PROCEEDINGS

of the

NORTH DAKOTA ACADEMY OF SCIENCE

Founded December, 1908

VOLUME XII

1958

OFFICERS

President - - - - - - - - Arthur W. Koth, University
President-Elect - - - - - Harold J. Klosterman, NDAC
Secretary-Treasurer - - - Ben G. Gustafson, University
Historian - - - - - - - - G. A. Abbott, University
Additional Members of Executive Committee:
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Cyril C. Moore, Minot State Teachers College
Benjamin DeBoer, University

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Rae H. Harris *(Chairman)*
G. A. Abbott
Ernest D. Coon
Ralph E. Dunbar
Ben G. Gustafson

Published jointly by the University of North Dakota and the North Dakota Agricultural College

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July, 1958

GRAND FORKS, NORTH DAKOTA

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UND PRESS

50TH ANNIVERSARY MEETING NORTH DAKOTA ACADEMY OF SCIENCE

FRIDAY, MAY 2, 1958

President Warren C. Whitman called the 50th Annual Meeting of the North Dakota Academy of Science to order at 9:00 a. m. in the beautiful Memorial Union Ballroom of the North Dakota Agricultural College Student Union.

Greetings were extended to the fine crowd which was present and announcements were made concerning the program. The necessary committee meetings were announced.

The ten papers on the morning program proceeded in order, numbers 2 to 9 inclusive were the student papers. A coffee break was held at 10:30 a. m.

The Business Meeting was called to order at 11:30 a.m., on schedule. The Nominating Committee reported at 11:30 a.m. with a slate of officers for the 1958-1959 year. The members of the committee were:

W. E. Cornatzer, Chairman
Harry B. Hart
H. W. Murphy
C. C. Moore
Glenn S. Smith

The Slate presented was:

President	A. W. Koth
President Elect	Harold J. Kolsterman
	J. Frank Cassell
Secretary-Treasurer	Ben G. Gustafson
Historian	G. A. Abbott
Executive Committee	Cyril C. Moore
	Benjamin DeBoer
	Ralph A. Young

F. Rathmann moved the adoption of the report. George Busch seconded the motion and it was carried. It was decided that balloting should be by prepared ballot from 2:00 to 4:30 p. m. in room 204 of the Chemistry Building, where the afternoon meetings were to be held.

Dr. A. Roger Denison, of Amerada Petroleum Corporation, was introduced and was well received. The meeting adjourned at 11:50 a. m. for lunch.

The afternoon meeting was called to order in the Memorial Union Ballroom at 1:30 p.m. by President Warren C. Whitman.

The invited paper, "Wheat Rust Research at the North Dakota Agricultural College", was presented by Glenn S. Smith, who has

worked on the problem for a long time. He did a very able job of summarizing the fine work which has been done.

At 2:00 p.m. the meeting adjourned to room 204 of the Chemistry Building. The afternoon papers, numbers 11 to 20 inclusive were presented. Dr. Warren C. Whitman presided.

The Academy returned to the Memorial Union Ballroom at 6:15 p.m. for the 50th Anniversary Dinner. Over 200 members and guests were present. Dr. Warren C. Whitman presided. This was a joint meeting with the Red River Valley Section of the American Chemical Society and the N.D.A.C. Sigma Xi Club. Greetings were extended by President Fred S. Hultz of the North Dakota Agricultural College. Special Anniversary Guests were introduced; followed by the new officers of the Academy of Science, the officers of the Red River Valley Section of the American Chemical Society and those of the North Dakota Agricultural College Sigma Xi Club.

The roll of Honored Academy Members, over 25 years in the Academy, was called. It was noted that two of the founders were in the group. One was in attendance, Dr. George A. Abbott, Professor Emeritus of Chemistry at the University, Secretary of the Academy for 42 years, and the present Historian of the Academy. The other one, Dr. Lynn B. McMullen, formerly Professor of Physics at Valley City Teachers College and now President Emeritus of Eastern Montana State College was not present. Dr. McMullen did extend greetings. There were more than 20 members of this honored group present.

The next order of business was the distribution of the "The First Fifty Years", a History of the North Dakota Academy of Science (1908-1958) and written by the Academy Historian, Dr. George A. Abbott. The History was well received and the author was called upon. Dr. Abbott generously responded with one of his short gems on history, philosophy and science. This great and good man, scholar, teacher and Christian had made another of his generous and valuable contributions to his beloved life's work in the field of science.

The North Dakota Foundation for Engineering and Science Scholarship Awards to the ten scholarship winners and to the selected outstanding High School Science Teachers were then made by Mr. Edward C. Lawson, President of the Foundation and Dr. E. J. O'Reilly, the Scholarship Committee Test Chairman for the Foundation.

Dr. Wilson Laird introduced Dr. A. Rodger Denison, Vice-President of Amerada Petroleum Corporation, who presented the A. Rodger Denison Research Prizes to the winners of the Student Papers. Dr. Denison commented briefly on the changes that had taken place over the last decade. He then presented the award winners—First place went to John G. Green, Second place to Gary N. Fauskin and Third place to Robert B. Ericson.

Mr. Arthur W. Koth then introduced the guest speaker, Mr. A.

H. Shapley (Boulder, Colorado), Vice-Chairman of the United States National Committee for the International Geophysical Year. He gave us an illustrated lecture filled with personal anecdotes that was entertaining, scholarly and informational. He spent much time answering questions at the end of his lecture. The Academy was fortunate to secure his services.

SATURDAY, MAY 3, 1958

The meeting was called at 8:30 a.m. in the Memorial Union Ballroom. The scheduled program followed and the regular Business Meeting was called at 11:30 a.m. President Arthur W. Koth took over. The election results were officially announced—Harold J. Klosterman, President-elect; Ben G. Gustafson, Secretary-Treasurer; George A. Abbott, Historian; and Cyril C. Moore and Benjamin DeBoer to the Executive Committee.

Warren Whitman moved the Minutes of the 1957 session be approved as printed. Seconded by Rae Harris. Carried.

Ben G. Gustafson presented the report of the Secretary-Treasurer with the report of the Auditing Committee (A. W. Koth and Wm Cornatzer). He moved the acceptance of the report, seconded by Wm. Cornatzer. Carried.

Ralph Dunbar gave a complete report on the December 26-30, 1957 meeting in Indianapolis of the A.A.A.S. He had attended 22 sessions and told of the reorganization which was taking place in the A.A.A.S. He also told of the many opportunities that seemed to exist for Prize and Grant Monies. Rae Harris moved the adoption of the report. J. Donald Henderson seconded the motion. Carried.

J. Donald Henderson moved that the Academy grant up to $50 towards the expenses of the Academy Representative to the Annual A.A.A.S. Meetings. C. C. Moore seconded the motion. Carried.

E. V. Estensen presented the report of the Resolution Committee, which follows:

REPORT OF THE COMMITTEE ON RESOLUTIONS

North Dakota Academy of Science, May 3, 1958

1. We express appreciation to the North Dakota Agricultural College and to the Student Union for the use of their facilities by the Academy.
2. To the press of the State we express appreciation for the news coverage of the activities of the Academy.
3. We thank the Red River Valley Section of the American Chemical Society and the Sigma Xi Club for cooperating in the sponsorship of the informal dinner and evening's speaker.
4. We express special gratitude to the University of North Dakota, North Dakota Agricultural College, and Jamestown College for continuing the policy of financing the publication of the Proceedings of the North Dakota Academy of Science.

5. We appreciate the opportunity afforded to view the Exhibit sponsored by the Atomic Energy Commission.
6. We express appreciation to A. Rodger Denison of the Amerada Petroleum Corporation for the student research prizes.
7. We are grateful to those who have contributed to the scholarship fund of the North Dakota Engineering and Science Foundation.
8. We recognize and appreciate the work of the many students and their advisers in the preparation of research papers, and grateful to the committees who served as judges in selecting papers and awarding prizes.
9. We express our very deep appreciation to Dr. G. A. Abbott, charter member of the Academy, for his authorship and issuance of the brochure entitled "The First Fifty Years—North Dakota Academy of Science," made available on the occasion of the Golden Anniversary of the Academy.
10. We record with regret the passing of three of our members: Dean W. F. Sudro, Dean H. L. Walster, and Mr. E. D. Cypert.
11. We recognize the arduous task of editing the Proceedings of the North Dakota Academy of Science, and therefore express appreciation for the editorial efficiency of the Publications Committee.
12. To the officers and the various committees who provided the excellent program for the Golden Anniversary of the Academy, we are both indebted and most grateful.

Committee: W. H. Moran
P. A. Nystuen
E. V. Estensen, Chr.

E. V. Estensen moved the adoption of the report. Seconded by C. W. Fleetwood. Carried.

Harold J. Klosterman reported for the Membership Committee; presenting 63 names for Individual Memberships and 7 names for Sustaining Memberships. Harold J. Klosterman moved the adoption of the report. F. H. Rathman seconded the motion. Carried.

