					(3) 1.4	(57) 26.8	(115) 54.2	(37) 17.4			
II	L. Pect.	35					(1) 2.8	(7) 20.0	(26) 74.2	(1) 2.8			
Evansville, Wisconsin	R. Pect.	35			(1) 3.0			(8) 22.8	(26) 74.2				
Allen's Creek	Dorsal	35						(3) 8.6	(19) 54.3	(11) 31.4	(2) 5.7		
Dec. 1931	Anal	35						(5) 14.2	(20) 57.1	(9) 25.7	(1) 2.8		
III	L. Pect.	59					(4) 6.8	(14) 23.7	(38) 64.4	(3) 5.1			
Evansville, Wisconsin,	R. Pect.	59						(17) 28.8	(41) 69.5	(1) 1.7			
Spring fed creek	Dorsal	59					(2) 3.4	(12) 20.3	(32) 54.2	(13) 22.0			
May, 1932	Anal	59					(1) 1.7	(16) 27.1	(30) 50.8	(8) 13.6	(4) 6.8		
IV	L. Pect.	433	(1) 0.2	(2) 0.5	(2) 0.5	(3) 0.7	(4) 0.9	(36) 8.3	(364) 84.0	(20) 4.6	(1) 0.2		
Franklin Spring	R. Pect.	433		(2) 0.5		(2) 0.5	(3) 0.7	(33) 7.6	(367) 84.7	(24) 5.5	(2) 0.5		
Pond	Dorsal	433			(1) 0.2		(6) 1.4	(88) 20.3	(241) 55.7	(91) 21.1	(6) 1.4		
Nov. and Dec. 1931	Anal	433				(1) 0.2	(2) 0.5	(109) 25.2	(239) 55.2	(78) 18.0	(4) 0.9		
	L. Pect.	173		(1) 0.6	(3) 1.7	(5) 2.9	(15) 8.7	(22) 12.7	(113) 65.3	(11) 6.4	(2) 1.2	(1) 0.6	
V	R. Pect.	173				(7) 4.0	(5) 2.9	(24) 13.9	(122) 70.5	(12) 6.9	(3) 1.7		
Franklin Spring Pond	Dorsal	170			(1) 0.6		(2) 1.2	(28) 16.5	(102) 60.0	(32) 18.8	(5) 2.9		
	Anal	172		(1) 0.6			(4) 2.3	(42) 24.4	(95) 55.2	(24) 14.0	(6) 3.5		
Nov. 1932	Caudal	172					(1) 0.6		(2) 1.2	(12) 7.0	(134) 77.9	(18) 10.5	(5) 2.

TABLE 2—Concluded

Collection	Fin	Number of individuals	Number of Rays 4	5	6	7	8	9	10	11	12	13	14
VI Franklin Spring just below pond Nov. 1932	L. Pect.	131			(1) 0.7		(3) 2.3	(9) 6.9	(103) 78.6	(14) 10.7	(1) 0.7		
	R. Pect.	131					(3) 2.3	(9) 6.9	(109) 83.2	(9) 6.9		(1) 0.7	
	Dorsal	130						(17) 13.1	(72) 55.4	(39) 30.0	(2) 1.5		
	Anal	131				(1) 0.8	(2) 1.5	(15) 11.5	(81) 61.8	(32) 24.4			
	Caudal	130						(1) 0.8	(2) 1.5	(9) 6.9	(114) 87.7	(2) 1.5	(2) 1.5
VII Kent Creek	L. Pect.	137			(1) 0.7		(3) 2.2	(42) 30.6	(86) 62.6	(5) 3.7			
	R. Pect.	137		(2) 1.5		(1) 0.7	(2) 1.5	(27) 19.7	(99) 72.2	(5) 3.7	(1) 0.7		
	Dorsal	137					(1) 0.7	(9) 6.6	(76) 55.5	(48) 35.0	(3) 2.2		
	Anal	137						(8) 5.8	(64) 46.7	(57) 41.6	(7) 5.1	(1) 0.7	
VIII Buffalo Creek	L. Pect.	675				(1) 0.1	(1) 0.1	(50) 7.6	(583) 86.3	(40) 5.9			
	R. Pect.	675						(48) 7.1	(572) 84.7	(51) 7.6	(4) 0.6		
	Dorsal	675				(1) 0.1	(9) 1.3	(154) 22.8	(441) 65.3	(68) 10.1	(2) 0.3		
	Anal	675					(6) 0.9	(152) 22.5	(423) 62.6	(94) 13.9			
IX Nippersink Creek	L. Pect.	352					(1) 0.3	(58) 16.4	(286) 81.3	(7) 2.0			
	R. Pect.	352					(1) 0.3	(44) 12.5	(301) 85.5	(6) 1.7			
	Dorsal	352					(8) 2.3	(107) 30.4	(191) 54.3	(46) 13.1			
	Anal	352					(6) 1.7	(95) 26.9	(182) 51.7	(66) 18.7	(3) 0.9		
X Harrison Ditch	L. Pect.	81					(1) 1.2	(5) 6.1	(62) 76.5	(13) 16.0			
	R. Pect.	81						(3) 3.7	(67) 82.7	(10) 12.3	(1) 1.2		
	Dorsal	81						(11) 13.6	(40) 49.4	(29) 35.8	(1) 1.2		
	Anal	81					(1) 1.2	(9) 11.1	(44) 54.3	(23) 28.4	(4) 4.9		

example, in collection I 10 rays in these four fins were observed the following number of times:

Left pectoral	178
Right pectoral	171
Dorsal	138
Anal	115

Similarly, in every other collection the pectorals as a group had more counts in the mode than had the dorsal and anal, usually 20-30 per cent more. In most collections the left and right pectorals did not differ with respect to modal counts by more than five per cent. This was also true in the case of occurrence of modal counts in dorsal and anal.

Another way in which these fin pairs differ is in number of low counts and high counts. In the pectoral fins there were more counts of 4, 5, 6 and 7 rays than were found in dorsal and anal, but the dorsal and anal fins showed more counts of 12 rays.

A study of the means for these fins also showed a pairing of values. In 8 of the 10 collections, means for dorsal and anal were higher than for pectorals. In another collection, however, the reverse was true, and in still another the means for all fins were about the same.

Pierson's correlation coefficient (r) has been used here to express the tendency for pectoral fins of individual sticklebacks to have the same number of fin rays on right and left sides. The bilateral arrangement of these fins would seem to suggest the likelihood of rather high correlation. This measurement has also been applied in the case of the dorsal and anal, dorsal and right pectoral and dorsal and left pectoral. The results are shown in the following tabulation. It should be remembered that perfect positive correlation is expressed by $r = +1.0$ and values of r greater than $+0.3$ are usually considered significant. These determinations were based on the specimens in all collections combined.

Correlation between ray number in:	*r*
Left pectoral and right pectoral	$+0.327 \pm 0.013$
Dorsal and anal	$+0.474 \pm 0.012$
Dorsal and left pectoral	$+0.038 \pm 0.020$
Dorsal and right pectoral	$+0.005 \pm 0.020$

Thus there seems to be a definite tendency for left and right pectorals to have the same number of rays, and the same tendency is also found in the case of dorsal and anal, but there was no correlation between ray number in the dorsal with either of the pectoral fins.

It would seem that the most likely explanation of correlation between the pectorals, and also between dorsal and anal would rest on the theory of segmental origin of the fin rays; that is, that each individual ray originates from an individual myotome.* In the stickleback the position of the dorsal fin is directly above the anal which indicates that most of the rays in the two fins probably do originate from the same group of myotomes. In the case of the pectoral fins the origin of the rays, according to the widely accepted "lateral-fold theory" is also in the myotomes, and it would be expected that the rays on right and left fins had usually come from the same segments, but from a different set than those which gave rise to the dorsal and anal. The circumstance that the pectoral fins, the dorsal and the anal all have a mode of 10 rays must be looked upon as accidental.

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EXPEDITIONING IN MEXICO

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During the summer of 1938 I took a group of five students of the University of Illinois on a three months biological expendition to the state of Nuevo Leon, Mexico. Our objective was to study the flora and fauna of Cerro Potosi, a 12,500 foot mountain in the Sierra Madre Oriental range, 81 miles south of Monterrey. This mountain is of particular interest because it is the highest between the peaks about Mexico City on the south and the Rockies on the north, and because so little biological exploration has been done in northeastern Mexico. It is of great interest to learn the range of the flora and fauna which extends southward and northward here from the more intensely investigated southwestern United States and from the more intensely investigated southern Mexico and eastward from western Mexico, which is also better known.

The truck in which we travelled is a two ton International which was well equipped to meet the requirements of such a trip and which has been improved for this coming summer's trip. It is painted a silver colour to throw off the hot Mexican sun, carries a radio and an extra large battery and generator, has five forward speeds to carry us up and down difficult arroyos and down riverbeds where there are no roads, and has a ten foot extension tent on one side. It is equipped to carry two tons of equipment, to provide a little laboratory space, and to carry five or six men and their personal belongings comfortably.

We left Urbana early in June and after experiencing little difficulty in getting our numerous guns and collecting equipment across the border we collected for a few weeks in the lowlands of Nuevo Leon. By the first of July we had made a camp of two tents and a plank wall for wind protection in a colorful little mountain meadow, the floor of which was covered with thousands of low flowers, and which was surrounded on three sides by the rising mountain bearing a magnificent stand of tall, dark pine trees. We celebrated the fourth of July by making ice-cream from our canned milk and freezing it in the drifts of hail that surrounded camp and had ripped much of our canvas.

From this high camp the party's zoologist attempted to study the ecology of the mammals and birds of the peak, but soon gave it up because of the difficulties involved. Feeding on the vegetation at the peak we found many groups of deer which returned to the shelter of the low juniper as the sun rose in the morning. These deer proved to be larger deer than were supposed to be present in this part of Mexico. The holes of the ubiquitous Mexican mouse, *Microtus mexicanus*, were everywhere in the low growth near the peak, while at the meeting of the alpine summit and the low juniper zones, and only there, we found the tiny rare shrew, *Sorex emarginatus*. Nesting on the ground near the peak and laying its three or four eggs in a nest of woven grass, we often found the Mexican junco, *Junco phaenotus phaenotus*, which has never been recorded from Nuevo Leon previously. Lower in the pine forest we found Clarks' nutcracker, *Nucifraga columbiana*, never before recorded in Mexico, and nesting in the high pine forest at about ten thousand feet we also found the hawk, *Falco sparverius sparverius*, never known to breed before in eastern Mexico.

Although less than 200 species of plants were collected from Cerro Potosi they well illustrate the scientific interest of the place. A great number of new species were among those taken, a high degree of endemism was demonstrated, and considerable extension of range for a large number of species was shown.

Because there is little water in evidence the isolated natives of one little hamlet, who told us that they had never seen a foreigner before, did not recognize any word for "fish" or for "turtle" which was in our dictionary, and did not recognize any description of them since none are present for many miles around. I was surprised one day to find a rattlesnake under a log as high as 9,000 feet and later this proved to be a new species as well as most of the other rattlesnakes from this locality. Another surprise was to find two of the four species of termites which are found in Illinois under a log

Fig. 1. When a "bridge" gives way. Note deerskin apron on man second to right; characteristic of workers in rural regions.

at 9,000 feet elevation on Cerro Potosi, an unusually high altitude for these species. A single tarantula was also found at this height. All of the cranflies, Family Tipulidae, proved to be new species, as did a great number of other insects, especially the Orthoptera. One of the most interesting of these is a highly specialized fly of the Family Streblidae, the bat-parasites, which I found on the bat *Leptonycteris nivalis*. This weak-winged fly lives in the fur of the bat until the female loses its wings and sometimes its legs and burrows into the external muscle layer of the bat. Then with her abdomen protruding she drops live larvae to the ground where they change to pupae. The bats on which this fly lives nest by the thousands in a large cave high on the mountain-side and shared, when we were there, one of the lower reaches of the cave with a big, old mountain lion from which we kept our distance. From all of the animals we took the external parasites: lice, fleas, and ticks. From a vulture came a single large chewing louse, quite as large as the largest louse known.

THORACICO-ABDOMINAL VENULES, THEIR ETIOLOGY AND TREATMENT

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For many years I had observed dilated capillaries at various areas on the surface of the human body and speculated about their significance. My attention was particularly centered on the thoracico-abdominal region where they seemed to be found oftener and in greater numbers than elsewhere on the surface of the human body. In some cases there were only a few, scattered haphazard, while in others they were numerous and appeared in bizarre forms and symmetrical groupings, often suggesting an arch, formed of filagree work of delicate rose color, fine stroke and outline. In others they resembled metabolism record charts of a patient with rapid respiration. Some other cases simulated the maps of groups of river basins wherein all the tributaries have been delineated with all their meanderings and zigzaggings. In still others they looked like the ornamental Hebrew script or merely a flush occupying a narrow strip across the lower anterior thoracic region corresponding approximately to the insertion of diaphragm and thoracic wall.

Individual enlarged capillaries are approximately 2 to 40 millimeters long and 1/5 to ½ millimeter wide. Their area of distribution in the thoracico-abdominal region lies between the fifth rib and the costal margin. They rarely extend as high as the fourth rib and as low as the umbilicus and pubis. In general they parallel and overlie the line of insertion of the diaphragm to the anterior thorax and extend laterally as far as the axillary lines.

The manner of their arrangement suggests the form of a Tudor arch in many cases, in exceptional cases the arch may extend downward and forward from the axillary lines to the umbilicus and make a complete circle. Rarely they may extend laterally down the abdomen reaching the pubis on both sides to form an ellipse. More often the circle and ellipse are fragmentary. In early and mild cases a blotchy erythema is discernible over the liver area which may develop to actual venules or may disappear under proper treatment.

The Portal trunks break up into smaller branches in the substance of the liver and the branches into capillaries at the periphery of the lobules in the space of Kiernan where they become confluent with the capillaries of the hepatic artery. This porto-arterial blood enters into the sinusoids in the substance of the lobule and reaches every hepatic cell. Then these vessels converge to the center to form the central lobular vein.

Inflammation in the portal vessels, even mild, may easily compress the portal capillaries in perilobular area in the space of Kiernan and may, if continuous, partially or completely obstruct them and cause varied degrees of portal hypertension or damming back of the portal blood. Less often the obstruction may be elsewhere in the portal system.

The mild degree of obstruction is compensated by diverting enough of the portal blood, through existing channels, to caval circulation. These anastomoses are through the coronary veins of stomach to aesophagal plexus at cardias; through the superior hemorrhoidal veins to middle and inferior hemorrhoidal veins at rectum and through the para umbilical veins to the veins of thoracico-abdominal region. The lower anterior chest and upper abdominal wall are in the portal domain.

In cases of greater obstruction the glisson's capsule of the liver is hypertrophied and highly vascularized and becomes adherent to diaphragmatic and parietal peritoneum finding outlet through diaphragmatic intercostal, peritoneal, mammary, axillary and other veins. In still higher degree of obstruction abdominal visceral and omental branches of the portal system are highly congested and become adherent to the parietal peritoneum communicating with peritoneal and abdominal plexuses of veins.

The circles and ellipses of venules I have considered to be due to communication between mesenteric veins of transverse, ascending and descending colon, and parietal peritoneal and superficial abdominal plexuses. Lower thoracic arch of venules always form part of the circles and ellipses, but the circle and ellipse were never found together. In the formation of circle and ellipse of venules, pressure on the vena cava may be a contributary factor, but these cases have atrophic liver, no ascitic fluid or any other cause of intra-abdominal pressure discoverable.

On careful examination and inquiry into the dietetic habits of the patients with the thoracico-abdominal venules, I found that, with rare exceptions, they habitually consumed excessive amounts of sugar.

Average annual per capita consumption of sugar in United States during the last ten years was 97 pounds. Sugar is a habit-forming food, the temptation to increased consumption being always present. For the use of this paper, those who consume habitually large amounts of sugar are to be called "sugar addicts." In many such cases blood sugar was not as high nor did urine contain sugar as often as one would expect. It was a surprise to find some of the sugar addicts with comparatively low blood sugar. Excessive sugar absorption may lead to hyperinsulinism. This may account for low blood sugar in some early cases. However, hypoactivity of the pancreas follows sooner or later, and in many of the older cases glycosurea is found to be due to portal hypertension and exhaustion of the pancreas. Reduction of the amount of the sugar consumed did not bring on symptoms of hyperinsulinism, so far as my observation goes.

Sugar addicts with thoracico-abdominal venules are middle aged or older, suggesting addiction of long duration. Yet intensive degree of addiction and hypersensitiveness to sugar may bring it on earlier. I have seen one at the age of 5, one at 8, one at 14, and another at 18, and several in early twenties. There may be venules in thoracico-abdominal region when there is no demonstrable dilitation of the subcutaneous abdominal veins. The relationship between the venules and portal circulation is suggested because the reduction in sugar ingestion and other measures to relieve the portal circulation, reduces the venules both in size and number and may even cause their disappearance in some cases, reappearing when the addiction is resumed.

1. Each gram of sugar in the process of its conversion into glycogen binds three grams of water which leads to overfilling of the portal system and general plethora.

The following quotations from J. H. P. Paton's article in *The British Medical Journal* of April 29, 1933, on "Relation of Excessive Carbohydrate Ingestion to Catarrhs and Other Diseases" is pertinent to our subject.

"McClendon has demonstrated water retention after high glucose feeding in man. Ramsay has described occurrence of visible congestion and exudate in the retina of the patients whose carbohydrate intake is in excess of what they can tolerate and has pointed out that this is an index of the state of capillaries elsewhere in the body. . . . It may be concluded that the tendency to suffer from a variety of chronic catarrh and exudative processes is associated with intolerance of carbohydrates, especially sugar. As a corollary of this it may be assumed that even in persons of high tolerance a similar liability to chronic catarrhal inflammation will result if the absorption of carbohydrates is sufficiently excessive."

Paton gives statistics of a boarding school for young women on catarrhal diseases of more than seven days' duration.

Average incidence

1904–1913	2.6 Per cent.
1914–1917	0.8 Per cent.

He sees a connection between the reduced consumption of sugar during the Great War and reduction in incidence of catarrhal diseases and finds the degree of prevalence of the same class of diseases proportionate to the amount of carbohydrates, especially sugar, consumed.

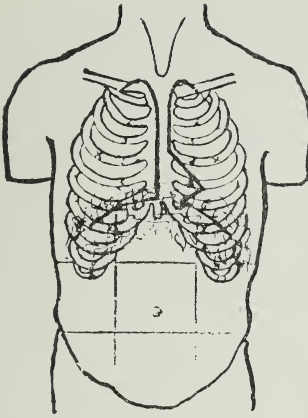
2. In addition to possible toxicity of sugar itself, there is the indirect action due to its decomposition and synthetization products. Sugar ingested may not all be absorbed but leave a residue to ferment in the lower ileum, forming acetic, lactic, valeric, oxalic, and other acid substances. Arrival of the contents of ileum at the more complex chemical environment of the colon is followed by formation of still other substances, fluid and gaseous, of which a certain amount is absorbed and reach portal circulation. It is reasonable to assume that this factor plays a part in the development of hepatic cirrhosis.

Over ten years ago Anthony Bassler expressed himself on this phase of the subject as follows: "I have yet to see one instance where at operation, whether the individual was alcoholic or not and a portal cirrhosis was disclosed, there was not present and easily demonstrable a saccharo-butyric toxemia in the intestional canal." On a communication to the author, he reaffirmed the above statement as follows: "I remember the quotation well and have not changed my opinion to any extent, in fact, had there been any doubt, subsequent clinical experience could not have done other than bring me to the belief that moderate degrees of liver cirrhosis are not due to alcohol except as it enhances a saccharo-butyric toxemia."

3. Excessive consumption of sugar and other carbohydrates, in many cases, engenders serious deficiency in diet which may play a direct part in the development of cirrhosis of the liver, as has been suggested by C. L. Connor and others for alcoholic cirrhosis of the liver.

4. There is still another class of cases, small in number, who suffer from carbohydrates intolerance, irrespective of the kind ingested, who could not be called excessive consumers of carbohydrates; yet have the same signs and symptoms.