Wm. E. Cornatzer raised the question of the Sustaining Membership and moved that the money from these be set aside for Science Scholarships. Whitman seconded the motion. There was some discussion. Then Ralph Dunbar offered a substitute motion which was acepted, to refer the matter to the Executive Committee with power to act. J. Donald Henderson seconded the motion. Carried.

C. C. Moore extended an invitation to hold the 1959 meeting at Minot State Teachers College. An invitation was also extended from the University. Wm. E. Cornatzer pointed out to the group that the Executive Committee decides upon the place of meeting.

Loren Potter expressed his appreciation of the assistance he had received from the members of his local committee on arrangements.

O. A. Stevens reported on the Science Books purchased for the

State Library and presented a letter of appreciation from (Mrs.) Hazel W. Byrnes, the Director. The letter is reprinted here by order of the group.

STATE LIBRARY COMMISSION
Bismarck, North Dakota

April 10, 1958

Mr. O. A. A. Stevens
North Dakota Agricultural College
Department of Botany and Plant Pathology
State College Station
Fargo, North Dakota
Dear Mr. Stevens:

The Science books have had splendid usage, not as a set but individually. We have sent them out to meet calls for Chemistry, Wild Life, Mammals, Engineering, Oil and all the other subjects.

Three are out at the present time, the last three mentioned. All have been out two, three and five times. The calls come mostly from high-school superintendents or teachers, but also from individual adults and one request referred to us from one of the bookmobile librarians wishing it for a crippled boy.

We surely thank you for these books. We have ordered other copies of books in the set for which we have had the greatest demand.

Sincerely,
(Mrs.) Hazel Webster Byrnes, Director

O. A. Stevens gave the report of the Necrology Committee and gave a tribute to the life and work of Harlow Leslie Walster, long time Dean of Agriculture and Director of the Agricultural Extension Division at the North Dakota Agricultural College. The report was approved and it was ordered that the tribute be printed in the minutes.

HARLOW LESLIE WALSTER, 1883-1957

Few people have made a greater impact on North Dakota agriculture than Dr. Harlow Leslie Walster who came to the Agricultural College in 1919 as Professor of Agronomy. He later became Dean of Agriculture, Director of the Experiment Station and for a time was also Director of Extension.

Born on a farm near Madison, Wisconsin, he taught rural schools four years before entering the University of Wisconsin where he received his B.S. Degree in 1908. His M.S. degree was taken at Harvard in 1913 and Ph.D. at the University of Chicago in 1918. From 1913 to 1918 he was Assistant Professor of Soils at the University of Wisconsin.

His professional interest was plant physiology in its broadest sense. His personal interests were many with accent upon historical

features. His library, which was presented to the Agricultural College, contained many volumes on the livestock industry and his work was perhaps more fully appreciated by the members of that group than by any other.

He was deeply interested in the flax crop and was active in the development of the Flax Institute of America of which he was president from 1931 to 1951. He was equally interested in the durum wheat industry. In brief, he was deeply interested in everything that concerned the advancement of the welfare of agriculture and the people.

As with many whose time is occupied by administration, his opportunity for detailed research soon became much limited. His writings became largely editorial and interpretative. He was at his best when touring the state with a small group, where mutual exchange of information was highly stimulating. In 1945 he traveled over a large part of the state and wrote a series of articles on it for the Fargo Forum. At the University, he had emphasized debate and as an effective speaker he was much in demand in this area.

He was continually exploring the library, and following his retirement in 1953, he was able to devote most of his time to such research. He had compiled an account of the work and publications of some pioneer staff members in the experiment station: C. B. and L. R. Waldron, H. L. Bolley, E. F. Ladd and J. H. Shepperd. We deeply regret that he could not have continued this work a few more years.

Rae Harris moved the acceptance of the report, seconded by F. H. Rathman. Carried.

Ben G. Gustafson reported on the work being done to give the Academy legal status as the official State Academy of Science.

The meeting was adjourned.

The Financial Statement follows on the next page.

NORTH DAKOTA ACADEMY OF SCIENCE

Financial Statement

June 1, 1956 to May 1, 1958

Receipts:

Balance 6/1/56		$ 554.61
Deposits 6/1/56 to 5/1/58		1605.05
Cash on hand 5/1/58		72.52
Total Receipts		$2232.18

Expenditures:

A.A.A.S — Dues	$ 8.50	$ 8.50
Press-printing		
Proceedings	465.87	
Others	94.00	559.87
Postage	4.32	
	120.65	124.97
Scholarship Fund	193.00	193.00
Science Fair	50.00	50.00
Science Books	51.00	51.00
Exchange	0.05	0.05
Stenographic Help	8.00	8.00
Banquet	212.35	
	3.85	216.20
Denison Prizes	90.00	90.00
Change	15.00	15.00
Total Expenditures		$1316.59

Assets:

On Depost at		
Red River National Bank	$ 843.07	
Cash on Hand	72.52	
Total Assets		$ 915.59
Assets + Expenditures		$2232.18

A NEW SOLID MEDIUM FOR THE CULTIVATION OF MYCOBACTERIUM TUBERCULOSIS[1]

Gary N. Fauskin

Department of Bacteriology

University of North Dakota, Grand Forks, North Dakota

INTRODUCTION

Mankiewicz (1) has shown that brain heart infusion broth which has supported the growth of **Candida albicans,** and has been Seitz filtered will then support the growth of **Mycobacterium tuberculosis var. hominis;** whereas, ordinary brain heart infusion will not. This medium is, of course, liquid, and to date no research has been reported on the use of a solidified counterpart of this medium.

The purposes of these researches were twofold; firstly, to solidify the above medium and compare the growth of nine strains of **Mycobacterium tuberculosis var. hominis** on this new solid medium with the growth obtained on several solid media. For the purpose of this report the liquid medium, either Seitz filtered or autoclaved, will be referred to as Brain heart infusion-**Candida albicans** medium.

Two batches of brain heart infusion-**Candida albicans** medium were prepared. One batch was Seitz filtered and the other was autoclaved. Each batch was then divided into three portions. One portion of each batch was solidified by the addition of agar in water. (See Table 1 for the contents of the experimental media). Agar, however, has been shown to inhibit the growth of **Mycobacterium tuberculosis** (2) through its content of long-chain fatty acids, and one might assume that such media would not support good growth of the organism. Long-chain fatty acids have a dual effect in the metabolism of **Mycobacterium tuberculosis** (3). A small amount is desirable, but larger quantities inhibit growth. Albumin has been used in agar media to bind most of the long-chain fatty acids leaving a small amount available to the organism (4). Bovine serum has been cited as a good source of albumin for this purpose (5), hence bovine serum was added to the second portions of each batch of brain heart infusion-**Candida albicans** medium in addition to agar in water (6). Charcoal has also been shown to bind these long-chain fatty acids (2) and therefore charcoal (Norite A) was added to the third portions in addition to agar in water.

MATERIALS AND METHODS

With the exception of Kirchner's semi-solid agar medium, all media used were solid. The six solid media in current use, chosen for use in this experiment, are listed in Table 2. Peizer-Schechter agar was made according to Klein et al. (7) as modified by Peizer et al. (8). Charcoal medium (Triton malachite green-charcoal agar

medium) was made by adding 1.25 ml of a 2% aqueous solution of malachite green and substituting 0.5 ml. of WR 1339 (Triton) for Tween^{R} 80 (9) in the basal used by Hirsch (2). Modified Kirchner's semisolid agar medium was made according to Mackie and McCartney (10) except that to 900 ml. of the medium, 1.25 gm. of Bacto-agar (Difco) was added. The medium was autoclaved at 15 pounds pressure (121°C.) for fifteen minutes, cooled to about 50° - 55°C.; 100 ml. of sterile horse serum (commercial) was added (without penicillin) to make the medium similar to that used by Knox (11). Oleic acid-albumin agar (Davis and Dubos) medium (12), blood agar medium (13) and Lowenstein's (Jensen-Holm) medium (14) were made according to the quoted references.

Expermental media: In addition to the above, six experimental media were devised. Brain heart infusion-**Candida albicans** medium, as described in the introduction was made as follows:

For 1000 ml.

Bacto-brain heart infusion (Difco)	37.0 gm.
Water (distilled)	1000.0 ml.

The brain heart infusion and water were mixed in a two liter Erlenmeyer flask, stoppered with a gauze-cotton plug and autoclaved at 15 pounds pressure (121°C.) for fifteen minutes. Two flasks of media were made in this manner. To each flask 1.5 ml. of an emulsion of a two-day-old **Candida albicans** culture (grown on Sabouraud's agar slants) plus 5 ml. of sterile distilled water was added. The flasks were incubated at 37°C. for exactly 24 hours (1). At this point the medium is referred to as brain infusion-**Candida albicans** medium or basal medium (Table 1).

One flask was autoclaved at 15 pounds pressure (121°C.) for fifteen minutes, the other was Seitz filtered. Each batch was divided into three 300 ml. portions and six experimental media were made as follows:

TABLE 1 EXPERMENTAL MEDIA

Medium	Contents		
A	Basal medium (Seitz filtered)	water and agar	
B	Basal medium (Seitz filtered)	water and agar	bovine serum
C	Basal medium (Seitz filtered)	water and agar	Charcoal (Norite A)
D	Basal medium (autoclaved)	water and agar	
E	Basal medium (autoclaved)	water and agar	bovine serum
F	Basal medium (autoclaved)	water and agar	Charcoal (Norite A)

In media A and D, 6.0 gm. of Bacto-agar (Difco) was added to 300 ml. of distilled water, autoclaved at 15 pounds pressure (121°C.) for fifteen minutes in an aspirator bottle and allowed to cool to about 50° - 55°C. Three-hundred ml. of the appropriate portion of basal medium was added. In media B and E the same amount of agar was dissolved in 240 ml. of water, autoclaved, allowed to cool, and 60 ml. of bovine serum (Seitz filtered) plus 300 ml. of basal medium was added. Media C and F were made exactly as were A and D but 0.6 gm. of Norite A was added to the agar and water prior to autoclaving.

Mankiewicz (1) postulated the production of a growth factor by **Candida albicans** and her liquid medium was Seitz filtered. On the assumption that this growth factor might be heat labile, we added the agar to the Seitz filtered basal medium in the form of a cooled, autoclaved agar-water mixture to produce media A. B and C. Media D, E and F were similarly solidified to make a comparison of growth on the media from the Seitz filtered and the autoclaved basals valid.

All of the currently used and experimental media were dispensed as 20 ml. portions in 25 x 150 mm. screw-capped test tubes, slanted to produce about a one-inch butt. All tubes were incubated at 37°C. for 48 hours to check for sterility, and to exhaust excess moisture.

Nine subcultured strains of **Mycobacterium tuberculosis var. hominis** were acquired from the North Dakota Public Health Laboratories. Two 16-ounce standard prescription bottles, containing 50 ml. each of Tween-albumin medium, were inoculated for each of the nine strains. Tween-albumin medium was prepared from the basal medium used by Tarshis and Elberg (12) without the agar. The basal medium was dissolved with heat and stirring, autoclaved at 15 pounds pressure (121°C.) for fifteen minutes, and allowed to cool to about 50° - 55°C. One hundred ml. of Seitz filtered 5% al-

TABLE 2

Amount of Growth on Media Tested

	Strain Number								
Culture Medium	1	2	3	4	5	6	7	8	9
Peizer-Schechter	--	--	--	contaminated		--	--	--	--
Charcoal	-	-	-	+	-	-	-	-	-
	-	-	-	+	-	-	-	+	-
Kirchner's	-	-	-	++	+++	+	++	-	-
	-	-	++	+++	+++	+	++	+	-
Davis and Dubos	++++	+++	+++	+++	+++	+++	+++	+++	+++
	++++	+++	+++	+++	+++	+++	+++	+++	+++
Blood Agar	++++	+++	++++	++++	++++	++++	++++	++++	-
	++++	+++	++++	++++	++++	++++	++++	++++	-
Lowenstein (control)	++++	++++	++++	++++	++++	++++	++++	+++	++
	++++	++++	++++	++++	++++	++++	++++	+++	++
A	-	-	-	-	-	+	-	-	-
	-	-	-	-	+	+	-	-	-
B	++	+++	+++	+++	++	+++	+++	++	+++
	++	+++	+++	+++	++	+++	+++	+++	+++
C	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-
D	-	+	+	-	-	+	-	-	-
	-	+	+	-	-	+	+	+	+
E	+++	+++	+++	+++	++	++	+++	+	++
	+++	+++	+++	+++	++	+++	+++	+++	+++
F	-	-	-	-	-	-	+	-	-
	-	-	-	-	-	-	-	-	-

bumin[1] in 0.85% sodium chloride solution was added aseptically. The completed medium was dispensed as 50 ml. portions in eighteen 16-ounce prescription bottles. Bottles of the test organisms were incubated horizontally at 37°C for 5 weeks. Bottles were horizontal

to permit maximal oxygen diffusion. One screw-capped test tube of each of the twelve media was inoculated with one 3 mm. loopful of culture from each prescription bottle, which had been shaken on a mechanical shaker to provide homogeneity. This resulted in two tubes of each of the twelve media for each of the nine strains of organisms. These tubes were incubated at 37°C. and checked for growth daily for a ten day period.

RESULTS

At the end of ten days the amount of growth on Lowenstein's (Jensen-Holm) was arbitrarily assigned a value of four plus and recorded in Table 2 along with amount of growth on other media employed.

As was expected, the long-chain fatty acids being free, experimental media A and D (see Table 1 for contents) showed essentially no growth. It is interesting to note that experimental media C and F, containing charcoal as a fatty acid binding agent also showed essentially no growth with a concentration of charcoal that has been used in other media (2). No explanation can be offered for this result. Media B and E (those with bovine serum as fatty acid binders) showed fairly good growth. Note also (Table 2) that amount of growth on medium E, containing autoclaved basal medium. compares closely with that on medium B, containing Seitz filtered basal medium. Almay be substituted for Seitz filtration in producing a solid medium. Autoclaving does not destroy the ability of the resultant medium to support growth.

Since, in producing the solid media, the basal was diluted by 50% with water or water plus bovine serum, it is felt that if agar were added to the basal just prior to autoclaving, then bovine serum were added aseptically, still better growth than on medium E would result. Further studies could prove or disprove this speculation, at which time the effects of varying the concentration of the dried brain heart infusion in the basal as well as the concentration of bovine serum in the final medium could be observed. Addition of penicillin or a dye, such as malachite green, with comparison of the results of growth from sputum samples on this variation of medium E with that on other media in current use would prove whether or not clinical use of this medium is feasible. Medium E combines the good factors of growth, ease of preparation and low cost.

SUMMARY

It has been shown that brain heart infusion broth which has supported the growth of **Candida albicans,** and has been Seitz filtered, will then support the growth of **Mycobacterium tuberculosis var. hominis.**

The object of our experiment was to solidify this medium in several variations and check their abilities to support the growth of **Mycobacterium tuberculosis var. hominis.**

These experimental media were produced by growing **Candida albicans** in two batches of brain heart infusion broth. One batch was Seitz filtered and the other was autoclaved. Each batch was then divided into three portions which were solidified by the addition of agar and water. To the second and third portions of each batch, bovine serum and charcoal were added respectively to bind the long-chain fatty acids in the agar.

Growth which was comparable to certain of the currently used culture media for growth of **Mycobacterium tuberculosis var. hominis** was observed on the experimental bovine serum media. Variable and scattered growth appeared on the other experimental media. Attributes of bovine serum medium are its relative inexpensiveness and ease of preparation.

ACKNOWLEDGEMENT

The author wishes to express his appreciation to Professor Richard M. Marwin of the Department of Bacteriology in the School of Medicine for both advice and assistance during this project.

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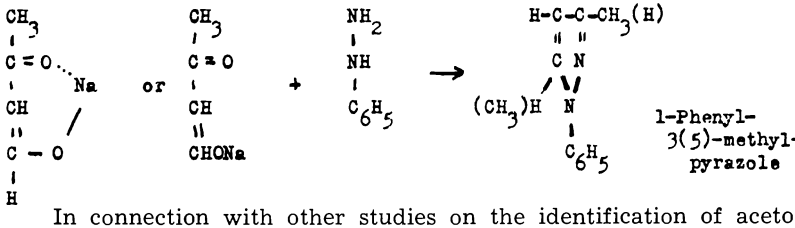
PREPARATION AND PROPERTIES OF SOME PYRAZOLE DERIVATIVES FROM ACETO-ACETALDEHYDE AND SUBSTITUTED PHENYL- HYDRAZINES

Sylvia Ebel, M. Duane Enger, Roger Johnson,
F. H. Rathmann, and Janice Swenson
School of Chemical Technology
North Dakota Agricultural College, Fargo, North Dakota

INTRODUCTION

Aceto-acetaldehyde in the form of its sodium salt reacts with hydrazine and phenyl hydrazine to yield substituted pyrazole derivatives. (1)



In connection with other studies on the identification of aceto-acetaldehyde, it was desirable to prepare solid crystalline pyrazole derivatives. For reasons of analytical differentiation, it was desirable furthermore that some of these derivatives contain halogen atoms rather than only C, H, O, and N.

EXPERIMENTAL

1-Phenyl-3-methyl pyrazole (2,3) ($C_{10}H_{10}N_2$) was prepared as described by Claisen (4) by reacting equimolar amounts of sodium aceto-acetaldehyde and phenyl hydrazine hydrochloride in aqueous solution, stirring said solution for 4 hr., and collecting the brown oil that separated. The ether extract of the oil was dried with Na_2SO_4, filtered, and distilled, b.p. approx. 256°C at 730 mm. This distillate was fractionated **in vacuo** using a water aspirator, b_{12} 123°C. The

middle fraction was an almost water white liquid; d_4^{30} 1.077, Rm = d_4^{30} 1.077, nD 1.577, Rm = Mrd by use of the Lorenz-Lorentz

$$\left(\frac{n^2 - 1}{n^2 + 2}\right)\frac{M}{d}$$

formula found 48.3; calcd. from sum of atomic refractions 48.97 (5).