The number of my clinical record of the patients suggesting the causal relationship of sugar addiction to thoracico-abdominal venules had reached about 80 when I noticed that many of my cases



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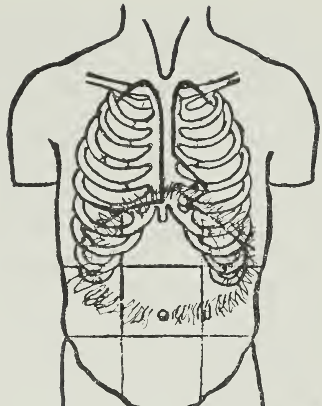

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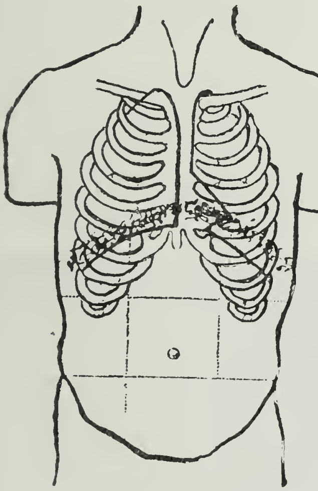

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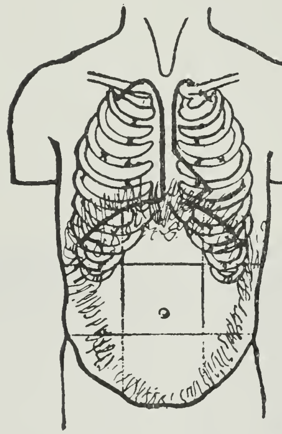

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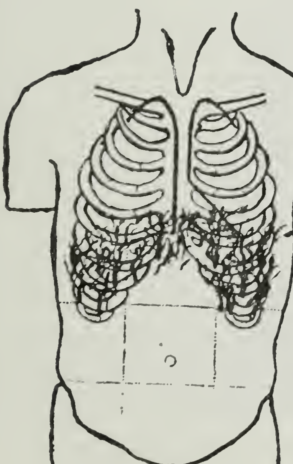

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had chronic non-active or healed tuberculous areas in their lungs. In subsequent cases with careful examination I found the presence of healed tuberculous areas to be more frequent than I had at first believed to be the case. I have not since seen a well marked case of thoracico-abdominal venules without the pulmonary lesions.

Under the treatment directed toward the relief of portal embarrassment, the general improvement in the patient's condition was more prompt than would have been possible in a case of clinical tuberculosis. To my definite knowledge only one of my cases developed into clinical tuberculosis. I have come to regard as benign or healed the tuberculous lesions of the lungs co-existent with well marked thoracico-abdominal venules.

Thoracico-abdominal venules mean: A person, with comparatively small liver, who ingests excessive amounts of sugar or other carbohydrates, with a variable degree of cirrhosis of the liver, with healed tuberculosis of the lungs, chronic catarrh of the mucus membrane with the history of frequent exacerbation because of sugar debauch and bad weather. In addition there may be excess of urobilin in the urine, loss of weight, tenderness to percussion on the liver, general depression, inertia, toxemia, feeling of weight in the hepatic region, continuous gaseous distention, brown rings around the eyes, persistent bad breath, bilious attacks, headaches after meals, etc.

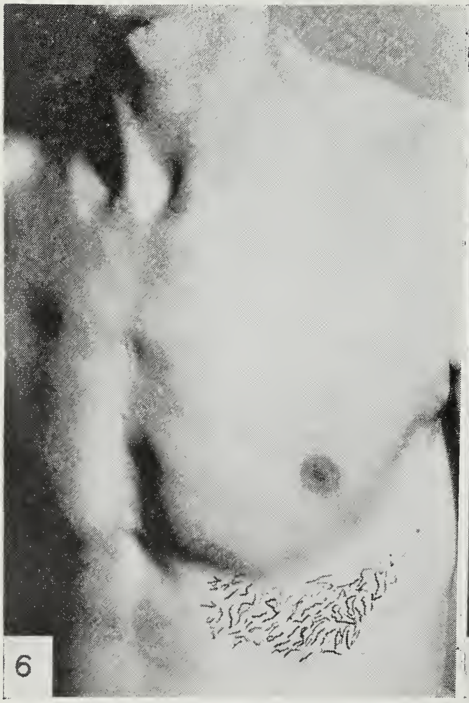
Ninety-four of my cases have been studied with special care, 104 somewhat casually. I have seen several hundred more cases during the last 15 years, but in their records only a brief mention of the special syndrome was made, unless the case presented unusual features.

With the portal obstruction compensated by new routes to the caval system, the patient is relieved of his symptoms and his life is not shortened nor health depreciated materially on condition that he live on a balanced diet, and limited liquids, at about the minimum physiological requirements. Salines, bile salts, calomel and sod salicyiate are useful drugs in the treatment of this class of cases.

I have seen the venules in various stages of their development. I have been lead to think that excessive consumption and intolerance of carbohydrates, especially sugar, is one of the factors in the development of cirrhoses of the class I have described.

Were it not for the accumulating evidence of the carbohydrate toxicity and the favorable results obtained from the application of the theory put forth in this paper, this report would not have been made.

S. T., farmer, 62 years old, who consulted me Oct. 12, 1932, has felt tired all his life. For years he had lived mainly on carbohydrates, including sugar. He has small liver, low blood pressure, and irritable colon. Never constipated, he has



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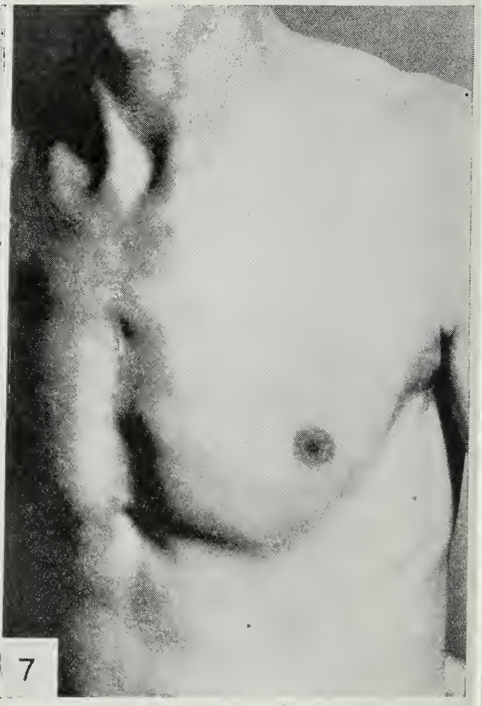

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Note to above: Figs. 6 and 7 are from the same photograph, with venules traced in ink on fig. 6 for this reproduction.

colicky attacks with frequent loose stools. He has an old tuberculous lesion in the left apex to the third rib anteriorly. He has the venules in lower anterior chest and on the right side they extend to the right ramus of the pubis forming about ½ of an ellipse.

Aug. 26, 1934. C. A. L., farmer, 56 years old, has a complete ellipse of the venules, the longer diameter reaching from the lower thorax to the pubis. This is one of the two unbroken ellipses among over 500 cases of venules I have seen. He has been an extreme type of sugar addict all his life, heavily sugaring everything he ate. Urine was loaded with sugar, blood sugar 165 milligram per cent, three or four sour and loose stools a day. He feels worse if bowels move less often. Liver atrophic and tender to moderate percussion.

Nov. 16, 1934. Mrs. E. N., sugar addict. There are ample evidences of chronic tuberculous lesions in her lungs with slight or no activity. Liver dullness two inches; venules over lower anterior chest where the diaphragm fuses into the internal surface of the chest wall are arranged compactly in a narrow strip resembling Hebrew or Arabic script.

June 24, 1935. H. P., 15 years old. At the age of seven he had an attack of nausea, vomiting, fever, tenderness under right costal arch and grayish stools for several days. He had a similar and severer attack the following year. Since then he has had the attacks at more frequent and irregular intervals. There are non-active tuberculous lesions in the upper chest. He is a sugar addict, liver dullness 1½ inches. The venules are found in lower anterior thorax, being more marked on the left side.

1935. J. B. McG. Age 44. Teacher, who had no history of sugar addiction, yet he had a well developed arch of venules in lower anterior thoracic region and signs and symptoms that accompany it. I considered this a case of carbohydrate intolerance, balanced his diet, reducing his carbohydrate intake. He felt better within a short time and after several months no venules could be made out in his lower anterior thoracic region.

May 6, 1938. A. C. A. 68 years. Retired, had chronic catarrh for many years. His nose and naso-pharynx filled up with catarrhal exudate, so that he had to syringe them with normal saline or alkaline antiseptic four or five times a day to be able to breathe through his nose. He has thoracico-abdominal venules and confessed to using sugar in almost every food he ate. His diet was balanced, sugar being greatly restricted. In a short time he improved considerably. About one month ago he reported that he is getting along comfortably with one treatment a day.

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STUDIES ON STARVATION IN LARGEMOUTH BASS

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It is known that fish can endure for long periods of time without food. Previous quantitative studies on starvation of bass are unknown to the writer. The purpose of this study was to determine the changes in weights and lengths of live largemouth bass, as well as the changes in the weights and composition of various organs of the body during complete starvation. In order to see if all parts of the body are equally affected by inanition, the water content, the organic, and the inorganic substances in the different organs were investigated.

Method.—The eighteen largemouth bass fingerlings (Huro salmoides) used in the experiment were obtained at Fork Lake, near Mount Zion, Illinois, on October 21, 1938. They were placed in separate aquaria at the Experimental Zoological Laboratory of the University of Illinois. These aquaria were kept clean and covered with black cloth to prevent the growth of algae.

The period of starvation—from October 22, 1938 to February 25, 1939—was 126 days. At the beginning of the experiment, the fingerlings varied in standard length from 101 to 119 mm.; in total length from 124 to 147; and in weight from 21.16 to 35.71 grams. Each week the live bass were weighed and measured by a standard technique. Notes were kept concerning the activity, external appearance, and body contours of each fish. The water temperatures remained constant throughout the experiment, averaging 23.86° C.

Each week one fish was chosen by lot, killed, and dissected under water by a uniform method. The excess moisture was removed from each organ immediately after excision. Each organ was placed in a covered weighing bottle and the wet weight determined. The parts were then transferred to platinum crucibles and dried for two days in an oven at 102° C. to reach a constant weight. The ashing was done in a furnace at about 800° C. for two hours. All weights of the organs were obtained on a chainomatic balance accurate to .00001 gram.

An experiment to determine the effect of feeding on growth subsequent to a prolonged period of complete starvation on two of the starved fish was begun February 19. Both fish refused to eat at first and were forcibly fed. The amount of food per day was gradually increased. One fish died after the first week but the other lived and started to grow again.

Results.—During the experiment one fish died from starvation. There was a gradual decline in average live weight during the 19 weeks from 26.945 to 11.842 grams, an average loss of 56 per cent. All fish did not lose at exactly the same rate. The greatest average weekly loss, 1.449 g., in live weight occurred the first week of starvation while the smallest weekly loss, .672 g., was the seventeenth week. Although the losses fluctuated, the early loss was greatest due to the digestion of food present in the alimentary canal and rapid utilization of the stored fat and glycogen.

The average decrease in standard length was from 108.72 mm. to 103.69 mm. Growth in length continued for the first week, but afterwards there was a gradual decrease.

The external appearance of the bass changed strikingly. At first they had a healthy plump appearance; but as starvation continued, extreme thinness and emptiness of the body cavity was evident. The scales examined from the starved fish showed marked erosion on the edges.

The per cent of the original wet weight of the body of the fish was determined for each organ. The organs of the unstarved fish were used as 100 per cent and the others calculated on this basis. A moving average of five weeks was used in smoothing the graph. The following changes in original weight were observed. The eyes increased from 100 to 113 per cent during the 19 weeks of starvation. The head decreased gradually to 79 per cent, the fins to 56 per cent, the gills to 52 per cent, the digestive tube to 22 per cent, the trunk (without viscera) to 38 per cent, the heart to 19 per cent, and the liver to 16 per cent. The eyes increased in wet weight — their organic and mineral substances were constant, or declined slightly. The greatest losses occurred during the first four weeks. It seems logical that the early loss of weight in the liver would be greatest because of readily available glycogen and fat. Graphs were made for the dry weights and ash weights of the organs. They showed practically the same results as the wet weight curves. The per cent of water in the entire body of the fingerlings during starvation was found to remain nearly constant—77 per cent. The organic substance of the body, that part lost on ignition, gradually decreased from 17.93 per cent and 13.80 per cent while the percentage of inorganic substance or ash doubled. This is because the fish shrunk to half their original weight.

Bass usually die after a prolonged period of starvation. The fish which survived in this experiment was not attracted by food and the digestive system had begun to atrophy. This individual required 8 grams of food to increase its weight one gram whereas normal bass require 3½ to 5 grams.

These studies were carried on under the supervision of Dr. David H. Thompson of the Illinois Natural History Survey whose advice and suggestions have been very helpful in the preparation of this paper.

OBSERVATIONS ON *BALANTIDIUM COLI* IN CULTURE

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Ever since MacDonald divided the ciliated protozoa in swine of the genus *Balantidium* into two species, *B. coli* and *B. suis*, there has been doubt whether the separation is valid. Since it is important from the standpoint of the etiology of balantidial dysentery to know whether one or two species are involved, the present investigation was undertaken. The most important difference between the two species is in their length-width ratios. *B. suis*, which is relatively thin, has a length-width ratio of approximately 1.8; the length-width ratio of *B. coli* is approximately 1.3. Balantidia from the ceca of pigs were fixed in Kleinenberg's solution, and 100 individuals from each pig were measured. Culture media were then inoculated with material from the ceca, and 100 individuals from the first culture transfer were fixed in Kleinenberg's and measured. In some cases measurements were made of balantidia from further culture transfers. A total of 1900 balantidia from eight swine were measured in the present investigation. It was found that the change from the cecum to the artificial culture medium had a significant effect on the length of the protozoa, and that it could markedly alter their length-width ratios. In six cases, the mean length-width ratio became smaller on cultivation (i. e., the individual became more *coli*-like), the reduction varying from 0.10 to 0.53 units. In two cases the shift was in the opposite direction, and the length-width ratios increased from 0.10 to 0.18 units. Thus it has been shown that the length-width ratios of strains of *Balantidium* are not constant and that in one case a strain which was of the *suis* type in the cecum became *coli*-like in culture.

A CASE OF POISONING IN THE COTTON-MOUTH MOCCASIN

(Agkistodon piscivorus)

Francis X. Lueth

State Natural History Survey, Urbana, Illinois

Until recently, most authorities believed that poisonous snakes were immune to their own venom. The occasional story of a rattlesnake committing suicide was classified as a myth and grouped with the stories of the hoop snake and of snakes charming their prey. Karl P. Schmidt, Curator of Reptiles and Amphibia at the Field Museum, in his publication *The Truth About Snake Stories* said, "All available information . . . indicates that snakes are immune to their own venom and in experiments I have made personally, causing a rattler to bite himself, there was no visible effect." Certainly he did not stand alone in his opinion. Many herpetologists had seen rattlesnakes strike themselves or other rattlers with no ill effects.

To demonstrate the killing power of snake venom to a few sportsmen, a white mouse was put into a cage of nine baby cotton-mouth moccasins of the Illinois Natural History Survey collection. The snakes became wild. They struck at the mouse and then at each other. The mouse died after about seven minutes. The snakes, however, continued to strike at and bite each other. There wasn't a snake that wasn't bitten at least once. Two had been bitten badly enough to draw blood. Later crystallized venom was found on the head of one of the snakes and on the back of another. The snakes apparently suffered no ill effects and to all present, it appeared to be conclusive proof that poisonous snakes could not kill each other.

The first published account of the poisoning of snakes by venom was by Dr. H. K. Gloyd (1933). He published an account of the killing of a diamond-backed rattlesnake by a cotton-mouth moccasin. Death occurred seventy-one hours after the rattlesnake was bitten. Dr. Gloyd referred to other cases of self-inflicted bites or bites by nearly related species that were not fatal.

Almost immediately there appeared accounts of other cases of snake poisoning. There was a case of a rattlesnake poisoned by a self-inflicated bite: death occurred in a few hours (Wooster, 1933). In a case of two rattlesnakes killed by a cotton-mouth moccasin (Conant, 1933) death occurred in six and a quarter hours and in nine and a quarter hours.

To study the immunity of rattlesnakes to their venom, Nichol, Volney, and Peck (1933) made two rattlesnakes bite themselves. One died in two hours and forty minutes; the other lived for more than six hours. Four rattlesnakes were injected with five minims of venom. One died forty-five hours later and the other three survived after showing local swellings. To the experimenters, this indicated a high but not complete immunity.

On July 27, 1938, some tadpoles were put in the water bowl of a cage containing three of the cotton-mouth moccasins that were mentioned earlier. Two snakes immediately went to the bowl and started to fish for the tadpoles. One snake grabbed the other by the head. This occurred at 2:20 P. M. The head of the victim was almost hidden in the jaws of the attacker. The fangs apparently entered the head of the victim just below the eye. Both fangs seemed to be well imbedded. There was a furious tussle, both pulling and lashing their tails. At the end of eight or nine minutes, the snakes were still fighting. The struggle was finally ended when the attacker was tapped on the head with a pencil. The victim came to the front of the cage and climbed part way up the glass. She, for it proved to be a female, remained there for some time. She was bleeding from a single wound in the lower jaw. The bleeding soon stopped and by 4 P. M. the snake appeared to be all right.

The next morning, however, she was apparently lifeless, but moved when touched. She was sensitive in the region of the neck, which for a length of about one inch had swollen to almost double the normal size. There was a watery substance oozing from the neck. The lower jaw was swollen posterior to the bite. The entire body appeared to be slightly swollen, but this was probably due to inhaling a great amount of air, as a normal appearance was assumed when she exhaled. Respiration was slower than normal.

That afternoon the swelling was slightly reduced. She kept her head flat against the bottom of the cage, something unusual for this species. The snake was still alive at 4:30 P. M., July 28.

On July 29, at 9:00 A. M. the snake was dead. Dissection showed two clots; one in the lower jaw just below the right eye, the other on the neck about a half inch posterior to the eye. The region around each clot was highly discolored. There was a great extravasation of blood and there was an accumulation of lymph in this region. There was also a degeneration of muscular tissue. All of these are symptoms of snake bite.

There was no evidence of the fangs having hit any part of the nervous system. It is true there was some bleeding but death could not be attributed to loss of blood. As the temperature was 85° to 95° F. in the cage where the snake was kept, it was suggested that there was plenty of time (twenty-six to forty-one hours) for the snake to die from infection. The appearance of the wound, however, was not like that of infections I have observed in snakes.

The fact that the snake held on for some time, and that there was a tussle while he was biting, might be an explanation as to why this bite was fatal and previous ones were not. The longer time of holding would allow more time for the venom to be injected. The fighting would cause increased pressure on the venom sacs resulting in a greater flow of venom.

From available data, it appears that venomous snakes are not immune to venom in large quantities.

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MAMMARY TUMOR LOCATION IN MICE*

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Spontaneous tumors are frequent in reflected or aberrant mammary tissue of the C3H female mice. This report deals with some possible etiological factors for these tumors.

Bagg (1) and Bogen (2) suggested blockage of the ducts with the resultant milk stagnation as a possible tumor cause. Fekete and Green (3) demonstrated duct blockage to be influential in determining tumor site and occurrence time but tumors were not produced in non-tumor strain animals by blockage alone. Mammary tissue in mice bearing a "latent cancerism" seems more susceptible to stimulation by ovarian endocrines than normal mammary tissue, Cramer (4). Loeb et al (5) have decreased breast cancer in tumor strain animals by early ovariectomy. Clinical evidence of specific endocrine dysfunction as a cause of human breast cancer is scanty, Allaben and Owen (6), Noronha (7). Cheatle (8) noted that the morphological effects produced in mice with estrogens by Lacassagne (9) were similar to Schimmelbusch's disease in women. Atypical growths in mammary glands of animals produced by large dosages of estrogens were first reported by Goormatigh and Amerlinck (10), and later by Burrows (12), Gardner et al (11) and others. Loeb et al (13) believe that cystic conditions, stagnation and inspissation of the secretions inhibit growth rather than promote

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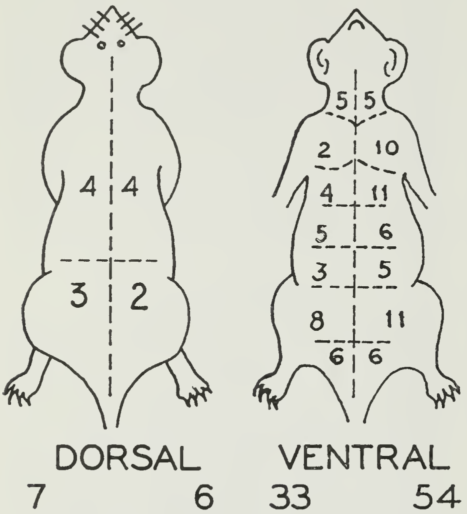
cancerous changes. Davis (14) however, demonstrated that partial vessel ligation did lead to tumor formation in other organs.

In this study one hundred female mice of the C3H strain, selected at random, bearing spontaneous adeno-carcinomas of the mammary glands were used.



Tumors appeared in approximately seventy-three per cent of the multiparous females at an average age of ten months. In non-breeding females an incidence of four per cent was noted.

Growth activity coincident with pregnancy but not functional drainage (suckling) was found to be important in etiology. Spontaneous tumors in the aberrant mammary glands tissues were not more common than those occurring in the normally located glands. The aberrant glands are rarely suckled by the young as these glands possess but a vestigial or no nipple. It is thus difficult to specify lack of mammary gland drainage as an etiological factor in spontaneous mammary tumors in mice.

In a series of experiments utilizing irradiation it was found that non-sterilizing and sterilizing dosages of x-rays reduced the subsequent incidence of breast cancer. Conversely a period of breast hyperplasia induced in non-breeding females by a month of low estrogen dosage did not increase tumor incidence in these animals. In an occasional immature male of a non-tumor strain similar small doses of estrogens over a five week period, duct papillomata (a probable precancerous condition) were noted.

It is believed that the hyperplasia of breast tissue resulting from natural or induced endocrine stimulation is not alone the cause of mammary cancer in mice but that this hyperplasia may work in conjunction with a characteristic of the tissues which may be termed "latent cancerism."

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TULAREMIA IN ILLINOIS

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Tularemia is an acute blood stream infection due to the Bacillus tularense. In 1911 the Bacillus tularense was discovered by McCoy, who was examining ground squirrels for plague. In 1912 the organism was isolated and studied by McCoy and Chapin. Two years later Wherry discovered large numbers of rabbits in Kentucky and Indiana dying from tularemia. He also pointed out the possibility of the transfer of the disease from rabbit to man. By the year 1930 many reports were made on the presence of the disease in a large variety of wild and domesticated animals, chief of which were wild rats, meadow mice, sheep, quail, opossum, and fox squirrels. Since 1930 the disease has been found in cats, dogs, hogs, coyotes, and others.

The incubation period of the disease apparently depends upon: (1) the virulence of the infecting organisms; and, (2) the number of organisms gaining entrance to the blood stream of the victim.

The onset of the illness may occur from one to twenty-one days after the time of the infection. The average in our study was 3.9 days. Persons of all ages, races and of either sex seem to be equally susceptible. The duration of the illness varies from two weeks to one year. The disease may present itself as any one of four different clinical pictures, all caused by the Bacillus tularense.

The most common of these types was the ulcero-glandular type, or 92.8 per cent of all infections. In this case the patient will have an ulceration at the site of the injury where the invading organisms have entered the body. The lymph glands draining this area become swollen and painful about twenty-four hours before inflammation occurs at the site of the infection. In about 50 per cent of the cases these glands will suppurate. A swollen, painful, papule appears at the site of the infection. This papule breaks down and frees a necrotic plug, leaving an ulcer about one centimeter in diameter.

The second type is the oculo-glandular infection, (0.8 per cent), usually caused by splashing infected blood into the eye, or rubbing the eye with a contaminated hand. In this type the primary infection is in the conjunctiva rather than the skin. The papule appears and breaks down, leaving an ulcer. Permanent impairment of the vision may occur. Fulminating cases running a rapidly fatal course, do occur in this type.

The glandular type is the third in our series, (3.2 per cent). These cases are seen in persons, who after dressing rabbits, have swollen, painful lymph glands with no corresponding inflammation at the site of the infection.

The fourth classification is the typhoidal type (3.2 per cent). Here fever is the only outstanding symptom. Diagnosis must be made serologically, and from a history of having eaten improperly cooked rabbit meat. Fever is a cardinal symptom of the illness and is usually present for two to three weeks. Weakness, loss of weight, chills, sweats, and prostration accompany the fever. The recovery is slow and it is rare for a victim to be able to resume his occupation in thirty days. Some cases are not recovered a year later. Recovery is rarely accompanied by sequelae and it gives a very good immunity.

The diagnosis of the disease depends upon the history of contact with game, the finding of the dermal or conjunctival ulcer, inflamed glands, fever, chills, prostration and a negative tularemia agglutination test, followed by a positive test during or after the second week of the disease. One of our cases remained serologically negative until the fifth week after the onset of the disease.

The first case of tularemia reported to the Illinois Department of Public Health occurred in 1926. In the subsequent years we have had the following number of reported cases and deaths.

Year	Cases	Deaths	Year	Cases	Deaths
1926	1	--	1932	134	4
1927	14	----	1933	172	9
1928	10	---	1934	134	11
1929	36		1935	69	4
1930	139	2	1936	91	6
1931	126	2	1937	109	5
			1938	459	32

Tularemia Reported in Illinois by Months, 1926-1939

Month	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939
January	------	5	2	2	19	47	27	45	27	29	10	34	18	70
February	------	------	------	------	10	4	7	7	10	11	6	12	4	26
March	------	------	------	------	5	7	2	4	7	5	3	9	2	------
April	------	------	------	------	2	2	3	------	------	1	1	2	4	------
May	------	------	------	------	------	1	2	------	2	2	------	2	7	------
June	------	------	------	------	2	------	------	------	1	1	------	2	------	------
July	------	------	1	------	------	1	1	1	1	------	3	3	4	------
August	------	------	------	------	2	2	------	2	1	------	1	2	6	------
September	------	------	------	------	1	------	2	4	3	1	2	1	5	------
October	------	------	------	------	------	------	1	2	5	1	8	------	5	------
November	1	1	3	2	9	8	13	15	16	6	8	3	54	------
December	------	8	4	32	89	54	76	92	61	12	49	39	350	------
Totals	1	14	10	36	139	126	134	172	134	69	91	109	459	------

The three principal factors to be considered in the spread of a disease are (1) the source, which was the cotton tail rabbit for 99.6 per cent of the human cases in Illinois in 1938; (2) the mode of transmission of the infecting organism; and (3) the susceptible individual.

Now to take up each of these three steps in order, we begin with the source. The source for our human cases has been the cotton tail rabbit. The disease is spread among the animals by fleas and ticks biting an infected rabbit and then passing the organism into the blood of another animal when it has an opportunity to change hosts.

The causative organism being carried in the blood stream may be found in any organ of the infected rabbit carcass.

Any method of transferring the Bacillus tularense from the blood stream of the rabbit to that of the human is a possible mode of transmission. The bacteria usually gain entrance into the blood stream of the victim through an abrasion on his hand at the time of dressing or preparing the rabbit. It is also possible for the organism to enter the blood stream through the conjunctiva. The victim may be infected by blood splashed into his eye, or by rubbing his eye with a contaminated hand. Inasmuch as the organisms are carried in the animal's blood, they are found in all the tissues. Long periods of intense refrigeration will not kill the Bacillus tularense. However, thorough cooking destroys them. We may safely eat properly cooked rabbit meat even though the animal was infected with tularemia. Likewise, the person that eats insufficiently cooked meat from the infected animal may expect to contract the disease. Thus, we have traced the disease from animal to animal by way of blood sucking parasites, and from animal to man by way of skin abrasions, the conjunctiva, and gastro-intestinal tract.

We have at hand all the essential facts needed for the initiation of a program of control for tularemia. Namely, we know the causative organism, the reservoir of infection, and the mode of transmission. One desirable factor is lacking—a satisfactory method of immunization.

In reviewing the links in the continuity of the spread of this infection, we see that it is impossible to rid our wild animals of their parasites. The increase in the number of reported cases of tularemia in 1938 was more than likely due to the increase that has occurred in our rabbit population. This has been the result of the ruling of the Department of Conservation forbidding the sale of wild rabbits. Many farmer boys who previously earned pocket money selling dressed rabbits are no longer bothering to hunt them. This increase in the number of rabbits facilitates the spread of the disease among rabbits and leaves a greater number of them to be potential sources of the disease. However, the disease could never be eliminated even though we tried to exterminate the rabbit. Thus, we have no effective means of striking at the source. The mode of transmission is the weakest link in the chain. The simple precaution of wearing strong rubber kitchen gloves will prevent the entrance of the Bacillus tularense into the blood stream of the person dressing or handling the animal carcass.

It is for this reason that the Illinois Department of Public Health is carrying on a program of education to combat this relatively new disease. The necessary information for the protection of the individual is carried to the public by means of radio addresses, newspaper releases and the distribution of free pamphlets.

THE SILVERFISH IN A NEW ROLE

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Silverfish—swiftly moving wingless insects of the order Thysanura, have been known for many years as pests of libraries and museums where they chew off labels, bindings and sheet edges. The invention in recent years of the synthetic fabric, rayon, has given these insects a new food item. Manufacturers and finishers of rayon cloth have become interested in an investigation of damage by silverfish because of the increasingly many reports of damage. Although most of the damage occurs in homes, the housewife usually complains to the retail store manager, and he in turn often refers the case to the manufacturer since the holes and roughened spots resemble manufacturing defects.

There are two species of silverfish that may be found in the household. The firebrat, *Thermobia domestica*, flourishes in a temperature as high as 100° F., while the true silverfish, *Lepisma saccharina*, prefers a much cooler habitat. Both species demand a high relative humidity or access to moisture. Thus, it is common to find *Thermobia domestica* in bakeries and *Lepisma saccharina* in greenhouses. The firebrat seems to be better adapted to home conditions and is the species most often found there.

During an investigation by the author on the relationship of the silverfish *Thermobia domestica* to rayon injury, reports of damage were received from cities throughout the United States. No doubt injury occurs whenever the insects become so numerous that they spread over an entire house. The situation in the towns of Champaign and Urbana, Illinois is probably typical of many localities. *Thermobia domestica* was very numerous in these towns during the summer of 1937. Houses were found to be swarming with this insect. Where individuals were so plentiful, they had not confined themselves to cupboards, closets, drawers, the attic and basement where they are usually found, but had spread into the living rooms and had attacked such rayon articles as curtains, knit underwear and dresses.

Damage to rayon fabrics is easy to detect if examined microscopically. Even with the naked eye it is not difficult to identify. It consists of scraped areas or actual holes. The outline of the holes is irregular and jagged. Under the microscope the ends of the fibers cut off by the firebrat have a swollen, jagged appearance, which is quite different from ordinary cut ends. Clinging to the fibers and visible to the eye as minute silvery specks are numerous scales. These scales are very easily detached from the body of the silverfish and are scattered over the area on which the insect feeds. The powdery-like excrement also clings closely to the fabric and may serve for identification. However, if the damaged article is roughly handled or cleaned, the scales and excrement are shaken off and identification must be made by the appearance of the damage and the cut fibers.

It has been a question whether the silverfish eats rayon for the fiber itself or for the finishing agents used upon it. *Thermobia domestica* will readily eat pure viscose and cuprammonium rayon, exclusive of any finish. An examination of the excrement of insects fed upon these yarns shows that the silverfish can digest these particular kinds of rayon. However, there must be some necessary food element lacking since the insects die off if fed for a long period on rayon alone. An examination of the digestive tract did not reveal any protozoan symbionts, such as are present in cellulose-eating termites.

The firebrat has two sources of food in rayon articles for not only is the rayon attractive, but some of the finishing agents are very eagerly sought. Certain finishing agents used upon rayon are much more attractive to the firebrat than others. These insects have long been known to be fond of starch, as evidenced by their frequency in bakeries, and their attacks on starched clothing. Thus, any rayon fabric containing an appreciable amount of starch would be a source of food. Gums of various sorts are very commonly used on rayons and were found to be attractive to silverfish. The lighter vegetable and mineral oils, gelatine and glycerine are eaten. The rayon fabrics containing sulfonated compounds were not very attractive since either the sulphur or the fatty matter is disagreeable to the insects. Experiment showed that the degree of attractiveness is inversely proportional to the amount of fatty material contained. Spencer (1924) found that sulfonated paper was not attractive to *Thermobia domestica.*

Since silverfish are easily and cheaply destroyed it would seem that the easiest way to prevent their attacks on rayon would be to destroy them before they increase to injurious numbers. However, since they are nocturnal insects and often cause damage before their presence is suspected, it may be feasible to attempt to render rayon immune to silverfish attacks as wool is now being proofed against clothes moths and carpet beetles.

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NOTES ON THE PREDACEOUS STINK BUG, *APATETICUS CYNICUS* SAY

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In February of 1935, an egg mass of *Apateticus cynicus* Say was collected in Cummington, Massachusetts and brought into the Massachusetts State College Entomology Laboratory at Amherst. The seventeen eggs were placed in a dry tin pillbox and left undisturbed in the laboratory until April 14 when four of the eggs hatched. Two of the young nymphs died the first day after hatching, but the other two, which later fortunately proved to be a male and a female, survived and lived until July 15 and 16, respectively.

The two nymphs were placed in separate cages on the author's desk and observations were made several times each day to determine as much as possible about the life cycle of these insects.

An adequate cage was made for each insect by standing a glass lantern chimney on a base of glass and covering the chimney above with a piece of cheese cloth which was held in place by a rubber band. A small glass of water was placed in the cage and covered with a disc of cardboard which had a small opening in the center for the insertion of an apple twig. At two-day intervals, larvae of the apple tent caterpillar, *Malacosoma americana* Fabricius, or of the gypsy moth, *Porthetria dispar* Linné, were placed in the cage on a fresh apple twig as food for the *Apateticus* stages.

As shown in the following table, a definite fasting period was noted directly before the second, third and fourth nymphal instar molts.

A COMPILATION OF RANDOM DAILY OBSERVATIONS OF A PAIR OF *APATETICUS CYNICUS* SAY

	Male	*Female*
Length of first instar	16 days	6 days
Length of second instar	7 days	11 days
Fasting period prior to second molt	4 days	8 days
Length of third instar	7 days	7 days
Fasting period prior to third molt	3 days	4 days
Length of fourth instar	12 days	11 days
Fasting period prior to adult stage	7 days	6 days
Total length of nymphal stage	42 days	35 days
Length of adult stage	53 days	61 days

Observed copulation took place on the following days after the last nymphal molt of the female: 14, 16, 24, 25, 30, 34, 43, 47, 48, 54 and 55. The duration of the eleven different acts varied from fifteen minutes to six hours.

On the fifty-fourth day of adult life and six days before the female died, there were ninety-six eggs laid on an apple twig in three hours.

STATE OF ILLINOIS

HENRY HORNER, Governor

TRANSACTIONS

OF THE

ILLINOIS STATE ACADEMY OF SCIENCE

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ANNOUNCEMENT

Thirty-third Annual Meeting

Friday and Saturday, May 3 and 4, 1940

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ANNOUNCEMENTS

All authors who desire to submit papers for publication in the 1940 Transactions of the Academy must leave them with their Section Chairman on or before May 3rd.

The Committee on *Research Grants from the American Association for the Advancement of Science* announces that each year $200 is granted the Academy for use in the aid of research projects. Requests for small grants from this fund will be received up to February 1, 1941, and should be accompanied by a detailed statement of preceding background, general purpose, and estimated expenses. All such requests should be supported by three letters of recommendation sent directly by the writers. Customarily grants are made only to scientists connected with smaller institutions within the State. Correspondence should be directed to C. H. Behre, Jr., Department of Geology and Geography, Northwestern University, Evanston, Illinois.

The Academy has received an invitation from the Government of the United States to send delegates to the *Eighth American Scientific Congress* convening in Washington, D. C. May 10-18, 1940. This Congress is meeting for two cardinal purposes: To advance scientific thought and achievement; To assist in celebrating the 50th anniversary of the Pan American Union. Present also are the basic purposes of all inter-American meetings; namely, the examination of problems peculiar to this hemisphere, and the promotion of better understanding among the American Republics. Sectional Meetings are held similar to those of the Academy, with History, Statistics, Jurisprudence and Economics Sections in addition. *Any member contemplating attendance at this Congress, please communicate with R. F. Paton, University of Illinois, Urbana, Illinois as soon as possible.*

The Illinois chapters of the *American Society of Physics Teachers* are sponsoring a symposium on Physics as Related to Engineering Education, in conjunction with the Academy meetings. Anyone interested may secure particulars by communicating with Prof. V. F. Swaim, Bradley Polytechnic Institute, Peoria.

The Senior Academy urges members of the Junior Academy to plan on joining the Saturday morning field trips.

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- W. C. Rose, University of Illinois, Urbana

Committee on Publications:
- Evelyn I. Fernald, Rockford College, Rockford, Ex-officio
- R. F. Paton, University of Illinois, Urbana, Ex-officio
- W. M. Luce, University of Illinois, Urbana

Committee on Ecological Bibliography:
- A. G. Vestal, University of Illinois, Urbana

Committee on High School Science and Clubs:
- Audry C. Hill, Chester High School, Chester, **Chairman**
- Mary Creager, Vienna, **Chairman of Exhibits**
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- Louis A. Astell, University High School, Urbana, **Editor, "Science Club Service"**
- Rose M. Cassidy, Maine Township High School, Desplaines, **Contributing Editor for Illinois, "Science Club Service"**
- Rosalie M. Parr, University of Illinois, Urbana, **Radio Chairman**
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- Local Arrangements Chairman for 1940 Meeting: Frank Seiler, Galesburg High School, Galesburg

Delegate to the American Association for the Advancement of Science:
- L. J. Thomas, University of Illinois, Urbana

Delegate to the Conservation Council of Chicago:
- V. O. Graham, 4028 Grace St., Chicago

Publicity Director—Annual Meeting May 3-4, 1940, at Galesburg: Wade Arnold, Knox College, Galesburg

General Chairman, Galesburg Meeting: H. E. Way, Knox College, Galesburg

GENERAL PROGRAM

All Addresses and Section Meetings Are Open to the Public.

THURSDAY, MAY 2, 1940

6:00 p. m. Council dinner at the Galesburg Club, Galesburg.

7:30 p. m. Meeting of the Council, Galesburg Club, Galesburg.

FRIDAY, MAY 3, 1940

Knox College, Galesburg, Illinois

8:00 a. m. *Registration* by all members and guests. Securing of final program, and tickets for the annual banquet. Registration for Saturday Field Trips. Old Main, Knox College.

8:00 a. m. *Meeting of the Council* with local committee and delegates from affiliated societies. Room 103 Science Hall.

GENERAL SESSION, Knox College Theatre—Alumni Hall.

8:45 a. m. *Preliminary business meeting.* Appointment of committees on nominations, resolutions, and auditing. Adjournment until 11:45 a. m. All members should attend.

9:00 a. m. *Welcome*: Carter Davidson, President of Knox College.
Presidential Address: *Michael S. Bebb, Illinois Botanist and Letter-Writer* (Illustrated)—Professor Evelyn I. Fernald, Rockford College, Rockford.
Science and the Common Life—Professor Anton J. Carlson, University of Chicago, Chicago.
Looking Through Great Telescopes—(Illustrated with movies)—Professor Oliver J. Lee, Director, Dearborn Observatory, Northwestern University, Evanston.

11:45 a. m. *Annual business meeting of the Academy*: reports of officers and committees and other business.
Adjournment at 12:00 until 5:00 p. m.

12:00 Noon. *Luncheon.* Seymour Hall Dining Room. Tables for special groups may be reserved by communicating with H. E. Way, Galesburg. Arrangements have already been made for all interested in Physics and Engineering Science to lunch together.

1:00-4:30 p. m. *Exhibits*: Junior Section High School Science Club exhibits on display, Gymnasium, Galesburg High School.