Sodium acetoacetaldehyde in aqueous solution was allowed to react with an aqueous solution of 2,5-dichlorophenylhydrazine hydrochloride. The water-insoluble product was then recrystallized either from a large volume of hot water, or from hot dilute alchohol (50%). Long white needles separated out after several days. **1-(2, 5-Dichlorophenyl)-3-methyl-pyrazole** melts at 87-89.5°C.

1-(2,4,6-Trichlorophenyl)-3-methyl-pyrazole ($C_{10}H_7N_2Cl_3$) was prepared in aqueous solution from 2,4,6-trichlorophenyl-hydrazine hydrochloride and sodium aceto-acetaldehyde. The resulting crystalline product was purified by recrystallization from hot water. This resulted in white needle crystals with a m.p. (very sharp) of 105-105.5°C. A Carius determination on an impure product showed 40.51% Cl, as compared with a calculated value of 40.66% Cl. We intend to repeat this analysis.

1-(Para-bromophenyl)-3-methyl-pyrazole ($C_{10}H_9N_2Br$) has been prepared before by A. Michaelis and G. Schwabe (by reduction of **p**-bromophenyl-3-methyl-5-bromo-pyrazole (6) as a white crystalline product with a melting point of 94°C. Our work differs in that we prepared this compound by reacting equimolar amounts of **p**-bromophenyl-hydrazine hydrochloride and sodium aceto-acetaldehyde in aqueous solution. 4.46 g. of the **p**-bromophenylhydrazine hydrochloride was dissolved in 100 ml. of H_2O, filtered, and then added slowly to 2.16 g. of sodium aceto-acetaldehyde dissolved in 50 ml. of ice water (this solution was effected in ice water to prevent any changes in the reagent that might have occurred due to heat of solution) contained in a 500 ml. Erlenmeyer equipped with motor stirrer. A layer of ether was maintained on top of the aqueous solution of reactants in order to dissolve the product and prevent the formation of heavy oil which would entrain some of the unreacted reagent. A preliminary run without ether showed that the reaction required at least six hours for completion. This ether layer became a reddish brown color as the reaction developed. The solution was stirred for five hours as the reaction took some time for completion. At the end of this time the aqueous and ethereal layers were shaken together in a separatory funnel, the aqueous layer was discarded, and the ethereal extract was dried with Na_2SO_4. Upon driving off the ether we obtained a brown oil that soon crystallized.

We distilled this brown oil in vacuum, b.8mm. 95°C. This distillation produced a white vapor that condensed in the form of white crystals. A solid nearly black residue remained in the distillation flask. The white crystals were slightly soluble in hot H_2O, soluble in ethanol, and very soluble in ether. We recrystallized the impure

crystals (m.p. 83-87°C) from a solvent pair of ethanol and water, obtaining thereby white, flake-like crystals that melted very sharply at 95.5°C (corr.).

Some of these crystals were dissolved in dilute HCl solution. Upon addition of ammonia a precipitate formed. A picrate salt was also formed, which is to be characterized.

Work remains to be done on the full characterization of this (**p**-bromo-phenyl)3-methyl-pyrazole. A Carius determination has been run on an impure product. The determination showed a halogen content of 33.82%, and 33.90% as compared with a calculated value of 33.72%. This shall be repeated on the pure product.

Summary

1. New data have been obtained on 1-phenyl-3 (5) methyl-pyrazole.
2. 1-(Parabromo-phenyl-)-3-methyl-pyrazole has been prepared by a new method.
3. 1(2,5-Dichlorophenyl-)- and 1-(2,4,6-trichlorophenyl-)-pyrazoles have been prepared and described.

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PREPARATION AND CHARACTERIZATION OF ACETOACETALDEHYDE (BUTANONE-3-AL-1)

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INTRODUCTION

Since the first published work of Claisen on acetoacetaldehyde (1), further research has been conducted and reported (2,3,4,5,6,7). These investigations resulted from interest in obtaining information

:oncerning the preparation and properties of acetoacetaldehyde. These ıttempts to prepare the pure compound were unsuccessful.

Acetoacetaldehyde is very unstable at room temperature. This ındoubtedly is the chief factor preventing successful results. Claisen ılso commented on the instability of this compound stating that the :ree aldehyde cannot be isolated because when it is liberated, three nolecules immediately condenses to form 1,3,5-triacetyl-benzene.

$$3CH_3\text{-}CO\text{-}CH_2CHO \longrightarrow 1,3,5\text{-}C_6H_3(CH_3CO)_3 + 3H_2O$$

Present interest in acetoacetaldehyde is enhanced by the fact that it is probably present in the intermediate products of combustion of gasolines used in internal combustion engines (8), and by the conjecture that it is involved in human metabolism in the formation of blood pigments (9). There is also evidence that acetoacetaldehyde is a product of the thermal decomposition of polyvinyl nitrate (10,11).

EXPERIMENTAL PART

Sodium acetoacetaldehyde is prepared in absolute ether which is cooled in an ice bath (1). Alcohol-free sodium ethoxide is mixed in equimolar quantities with acetone and ethyl formate using a tenfold volume of absolute ether as a reaction medium. After twelve hours the sodium acetoacetaldehyde which has separated out as a light yellow mass is filtered off. The reaction proceeds as follows:

$$C_2H_5ONa + C_2H_5OOCH + CH_3COCH_3 \longrightarrow CH_3\text{-}CO\text{-}CH = CHONa + C_2H_5OH$$

Sodium acetoacetaldehyde is stable at room temperature but is extremely deliquescent and must be stored in a well-stoppered bottle. No method has yet been devised for the recrystallization of the sodium salt as it is very soluble in cold water and alcohol, but insoluble in ether and benzene.

The structure of the sodium salt may be represented by any one of the following:

I $CH_3CONa = CH\text{-}CHO$
II $CH_3\text{-}CO\text{-}CHNa\text{-}CHO$
III $CH_2\text{-}CO\text{-}CH = CHONa$

Analysis indicates that only one sodium atom adds on during the preparation.

Acetoacetaldehyde is prepared by the acidification of the sodium acetoacetaldehyde with gaseous AcOH carried by a stream of nitrogen gas. The apparatus used is rather complex-looking but simple in actual operation. Nitrogen is passed by a manometer (Slide) through a drying tube containing $CaCl_2$, past another manometer, through a gas bubbler containing the CH_3COOH, by a manometer, through the reaction tube, upward from the bottom, into a cold finger immersed in a bath of dry ice and acetone and then to a manometer and out through a gas flowmeter.

The reaction tube contained sodium acetoacetaldehyde and glass wool in alternate layers. The cold finger at -80°C was used to entrap

the acetoacetaldehyde vapors, condense and crystallize them. The manometers placed at various parts of the closed system were used to observe pressure differences. The gas flowmeter was used to measure time-flow of the nitrogen through the system.

The preparation of acetoacetaldehyde was run many times, each for various lengths of time. The gas carrying the acid was run at different rates, all at room temperature. Different lengths and diameters of tubing were used as well as different methods of packing the layers of glass wool and sodium derivative. All of these innovations had little if any effect on the preparation.

Every run attempted was successful although with small yields. All the physical measurements determined were made in a small unheated outside shed. The shed contained the necessary apparatus such as an analytical balance, Abbe' refractometer, pycnometers, etc. The reaction was run on some of the coldest days in the winter of 1957-58, and then the physical measurements were taken. Due to the mildness of our winter this year there were not many good days in which to work.

Acetoacetaldehyde is a colorless liquid, free-flowing, with pleasant ketonic odor followed by a pungent odor. It becomes viscous at —30°C and solidifies to a white crystalline solid at —40°C. It is quite stable at —80°C. The prepared aceto-acetaldehyde gives a positive Schiff's fuchsine aldehyde test.

The heating curve of frozen acetoacetaldehyde was plotted as temperature vs. time, (Slide), and the flat part of the curve indicated a melting point of —33° to —32°C. The densities were taken by means of a small half-ml. pycnometer using toluene and carbon tetrachloride as reference liquids.

TABLE I

Temperature	Density Found
— 2°C	0.916
—13°C	0.899

Only one refractive index was taken, and that was found to be 1.3570 at —2°C. From this and the density at —2°, the molar refraction came out to be 20.97. The Lorentz-Lorenz equation was used:

$$R_{md} = \left(\frac{n^2 - 1}{n^2 + 2}\right)\frac{M}{d}$$

The value calculated (12,14) for the enol form was 21.74 and that for the keto form 20.70. This indicates that about one-fourth of the material is in the enol form.

From the previously suggested structures of sodium acetoacetaldehyde it follows that the unstable free aldehyde would probably exist as a keto-enol tantomer. Compounds similar to the one investigated, such as acetoacetic ester (13) and pentanedione 2,4, generally exhibit similar tautomerism. Compounds with a methylene group adjacent to a carbonyl group exist in either a keto or enol form.