1:30 p. m. *Section Meetings.* Election of Chairmen for 1940-41. Papers, demonstrations and discussions. Knox College class rooms. *All papers to be considered for publication must be turned in at the close of these Section meetings.*

5:00 p.m. *Final business meeting.* Election of officers for 1940-41. Announcement of grantees for A. A. A. S. Research Awards.

6:15 p. m. *Annual Banquet.* Informal, Seymour Hall Dining Room, price $1.00. Reservations made in advance by personal application or by mail to Mr. C. L. Furrow, Knox College, Galesburg, Illinois. Tickets should be called for before 10:30 a. m., Friday, May 3, Alumni Room, Old Main, Knox College.
Speakers at the Banquet:
Ralph Hawthorne, Pres., Chamber of Commerce, Galesburg;
C. J. Adamec, Dean, Knox College;
J. Carl Hart, Vice-President, Chamber of Commerce, Galesburg.

8:00 p. m. *Annual Public Lecture.* Galesburg High School Auditorium. *The Artificial Creation of Speech.* (Slides and Film.) Dr. J. O. Perrine, Vice-President, American Telephone and Telegraph Company.

SATURDAY, MAY 4, 1940

9:00 A. M. FIELD TRIPS

The local committee will arrange transportation if reservations are made on Friday at the registration desk, Alumni Room, Old Main. Those planning to go on any but the Railroad Trip should leave orders at the same desk Friday for box lunches to be picked up at 8:30 Saturday morning, and should wear hiking clothes on the trips. All trips except the Anthropological begin at Science Hall promptly at 9:00.

Special Trip. The Burlington Railroad has arranged a special trip through the electrified railroad yards. A special train for Academy members will be made up at the C. B. & Q. Station, Seminary and Tompkins Streets, and special guides have been detailed to explain the working of the Humps, the electric braking system, the tie-treating plant and many other points of interest.

Anthropology Trip. Meet in front of Old Main. Cars will proceed to Black Hawk State Park near Rock Island where the fine museum of Indian material is of particular interest. Box lunches will be eaten in this Park, after which a visit will be paid the Museum of the Davenport Academy of Science, Davenport, Iowa, where the trip will end.

Geological Trip. Sponsored by the State Geological Survey, for the general membership of the Academy, this trip in the Galesburg and Monmouth region will provide an opportunity for observing bedrock strata of the Pennsylvanian and Mississippian systems, glacial drift and loess and physiographic features, and for collecting fossils. It will be conducted by Dr. M. M. Leighton, Dr. George E. Ekblaw, Mr. L. E. Workman, and Prof. H. R. Wanless.

Biological Trip, sponsored by the State Natural History Survey. The area visited will be the bottom lands and bluffs adjacent to the Mississippi River, about 30 miles west of Galesburg. Upland game management practices will be explained and demonstrated at Crystal Lake Club. The fisheries possibilities of the Mississippi River in this region will be discussed and fish collections made for demonstration and discussion purposes. A visit to the Aquawka Game Refuge will provide an opportunity for study of the local flora. Dr. H. T. Frison, Dr. L. R. Tehon, Dr. D. H. Thompson and Mr. Arthur S. Hawkins will serve as leaders for the trip.

PROGRAM OF SECTION MEETINGS

All Meetings will be held at Knox College, Galesburg, Illinois

FRIDAY, MAY 3—1:30 p. m.

AGRICULTURE, Melvin Henderson, University of Illinois, Urbana, *Chairman*

Room 207 Alumni Hall.

Election of Chairman for 1940-41.

1. Influence of Age on the Value of Seed Corn—G. H. Dungan, University of Illinois, Urbana.
2. The Military Tract and its Agriculture—C. H. Oathout, Western Illinois State Teachers College, Macomb, Illinois.
3. Soil Conservation in Relation to the AAA Program—O. L. Whalin, University of Illinois, Urbana.
4. Vocational Agriculture in a Permanent Program of Agricultural Improvement—B. A. Tomlin, Assistant Supervisor, Agricultural Education, Springfield.
5. Probable Effect of Weeds upon the Fertility of Soils—H. J. Snider, University of Illinois, Urbana.
6. (Topic to be announced) —D. M. Hall, Extension Project Supervisor, College of Agriculture, University of Illinois, Urbana.

Turn papers in to Section Chairman at end of meeting.

ANTHROPOLOGY—F. L. Barloga, Peoria, *Chairman*

Room 201 Old Main

Election of Chairman for 1940-41.

1. Trail Markers in Illinois—(Illustrated)—Raymond E. Janssen, Northwestern University, Evanston.
2. The Prehistoric Villages and Camp Sites of the Peoria Lake Area—A. R. Buis, Peoria High School, Peoria. (Illustrated.)
3. Prehistoric Aboriginal Pottery of the Peoria Region—(Illustrated) —Ethel Schoenbeck, Peoria Academy of Science, Peoria.
4. Panel Discussion followed by question and comment period—Members of Section.

Subject: What is Hopewellian?

Discussion Leader: Thorne Deuel, Chief, Illinois State Museum, Springfield.

Other Members of Panel: H. L. Spooner, Peoria, Academy of Science; Donald Wray, Peoria, Illinois State Archaeological Society; J. B. Ruyle, Illinois State Archaeological Society, Champaign.

Turn papers in to Section Chairman at end of meeting.

BOTANY—L. H. Tiffany, Northwestern University, Evanston, *Chairman*

SECTION A—Room 211 Old Main.

Election of Chairman for 1940-41.

1. Recent Trends in Plant Disease Control—Neil E. Stevens, University of Illinois, Urbana.
2. A check-list of Illinois algae with new records from Cook County—M. E. Britton, Northwestern University, Evanston.
3. Mosses of Moultrie County—R. Harold Vaughn, Sullivan High School, Sullivan.
4. A preliminary report on the comparative anatomy of the Eucommiaceae—Oswald Tippo, University of Illinois, Urbana.
5. Projects for Biology—J. W. Hudson, Loyola University, Chicago.
6. Cotyledon numbers in conifers—Dorothy Butts and J. T. Buchholz, University of Illinois, Urbana.
7. Peculiarities in the Stems and Cones of Knob-cone Pine—J. T. Buchholz, University of Illinois, Urbana.
8. Notes on Embryo Development in Hippuris—Margaret Kaeiser, University of Illinois, Urbana.
9. A Newcomer's Impressions of the Botany of Illinois—George N. Jones, University of Illinois, Urbana.
10. The Pycnothyrium in the Taxonomic System of the Fungi Imperfecti—L. R. Tehon, Natural History Survey, Urbana.

Turn papers in to Section Chairman at end of meeting.

SECTION B—Room 212 Old Main.

1. A phytoplankton study of Lake Michigan at Evanston, Illinois—Kenneth E. Damann, Northwestern University, Evanston.
2. Relation of the Effects of Growth-Promoting Substances to Photosynthetic Activity, the Mass Law of Growth, and Seed Germination—Stanley William Oexemann, University of Illinois, Urbana.
3. Soil Moisture and Plant growth—Glenn Ray Noggle, University of Illinois, Urbana.
4. Grass Factor "X" in Young Leaves of Cereal Plants—F. Lyle Wynd, University of Illinois, Urbana.
5. Estimation of Riboflavin (Vitamin B2) in Plant Tissue—Stanley A. Watson, University of Illinois, Urbana.
6. Relationships of Nitrogen Metabolism in Plants—Dalibor Bubenicek and F. L. Wynd, University of Illinois, Urbana.
7. Some Temperature Relations of Tropisms—Harry J. Fuller, University of Illinois, Urbana.
8. Some Effects of Growth Substances on Petioles of Coleus Plants—R. Maurice Myers, Northwestern University, Evanston.
9. Recent Migrational Trends in the Distribution of Weeds in Kansas—Frank C. Gates, Kansas State College, Lawrence. (By title)
10. Observations on Stigmaria and Isoetes—Wilson N. Stewart, University of Illinois, Urbana.

Turn papers in to Section Chairman at end of meeting.

CHEMISTRY—James Neckers, Southern Illinois State Normal University, Carbondale, *Chairman.*

SECTION A—RESEARCH—Room 203 Science Hall

Election of Chairman for 1940-41.

1. 2-Chloro-3, 5-bis (acetylamino) Toluene—G. R. Yohe, State Geological Survey, Urbana.
2. The Introduction of Fluorine into Aromatic Nuclei by Means of Ammonium Fluoborate—G. C. Finger and F. H. Reed, State Geological Survey, Urbana. (Slides.)
3. Hydrogen Bonds involving the C-H Linkage—E. Ginsberg, University of Illinois, Urbana.
4. Enediols—R. V. Lindsey, University of Illinois, Urbana.
5. A Series of Substituted 1, 5-Diphenyl-pyrazoline-3-carboxylic acids —Edward L. Hill, Carthage College, Carthage.
6. Foam Stability—Sidney Ross, Monmouth College, Monmouth.
7. Copper in Tomatoes—William J. Shannon, University of Illinois, Urbana.
8. Optical isomerism of biphenyl derivatives—H. M. Teeter, University of Illinois, Urbana.
9. Chemical Analysis by Means of the Spectrograph—Russell J. Kiers, University of Illinois, Urbana.
10. Solubility and Etherates of Anhydrous Magnesium Perchlorate—Frank J. Seiler, Galesburg High School, Galesburg. (Slides.)
11. Synthetic Hydrocarbon Reactions in Petroleum Refining—Gustav Egloff, Universal Oil Products Company, Chicago.
12. Effect of Catalysts on Structure of Vinyl Polymers—E. H. Riddle, University of Illinois, Urbana.

Turn papers in to Section Chairman at end of meeting.

SECTION B—EDUCATIONAL—Room 304 Science Hall

1. Opportunities for Women in Chemistry—Virginia Bartow, University of Illinois, Urbana.
2. Adapting Chemistry to the Needs of the Citizens—Lawrence F. Tuleen, J. Sterling Morton High School, Cicero.
3. The Use of Calcium Hypochlorite for Gymnasium Sanitation—Howard W. Adams and Delbert N. Eggenberger, Illinois State Normal University, Normal.
4. Some Recent Additions to the Chemistry of indium—Therald Moeller, University of Illinois, Urbana.
5. Presentation of Atomic Structure to College Freshmen, 1905-1940—Sister Mary Martinette, Mundelein College, Chicago.
6. Home-made Structural Models—C. W. Bennett, Western Illinois State Teachers College, Macomb.
7. The Southern Illinois Chemistry Teachers Association—C. A. Grosse, Carbondale Community High School, Carbondale.

8. The Future of Chemistry as a Specialized Science in the High School Curriculum—T. A. Nelson, Decatur High School, Decatur.
9. The Student, The Teacher, and The Glands—Charles L. Haggard, Zeigler High School, Zeigler.
10. The Detection of oxy-halogen anions—J. H. Reedy, University of Illinois, Urbana and Sister Joan Preising, College of St. Francis, Joliet.

Turn papers in to Section Chairman at end of meeting.

GEOGRAPHY—Clare Symonds, Quincy, *Chairman.*

This section is sponsored by Illinois Chapter of the National Council of Geography Teachers.

Room 311 Old Main

1. A Method of Showing the Distribution of Native Vegetation on a Small Scale—Robert J. Voskuil, University of Illinois, Urbana.
2. The New Oil Industry of Illinois and Its Implications in the Social and Economic Life of Southern Illinois—Elmer W. Ellsworth, Centralia.
3. The Market Factor: Its Effect on Cultural Landscapes—Alfred W. Booth, University of Illinois, Urbana.
4. An Urban Rural Ecotone—Thomas F. Barton, Southern Illinois State Teachers College, Carbondale.
5. Geography in the High Schools of Southern Illinois—Erselia M. and Thomas F. Barton, Carbondale.
6. Climatic Regions of Illinois—Dalias A. Price, University of Illinois, Urbana.
7. Brittany and Cornwall: Geographical Twins—Mabel Crompton, Illinois State Normal University, Normal. (Illustrated.)
8. Major Coal Movements in the U. S. and their Significance—W. H. Voskuil, State Geological Survey, Urbana.

Election of Chairman for 1940-41. *Discussion of proposal to have two sections of geography—one to be research, the other educational.*

9. Geographic Axioms as Teaching Aids—Arthur B. Cozzens, University of Illinois, Urbana. (Illustrated.)
10. (Title to be announced.)—Henry L. Kellogg, Engineer, Illinois State Planning Commission, Chicago.
11. Fairmont Rural Study—Roscoe Lefler, University of Illinois, Urbana.
12. The Curious Caspian—W. O. Blanchard, University of Illinois, Urbana.
13. Selling Geography to the Public School Executive.—Robert G. Buzzard, President, Eastern Illinois State Teachers College, Charleston.

Turn papers in to Section Chairman at end of meeting.

GEOLOGY—David M. Delo, Knox College, Galesburg, *Chairman.*

Room 315 Old Main

Election of Chairman for 1940-41.

1. Blowouts and Sickle-shaped Dunes along Southern Lake Michigan—W. E. Powers, Northwestern University, Evanston.

2. Additional Notes on the Geodes of the Warsaw Formation—Percival Robertson and Marshal Brooks, Principia College, Elsah.

3. Geographical Contributions to Social Life—G. G. Cole, Wheaton College, Wheaton.

4. The Use of Natural Color Slides as an Aid in Geologic Teaching—H. R. Wanless, University of Illinois, Urbana.

5. The Research Program of the State Geological Survey and its New Facilities—M. M. Leighton, Chief, State Geological Survey, Urbana.

6. Strip Mining as a Competitive Factor in the Illinois Coal Mining Industry—Gilbert H. Cady, State Geological Survey, Urbana.

7. Fusain Content of the Fine Sizes of Illinois Coal—Bryan C. Parks and L. C. McCabe, State Geological Survey, Urbana.

8. Coordinate Time and Stratigraphic Terms—A. H. Sutton, University of Illinois, Urbana.

9. Typical Lower Mississippi Valley Silurian Lithology in Southeastern Wisconsin—John R. Ball, Northwestern University, Evanston.

10. A Restudy of Lesquereux's Fossil Plant Type from Illinois—Ray E. Janssen, Northwestern University, Evanston.

11. Aerial Photography—Harry McDermith, Urbana.

12. The Platteville-Galena Formations Exposed Near LaSalle and Ottawa, Illinois—J. S. Templeton, State Geological Survey, Urbana.

13. Pipette analysis as applied in clay research—R. A. Rowland, State Geological Survey, Urbana.

14. Glacial Lake Watseka—Geo. E. Ekblaw, State Geological Survey, Urbana.

15. Pre-glacial River Ticona—H. B. Willman, State Geological Survey, Urbana.

16. Recent Oil and Gas Development in Illinois—George V. Cohee and Charles W. Carter, State Geological Survey, Urbana.

Turn papers in to Section Chairman at end of meeting.

PHYSICS—C. N. Wall, North Central College, Naperville, *Chairman*

Room 103, Science Hall.

Election of Chairman for 1940-41.

1. Electrical Properties of the Human Body—O. L. Railsback, Eastern Illinois State Teachers College, Charleston.
2. High Potential and other Phenomena—G. C. Godejahn, Central Scientific Company, Chicago.
3. Advantages of Standard Sizes for Optical Panels—Clarence R. Smith, Aurora College, Aurora.
4. The Use of the R. W. Wood Replica Diffraction Gratings in a Study of Virtual Spectra—D. L. Barr, W. M. Welch Manufacturing Company, Chicago.
5. The Measurement of Velocity with Graflex Camera—R. E. Harris, Lake Forest College, Lake Forest.
6. Application of High Speed Photography to some Particular Ballistic Problems—Robert L. Womer, Western Cartridge Company, Chicago.
7. Distinguishing Characteristics for Particulate Carbonaceous Materials Dicharged to the Atmosphere by Fuel Burning Sources—Sidney Bloomenthal, University of Chicago, and Isadore Deutch, Chicago Department of Smoke Inspection and Abatement.
8. Wave Characteristics with Some Demonstrations for General College Physics—V. F. Swaim, Bradley Polytechnic Institute, Peoria.
9. Methods and Practical Applications of Vibration Isolation—H. A. Leedy, Research Foundation of Armour Institute of Technology, Chicago.
10. Some Physical Properties of Uranium—W. L. Hole, Elmhurst College, Elmhurst.
11. Lifetimes of Excited States in some Polyatomic Molecules—G. M. Almy and Scott Anderson, University of Illinois, Urbana.
12. Temperature—Lester I. Bockstahler, Northwestern University, Evanston.
13. (a) A Simplified Experiment for the Determination of the Stefan-Boltzmann Law of Radiation.
    (b) An Unusual Lunar Spectrum—Ph. A. Constantinides, Wright Junior College, Chicago.
14. Pressure and Volume Relation of the Toy Balloon—Frank L. Verwiebe, Eastern Illinois State Teachers College, Charleston.
15. A New Method for Production of Radioactive Hydrogen of Atomic Weight Three—R. D. O'Neal and M. Goldhaber, University of Illinois, Urbana.

Turn papers in to Section Chairman at end of meeting.

PSYCHOLOGY and EDUCATION—J. T. Cavan, Rockford College, Rockford, *Chairman*

Room 301 Old Main.

Election of Chairman for 1940-41.

1. The Vowal Format and What It Means in Speech and Vocal Music—O. Irving Jacobsen, Shurtleff College, Alton.
2. Implications for Education of Data on Youth—J. M. Hughes, Northwestern University, Evanston.
3. Social Forces and College Adjustments—Jordan T. Cavan, Rockford College, Rockford.
4. A Summary of Investigations of Transfer of Training in Education —Helen R. Messenger, Northern Illinois State Teachers College, DeKalb.
5. An Analysis of Attitudes Tests—Isabel C. Stewart and O. F. Gallaway, MacMurray College, Jacksonville.
6. Validity of Rank in High School Class and of Psychological Test Scores in Predicting Academic Success in College—C. E. Erffmeyer, North Central College, Naperville.
7. A Study of the Recitation Procedure Compared with the Unit-Directed Study Procedure in Modern History Classes in Eight Illinois High Schools—Robert S. Ellwood, Illinois State Normal University, Normal.
8. Trends in Science Education—Carroll C. Hall, Springfield High School, Springfield.

Round Table Discussion: Issues in Testing and in Science Teaching. (As time permits.)

Turn papers in to Section Chairman at end of meeting.

ZOOLOGY—Wilbur M. Luce, University of Illinois, Urbana, *Chairman*

Room 206 Alumni Hall.

Election of Chairman for 1940-41.

1. The Host of Another Illinois Species of Brachymeria (Hymenoptera)—B. D. Burks, State Natural History Survey, Urbana.

2. Comparative Populations of Game, Fur, and Other Mammals—Carl O. Mohr, State Natural History Survey, Urbana. (Lantern.)

3. Paratonsillar Myiasis—Eugene R. Dougherty, Springfield Junior College, Springfield.

4. Cephalic Deformities in Embryos of Massasanga Rattlesnake (*Sistrurus c. catenatus Rom.*)—Bertrand A. Wright, University of Illinois, Urbana. (Lantern.)

5. The Family Life of the Marsh Hawk—Charles K. Carpenter, Wheaton. (Lantern.)

6. The Effects of Nicotine and Cigarette Smoke on Pregnant Female Albino Rats and Their Offspring—J. M. Essenberg, Justin V. Schwind and Anne R. Patras, Loyola Medical School, Chicago.

7. The Action of Growth Stimulants on Proteins—Seward E. Owen, Cancer Research Unit, Veteran's Administration, Hines.

8. Studies on Ambush Bugs—W. V. Balduf, University of Illinois, Urbana. (Lantern.)

9. Illinois Distribution Records of the Black Widow Spider—Kenneth L. Knight, University of Illinois, Urbana.

10. Mexican Zoogeography for the Touring Teacher—Harry Hoogstraal, University of Illinois, Urbana. (Lantern.)

11. Induced Ovulation in Rana pipiens—T. W. Robinson and H. C. Hill, University of Illinois, Urbana.

12. A Case of Extreme Curvature in Regenerating Fin Rays—Donald F. Hansen, State Natural History Survey, Urbana.

13. The Effect of Starvation on the Fowl Cestode *Raillietina cesticillus*—W. Malcolm Reid, Monmouth College, Monmouth. (Lantern.)