From our measurements it seems as if acetoacetaldehyde at —2°C exists mainly in the keto form.

An ultraviolet spectrophotometric analysis of a 0.00010 M aqueous solution of sodium acetoacetaldehyde showed a strong absorption in the 280-282 mu range (Slide).

The addition of a five-fold excess (with respect to the sodium acetoacetaldehyde) of HCl to the 0.00010 M sodium salt solution resulted in an almost complete depression of the 280-282 mu peak. The addition of a sufficient quantity of NaOH to neutralize the acid present in the solution plus giving a two-fold excess not only restored the peak, but caused a more intense absorption than that of the neutral salt solution. The degrees of hydrolysis were calculated from the ratios of the absorption intensity relative to the value in a large excess of alkali. The pK's were then calculated and found to be about 8.3, which may be compared with that of 7.6 obtained from pH titration measurement at 10,000 times as high a concentration. The discrepancy is probably due to relatively large effects of CO_2 upon the extremely dilute solutions.

Some things that were not investigated due to weather conditions and lack of time that are to be included in further work are:

a. Selective bromination. The addition of bromine to the compound should give a good value for the tautomeric equilibrium constant.
b. Molecular weight determination by the depression of the freezing point of benzene.
c. Vapor density and vapor pressure measurements.

Discussion

The ultraviolet absorption of sodium acetoacetaldehyde in the 280-282 mu range is attributable to the dissociated enol form of sodium acetoacetaldehyde. This peak disappears almost completely in excess acid.

The addition of excess acid shifts the tautomeric equilibrium toward the keto form which does not absorb ultraviolet radiation to any appreciable degree in the 280-282 mu range. The addition of excess NaOH shifts the equilibrium toward the enol form. The attempts to prepare pure acetoacetaldehyde were very successful, although the yields were low The work done here has been a preliminary investigation, and has been qualitative rather than quantitative.

SUMMARY

1. Free acetoacetaldehyde has been prepared by the action of acetic acid vapors on the sodium salt.

2. Physical constants such as melting point, density, and index of refraction were measured. The molar refraction indicates the presence of keto-enol tautomerism.

3. An investigation of the ultraviolet absorption of sodium acetoacetaldehyde established a peak in the 280-282 mu range. Addition of excess acid and base offer some indication as to the reaction of the sodium salt in aqueous solutions.

4. pH-titration data indicate a pseudo-acid pK value of 7.6.

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FURTHER STUDIES IN THE ISOXAZOLE SERIES

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Adolfo Quilico and Raffaello Fusco[1] in the Istituto di Chimica Generale della Reale Universita, Firenze, Italy, found that an isoxazole ring compound may be prepared by condensation of 1'-chlorobenzaldoxime with a keto-ester such as acetoacetic ester. Further studies by Quilico, Panizzi, Cavazzati, and Rathmann[2,3,4,5] indicated

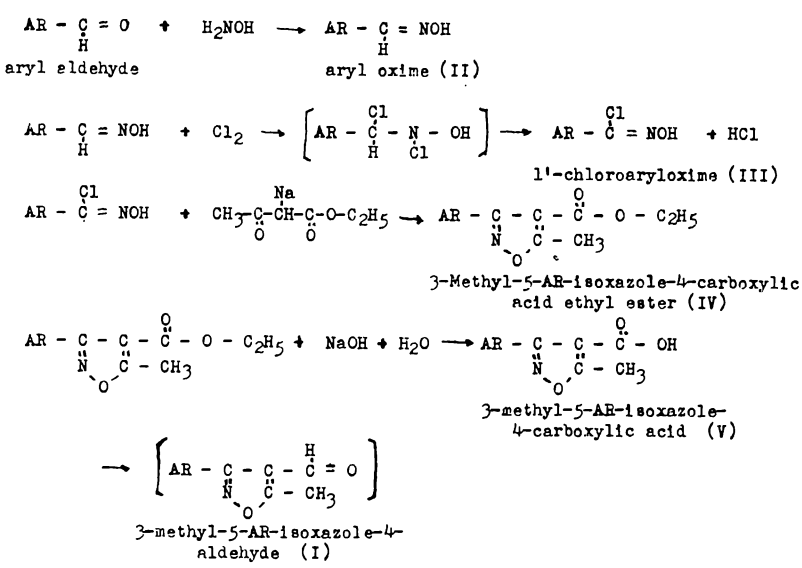
that the aldehydes of such isoxazoles, especially 3-methyl-5-phenyl-isoxazole-4-aldehyde, (I), behave in essentially the same way as an aromatic aldehyde.[8]

The work reported here was done with the intent of preparing other isoxazolyl aldehydes so that their behavior may also be studied. Several new compounds including two members of the isoxazole series have been prepared. The last, 3-methyl-5-(2,4-dichlorophenyl)-isoxazole-4-carboxylic acid, (V b), will later be reduced via the anilide to the aldehyde, (I b).

EQUATIONS FOR REACTIONS

AR aryl group

a p-chlorophenyl
b 2,4-dichlorophenyl
c phenyl



EXPERIMENTAL

2, 4-Dichlorobenzaldoxime (II b)

Portions of 2, 4-dichlorobenzaldehyde and 40% NaOH solution were added alternately with stirring to 140 g. (2 moles) of NH_2OH-HCl until a total of 500 g. (5 moles or 25% excess) of NaOH and 350 g. (2 moles) of the aldehyde had been added. The reaction mixture was cooled in an ice bath throughout the additions. The solution was then neutralized with concentrated HCl and the crystals collected and dried. Recrystallization from benzene yielded white, needle-shaped crystals melting at 136-137° C. (Beilstein reports 136-137°C.)[6]

1-Chloro-2, 4-dichlorobenzaldoxime (III b)

A solution of 30.25 g. (0.157 mole) of (II b) in chloroform was

cooled in ice while dry, HCl-free chlorine was passed through it. Introduction of the chlorine gas produced a brilliant green color, probably the color of an intermediate nitroso compound (see "Equations of Reactions," slide), which changed to yellow on completion of the reaction.[7] The chloroform was then evaporated under vacuum and the crystals collected and dried. Recrystallization from petroleum ether yielded white, needle-shaped crystals melting at 73.5° C. Yields of about 90% of the theoretical were obtained. The product was found to be soluble in methanol, benzene, chloroform, and petroleum ether.

3-Methyl-5-(2, 4-dichlorophenyl)-isoxazole-4-carboxylic acid ethyl ester (IV b)

Metallic sodium (2.3 g or 0.1 mole) was dissolved in 100 cc. absolute methanol, 12.5 g. acetoacetic ester added, and the mixture refluxed for 30 minutes. The flask was cooled in ice, and a methanolic solution of 20.2 g. of the chloro-oxime (III) was added with shaking. After standing overnight, the methanol was evaporated and the reaction mixture dissolved in 100 ml. each of ether and water. The layers were separated and the ether layer was washed three times with 4% NaOH solution. The NaOH extract was acidified and extracted again with ether. The product was obtained from the ether layers by vacuum distillation. The pale yellowish liquid boiled at 120° C. at 16 mm. Hg pressure, had a refractive index of 1.5285 and a density of 1.2781_4^{23}. Molar refraction was:

Experimental	Calculated[9]
72.365	72.470

The product crystallized very slowly into white needles melting at 65-67° C., insoluble in water, and soluble in benzene, methanol, and ether.

3-Methyl-5-(2, 4-dichlorophenyl)-isoxazole-4-carboxylic acid (V b)

One gram of the ester, (IV b), was dissolved in absolute methanol, and 2 ml. of a saturated solution of NaOH in methanol was added. The solution was refluxed for one-half hour, the methanol evaporated, and water added. An oily residue was removed, the water acidified, and the crystals collected. Recrystallization from both $NaHCO_3$ solution and from ether gave white crystals melting at 162° C.

ACKNOWLEDGEMENT

The authors wish to express their thanks to Mr. William King for his aid and advice in photographing the crystals and obtaining the extinction angles.