14. Insects Taken by the Southern Pitcher Plant—Clarence J. Goodnight, University of Illinois, Urbana. (By title.)

15. An Annotated List of the Spiders of an East Central Illinois Forest (the William Trelease Woods, Urbana)—Sarah E. Jones, University of Illinois, Urbana. (By title.)

Turn papers in to Section Chairman at end of meeting.

JUNIOR SECTION PROGRAM

Audry C. Hill, *Chairman,* Chester High School, Chester.

Galesburg, Illinois

May 3-4, 1940

FRIDAY, MAY 3

8:00 a.m. Registration. Gymnasium, Galesburg High School.

8-10 a.m. Arrangement of competitive entries. Exhibits of Equipment of Scientific Companies. Gymnasium.

10-12 noon: Judging of competitive exhibits.

12-1:00 p.m. Luncheon of Junior Academy members. Congregational Church, across street from gym. Price, 30c.

1-2:30 p.m. Exhibits open for inspection by Junior Academy members.

1-4:30 p.m. *Exhibits open to public.*

2:30-4:30 p.m. Annual business meeting of official delegates of the Junior Academy. Auditorium, High School, Second floor of main building.

Address of Welcome. Mr. R. V. Lindsey, Superintendent of Schools, Galesburg.

Presentation of Junior Academy officials.

Roll call of clubs.

Music—Maine Chemistry Club Octet. Dedicated to Illinois Junior Academy.

Report of Junior Academy Delegates to A. A. A. S. Nadine Whitesides, Vienna Science Club, Vienna; Delbert Rainey, The Ferreters, Chester.

Science Play.

Election of 1940 *officers by official delegates.*

4:30-5:00 p.m. Removal of exhibits.

6:00-7:30 p.m. Annual Banquet. Universalist Church, Prairie and Tompkins Streets. Price 50 cents. Entertainment by Galesburg High School Choir and String Ensemble.

8:00 p.m. Annual Public Lecture. Joint meeting of the Junior and Senior Academies. Knox College Theatre.

The artificial creation of speech. (Slides and film)—Dr. J. O. Perrine, Vice President, American Telephone and Telegraph Company.

Announcement of Junior Academy Elections.

Presentation of Awards.

Saturday, May 4—Same as trips for Senior Academy. Register Friday for transportation and lunches. Wear hiking clothes for all but Railroad Trip.

GENERAL INFORMATION

SENIOR ACADEMY REGISTRATION AND HEADQUARTERS

Old Main Building, Knox College

Telegrams and other messages may be sent to individuals in care of Mr. H. E. Way, Knox College, Galesburg, Illinois, and called for at the registration desk. Changes of schedule or program and other special announcements will be posted near the registration desk.

Secure tickets for banquet before 10:30 a.m., Friday, May 3rd, at the registration desk. If you cannot arrive by that time and wish tickets send check or money order to reach Mr. C. L. Furrow, Knox College, Galesburg, Illinois, before Wednesday, May 1st. For your convenience in making reservations, a printed form is enclosed with this program.

HOTEL AND ROOM ACCOMMODATIONS

Persons wishing hotel accomodations should write as soon as possible directly to the hotel of their choice. Two hotels are available: The Custer, and The Broadview. Reservations for room accommodations can be arranged by communicating with the hotel direct.

JUNIOR ACADEMY REGISTRATION AND HEADQUARTERS:

Galesburg High School Gymnasium

Telegrams and other messages may be sent to individuals in care of Mr. H. E. Way, Knox College, Galesburg, Illinois, and may be called for in Room 108, Science Hall. Changes of schedule or program and other special announcements will be posted at the registration desk.

Housing facilities for out-of-town guests attending the Junior Section will be provided in private homes of Galesburg High School students at a minimum cost. Reservations should be made in advance with Mr. Frank Seiler, Galesburg High School, Galesburg, Illinois. Private homes—50c per person including breakfast.

STATE OF ILLINOIS
HENRY HORNER, Governor

Transactions

of the

ILLINOIS STATE ACADEMY OF SCIENCE

Volume 32 June, 1940 Number 4

Minutes of Council Meetings
Minutes of Thirty-Third Annual Meeting
Reports of Officers and Committees
Junior Academy Awards

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Vol. XXV, 1932. Quarterly issues.
Vol. XXVI, 1933. Quarterly issues (No. 3 exhausted)
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Vol. XXXI, 1938. Quarterly issues.
Vol. XXXII, 1939. Quarterly issues.

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TRANSACTIONS OF THE ILLINOIS STATE ACADEMY OF SCIENCE

Volume 32 June, 1940 Number 4

CONTENTS

PAGE

Minutes of meetings of the 1939-40 Council 249

Report of meeting with representatives of societies affiliated with the Academy 252

Reports of 1939-40 officers:

Secretary. Minutes of thirty-third annual business meetings, Galesburg . . . 253

Section meetings and general sessions, thirty-third annual meeting, Galesburg 254

Treasurer 255

Auditing committee's report 257

Editor 257

Librarian 257

Affiliated Societies 259

Reports of committees and delegates for 1939-40:

Conservation 260

Resolutions 261

Conservation Council 262

Legislation and finance 262

Conservation of archaeological and historical sites 263

Publications 263

Membership 263

A. A. A. S. Research Grants 263

A. A. A. S. Conference Delegates 264

High School science and clubs 266

Report on "Science Aids Service," Junior Academy publication 267

Winner of awards, Junior Academy 268

List of High School science clubs 273

List of scientific societies affiliated with the Academy 273

The index to Volume 32 will be published separately in September

STATE OF ILLINOIS
HENRY HORNER, *Governor*

DEPARTMENT OF REGISTRATION AND EDUCATION
JOHN J. HALLIHAN, *Director*

STATE MUSEUM DIVISION
THORNE DEUEL, *Chief*

Printed June, 1940

MINUTES OF MEETINGS OF THE 1939-1940 COUNCIL
ILLINOIS ACADEMY OF SCIENCE

The first meeting of the new council members was called to order at 8:00 A.M. May 6, 1939, by President Fernald in the board room of the State Museum at Springfield. Drs. Fuller and Furrow, past presidents, and Dr. Voth, retiring treasurer, also attended.

Minutes of the previous council meeting were read and approved. The first order of business was the setting up of special committees to be appointed by the council for the ensuing year. The committee on Conservation was appointed with the same personnel as the previous year plus one additional member, W. M. Gersbacher of Carbondale. The names of P. D. Voth, Chicago; A. F. Johnson, Rockford; and D. M. Delo, Galesburg were added to the membership committee. L. C. McCabe was appointed chairman of this committee, taking the place of H. E. Way, who was elected 2nd vice-president of the Academy and General Chairman for the Galesburg meeting at the annual election. Other committee changes were: Research grants, C. H. Behre, Jr. of Evanston made chairman and W. C. Rose of Urbana, the one new member of the committee, named to replace W. O. Blanchard, Urbana; W. M. Luce, Urbana made the third member of the Publications Committee; Dr. L. J. Thomas, Urbana, appointed delegate to the A. A. A. S.

Dr. George D. Fuller was appointed chairman of the new special committee on Academy finance called for by vote of the previous council. The publication fee was voted continued as in previous years though it was hoped it might be omitted another year.

The plans for the meeting at Galesburg were noted as well underway. Invitations for the annual meeting in 1941 were received from Chicago, Peoria, and Harrisburg and filed for later action of the council.

It was moved, seconded, and voted that the sixty-seven duplicate numbers of the *Transactions of the Illinois State Academy of Science* listed as follows:

Volume	*Year*	*Number of copies*
X	1917	2
XI	1918	2
XII	1919	1
XIII	1920	1
XIV	1921	1
XVI	1923	2
XVII	1924	2
XVIII	1925	2
XX	1927	2
XXI	1928	3
XXII	1929	2

		Number of parts			
		1	*2*	*3*	*4*
XXIII	1930	1		4	
XXIV	1931	3	3		4
XXV	1932		2	2	1
XXVI	1933		1	2	2
XXVII	1934	3	2		1
XXVIII	1935	4			3
XXIX	1936	2	2		1
XXX	1937	4			

and offered by the Knox College Library (through Professor C. L. Furrow) in exchange for certain other numbers requested by it and necessary to complete its files, be so accepted.

Names of members of the Academy deceased in 1938-1939 were read and the secretary was instructed to ask certain people to prepare memorials for publication in the *Transactions.*

The following special resolution presented by the Botany section was received as a memorial to Dr. Noé:

"It is with deep sorrow that the Botany Section of the Illinois State Academy of Science notes the passing of Dr. Adolf Carl Noé. Therefore, be it resolved that our sentiments be added to that of the Resolutions Committee of the Academy as a memorial to Dr. Noé, the man, and his achievements."

Paul D. Voth
L. E. Storer
Harry J. Fuller

After a short discussion of plans for council meetings during the year, the first meeting was adjourned at 9:00 A. M.

(Signed) R. F. Paton, *Secretary*

The second meeting was called to order by President Fernald at 12:30 P. M., November 4 in the seminar of the Physics Building at the University of Illinois in Urbana. Members of the senior council present, were past-president Wanless, vice-president Frison, the secretary, treasurer and the Junior Academy Representative. Present also by special invitation were the editor, chairman of the membership committee and three members of the Junior Council. Brief reports from the treasurer and the editor of the Academy Transactions were presented. The treasurer reported that funds for meeting the current expenses of the Academy were on hand. Due in no small degree to vigorous action of the editor the material for the next number of the Transactions was reported to be practically ready for the printer. The secretary reported on the correspondence he had had with members in the Geology section relative to the election of a successor to Dr. Croneis who resigned. After careful discussion Dr. D. M. Delo was appointed by the council as the section chairman of the Geology section for 1939-1940.

Considerable time was spent discussing the plans of the Junior Academy for the coming year. The senior council voted to support the Junior Academy with all the funds collected by the Junior group and not to exceed $50.00 in addition from the funds of the Senior Academy.

The Junior Representative was urged to organize the State into sections inviting one representative sponsor from each section to a meeting of the Junior Academy group to be held at the time of the next senior council meeting which was scheduled for the second week end in February at Galesburg. The secretary was instructed to work out further means of cooperation between the Junior and Senior Academy and to report at the next meeting.

Need for engineering clubs in the Junior Academy and for an engineering section in the senior Academy were expressed and steps were outlined for forming such a section for the annual meeting for the Academy this year.

Final decision on the 1941 meeting place of the Academy was postponed to a later date.

Dr. Voss reported on a list of missing members. It was noted that return postage on undelivered numbers of the Transactions was a large item of expense to the Academy and all members were urged to report address changes to either the secretary or the treasurer promptly.

The council meeting was held on November 4 because it coincided with the time of the fall High School Conference. This fact allowed a vigorous cooperation with the Junior Academy and it was voted to hold the fall council meeting in future years on the same occasion.

After some discussion of possible program material for the general session at the annual meeting, the council adjourned until February 10, at 3:25 P. M.

(Signed) R. F. Paton, *Secretary*

The third meeting of the Council of the Illinois Academy of Science convened at Knox College, Galesburg, Illinois, at 2:15 P. M. February 10, 1940. Seven members of the council were present. As the main business of the meeting was laying plans for the annual meeting in May, several members of the local committee on arrangements also attended part of the time. Minutes of the November meeting were read and approved.

Copies of the large number of the Transactions just published were examined and approval of the two-column page was unanimous.

Letters from section and committee chairmen indicating progress on the plans for the annual meeting were read and arrangements for section meeting places discussed with the local committee. Indications showed that plans for the annual meeting, both for the Senior and Junior Academy, were well advanced.

A letter from the A.A.A.S. telling of the research grant of $200 to the Illinois Academy for the current year was presented and referred to Dr. Behre, the chairman of the committee on awards. The grant was smaller than in the previous year due to a decrease in the number of members in the Illinois Academy who are also members of the national organization. There was some discussion of the nature of the research problems for which awards could be made and members were urged to advertise the fact that such funds were available. Reports from the holders of grants for the current year were presented.

The Secretary reported some activity leading toward the organization of an Engineering Science section in the Academy and attempts to reorganize and reestablish a social science section. There is excellent prospect that these sections will be functioning in another year.

Invitations for 1941 meeting were discussed and it was unanimously voted to accept the one from the Museum of Science and Industry, the Adler Planetarium and Astronomical Museum, the Chicago Academy of Science, the Field Museum of Natural History, the John G. Shedd Aquarium, and the Oriental Institute of the University of Chicago. The council felt that the Academy was particularly fortunate to have this opportunity to meet with these scientific organizations.

Reports on possibilities of cooperation with the American Institute in the organization of science clubs at the junior level in the State were outlined. Efforts to obtain the reaction of sponsors of such clubs particularly in the Junior Academy were mentioned. It was planned to arrange a joint meeting with the Academy council and representative sponsors from various parts of the state at some future date. No action beyond this was taken at this meeting. It was pointed out, however, that the time of the State high school conference at Urbana in November was favorable.

The meeting adjourned at 6:00 P. M.

(Signed) R. F. Paton, *Chairman*

The fourth meeting of the council was called to order by President Fernald at 7:30 P. M., May 2, 1940, at the Galesburg Club. All members were present but Dr. Deuel, who was unable to come, because of illness. Minutes of the previous meeting were read and approved.

The main business of the meeting was in checking details of the plans for the general and sectional meetings on Friday and trips on Saturday. This was quickly completed. Dr. Way gave a report on the local set-up indicating that all was in readiness to insure complete equipment and room facilities. Miss Hill also reported that all plans had been made for the Junior Academy exhibit the next day. The council voted unanimously their appreciation of the splendid coopreation of the city of Galesburg and Knox College through Dr. Way on behalf of the Academy.

It was voted that the secretary be instructed to arrange for the publication of the Consitution and By-laws of the Academy in mimeographed form for distribution to the council and committee and section chairmen.

A request for exchange membership from the New Hampshire Academy was referred to the Librarian with approval. A request for a set of the Academy publications from a Chinese University was heard but action postponed until more favorable times. Dr. Neil Stevens and Dr. R. E. Crist were appointed Academy representatives to the eighth Pan-American Scientific Congress to be held in Washington, D. C., May 10-18. The secretary reported some work on organization of Social Science and also on an Engineering Science section for the Academy. Dr. Wanless suggested that closer cooperation between student organizations in colleges along a similar line to that between the Academy and the high schools should be useful and it was recommended that this matter be discussed and brought up again at the council meeting in the fall.

A request from Mr. Astell, the editor of Science Club Service, for increased support from the Academy was read and on motion to grant, was voted. Need for prompt publication of papers submitted to the Academy was stressed and Dr. Way pointed out the provisions which had been made for receiving the papers to be presented the next day.

The meeting adjourned at 10:00 P. M.

(Signed) R. F. Paton, *Secretary*

Meeting of the Council with Affiliated Societies, May 4, 1940

This meeting was called to order at 8:00 A. M. by Dr. T. H. Frison, first vice president as the newly elected president V. O. Graham of Chicago was unable to attend. Reports were received from three of the affiliated societies and these appear elsewhere in this volume. After a brief discussion the council adjourned until the next meeting which will be held in Urbana at the time of the High School Teachers State conference held annually in the fall.

(Signed) R. F. Paton, *Secretary*

REPORTS OF OFFICERS AND COMMITTEES FOR 1939-40

Report of the Secretary

Minutes of the Thirty-third Annual Meeting, Galesburg

The meeting was called to order by President Fernald at 8:45 A. M. in Knox College Theater, Alumni Hall, Galesburg. Three special committees were appointed.

Nominating committee: H. R. Wanless, Chairman, G. D. Fuller, C. L. Furrow. *Committee on Resolutions:* Clarence Bonnell, Chairman, T. H. Frison, David M. Delo, *Auditing Committee:* L. P. Elliott, Chairman, James H. Sedgwick, Floyd L. Barloga.

These committees were instructed to report at the business meeting at five o'clock. Meeting adjourned at 9:00 A. M.

Annual business meeting. The annual business meeting of the Academy was held in Room 103, Science Hall at 5:00 P. M. President Fernald called the meeting to order. Minutes of the previous meeting having been published, they were not read. The following reports from committees and officers of the Academy were received and are published herewith. The affairs of the Academy seemed to be in excellent condition due to the effective cooperation and interest from those accepting responsibilities in Academy affairs. Those reports needing formal action by the Academy membership were voted approved. Members who were unable to attend the business meeting are urged to read the accompanying reports in order to learn more of the activities of the organization.

(Signed) R. F. Paton, *Secretary*

Report of the Committee on Nominations

President: V. O. Graham, 4028 Grace Street, Chicago.
First Vice President: T. H. Frison, State Natural History Survey, Urbana.
Second Vice President: C. R. Moulton, Museum of Science and Industry, Chicago.
Secretary: R. F. Paton, University of Illinois, Urbana.
Treasurer: John Voss, Manual Training High School, Peoria.
Librarian: Thorne Deuel, State Museum, Springfield.
Editor: Grace Needham Oliver, State Geological Survey, Urbana.
Junior Academy Representative: Miss Audry Hill, Chester H. S., Chester.

Committee on Conservation: T. H. Frison, State Natural History Survey, Urbana, Chairman. M. M. Leighton, State Geological Survey, Urbana. W. H. Haas, Northwestern University, Evanston. W. M. Gersbacher, S. Ill. State Normal University, Carbondale. David D. Lansden, Cairo. Paul Houdek, 710 N. Cross St., Robinson. R. S. Smith, University of Illinois, Urbana. J. H. VanCleave, University of Illinois, Urbana. W. C. Allee, University of Chicago, Chicago. E. L. Stover, E. Ill. State Teacher's College, Charleston.

Committee on Legislation and Finance: H. B. Ward, University of Illinois, Urbana, Chairman. Fay-Cooper Cole, University of Chicago, Chicago. Frank W. Aldrich, 1506 East Washington, Bloomington. Edson S. Bastin, University of Chicago, Chicago. B. Smith Hopkins, University of Illinois, Urbana.

Committee on Affiliations: To be appointed, Chairman. Paul E. Klopsteg, Central Scientific Co., Chicago. V. F. Swaim, Bradley Polytechnic Institute, Peoria. Clarence Bonnell, Harrisburg Township High School, Harrisburg. Glenn W. Warner, Wilson Junior College, Chicago.

Committee on Membership: Louis C. McCabe, State Geological Survey, Urbana, Chairman. Lewis H. Brown, Springfield High School, Springfield. J. H. Reedy, University of Illinois, Urbana. A. H. Sutton, University of Illinois, Urbana. Verner Jones, P. O. Box 128, Mattoon. Lester J. Bochstahler, Northwestern University, Evanston. N. D. Cheronis, 5556 Ardmore Ave., Chicago. J. F. Stanfield, Chicago Normal College, Chicago.

Committee on the Conservation of Archeological and Historical Sites: Fay-Cooper Cole, University of Chicago, Chicago. Frank W. Aldrich, 1504 E. Washington, Bloomington. M. J. Herskovits, Northwestern University, Evanston. M. M. Leighton, State Geological Survey, Urbana. Bruce W. Merwin, 601 W. Walnut St., Carbondale. J. B. Ruyle, 9 Main St., Champaign. H. B. Ward, University of Illinois, Urbana.

Committee on Research Grants from the American Association for the Advancement of Science: William O. Blanchard, University of Illinois, Urbana, Chairman. L. Hanford Tiffany, Northwestern University, Evanston. W. C. Rose, University of Illinois, Urbana. H. J. Van Cleave, University of Illinois, Urbana. H. E. Way, Knox College, Galesburg.

Committee on Publications: V. O. Graham, 4028 Grace St., Chicago, Ex-Officio. R. F. Paton, University of Illinois, Urbana, Ex-officio. W. M. Luce, University of Illinois, Urbana.

Committee on Ecological Bibliography: A. G. Vestal, University of Illinois, Urbana.

Committee on High School Science and Clubs:
Chairman: Audry Hill, Chester High School, Chester.
Assistant Chairman: Mary Creager, Vienna.
Chairman of Exhibits: (to be appointed from the Chicago area).
Assistant Chairman of Exhibits: John C. Ayers, Normal Community High School, Normal.
Co-Chairman of Judging: Allan R. Moore, J. Sterling H. S., Cicero. John Chiddix, 201 N. School St., Normal.
Editor: "Science Club Service" Louis A. Astell, University High School, Urbana.
Contributing Editor for Illinois: Rose M. Cassidy, Maine Twsp. High School, Des Plaines.
Radio Chairman: Rosalie M. Parr, University of Illinois, Urbana.

Advisory Committee:
Don Carroll, State Geological Survey, Urbana.
S. Aleta McAvoy, Rockford H. S., Rockford.
Allan R. Moore, J. Sterling Morton H. S., Cicero.
Rosalie M. Parr, University of Illinois, Urbana.
William Schwab, Jr., Madison H. S., Madison.
Frank Sieler, Galesburg H. S., Galesburg.
Lyell J. Thomas, University of Illinois, Urbana.
C. W. Whitten, 11 S. LaSalle St., Chicago.

Local Arrangements Chairman for 1941 Meeting:
(to be appointed from the Chicago area)

Delegate to the American Association for the Advancement of Science: L. J. Thomas, University of Illinois, Urbana.

Delegate to the Conservation Council of Chicago: V. O. Graham, 4028 Grace St., Chicago.

Publicity Director, Annual Meeting May 2-3, 1941, at Chicago: John A. Maloney, Museum of Science and Industry, Chicago.

General Chairman, Chicago Meeting: C. Robert Moulton, Museum of Science and Industry, Chicago.

(Signed) H. R. Wanless, *Chairman*
Geo. D. Fuller
C. L. Furrow

Section Meetings and General Sessions

The general session of the Academy was called to order by President Fernald at 9:00 A. M. in Knox College Theatre in Alumni Hall. An unusually large group were in attendance. Dean C. J. Adamic graciously welcomed the Academy to Knox Campus, and Dr. Fernald then gave presidential address, an illustrated lecture on "Michael S. Bebb, Illinois Botanist and Letter-Writer."

A lecture, "Science and the Common Life," by Anton J. Carlson, University of Chicago, and "Looking through Great Telescopes," consisting of motion pictures and a lecture by Oliver J. Lee of Dearborn Observatory, completed the morning's program.

The noon luncheon saw a new departure, several of the scientific sections lunching together. This facilitated the transaction of general business after the meal and conserved time for the presentation of the section papers.

All the sections were well represented and interesting programs well attended. New section chairmen for next year were elected as follows:

Section Chairmen for 1940-1941

Agriculture: Mr. C. H. Oathout, W. Ill. State Teachers College, Macomb.
Anthropology: Mr. Floyd Barloga, 1423 N. Glenn Oak, Peoria.
Botany: Mr. Paul Voth, Dept. of Botany, U. of Chicago, Chicago.
Chemistry: Mr. Geo. H. Reed, Knox College, Galesburg.
Geography: Dr. Arthur B. Cozzens, University of Illinois, Urbana.
Geology: Marvin Weller, State Geological Survey, 305 Ceramics, Urbana.
Physics: Ph. A. Constantinides, Wright Junior College, Chicago.
Psychology & Education: O. Irving Jacobsen, Shurtleff College, Alton.
Zoology: Dr. W. V. Balduf, Dept. of Entomology, University of Illinois, Urbana.

The evening banquet held in Seymour Hall Dining Room went according to schedule and there was plenty of time for the members to get to the annual public lecture where the Senior and Junior Academies together heard a most interesting lecture by Dr. J. O. Perrine, Vice-President of the American Telephone & Telegraph Company. Pedro the Voder spoke like a man for Dr. Perrine and it would have been hard to imagine a more perfect and complete demonstration of one of the results of the years of careful and imaginative research carried on by this company. The Illinois Academy is greatly indebted to the Bell Laboratories for giving members of the Academy the privilege of listening to this demonstration lecture.

After the lecture the Junior Academy awards were made. The members of the Senior Academy who could, remained for these awards and observed the enthusiasm of the Junior branch of the Academy. The general impression was that the joint meeting was a distinct success.

The field trips Saturday morning were unusually well prepared. The Junior Academy members attended in large numbers and reported a fine trip in every case. The leaders of these groups gave real service to the Academy in helping to maintain this excellent tradition of the annual Illinois Academy meetings.

(Signed) R. F. Paton, *Secretary*

Report of the Treasurer

For the fiscal year May 1, 1939 to April 30, 1940

Receipts

Balance on hand April 30, 1939		$217.19
Dues and initiation fees:		
Annual members	$776.25	
Affiliated societies	14.50	
Libraries	4.00	
		794.75
Sale of transactions		1.00
Editorial and excess pages fees		265.50
Research grants by the A. A. A. S.		225.00

Junior Academy:		
Dues and initiation fees	$100.15	
Sale of Science Club Service	6.25	
Grants for trophies	14.00	
		120.40
		$1623.84

Expenditures

Expenses of the Annual Meeting, Springfield, 1939:		
Officers' expenses	$ 57.46	
Annual Address	25.00	
Section Chairmen, expenses	42.28	
		124.74
Expense of Editor of Transactions		10.67
Expenditures of Treasurer:		
Dues notices and postage	19.00	
Rubber stamps	3.01	
Envelopes	2.45	
		24.46
Expenditures of Secretary, postage		14.83
Printing of Transactions		355.14
Postage and transportation of Transactions		19.09
Conservation Council		2.00
Research grants:		
Fred R. Cagle	$ 85.00	
Marie A. Hinrichs	70.00	
Paul Beaver	70.00	
		225.00
Bank charge		1.08
Junior Academy:		
Expenses of the Annual Meeting, Springfield, 1939:		
Annual Address	10.00	
Exhibit expenses	14.15	
Officers' expenses	8.80	
Trophies	37.42	
Engraving	2.40	
Printing	14.90	
		87.67
Printing of Science Club Service		62.20
Printing of Diplomas		4.24
Balance in Commercial Merchants National Bank and Trust Company of Peoria		692.72
		$1623.84

Statement of Resources, April 30, 1940

Balance in Commercial Merchants National Bank and Trust Company of Peoria	692.72
Certificate of Deposit No. 760 for Meyer Block Bonds (Chicago) for an Aggregate Principal Amount of $300.00	value unknown
Certificate of Interest No. 13 for Forbes Building (Chicago) for original value of $300.00	value unknown
	$692.72

The membership of the Academy consists of 67 life members, 558 members paid up to and including the year 1940, 132 members one year in arrears, 68 members two years in arrears, and 57 members three years in arrears. The latter, according to the constitution will be dropped at the Galesburg meeting.

The total membership is 937 which includes 112 new members but does not include the members who are three years in arrears.

During the year 13 members have resigned, 15 have died, and 54 have removed leaving no forwarding address.

The Academy has added 11 new Junior Academies, 21 are fully paid up, 13 are one year in arrears, 16 two years in arrears, and one three years in arrears. The Junior Academy is self-supporting.

(Signed) John Voss, *Treasurer*

Report of the Auditing Committee

This is to certify that we have examined the accounts of John Voss, Treasurer of the Illinois State Academy of Science, for the year May 1, 1939 to April 30, 1940 and find them correct. The balance of $692.72 is on deposit at the Commercial Merchants National Bank and Trust Company of Peoria, Illinois.

(Signed) L. P. Elliott
James H. Sedgwick
Floyd L. Barloga

Report of the Editor

The cost of printing the Academy *Transactions* during the year 1939-40 has been as follows:

	State funds	*Academy funds*
Vol. 31, No. 4 (June, 1939)	......	$145.00
Vol. 32, No. 1 (Sep. 1939)	$194.42	......
No. 2 (Dec. 1939)	692.55	90.00
No. 3 (Mar. 1940)	......	84.40

Inasmuch as the State funds have been increased for the biennium from $2000 to $3000, the Academy may possibly see its way clear this year to dispense with the Editorial Fee of $1.00 which has been for several years past charged each author publishing.

An increase in membership this year, due to an active campaign under the leadership of L. C. McCabe, has aided materially in increasing funds for Academy use.

(Signed) Grace Needham Oliver, *Editor*

Report of the Librarian

Approximately 350 copies of the Transactions of the Illinois State Academy of Science were sent out in response to special requests during the past year. Many of these were sent to complete files of libraries and scientific societies on the exchange list of the Academy. Numerous requests were also received from new Academy members.

Following is a list of Transactions now on hand including those that were published since the last annual meeting.

Single Volumes

Vol. I	1 copy
Vol. II	454 copies
Vol. III	443 copies
Vol. IV	136 copies
Vol. V	291 copies
Vol. VI	126 copies
Vol. VII	385 copies
Vol. VIII	435 copies
Vol. IX	303 copies
Vol. X	408 copies
Vol. XI	14 copies
Vol. XII to XXII	Out of Print

Quarterly Volumes

Vol. XXIII No. 1	25 copies
Vol. XXIII No. 2	NONE
Vol. XXIII No. 3	NONE
Vol. XXIII No. 4	9 copies
Vol. XXIV No. 1	18 copies
Vol. XXIV No. 2	249 copies
Vol. XXIV No. 3	NONE
Vol. XXIV No. 4	NONE
Vol. XXV No. 1	848 copies
Vol. XXV No. 2	304 copies
Vol. XXV No. 3	260 copies
Vol. XXV No. 4	296 copies

Vol. XXVI No. 1	14 copies
Vol. XXVI No. 2	250 copies
Vol. XXVI No. 3	220 copies
Vol. XXVI No. 4	332 copies
Vol. XXVII No. 1	412 copies
Vol. XXVII No. 2	224 copies
Vol. XXVII No. 3	NONE
Vol. XXVII No. 4	97 copies
Vol. XXVIII No. 1	62 copies
Vol. XXVIII No. 2	45 copies
Vol. XXVIII No. 3	NONE
Vol. XXVIII No. 4	381 copies
Vol. XXIX No. 1	327 copies
Vol. XXIX No. 2	328 copies
Vol. XXIX No. 3	NONE
Vol. XXIX No. 4	187 copies
Vol. XXX No. 1	340 copies
Vol. XXX No. 2	357 copies
Vol. XXX No. 3	NONE
Vol. XXX No. 4	363 copies
Vol. XXXI No. 1	384 copies
Vol. XXXI No. 2	301 copies
Vol. XXXI No. 3	NONE
Vol. XXXI No. 4	337 copies
Vol. XXXII No. 1	148 copies
Vol. XXXII No. 2	755 copies
Vol. XXXII No. 3	200 copies

Following are the publications received in exchange for the Transactions of the Illinois State Academy of Science:

1. The American Midland Naturalist.
2. The Journal of the Alabama Academy of Science.
3. Journal of Arnold Arboretum.
4. The Audubon Bulletin.
5. Pamphlets of the Council for Industrial and Scientific Research of the University of Australia.
6. Australian Zoologist.
7. Publications of Bibliotheek Landbouwhoogeschool.
8. Butler University Botanical Studies.
9. Proceedings of the California Academy of Science.
10. Publications in American Archaeology and Ethnology Univ. of Calif.
11. Occasional papers California Academy of Sciences.
12. Publications of the University of California.
13. Publications in Zoology University of California.
14. Report, Circulars, Bulletins, Department of Agriculture, Canada.
15. Annual Report of the Geological Survey of the Canada Dept. of Mines.
16. Memoirs of the Canada Geological Survey.
17. Economic Geology Series memoirs of the Canada Geological Survey.
18. Annual Reports of the National Museum of Canada.
19. Bulletins of the National Museum of Canada.
20. Bulletins, Leaflets, Chicago Naturalist of the Chicago Academy of Sciences.
21. Proceedings of the Colorado Scientific Society.
22. Studies of the University of Colorado.
23. Fifth Annual Report, of the Institute of Fan Memorial.
24. Herbage Publication of the Imperial Bureau of Plant Genetics.
25. Plant Breeding Abstracts of the Imperial Bureau of Plant Genetics.
26. Proceedings of the Indiana Academy of Science.
27. University of Indiana Science Series.
28. Arquivos do Instituto de Biologia Vegetal.
29. Transactions of the Kansas Academy of Science.
30. Lloydia, Lloyd Library and Museum.
31. Geological Series, University of Manitoba.
32. Reprints, University of Manitoba.
33. Publications of the Michigan Academy of Sciences, Arts, and Letters.
34. Occasional Papers of the Museum of Anthropology of the University of Michigan.
35. Bulletins of the Minnesota Academy of Science.
36. Biennial Reports of the Mississippi Geological Survey.
37. Bulletins of the Mississippi State Geological Survey.
38. Studies of the University of Missouri.
39. Proceedings of the Missouri Academy of Sciences.
40. Annual Report of the Agricultural Experiment Station, University of Montana.
41. Bulletins and Circulars of the Agricultural Experiment Station, Montana State College.
42. Bulletins of the Museum National D'Histoire Naturelle.

43. Publications of the Polish Museum of Zoology.
44. Natur Und Volk, Senckenberg Museum, University of Frankfort.
45. Proceedings, Abstracts of papers of the Nebraska Academy of Sciences.
46. New Mexico Anthropologist, University of New Mexico.
47. Technical Publications and Bulletins of the New York State College of Forestry.
48. Annual Reports, Proceedings of Ohio Academy of Science.
49. Bulletins of the Ohio Biological Survey.
50. Bulletins of the Ohio State University.
51. Proceedings, Year Books of the Academy of Natural Sciences of Philadelphia.
52. Museum Service of the Rochester Museum of Arts and Sciences.
53. Miscellaneous Collections Smithsonian Institution.
54. Reprints from Annual Reports Smithsonian Instituion.
55. Journal of the Tennessee Academy of Science.
56. Transactions of the Texas Academy of Science.
57. Annual Reports, progress reports of the Texas Agricultural Experimental Station.
58. Bulletins, Circulars, of the Texas Agri. Experiment Station.
59. Bulletin of the Geological Institution of the University of Upsala, Sweden.
60. Proceedings and Program of the Virginia Academy of Science.
61. Publications in Biology of the University of Washington.
62. Publications, Supplementary Series of the University of Washington.
63. Proceedings of the West Virginia Academy of Science.
64. Bulletins of the West Virginia Scientific Association.
65. Publications of the University of Wyoming.

(Signed) Thorne Deuel, *Librarian*

Three of the societies affiliated with the Illinois Academy of Science submitted the following reports:

The Illinois Nature Study Society of Elgin, Illinois, celebrated its 20th anniversary Thursday 27th, 1940. The Society has met the first Tuesday in each month the year round, and opens the meetings with nature notes and roll call. A paper on some aspect of nature is presented at each session.

In the past many field trips have been taken, such as Fish Hatchery, Morton Arboretum, Peat Bed, Trout Park, which is now the Elgin Botanical Garden, of which the Society is one of the sponsors, Game Farm and many nearby points of interest.

The Society is affiliated with the Chicago Conservation Council, and their monthly reports are read at our meetings, and our delegate attends some of the Council meetings.

We receive reports and recommendations from the National Parks Association and Wild Life, and other conservation groups.

(Signed) Mrs. Harriet M. Armstrong

The Science Club of Rockford College was organized to acquaint students with all fields of service; to further the interest of members in their own fields; and to further the spirit of cooperation between the college science departments.

This year the Science Club has presented two speakers at open meetings to which the members of the college community and the general public were invited. On Nov. 14, Mr. S. A. Sponder, president of the Rock River Valley Council of Engineers, gave an illustrated talk on "Motion Study Engineering." On March 4, the Service Club banquet was given in honor of Dr. M. M. Leighton, Chief of the Geological Survey of Illinois. After the banquet, Dr. Leighton spoke in Tolcott Hall on "Scientific Research and Our Mineral Resources." April 27, members of the Rockford College Science Club assisted in presenting a Science Exhibition sponsored by the Northern Illinois Science Academy. We are planning to show a film on photography some time in May.

(Signed) Diana Porikos, *Secretary-Treasurer*

Report from the University of Illinois Section of the A. C. S.

I have accepted the duty which falls to the delegate of an affiliated organization, the American Chemical Society, and will present briefly a resume of an outstanding piece of work that has been in progress for the past five years under a competent committee of this organization and that should be of considerable interest to members of the Illinois State Academy of Science.

The committee on "The Professional Training of Chemists" in those colleges, universities, and technical schools, which provide training that leads to the qualification of men and women as professional chemists has published three reports in the News Edition of Industrial and Engineering Chemistry during the year 1939.

In 1937, and again in 1938, questionnaires sent to educational institutions of higher learning in the United States received approximately four hundred replies which served as the basis from which the proposed minimum standards for accrediting chemistry departments were formulated as published in these articles. Further work of the committee in 1940 is concerned with the matter of visitation and rating of chemistry departments by these standards.

The purpose of the American Chemical Society in accrediting chemistry departments is to determine what students will be qualified to become members of this organization in minimum time and to have available a list of schools where students may be advised to go who wish to become "professional chemists." A statement of minimum requirements gives to educational institutions a pattern that will serve as a basis for determining the extent and quality of the teaching personnel, the required physical equipment, and the necessary annual budget for sustaining a proper chemical education program.

Rating of the chemistry departments includes educational standards for administrative and staff members of the faculty, size of quiz and laboratory sections, laboratory equipment, and text books used.

Minimum standards for a chemical curriculum for the Bachelor's degree are set up. Besides prescribed courses in chemistry, this curriculum includes mathematics, foreign languages, English, and humanities. These standards are intended for those students who intend to go into industry. In many cases those students who intend to go on with graduate work may not attempt to fulfill these requirements.

The American Chemical Society Committee has already visited a number of educational institutions for the purpose of rating the chemistry departments. By June one hundred departments will have been visited and by January 1, 1941 one hundred-fifty departments out of the four hundred who replied to questionnaires and came nearest to fulfilling requirements, will have been rated.

The national committee that has developed this work is composed of the following members:

Robert E. Swain, Chairman; Erle M. Billings, Secretary; Roger Adams; A. W. Hixson; H. B. Weiser; W. A. Noyes, Jr.

(Signed) Rosalie M. Parr.

Report of the Committee on Conservation

Since the time of the last meeting, your Committee on Conservation has continued to to keep in close touch with all federal and state legislation pertaining to the preservation and utilization of our natural resources. During the past year there have been some notable advances in the conservation program of our own state and throughout the country as a whole. As usual, there has been some proposed federal legislation pertaining to national parks, national monuments and national forest units which has had undesirable features. Most of these unwise proposals originate with local groups desirous of exploiting the resources of federal lands which have been set aside by the nation for other purposes.

One such bill is the federal House Resolution 6975. This bill aims at the reconveyance to the State of Montana of a portion of the land now within the bounderies of the Yellowstone National Park. This assault on the oldest and grandest of our national parks has been protested by your Conservation Committee by registering with all Illinois representatives in the House our opposition to the enactment of such a bill.

Last year our Committee report gave considerable emphasis to the new Pittman-Robertson Bill or Federal Aid in Wildlife Restoration Act. I am glad to report that the program in Illinois anticipated at that time is now well under way. Furthermore, this program is one of the most far-reaching steps in conservation undertaken in the state over a period of many years. The projects now in progress in the state are being sponsored jointly by the Illinois State Department of Conservation and the Illinois Natural History Survey. A more or less complete report of these projects may be found in the 1940 spring issue of "Illinois Conservation," published by the State Department of Conservation at Springfield, Illinois.

Another forward step in the conservation program of Illinois during the last year has been the establishment of a new state forest unit in the sandy area of Mason and Tazewell counties. Approximately 5000 acres have now been purchased or are held in option in this area by the Forestry Division of the State Department of Conservation. A co-operative wildlife management project for this same area is being developed between the State Department of Conservation and the Illinois State Natural History Survey.

Several resolutions, resulting from Committee action, have been prepared for inclusion in the Resolutions Committee report to the Academy.

(Signed) T. H. Frison, *Chairman*

Report of the Resolutions Committee

WHEREAS, the Yellowstone National Park is the oldest and probably the grandest of our national parks, and is now in danger of having its boundaries altered by the elimination of approximately 3,000 acres from the park by transfer of these acres to the State of Montana, and

WHEREAS, the removal of this area from the Yellowstone National Park system would set a dangerous precedent for all of the national park areas,

THEREFORE, be it resolved by the Illinois State Academy of Science that it urge the Public Lands Committee of the United States House of Representatives and the Illinois members of the House of Representatives to protest the passage of House Resolution 6975.