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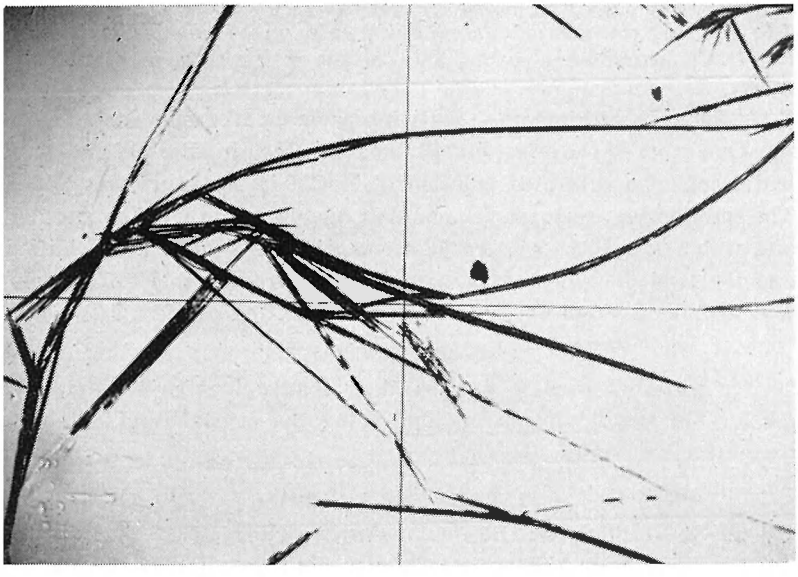
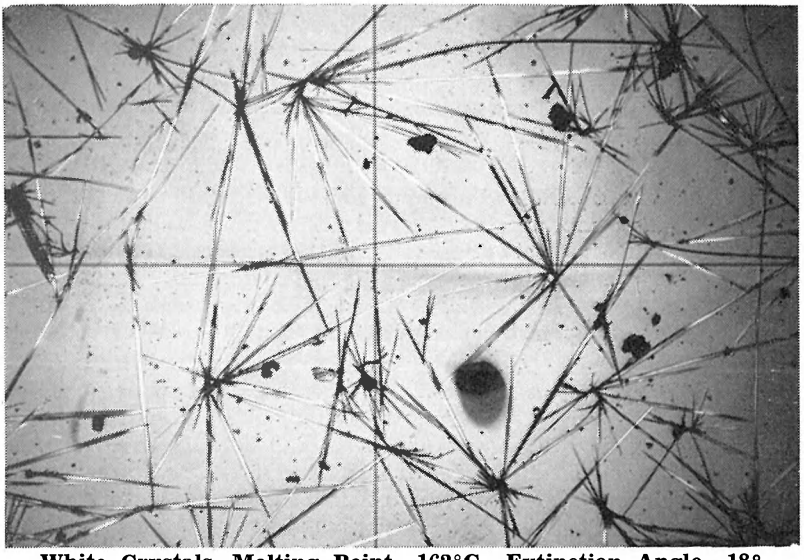
PHOTOGRAPHS OF CRYSTALS

1,-Chloro-2,4-dichlorobenzaldoxime (III)



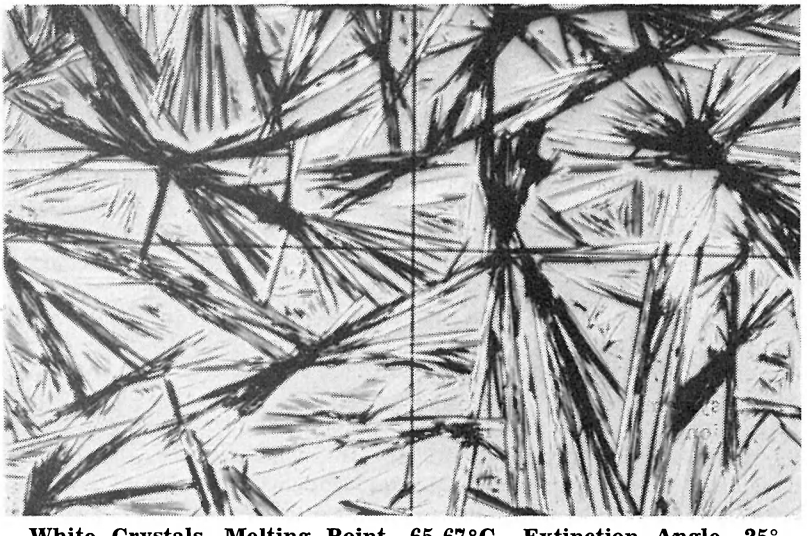
White Crystals, Melting Point—73.5°C., Extinction Angle—3°

3-Methyl-5-(2, 4-dichlorophenyl)-isoxazole-4-carboxylic acid (V b)



White Crystals, Melting Point—162°C., Extinction Angle—18°

3-Methyl-5-(2, 4-dichlorophenyl)-isoxazole 4-carboxylic acid ethyl ester (IV b)



White Crystals, Melting Point—65-67°C., Extinction Angle—25°

SOME COMPLEX-FORMING MOBILE PHASES OF COMMON CATIONS ON PAPER USING A CELLOSOLVE SOLVENT

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The use of a cellulose medium for the separation of different types of organic mixtures has become a standard procedure in analytical and industrial laboratories. Standard practice for the separation of large quantities of material has turned to packed columns of cellulose, alumina and Fuller's Earth. The separations of small quantities for analytical purposes has turned to the use of paper in strips or sheets.

The success of this procedure with organic compounds has led to many attempts by many workers to apply this technique to mixtures of inorganic cations and anions (Ref. 1-10). Some procedures have become standard for the quantitative analysis of alloys and special methods for the assaying of gold, uranium, platinum, and related metals. The influence on analytical procedures is best measured by the fact that you now find several hundred references each year where Chemical Abstracts had a half dozen such references in 1940 and 1941.

The use of filter paper for analytical purposes goes back to F. F. Runge (1850) and the Starch-Iodide paper test still in use. Modern day techniques actually date from the work of Schoenbein (11) and Goppelsroeder (12), a pupil of his. Feigl (13) has successfully developed recognized procedures for microchemical tests for many inorganic cations.

Pollard and McOmie (18) first reported in 1951 on a systematic scheme for separating groups of the common cations studied in his beginning qualitative analysis courses using for solvents Aq. Ammonia, Butanol saturated with 3M HCl, Butanol saturated with Ethyl Acetate +2% conc. HCl by volume, Acetylacetone saturated with water +0.5% conc. HCl by volume, +25% acetone by volume, Glacial acetic acid +25% Methanol by volume, Acetone +5% water by volume +8% conc. HCl by volume, straight Methanol, water saturated Pyridine, mixtures of 80% Methyl-n-propyl ketone + acetone + HCl, and a Butanol-acetic acid mixture.

A systematic use of complex-forming mobile phases for cation separations on paper and in cellulose columns is described by Williams (14) and Weil and Williams (15). The procedure is further developed (1949) by Pollard, McOmie and Stevens (16). They used a downward solvent migration to produce ultra-violet light sensitive spots on paper. Solvent mixtures were 50% n-Butanol, 10% HAc,

40% H_20 and a 50% Collidine — 50% water mixture. Kojic Acid, O-amino-benzoic acid, morin, 1-naphthyl amine-8-sulfonic acid, 2 naphthylamine-1-sulfonic acid and 8-Hydroxyquinoline were used for complexing and sensitizing agents with some success.

In 1951 Laskowski and McCrone (17) reported on procedures using an upward migration on a cylinder of paper with a number of solvents: dioxane, pyridine, chloroform, acetone, methanol, 1-proponol, 2-propanol, ethanol, and 1-butanol. Rf values for the various solvents are compared and special data are given for Cl-, $N0_3$-, $S0_4$ =, Sb, Ba, Cd, Ca, Co, Fe, Al, Cu, Hg, Ni and Pb.

The sophomore qualitative analysis class (Chemistry 203) at the University of North Dakota duplicated much of this work in the years 1952, 1953, and 1954. A source of constant unpleasantness and annoyance was (1) the instability of many solutions, (2) the smelly and irritating nature of many of these solvents and (3) the care that had to be exercised because of the toxic nature of some of them. This led to discussions in class of the possible use of socially more acceptable solvents with the cations trapped in chelate-forming-complexes that would move with the solvent front. This paper is a preliminary report on what was done and suggests starting points for further investigation.

During the next three years 1955-1956-1957 many combinations of complex-forming mobile phases were tried. Methanol and Ethanol were used with some success. From there the class went to some of the polyhydroxy alcohols: glycerol, ethylene glycol and propylene glycol showed some promise. One day in April of 1956 while looking on the chemical stock shelves one of the class suggested that the Methyl and Ethyl-cellosolves be tried. It was a happy accident. These solvent media are pleasant to work with, are non-toxic, easily dissolve organic compounds that can be used to form cation chelates, leave a dried surface on which a good identification test can be made and form stable solutions that can be kept for a long period of time.

This spring it was decided to assemble all of the accumulated data and select the most promising for verification and development. It was evident that one of the simplest and most effective means of securing a good solvent migration was on a cylinder of paper with an upward movement of the solvent. The following procedure was decided upon.

Sheets of Standard Sargent chromatographic paper were cut into pieces 11¼" by 11⅝". These were made into cylinders placed in large petri-dishes containing the solvent and covered with bell-jars to maintain a solvent atmosphere. Four spots were placed on a line 1⅝" from the bottom of each sheet as a starting point and the cylinders were removed when the solvent was 1" from the top. The sheets were then dried and developed.

The experiment was conducted starting with saturated solutions of Ag $N0_3$, Cu $(N0_3)_2$, Co $(N0_3)_2$, Ni $(N0_3)_2$, Pb $(N0_3)_2$, Cd $(N0_3)_2$ and Zn $(N0_3)_2$ prepared at room temperature. One drop, from a pipette calibrated to 23 drops per ml., of solution was placed on a point and migration data secured for the specific ion. Dilutions were made until a concentration was secured that gave a minimum amount of "trailing effect". Then simple combinations of two ions were used to see if comparable migration values could be secured and identifications made with each ion.

The three solvents used were solutions of Ethylene glycol monomethyl ether (methylcellosolve) plus (1) 1 gram of succinic acid, (2) 1 gram of Kojic acid or (3) 1 gram of Rubeanic acid per liter of solvent.

The results of the migrations are given in the following tables giving the ions involved, the concentrations used, the time of migration and the distance of migration. Standard spot tests were used to identify individual ions.

TABLE I

Ethylene Glycol Monomethyl Ether + Rubeanic Acid (lg./1.)

Ion	Concentration (g/100g H_20)	Time (hrs.-Mins.)		Distance (ins.)
Cu++	15.59	4	35	7 3/8
Co++	50.00	4	40	5 4/8
Cd++	75.00	4	58	5 5/8
Zn++	6.80	4	41	6 6/8
Pb++	7.06	3	40	5 7/8
Ni++	11.77	4	23	7 5/8
Ag+	28.48	4	10	4

TABLE II

Ethylene Glycol Monomethyl Ether + Rubeanic Acid (lg./1.)

Ion	Concentration (g/100g H_20)	Time (hrs.-Mins.)		Distance (ins.)
Cu++	3.90	4	18	7 4/8
Co++	12.50	7	28	8 5/8
Cd++	18.75	5	12	6 2/8
Zn++	3.40	7	33	7 3/8
Pb++	7.06	4	2	6 5/8
Ni++	2.94	5	4	8
Ag+	28.48	5	26	5 2/8

TABLE III

Ethylene Glycol Monomethyl Ether + Kojic Acid (lg./1.)

Ion	Concentration (g/100g H_2O)	Time (hrs.-Mins.)	Distance (ins.)
Cu++	7.79	4 19	7 7/8
Co++	3.13	5 56	6 2/8
Cd++	9.38	6 24	7 4/8
Zn++	6.80	5 29	7 4/8
Pb++	7.06	4 36	6 3/8
Ni++	2.94	5 27	8 3/8
Ag+	14.24	6 3	4 3/8

TABLE IV

Ethylene Glycol Monomethyl Ether + Kojic Acid (lg./1.)

Ion	Concentration (g/100g H_2O)		Time (hrs.-Mins.)	Distance (ins.)	
Ag+, Cu++	Ag+	14.24	6 12	Ag+	4 3/8
	Cu++	7.79		Cu++	7 3/8
Ag+, Co++	Ag+	14.24	6 36	Ag+	4 7/8
	Co++	6.25		Co++	7 6/8
Ag+, Ni++	Ag+	14.24	6 12	Ag+	4 4/8
	Ni++	5.88		Ni++	8
Ag+, Cd++	Ag+	28.48	4 41	Ag+	4 3/8
	Cd++	18.75		Cd++	6 6/8
Cu++, Cd++	Cu++	7.79	5 0	Cu++	7 1/8
	Ni++	5.88		Ni++	8 1/8
Cu++, Ni++	Cu++	3.90	5 33	Cu++	6 4/8
	Cd++	4.69		Cd++	7

TABLE V

Ethylene Glycol Monomethyl Ether + Rubeanic Acid (lg./1.)

Ion	Concentration (g/100g H_2O)		Time (hrs.-Mins.)	Distance (ins.)	
Ag+, Cu++	Ag+	3.56	5 22	Ag+	5 6/8
	Cu++	1.95		Cu++	4 6/8
A Ag+, Co++	Ag+	1.78	4 30	Ag+	3 5/8
	Co++	0.78		Co++	5 2/8
Ag+, Ni++	Ag+	3.56	4 40	Ag+	4 1/8
	Ni++	1.47		Ni++	7 1/8
Ag+, Cd++	Ag+	1.78	4 57	Ag+	3
	Cd++	1.17		Cd++	4 5/8
Cu++, Co	Cu++	0.487	5 12	Cu++	2 4/8
	Co++	0.390		Co++	6 2/8
Cu++, Ni++	Cu++	7.79		Cu++	7 2/8
	Ni++	5.88	4 48	Ni++	8
Cu++, Cd++	Cu++	7.79	4 38	Cu++	6 6/8
	Cd++	9.38		Cd++	7 3/8

It was evident from the Chromatograms secured that the Kojic acid in Methyl cellosolve had the best load carrying capacity and gave the most consistent migration values for the ions and compounds tried.

The data obtained suggest that the cellosolve solvents with the suitable complex-forming organic compounds may be a way to develop a system for the separation and identification of some of the common cations. Much more experimental work is indicated before any final conclusions can be drawn.

A possible method for the systematic chromatographic separation of some of the common cations has been described. Further work needs to be done on—

(1) Further testing of complex-forming agents.

(2) Calculation of maximum load carrying capacities in proper units.

(3) The nature of the complexes formed and their behavior in the cellosolves.

(4) The behavior of the alkali and the alkaline-earth metals needs to be carefully studied. Some of the data at hand look promising.

(5) The selection of spot reagents that will give several ion tests by variations in color patterns.

(6) Specific applications of the method described.

The results of the study to date are of interest because (1) the research was started and largely carried on by a Sophomore Class in the beginning analytical course and (2) a new use is suggested for an easily available and very socially acceptable group of solvent compounds with particular attention paid to one of them.

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THE INFRA-RED SPECTRA OF SUBSTITUTED ANILINES

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HISTORY

This problem was presented to the senior author during the course of a graduate research program carried out by Professor Richard R. Holmes and Raymond Bayer in 1956-1957. The problem was to identify by infra-red analysis several substituted anilines synthesized in the course of the above investigation. It soon became apparent that this could not be done with the existing literature and hence this program was undertaken.

EXPERIMENTAL

All of the spectra were taken on a Perkin-Elmer Model 112 single beam double pass recording infra-red spectrometer. In the NaCl region from 1600 cm.$^{-1}$ to about 675 cm.$^{-1}$ a cell with a 0.2 mm. path length was used. In the KBr region from 675 cm.$^{-1}$ to 400 cm.$^{-1}$ a path length of 0.5 mm. was necessary.

The compounds studied were purchased when they were commercially available. Others were synthesized in our laboratory. All compounds were recrystallized until a melting range, compatible with the literature, was obtained. With the exception of tribromoaniline this range was a few tenths of a degree.

In a few cases weak absorption bands were noted in the spectra of the purified compounds that appeared to be anomalous when compared with the spectra of related compounds. In every case it

was found that these weak absorption bands could be attributed to what would be an intense band of a compound that could be expected as an impurity.

The most satisfactory solvent for the NaCl region is carbon disulfide. It is well known[1] that primary aromatic amines react with carbon disulfide to give substituted thioureas in the following manner:

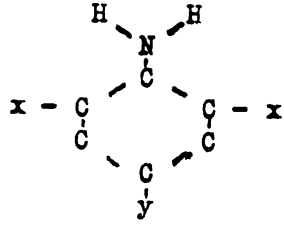
$$2ArNH_2 + CS_2 \leftrightarrows ArNH\text{-}\overset{\overset{S}{\|}}{C}\text{-}NHAr + H_2S$$

Several compounds were dissolved in CS_2 in a closed system with a delivery tube leading to a slightly acidic solution of cupric chloride. Only aniline formed a trace of precipitate. Furthermore, the spectra of the amines in carbon disulfide were compared with the spectra in methylcyclohexane, 2, 2, 4-trimethyl pentane, and carbon tetrachloride. No different absorption bands were noted although some of the bands were shifted of the order of one wave number. The authors have satisfied themselves that this shift is due to the difference in polarity of the solvents and is not caused by any chemical reaction. However, in all cases, the spectra were run in both carbon disulfide and methylcyclohexane. In the KBr region methylcyclohexane was employed as the solvent.

Concentrations varied from compound to compound in order to obtain the most satisfactory spectra. When semi-quantitative results were desirable a concentration of 40 mg. of solute to 1 ml. of solvent was used.

RESULTS

In Table I the absorption frequencies of the 1, 2, 3, 5-tetrasubstituted compounds are listed. A 1, 2, 3, 5-tetrasubstituted compound is one in which the substitution is in this fashion:



The X refers to a chloro, bromo, or methyl substituent and Y to a chloro, bromo, methyl, methoxy, or hydrogen substituent.

It is noted that in this type of substitution we have two isolated hydrogen atoms. Bellamy[2] has reported that the carbon-hydrogen out of plane deformation absorption appears in the region 900 to 860 $cm.^{-1}$ for an isolated hydrogen.

This statement should be limited to the penta-substituted compound with only a single isolated hydrogen, as with more than one

isolated hydrogen there will be more than one deformation mode.

Jones[3] has reported that for 1, 2,3, 5-tetrasubstituted benzenes the CH out-of-plane in-phase vibration should occur at 850 to 840 cm.$^{-1}$.

Table I shows that we have observed this vibration in the 860 to 850 cm.$^{-1}$ region in every case. It is further noted that for compounds with halogen substituents this vibration occurs at a slightly higher frequency (860 to 855 cm.$^{-1}$) than for the methyl substituted compounds (855 to 850 cm.$^{-1}$).