WHEREAS, in several of the new oil and gas fields of southern Illinois the oil is being produced with comparatively little cognizance of loss of reservoir energy through the escape of natural gas, and

WHEREAS, this loss of reservoir energy, according to experience in many fields in Oklahoma, Kansas and Texas, will result in a reduced recovery of oil from the oil sands, and

WHEREAS, only a fraction of this natural gas is being utilized either in restoring the reservoir energy of the oil sand or in generating useful heat and power, or in being passed through gasoline extraction plants, so that most of the natural gas resources as well as the the reservoir energy of the new fields are being wasted, and

WHEREAS, certain other wasteful practices exist in the new oil fields, including excessively close well spacing, etc., which effect the waste of natural resources,

THEREFORE, be it resolved by the Illinois State Academy of Science that it urge upon the legislative and executive branches of the State government the urgent need for a practicably feasible and scientifically sound conservation law with such provision for its administration as will promote industrial development and at the same time insure a maximum of good conservation practice.

WHEREAS, the Illinois State Academy of Science has, within the past year, lost by death, the following members: John W. Barwell, D. Julian Block, Henry C. Cowles, Wm. B.

Day, Dr. Clarence Earle, E. E. Hagler, Charles M. Johnson, F. G. Logan, W. I. Lyon, George W. Martin, Frank P. Norbury, James F. Porter, Mabel E. Smallwood, Dr. R. Sonnenschein, Dr. Isidor Tumpeer,

THEREFORE, be it resolved that the profound regrets of the Academy be expressed to members of the families of the deceased.

WHEREAS, officials of Knox College, especially President Carter Davidson, Professor H. E. Way, Mr. Wade Arnold, Professor C. L. Furrow, Professor William Calder, Professor Ira Neifert, Professor George Reed and Professor David M. Delo; officials of Galesburg High School, especially Mr. Frank Seiler; of the Galesburg Chamber of Commerce and of the Burlington Railroad have, by their cordial cooperation, contributed greatly to the success of the thirty-third annual meeting of the Illinois State Academy of Science,

THEREFORE, be it resolved that the Academy express its sincere thanks to the officials of these institutions.

WHEREAS, officers of the Illinois State Academy of Science have in the past year conducted the affairs of the program faithfully and efficiently,

THEREFORE, be it resolved that the sincere thanks of the Academy be expressed to these officers.

BE IT FURTHER RESOLVED that the secretary of the Illinois State Academy of Science is authorized and directed to record and send copies of these resolutions to all who should receive them.

(Signed) Clarence Bonnell, *Chairman*
T. H. Frison
David M. Delo

Report of the Delegate to the Conservation Council

Throughout the year Kings Canyon National Park has been before conservation groups. An important question involved the National Park standards for in order to establish this park some compromises seemed necessary. As established some grazing will continue throughout the lifetime of the lease holders. Many considered the two canyons of such outstanding beauty that they should be included. Because of private holdings and rights these were necessarily excluded from the park. It is to be hoped that standards may not be endangered and that our older National Parks may be held unchanged throughout all time.

The proposed Cascades National Park includes another dangerous proposition:—Shall mining interests be permitted in future National Parks? If they are, what will be the effect on National Park Standards? Will it be possible to create a new type of Park, comparable to a National Park and permit mining rights without breaking down all established safeguards? The proposed bill will make possible for all future parks to permit such rights.

The perennial assault on Yellowstone was again before us in two forms, one for diversion of water from Yellowstone lake, the other involved a direct gift of land to Montana. These are examples of items requiring the constant watchfulness of conservation groups.

The conservation picture in the state of Illinois is steadily improving under the guidance of a number of conscientious men. Much has been done and much remains to be done.

(Signed) V. O. Graham, *Chairman*

Report of Committee on Legislation and Finance

The arrangement with the Illinois State Museum for handling the publications of the Academy which are printed by the state is proceeding with satisfaction to all involved. Accordingly the plans which have been followed will be adopted for the coming year also.

(Signed) Henry B. Ward, *Chairman*

Committee on the Conservation of Archaeological and Historical Sites

I regret exceedingly to report again that nothing constructive has been accomplished toward the licensing scheme which we had for archaeological excavations or collection in the state. We have had a bill proposed and properly drawn and I think it would be effective if we could secure a proper licensing agent. At the present moment tne only possible agency of this kind would be the Illinois State Museum. I have talked this matter over several times with Dr. Deuel and he does not feel that he is yet in a position to take on the extra work which might result from assigning this task to him. I hope that we may ultimately work out a satisfactory scheme but unless we can get the proper licensing agency it is better to leave the matter alone.

(Signed) Fay-Cooper Cole, *Chairman*

Report of Committee on Publications

As recorded in the Committee's report of last year, a plan for obtaining copy for the Editor at an earlier date has been put into effect and all authors desiring to have their papers considered for publication must turn in typewritten copies of same at the end of their respective Section meeting on May 3rd. All participants giving papers at the Galesburg meeting who are not now members of the Academy have been sent notices by the membership chairman, and have also been notified by their Section chairmen, to the effect that only members of the Academy may publish in the Transactions. This is based on By-law VIII which so stipulates, with exceptions the Council may see fit to make.

The number of authors appearing in print is increasing: in 1938 there were 72; in 1939, 90. In view of this fact, a new format for the issue containing papers was adopted which allowed an increase of words to the page from 1000 to 1400. This meant that the 90 articles printed in 1939 occupied the same number of pages as did 72 in 1938. A considerable saving in expense was consequently enjoyed. Although there may be more authors publishing in the 1940 issue, due to a substantial increase in membership, it may still be possible to stay within the Academy printing budgets as the State allowance of funds for the biennium 1939-41 has been increased. If a favorable balance can be attained, it may be possible to eliminate the Editorial Fee.

(Signed) Geo. D. Fuller

Report on the Committee on Membership

About 300 personal and form letters were mailed to prospective members during the year. The response from this appeal and personal solicitation has been very satisfactory.

New members since last meeting and up to annual meeting, 120.

Expenses:

Stamps	$ 4.80
Mimeographing and typing	5.40
Printing	3.50
Total	$12.80

(Signed) Louis C. McCabe, *Chairman*

Report of the Committee on A. A. A. S. Grants

The committee on Research Grants of the Illinois Academy of Science has considered the applications so far received. There are three, all of which seem deserving. One of these arrived only very recently,—that from Dr. Cagle. The other two have been on hand since the first public announcement that these funds were available.

The committee recommends unanimously the granting of the following sums to the applicants mentioned:

To Professor C. L. Furrow, Department of Zoology, Knox College, Galesburg, Illinois: $75.00.

To Dr. Frank O. Green, Department of Chemistry, Greenville College, Greenville, Illinois: $75.00.

To Dr. Fred R. Cagle, Museum of Natural and Social Sciences, Southern Illinois State Normal College, Carbondale, Illinois: $50.00.

The grant to Dr. Furrow is to further his work on general sex conditions in the Genus Valvata, for purchase of apparatus and photographic materials. The grant to Dr. Green is to continue his study of Acylals and related compounds and specifically for the purchase of materials and apparatus. The grant to Dr. Cagle is to permit the purchase of equipment and to further the cost of transportation in conducting a survey of the amphibians and reptiles of Jackson and Union Counties, Illinois. In all three cases, the grants are in furtherance of work already carried on by the applicant.

I regret that I shall not be present at the annual meeting of the Academy, but take this opportunity to present the report of our committee, and to request the discharge of the committee after the acceptance of its report. May I also ask whether, if the report is received favorably, you will undertake to notify the recipients, or is this a duty of the chairman of your committee?

(Signed) Thorne Deuel
Chas. T. Knipp
W. C. Rose
Hanford Tiffany
Chas. H. Behre, Jr., *Chairman*

Report of the Delegate to the A. A. A. S. Academy Conference

The Academy Conference was called to order on December 27, 1939 at the Deshler-Wallick Hotel, Columbus, Ohio, by Dr. Bert Cunningham, Chairman (North Carolina Academy) who is also chairman of the special committee on Science Clubs. The most important business and first on the program was the report of the Special Committee by its Secretary, Dean Howard E. Endres of Purdue University (Indiana Academy). The report was voted accepted by the Academy Conference. The conference further recommended that the delegates to the Academy Conference be elected for a term of not less than three years.

In order to explain somewhat the implications of Dr. Ender's report it will be necessary to digress a bit to give some statement as to its history.

At the Richmond meeting of the Academy Conference 1938, your present delegate was elected to serve on a Special Committee to work out organization problems of Junior Academies, to discover the aims and relations of the American Institute Inc. and to seek through cooperation the unification of science club work in the United States. This Special Committee met at the Hotel Lincoln, in Indianapolis, Ind., Feb. 11, 1939, and certain recommendations were agreed upon concerning which more will be said later after you are informed about the relations of the American Institute. This organization is strictly a New York City institution founded in 1828 to promote industry and invention. Its importance dwindled with the development of industry, other large cities, Universities, and research programs over the United States. In 1928 the same year our Junior Academy held its first annual meeting at Macomb, Illinois a New York group of business men revived the old American Institute as sponsor for the Children's Fair in cooperation with the science club of the New York City school system.

For some time Professor Otis W. Caldwell, Permanent Secretary of the A.A.A.S. had been watching the growth of the Junior Academy from its inception in Illinois to a spread over 15 other States. He further noted its relations with State Academies. The offer of $54,000.00 annually for the next three years by the Westinghouse Company to promote science clubs was promptly steered into the hands of the American Institute. With this large sum of money at their disposal they have proceeded with high pressure business methods to incorporate the Junior Academies one by one as feeders to the American Institute Inc., although the original idea of the steering committee seems to have visualized a science club, Junior Academy, State Academy, A. A. A. S. relationship. This original idea, I might say, is essentially an extension of the existing relations of colleges and universities with the State Academy and the A.A.A.S. to the high school through a Junior Academy. It is a practical and workable system for stimulating earlier in the school career contacts with science. Its development depends upon trained teachers, intelligent and sympathetic superintendents and principals, which outside money cannot buy no matter how lavish the expenditure.

The following recommendations were made at the Indianapolis meeting of the special committee, which had representation from the American Institute:

1. *In states which have a state Academy of Science and a Junior Academy of Science*, any inquiring science club seeking admission to the "Associated Science Clubs" (The American Institute program) is to be referred to the Junior Academy of Science of the state in which the club is located for assignment of its membership.

2. *In states which have no state Academy of Science and no organized high school science clubs*, any organization of its science clubs shall bear the name "Associated Science Clubs" rather than the name "Junior Academy of Science."

3. *In states which have no state Academy of Science*, any inquiring high school science club seeking admission to the "Associated Science Clubs" shall be referred to the particular state of its location for membership and be known as the "Associated Science Clubs . . . ." (the state as the geographic unit).

4. *In any state which has an organized state Academy of Sciencc*, but no Junior Academy of Science, it is advised that if or when ten or more high school science clubs are organized, the General Secretary of the A.A.A.S. be directed to recommend to the existing State Academy of Science an initial establishment of a Junior Academy of Science.

The Academy Conference also voted to extend the activities of the special committee for another year with the power to act on matters pertaining to science clubs. The special committee on science clubs with the exception of Dean H. E. Ender of Purdue University, who was absent, voted December 29 to accept and put into force the recommendations of the Indianapolis meeting. These recommendations have already been presented to you. We are now fully aware that the American Institute is not living up to these recommendations and does not intend to do so unless they are compelled to by those in charge of our educational system.

Just what is involved in the nationalizing of all the science clubs in the United States by the American Institute? The Institute publishes a weekly magazine or news sheet with a subscription price of $1 per year; membership also carries with it dues of 25c per year. We have information that there are over 20,000 members of science clubs at present in the United States. As a business venture subsidized with sufficient funds for operating expenses they can afford to keep organizers in the field. Even though the annual turnover of clubs is great, they can insure a steady flow of money to New York.

The object of the Junior Academy movement in this state is to create and direct the interest in science of high school students—to give recognition and meaning to their science hobbies—to raise the science level in our high schools by emphasizing the need for more teachers trained in this field of activity. The officers of the Illinois Junior Academy have never been paid and do not expect remuneration for their services. They are elected by the Junior and Senior Academies. The duties of officers are prescribed by the constitution of the Junior Academy.

Last December 10th your delegate attended the state Principals' Association meeting at Bloomington, Illinois, where also there were representatives of other organizations connected with extra-curricular activities in high schools of the state. A new Board of Control having power over all extra-curricular activities including athletics was set up. Until next year the present Athletic Board will function. After that, the members will be elected by the entire Associations Legislative Committee with membership representation from some 17 districts. Each district will have a member assigned to each activity.

The Junior Academy has always lacked sufficient finances and close coordination among clubs of the several schools over the state. This is in part now remedied by the aid given by the University of Illinois Extension Department for the publication of Science Aid Service edited by Mr. Louis Astell. Beginning this fall, Mr. Astell will also visit science clubs over the state to give aid in organization and such services as may be needed to improve the club.

Sponsors trained in club activities have been an urgent need from the beginning of the Junior Academy. The University of Illinois Extension service is meeting this by courses for sponsors. Since some other academic activities in the state are given scholarships by some of our major institutions it is conceivable that science too will get such recognition. By and large, the Junior Academy in this state is on a more solid foundation than at any time since its inception.

Dr. E. C. Faust reported on the "Usefulness of Academy Research Grants" and on "What Basis should Junior A.A.A.S. Membership Awards be Made?" One hundred and seventy-eight A. A. A. S. research grants have been made since 1935. Twenty-two per cent of the 1938 grantees published their results. Many of the grants (67) were given to what were considered pioneer work in ecology, natural history and taxonomy. The Conference advised against grants for this type of work. Complaint was also registered that grants had gone to professors in state institutions. This was heartily discouraged; instead, grants to promising young men in smaller institutions was encouraged.

Sixteen Junior A.A.A.S. membership awards were made in 1939. Dr. Faust stated that in a number of cases he was not informed as to the method of selection of the Junior A.A.A.S. memberships and recommended that machinery should be developed by each Academy to furnish complete information on (1) Research grant and membership awards, (2) On the progress of research grantees, and (3) whether or not their papers were accepted or published. Dr. Faust's report was voted accepted and a continuation of this by him was requested.

Dr. P. D. Strausbaugh (West Virginia Academy of Science) gave a paper on the topic, "Can the Academy Serve as a Unifying Agent for the Various Scientific Organizations of the State?" He recommended affiliation of all scientific organizations of the state with the State Academy. His attention was directed to the fact that some Academies had been successfully doing this for many years.

Dr. J. C. Gilman (Iowa State Academy of Science) gave a paper on the "Organization of a State Academy of Science." He recommended that the offices of secretary and treasurer be combined for greater efficiency, that the Academy be closely affiliated with the A.A.A.S. and other scientific bodies of its locality.

The meeting was adjourned until a short business session at 9:00 A.M. December 30

(Signed) L. J. Thomas

Report of the Committee on High School Science and Clubs

The Committee on High School Science and Clubs consisting of Dr. Lyell J. Thomas. Mr. Louis A. Astell, Dr. Rosalie M. Parr, Miss Rose M. Cassidy, Mr. Harry L. Adams, Mrs. Mary Creager, and Miss Audry Hill met on November 3, 1939, in Urbana. Plans, were made to purchase certificates of membership for affiliated clubs. Mrs. Mary Creager, Chairman of Exhibits, was authorized to have the physics division in the competitive exhibits reorganized and to add a new photography division, which current interests demand. She also revised the entry blank form and a means of tagging the exhibits. Mr. Allen R. Moore devised new forms for the Judges which were used very successfully this year.

Arrangements were made for Mr. Thomas Corgan of the Maine Twp. High School to take a movie film of the Junior Academy activities in Galesburg during the 1940 meeting. This was done, and a fifteen minute film which will include several feet of interesting pictures of the site of the 1941 meeting at the Museum of Science and Industry in Chicago, will be ready for the Junior Academy Clubs to use by fall.

Steps were taken for the Junior Academy to obtain a place on the Annual State High School Program, and the objectives of the Junior Academy placed before the State High School Principals' Association and were received favorably.

Through the work of Dr. Lyell J. Thomas and Mr. Louis A. Astell, Dr. Robert Brown of the University of Illinois Extension Service has granted Mr. Astell of the Extension Service the privilege of rendering many valuable aids to the Junior Academy. This relationship promises to grow and be of tremendous aid to the Junior Academy.

Under the direction of Dr. Rosalie M. Parr, a widely varied and valuable Radio Science Series of programs was heard throughout the year over Radio Station WILL at 4:15 P.M. each Monday.

The cooperation of the committees and chairmen in charge of the Annual Meeting plus the excellent hospitality of the Galesburg High School under the direction of Mr. Frank J. Seiler made the event a highly successful one. Over 350 high school students registered, and 250 attended the banquet. 225 exhibits were entered in competition and these were viewed by several hundred students from surrounding High Schools in addition to those attending the meeting.

A profitable Sponsors' Meeting was held and plans made for an Annual Meeting of the Club Sponsors to be held during the Annual High School State Meeting. The afternoon program consisted of reports of the A. A. A. S. Delegates, Nadine Whitesides of Vienna, and Delbert Rainey of Chester, who attended the Columbus, Ohio meeting, student demonstrations, and an invitation to the 1941 meeting to be held at the Museum of Science and Industry in Chicago extended by Dr. Robert Moulton, Curator of the Department of Chemistry.

Candidates for the various student offices chosen from the student rating sheets for 1940-41 are as follows:

President: William Hahn, Zoo Club, Rockford Senior High School, Rockford.

Vice-President: Mary L. Bradley, Audubon Club, Bloom Twp. High School, Chicago Heights.

Secretary: Robert Dawson, Seminar Club, Canton.

A. A. A. S. Delegates

Jean Parker: Chemistry Club, Galesburg Senior High School, Galesburg.
William Best: Chemistry and Physics Club, J. Sterling Morton High School, Cicero.

Donors of Cups

Senior Academy—*All 'Round Cup.*

Illinois Biology Teachers' Association—*Biology Cup.*

The Illinois Association of Chemistry Teachers—*Chemistry Cup.*

W. M. Welch Scientific Co.—*Physics Cup.*

Central Scientific Co.—*Engraving Expense.*

(Signed) Audry Hill, *General Chairman, Illinois Junior Academy of Science*

Annual Report, *Science Aids Service*, 1939-1940

During the past year, the Division of University Extension of the University of Illinois has borne the office expense and a considerable part of the printing costs of the leaflet which continues the policies of *Science Club Service* and which is known as *Science Aids Service.* As a result it has been possible to produce a much more attractive and meaningful publication and to render a more constructive service to all cooperating Academies of Science. A total of three issues, representing some 12,000 words of information on various angles of science club work, have been made available to the affiliated and prospective clubs of the State. Thus, the Illinois Junior Academy of Science has enjoyed the benefits of three issues at a cost of approximately one-half of one issue. A more complete picture is to be found in the following statements.

Through the leadership of the Illinois State Academy of Science the uninterrupted publication of Junior Academy leaflets has extended over a seven year period. These leaflets represent a total of approximately 98,000 words of information bearing directly on the needs of the Illinois Junior Academy work and on the Junior Academy movement as a whole. The basic points of view have been that while clubs may not exist without leadership, they also may not operate most effectively without the accumulated experience available for that leadership. For such reasons the expansion of the leaflet and of the related services will continue to depend on the number of Academies that cooperate with each other in the various ways possible. A definite reduction in the costs for each Academy cooperating in the work is to be expected. To the extent that Academies of Science do cooperate in this matter, it will be possible to issue supernumerary leaflets and other aids of direct assistance to sponsors and students. This statement does not cover the total activities of the organization known as Science Aids Service, but it does point out the range of possibilities for benefit to the Illinois Junior Academy in particular and the Junior Academy movement in general.

That the publication program has met with success is found in the following facts:

I. *Present Status:* In addition to the continued support which the Illinois State Academy of Science has rendered by way of a Sustaining Membership, the Indiana State Academy of Science has voluntarily maintained its status of Sustaining Member for the fifth consecutive year. In addition, the Cooperative status has been maintained by the Iowa Academy for the fourth consecutive year, and by the Minnesota Academy for the third consecutive year.

II. *Forecasts:* Commitments have been made which will insure three issues of the leaflet devoted to Junior Academy needs for the next academic year. An effort will be made to increase the issues above that number since the Junior Academy movement appears to be gaining in depth and breadth and is in definite need of such a program.

By way of addition to the fundamental principles governing the publication and other activities related to the needs of Junior Academy organizations (*Transactions of the Illinois State Academy of Science*, Volume 31, No. 4, page 286, June 1939) I would suggest the importance of establishing and maintaining science club relationships within the framework of our educational system. This may be interpreted to include cooperation with the Principals' Association, with the other governing agencies including the North Central Association, and with such other organizations as are vitally, altruistically, and directly concerned with our educational system. Under any other circumstance, the Junior Academy movement is constantly at the mercy of a varied group of commercial and mercenary interests. It is sufficient to add that the Illinois Junior Academy of Science has to its credit, leadership in the direction of operation within the framework of the educational system.

(Signed) Louis A. Astell, *Editor*, *Science Aids Service*

Winners of Awards

The club which placed first in each division was presented a cup while those placing second and third were given certificates of recognition.

Physics Division

1. Morton Physics Club, J. Sterling Morton High School, Cicero.
2. Ready Kilowatts, Galesburg High School, Galesburg.

Chemistry Division

1. Maine Chemistry Club, Maine Township High School, Des Plaines—Park Ridge.
2. Morton Chemistry Club, J. Sterling Morton High School, Cicero.
3. Chem-Mystery, Normal Community High School, Normal.

Geology Division

1. Bloomington Geology Club, Bloomington Twp. High School, Bloomington.
2. Morton Weather Club, J. Sterling Morton High School, Cicero.
3. Joliet Jr. Mineralorist, Joliet Twp. High School, Joliet.

Biology Division

1. The Ferreters, Chester High School, Chester.
2. Bios, Normal Community High School, Normal.
3. Joliet High School Biology Club, Joliet Twp. High School, Joliet.

Photography Division

1. Morton Photography Club, J. Sterling Morton High School, Cicero.
2. Chemistry and Photography Club, Joliet Twp. High School, Joliet.

Junior High School Division

1. Lombard Jr. High School Science Club, Lombard Jr. High School, Galesburg.
2. Hitchcock Jr. High School, Galesburg, Illinois.
3. David Prince Science Club, David Prince Jr. High School, Jacksonville.

All-Round Division

1. The Chemistry Club, Galesburg High School, Galesburg.
2. Zoo Club, Rockford High School, Rockford.
3. V. T. H. S. Science Club, Vienna Township High School, Vienna.

I NEWSLETTERS

Handcraft Division

1. Maine Chemistry Club, Maine Twp. High School, Des Plaines—Park Ridge.
2. Morton Chemistry Club, J. Sterling Morton High School, Cicero.

Mimeograph Division

1. Bios Club, Normal Community High School, Normal.
2. Zoo Club, Rockford High School, Rockford.
3. Audubon Club, Bloom Twp. High School, Chicago Heights.

Hectograph Division

1. Morton Weather Club, J. Sterling Morton High School, Cicero.
2. The Ferreters, Chester High School, Chester.

II RADIO NOTEBOOKS

Individual

1. Mathilda Moeckel, The Ferreters, Chester.
2. Viola Behrend, Bios Club, Normal Community High School, Normal.
3. Nadine Whitesides, V. T. H. S. Science Club, Vienna.

Group

1. Harriet Harlenbower, Jeanne Fruse, Bios Club, Normal Community, Normal.
2. Mary Bruhnke, Eldrid Batzer, Emily Richmond, Edith Kautz, Eva Mae Legg, Maine Chemistry Club, Des Plaines—Park Ridge.
3. Emma Richards, Darl Golden, Zoo Club, Rockford.

III BIOLOGY DIVISION

Posters—Individual

1. Charlotte Wolcott—Joliet High School Biology Club, Joliet.
2. Erma Richards—Zoo Club, Rockford.
3. Ralph Gage—V. T. H. S. Science Club, Vienna.

Posters—Group

1. Ralph Gage, Gail Willbrand—V. T. H. S. Science Club, Vienna.
2. Barbara Carret, Mildred Hadley—Bios Club—Normal.
3. Kenneth Grott, Juanita Mueller—The Ferreters, Chester.

Projects—Individual

1. Lenor Friedman—Youth Science Society, Madison.
2. William Hahn—Zoo Club, Rockford.
3. Paul Backer—The Ferreters, Chester.

Projects—Group

1. The Ferreters—Chester.
2. Georgianna Raudes, Norma Scott, Youth Science Society, Madison.
3. Danville Science Club, Danville.

Commercial Products—Individual

1. Willard Rawley, Joliet High School Science Club, Joliet.
2. Paul Bartels—The Ferreters, Chester.
3. Lois Winker—Bios Club, Normal.

Commercial Products—Group

1. Erma Richards, Jean Gossman—Zoo Club, Rockford.
2. Bill Lusher, Arthur Hanson, Bill Keefe, Lois Ensbman, Bios Club, Normal.
3. The Ferreters, Chester.

Science Notebooks

1. Clyde Martin—The Ferreters, Chester, Bob Leach, V. T. H. S. Science Club, Vienna.
2. Shirley Sackett—Youth Science Society, Madison. Gladys McDowell—Youth Science Society, Madison.
3. Leona Braman—Joliet High School Science Club, Joliet. Louise Pettit—Ottawa Biological Club, Ottawa.

Models

1. Beatrice Johns—The Ferreters, Chester.
2. Ralph Gage—V. T. H. S. Science Club, Vienna.
3. Margaret Nesmith—Blue Island Bilogy Club, Blue Island.
4. Harold Ashley—Youth Science Society, Madison.

Collections—Individual

1. William Wood—Joliet High School Biology Club, Joliet.
2. Frederick Irion—Ottawa Biology Club, Ottawa.

3. Nadine Whitesides—V. T. H. S. Science Club, Vienna.

Collections—Group

1. Paul Johns, Hilda Meyer, Juanita Mueller—The Ferreters, Chester.
2. Fred Whitlark, Teddy Boydon—Joliet High School Biology Club, Joliet.
3. William Leibforth, Grace Meeven, Carol Hartley, Roger Garst, Carolyn Lace, Carol Lowen, Zoo Club, Rockford.

IV. GEOLOGY

Posters—Individual

1. James Steiner, Morton Weather Club, Cicero.
2. Roy Crane, Bloomington Geology Club, Bloomington.

Posters—Group

1. Max Myers, Robert Lebduska—Morton Weather Club, Cicero.
2. George Hall, Billy Baumgart, Bloomington Geology Club, Bloomington.

Projects—Individual

1. Frank Cizek—Morton Weather Club, Cicero.
2. Eldred Suhr—Morton Chemistry Club, Cicero.
3. Lee Hibble, Bloomington Geology Club, Bloomington.

Collections—Individual

1. Preston Hyatt—Mineralorists Club, Joliet.
2. Brooks Stanberry—Lombard Jr. High School Science Club, Galesburg.
3. Burdette Allen—Bloomington Geology Club—Bloomington.

Commercial Products—Individual

1. Anita Hyatt—Mineralorists Club, Joliet.

Science Notebook

1. Charles Rhea—Bloomington Geology Club, Bloomington.

Models—Individual

1. Gavin Steele—Bloomington Geology Club, Bloomington.
2. Grace Tracy, Chemistry Club, Galesburg.

V. CHEMISTRY

Posters—Individual

1. Howard Woodward, Maine Chemistry Club, Des Plaines—Park Ridge.
2. Robert Kent—Galesburg Chemistry Club, Galesburg.
3. John Geraldi—Morton Chemistry Club, Cicero.

Poster—Group

1. Wilbur Graef and Bill Cassidy—Maine Chemistry Club.

Project—Individual

1. Catherine Symonds, Galesburg Chemistry Club, Galesburg.
2. Leslie Casali—Chem-Mystery Club, Normal.

Projects—Group

1. Louis Horak, Frank Novak—Morton Chemistry Club, Cicero.
2. Wallace Norris, Granville Kemp—Chem-Mystery Club, Normal.
3. David Hurlbert, Kenneth Hallberg—Maine Chemistry Club, Des Plaines—Park Ridge.

Commercial Products—Individual

1. Wallace Beck—Morton Chemistry Club, Cicero.
2. Bob Lang, Maine Chemistry Club, Des Plaines—Park Ridge.

Collection—Group

1. Charles McKinley and Albert Hackmeister—Maine Chemistry Club, Des Plaines—Park Ridge.
2. Milton Tulis, Ed Melka, Roy Styskal, Ed Zolla—Morton Chemistry Club, Cicero.

Science Notebooks

1. Stanton Olson—Zoo Club, Rockford.
2. Dorothy Rasmussen, Maine Chemistry, Des Plaines—Park Ridge.
3. Margaret L. McArthy—Chem-Mystery Club, Normal.

Models

1. George Chott—Morton Chemistry Club, Cicero.
2. Roger Barnett, Maine Chemistry Club, Des Plaines—Park Ridge.

Collections—Individual

1. Beryl Liska—Maine Chemistry Club, Des Plaines—Park Ridge.
2. Dorothy Moore—Morton Chemistry Club, Cicero.

Commercial Products—Group

1. John Spangler, Edward Nissen—Maine Chemistry Club, Des Plaines—Park Ridge.
2. Casylda Pellas, Emily Zmek—Morton Chemistry Club, Cicero.
3. Dena Popyancheff, Margaret Walthen—Youth Science Society, Madison.

VI. PHYSICS DIVISION

Posters—Individual

1. Clayton Blout—Morton Physics Club, Cicero.

Posters—Group

1. Casylda Pellas, Bernice Fenel, Morton Physics Club, Cicero.

Projects—Group—Heat and Light

1. Paul Chambers, Jess Tawney—Youth Science Society—Madison.
2. Bob Botham, Bill White—Chemistry Club, Galesburg.
3. Charles Boydsten, Joy Webster, Ready Kilowatts, Galesburg.

Projects—Individual—Heat and Light

1. Darrel Sand—Ready Kilowatts, Galesburg.
2. Clayton Blout—Morton Chemistry Club, Galesburg.

Projects—Group—Mechanics and Sound

1. Charles Reith, Chairman—Ready Kilowatts, Galesburg.
2. Robert Nemecek, Clayton Blout—Morton Physics Club, Cicero.

Projects—Individual—Mechanics and Sound

1. Bernard Harvey—Zoo Club, Rockford.
2. Henry Dutch, Ready Kilowatts, Galesburg.
3. Chuck Ondra—Morton Physics Club, Cicero.

Projects—Group—Electricity and Magnetism

1. William Ruesch, Irvin Prakes, Robert Gruetter—Morton Physics Club, Cicero.
2. Roberts Diefendorf, Chairman—Ready Kilowatts, Galesburg.

Projects—Individual—Electricity and Magnetism

1. John A. Shaner—Ready Kilowatts, Galesburg.
2. Ted Schmidt—Chemistry Club, Galesburg.
3. Jack Fremgen—Morton Physics Club—Galesburg.

Notebook

1. George Zahour, Jr.—Morton Physics Club, Cicero.
2. Olga Vytlacil—Morton Physics Club, Cicero.

VII. ASTRONOMY

Projects—Individual

1. Harry Loeffler, Morton Photography Club, Cicero.
2. Fred Schmerbauch—The Ferreters, Chester.
3. Charlotte Todd—Zoo Club, Rockford.

VIII. PHOTOGRAPHY DIVISION

Group Movies

1. Jack Soper, Ed Youngman—Morton Photography Club, Cicero.

Group Lantern Slides

1. Fred Wunder, Charles Engman—Morton Chemistry Club, Cicero.

Individual Lantern Slides

1. Robert Hunnicutt—Galesburg Chemistry Club, Galesburg.

Individual Movies

1. Justice Shepro—Morton Photography Club, Cicero.

Individual Project

1. Harry Gregerson—Zoo Club, Rockford.
2. Barton Cross, Major J. W. Powell Club, Normal University High School.

Group Project

1. Robert Jacobs, Frank Wokas, Dominic Petraitis—Morton Photography Club, Cicero.

Individual Collection

1. Luther Eggman—Chemistry Club, Joliet.
2. George Thayer—Lombard Junior High School Science Club, Galesburg.

Individual Commercial Photography

1. Nadine Whitesides—V. T. H. S. Science Club, Vienna.

Individual Moving Object

1. Luther Eggman—Chemistry Club, Joliet.
2. Howard Zasadil—Morton Photography Club, Cicero.

Individual Photomicrographs

1. William Davis—The Ferreters, Chester.
2. Jean Parks—Galesburg Chemistry Club, Galesburg.
3. Fred Snoboda—Morton Photography Club, Cicero.

Individual Still Life

1. Luther Eggman—Joliet Chemistry Club, Joliet.
2. Vera Creager—V. T. H. S. Science Club, Vienna.
3. William Cramer—Biology Club, Clinton.

IX. JUNIOR HIGH SCHOOL DIVISION

Posters—Individual

1. Robert Dixon—Lombard Jr. H. S. Science Club, Galesburg.

2. Frederick Rupel—David Prince Science Club, Jacksonville.
3. Tom Bullis—Hitchcock Science Club, Galesburg.

Posters Group

1. Jack Pihl—Hitchcock Science Club, Galesburg.
2. Don Ewing, Bob Garrett—Lombard Science Club, Galesburg.
3. Jimmie Wood—David Prince Science Club, Jacksonville.

Projects—Individual

1. Lorraine James—Hitchcock Science Club, Galesburg.
2. Bob Garrett—Lombard Science Club, Galesburg.
3. Gordon Robertson, Hitchcock Science Club, Galesburg. Tied for second.

Projects—Group

1. Alan McClelland, Junior Childers, Norma Skaggs, Adorea Goodwin, Lorraine James, Jack White—Hitchcock Science Club, Galesburg.
2. Thomas Underwood, Jerry Johnson, Harry Peterson, Robert Sullivan—Lombard Science Club, Galesburg.
3. Donald Doe, Clara Curdie—David Prince Science Club, Jacksonville.

Commercial Projects—Individual

1. King—Lombard Science Club—Galesburg.
1. Edward Wickersham—Hitchcock Science Club, Galesburg. Tied for first.
2. G. H. Timmon—David Prince Science Club, Jacksonville.

Commercial Projects—Group

1. Jerry Johnson, Thomas Underwood—Lombard Science Club, Galesburg.
2. L. E. Vierra, G. H. Timmon, James Daniels—David Prince Science Club, Jacksonville.
3. Jan Bingston—Hitchcock Science Club, Galesburg.

Science Notebook

1. Lester Lee—David Prince Science Club, Jacksonville.
2. Eldon Herron—Lombard Science Club, Galesburg.
3. Marilyn Linnir—Lombard Science Club, Galesburg.

Models

1. Rob Ross—Hitchcock Science Club, Galesburg.
2. Lawrence Vierieck—David Prince Science Club, Jacksonville.
3. Lawrence Smith—Lombard Science Club, Galesburg.

Collections—Individual

1. Billy Hughes—David Prince Science Club, Jacksonville.
3. Bernice Calderone — Lombard Science Club, Jacksonville.

Collection—Group

1. None.
2. Bill Loring, Ronald Carlson—Lombard Science Club, Galesburg.
3. Lester Pierce, Bob Duncan, Jimmie Wood, Billy Highes, Vernon Medlock, David Prince Science, Jacksonville.

Outstanding Exhibits

The Senior Academy of Science presented a special certificate of recognition for the outstanding exhibit in each division. Those selected were as follows:

Biology Division

An ecological Study of the Plant Successions in a Cypress Swamp—The Ferreters, Chester High School, Chester.

Geology Division

Frank Cizek, Morton Weather Club, J. Sterling Morton High School, Cicero.

Chemistry Division

Electric Eye—Louis Horak, Frank Novak—Morton Chemistry Club, J. Sterling Morton High School, Cicero.

Physics Division

Stroboscope—Paul Chambers, Jess Tawney—Youth Science Society, Madison.

Photography Division

Group Lantern Slides—Fred Wunder, Charles Eggman—Morton Chemistry Club, J. Sterling Morton High School, Cicero.

Junior High School Division

Plant Behavior—Lorraine James—Science Club, Hitchcock Jr. High School, Galesburg.

High School Science Clubs Affiliated with the Illinois Academy of Science

Galesburg: Chemistry Club, High School; Frank J. Seiler.
Ready Kilowatts, High School, John Aitchison.
General Science Club, Hitchcock Jr. High School, Cassius Armstrong.
Biology Club, Senior High School, Mrs. Velma L. Whipple.
Lombard Jr. High School Science Club, Lombard Jr. High.

Danville: Danville Science Club, High School, C. O. Johnson.

Jacksonville: David Prince Science Club, David Prince Jr. H. S., Anna L. Stevenson.

East St. Louis: East Side Science Club, High School; T. W. Galbreath.
Lansdowne Science Club, Jr. High School; Elsie Hoenig.

Chester: The Ferreters, H. S.; Audry Hill.

Des Plaines—Park Ridge: Maine Chemistry Club, High School, Rose Cassidy.

McLeansboro: McLeansboro Science Club, High School; Edna Woodruff.

Vienna: V. T. H. S. Science Club, High School; Mary Creager.

Madison: Youth Science Society, High School, Wm. Schwab, Jr.

Royalton: Science Club, High School; Harry Batley.

Canton: Biology Seminar Club, High School; Margaret Middleton.

Mt. Carmel: Mt. Carmel Science Club, High School; B. D. Arrick.

Normal: Bios Club, Community High School, John C. Ayers.
Chem-Mystery Club, Community High School; J. C. Chiddix.
Major Powell Science Club, University High School; Blanche McAvoy.

Chicago Heights: Audubon Club, Bloom Twp. High School; Altha Haviland.

Joliet: Joliet Jr. Mineralorists Club, Joliet Twp. High School; Ben Hur Wilson.
Chemistry and Photography Club, Joliet Twp. High School; C. M. Eggman.
Joliet High School Biology Club, Joliet Twp. High School; H. V. Givens.

Ottawa: Biology Club, High School; Charles Alikonis.

Clinton: Bugology Club, High School; Charles R. Evans.

Blue Island: Biology Club, High School; Elizabeth White.

Cicero: J. Sterling Morton High School; Biology Club; C. B. Hitch.
Chemistry Club; W. L. Muehl, L. F. Tuleen, G. S. Porter.
Photography Club, Edward Bedrava.
Physics Club; D. L. Barr.
Weather Club; Allen R. Moore.

Rockford: Zoo Club; Aleta McEvoy, Rockford Senior High School.

Roodhouse: Scientia Fratres, High School, H. D. Barr.

East Moline: Bio-Chemics Club, East Moline High School; H. W. Pratt.

Bloomington: Bloomington Geology Club, High School; Harry L. Adams.

Scientific Societies Affiliated with the Academy

American Chemical Society, Illinois Section; C. C. Price, Sec., University of Illinois, Urbana.
Beta Pi Sigma, St. Xavier College; 4928 Cottage Grove Ave., Chicago.
Chicago Academy of Science; Lincoln Park, Chicago.
Chicago Nature Study Club; Emma F. Heerwagen, 2440 Ridge Ave., Evanston.
College of St. Francis; 303 Taylor St., Joliet.
Cyclothem Club; Dept. of Geology and Geography, University of Illinois, Urbana.
Illinois Association of Biology Teachers; A. C. Brookley, Sec.-Treas., Thornton Township High School, Harvey.
Illinois Association of Chemistry Teachers; S. A. Chester, Bloomington High School, Bloomington.
Illinois Nature Study Society; Mrs. H. M. Armstrong, Sec., 395 DuPage St., Elgin.
Illinois State Archaeological Society; 604 Caroline, Peoria.
Joliet Botanical Club; Lula E. Connell, Sec., 653 Third Ave., Joliet.
Knox County Academy of Science; Page L. Baker, Treas., Knox College, Galesburg.
Major Powell Science Club; Blanche McAvoy, Normal University, Normal.
Normal Science Club; Geo. A. Soper, Sec.-Treas., Normal University, Normal.
Peoria Academy of Science; Lois B. Hite, 609 Nowland Ave., Peoria.

STATE OF ILLINOIS

HENRY HORNER, Governor

TRANSACTIONS

OF THE

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