In only five out of ten cases have we observed a band in the 900 to 860 cm.$^{-1}$ region. This band is, with the exception of trichloroaniline, of medium to weak intensity and may be the out of phase

TABLE I

2, 6-Br_2-4-CH_3-NH_2	2, 6-Br_2-4-OCH_3-NH_2	2, 4, 6-Br_3-NH_2	2, 6-Cl_2-4-OCH_3-NH_2	2, 4, 6-Cl_3-NH_2
600s				560s
657w	657w	655m		656s
	688w	676s		
705w		705mw	700w	710mw
737s	740s	733s		732s
		757wi		757wi
787w	783s		787ms	
			795s	792vs
	840s	846mw	832s	805m
852s	858s	859vs	855s	858vs
				867s
897w	892m			
			913s	
997w				
1042msh	1050vs		1049vs	
1060s		1058m	1067vs	1067s
	1080s			1072sh
1088m		1089m	1087s	
				1098m
	1151w			1140w
	1181w		1182w	1160w
1190w		1196vw		1202w
1214m	1212m	1222w	1209s	1222mw
1238m	1238s	1228w	1238vs	
1294s	1285m	1292m	1288w	1288mw
				1300m
	1318s		1323s	
		1385m		1395m
1476s				
	1555m			
1574s	1583m			
1617s	1617m	1607wm		1607mw

TABLE I (Cont'd.)

2. 4, 6-Me_3-NH_2	2, 4, 6-Cl_3 -OH	2, 4, 6-Br_3 -OH	2, 4, 6-Br_3-OCH_3	1, 2, 3, 5-CCl_4
580m				
648m				
657m				
682vs		679s		688s
	710s	704s		
	732vs	737vs	740vs	
	760-70w	782	757wsh	
	796s	bd vw	778w	
	811m	802	822m	801vs
	814msh		829w	818vs
		843msh		833vs
854vs	855vs	858vs	858vs	857vs
	870m	871msh		
	916vw		918wsh	
958w	958vw		929w	
1010s			1000vs	
1028m				1036s
	1077w	1064vw	1065m	1049s
		1091	1097w	
	1130vw	bd vw		1112vs
1146m		1118	1109wm	1127vs
1156s	1157ssh	1157vs	1152w	1155m
	1164s	1194mw	1168vw	1179s
1234msh	1216s	1206w	1194wm	1188vs
	1228s	1231s		
1254s			1252s	1250s
	1272s	1271s		
1290s	1282s		1282w	
	1322vs	1316vs		
	1396vs	1383s	1373s	
1608s		1394ssh	1409s	
1622s				

bending mode, which should be infra-red inactive, or may be due to the nature of the substituent groups.

The skeletal mode which should be in the neighborhood of 675 $cm.^{-1}$ is found in varying positions and varying intensities for these tetra substituted compounds and no conclusions regarding the band have been reached.

In the other substitution pattern with isolated hydrogens, the 1, 3,15-trisubstituted compounds, the skeletal vibration is more constant than in the tetra-substituted compounds while the CH in phase bending mode is more variant.

Jones has reported these as occurring at 700 to 680 cm.$^{-1}$ and 850 to 830 cm.$^{-1}$ respectively. Bellamy reports 730 to 675 cm.$^{-1}$ and 865 to 810 cm.$^{-1}$ for the same vibrations.

Table II shows, with the exception of methyl group substituents where this absorption appears at 687 cm.$^{-1}$, that we have observed the skeletal vibration at a lower frequency than reported by either Bellamy or Jones. We have found this characteristic absorption in the 665 to 655 cm.$^{-1}$ region. It is therefore apparent that the position of this band is somewhat dependent on the nature of the substituent group.

We have found that the CH out-of-plane in-phase vibration generally occurs in the 860 to 835 cm.$^{-1}$ region. Again it is an intense band but positioned with much greater variancy than the corresponding vibration in the tetra-substituted compounds.

TABLE II

3, 5-Cl_2-NH_2	3, 5-$(CH_3)_2$ -NH_2	1, 3, 5-Me_3	3, 5-Me_2 -OCH_3
532w	580m		
	648m		
664vs	657m		
	682vs	690s	687s
803vs			
823vs	826vs		829vs
838vs		838vs	844ssh
	857s		867s
		880w	
		930m	917s
940vs	944w		953m
992s	955w	998m	995ms
		1014m	998wsh
	1033s	1039s	1036s
1066m			1072vs
1108vs			
		1165w	
	1175vs		1166vs
1198w			1194vs
1249vw			1268wsh
1285m	1284w		1294s
1303s	1312m	1302w	
	1330vs		1323vs
1415w	1373s	1377s	1378m
		1418s	
	1505w	1440s	1421s
1574s		1473s	
1593s		1577s	
1617m	1610s	1608s	

TABLE II (Con't.)

3, 5-Cl_2-CH_3**	3, 5-Br_2-CH_3**	1, 3, 5-Cl_3	1, 3, 5-Br_3
665s	664s	662s	659s
		718w	
	738s		748vs
794s		797vs	
		814s	
		832i	
846s	842s	850vs	848vs
897w			899vw
		905w	
987w	984w	995m	
	1016w		1013w
		1035m	
		1057s	
1092w	1094s	1095vs	1098s
			1116w
		1144m	
	1182w	1180m	
1234m			
		1260w	
1288w	1287w		
1349w		1374w	
		1393w	
		1393m	
		1414w	

The third frequency, the CH out-of-plane out-of-phase vibration, occurs only in four out of eight cases and the same postulations made regarding this mode in the tetra-substituted compound hold.

Additionally it will be noted that when the substituent groups are halogens another strong absorption band occurs in the region between the CH deformation region and the skeletal frequency. This is especially noteworthy in the case of chloro substituted compounds where this absorption occurs at 800 $\pm$ 10 cm.$^{-1}$ in every case. This is also consistent with the data in Tables I and III.

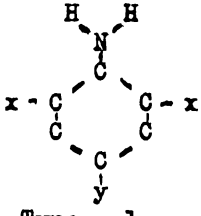
Although both Bellamy and Jones have assigned a wide carbon halogen frequency range it is evident that very little work has been reported on halogenated aromatics. The authors are inclined to assign the absorption at 800 $\pm$ 10 cm.$^{-1}$ to a carbon chlorine vibration and if this is correct it would be the CCl stretching mode as the bending modes are well known to occur at much lower frequencies. We specify this correlation only for the cases when the chlorines are meta one to the other.

The bromo substituent gives a strong absorption band at 740 $\pm$ 10 cm.$^{-1}$. Although this band occurs in every bromo substituted com-

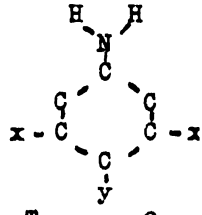
pound, it is, unfortunately, not unique to a bromo substituent as for example, in the case of 2, 6-dimethyl aniline (Table III).

It is seen from the above data and discussion that very little concrete evidence for distinguishing between 1, 2, 3, 5- and 1, 3, 5-substitution is obtained from the infra-red spectra. The authors feel, however, that the discerning worker can make this separation. The appearance of a band in the 860-850 cm.$^{-1}$ region in every case of 1, 2, 3, 5-substitution, the greater degree of consistency for the skeletal vibration of a 1, 3, 5-substituted compound, and the generally more complex spectra obtained for 1, 2, 3, 5-substitution give a fairly positive means of distinguishing between these two substitution types.

More difficulty is encountered in attempting to distinguish between:



Type 1



Type 2

We have found that type 1 will give a broad general absorption, even in very dilute solutions, in the KBr region from 650 to 400 cm.$^{-1}$. The tight intramolecular hydrogen bonding present in type 2 prevents this and the absorption is not apparent. However, when the substituents in the X positions of type 2 are methyl groups this broad absorption is present. This supports our contention that the absorption is due to the absence of intramolecular hydrogen bonding and not steric phenomena but leaves, at present, virtually no means of distinguishing between the two by infra-red analysis.

For 1, 2, 3-trisubstituted compounds Bellamy reports the CH deformation as a strong absorption in the 810 to 750 cm.$^{-1}$ range with a second band of medium intensity in the region 725 to 680 cm.$^{-1}$. Jones indicates a range of 780 to 760 cm.$^{-1}$ and 745 to 705 cm.$^{-1}$. Our data (Table III) indicate that Jones' regions are perhaps more accurate and that for these types of compounds at least, the range may be narrowed even further. We have observed a very strong absorption in the 770 to 755 cm.$^{-1}$ region and the second characteristic band, a strong one, at 733 to 712 cm.$^{-1}$. The consistency of our data and the good agreement with previous work indicate that this substitution pattern can be readily distinguished from the previous types.

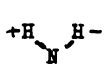
TABLE III

2, 6-Me_2 -NH_2	2, 6-Br_2 -NH_2	2, 6-Me_2 -OH	1, 2, 3--Cl_3 -OH	1, 2, 3-Cl_3
655w	656m			
677w	676s			
				695vs
	708s		712s	
733s	712s	729vs		
	732i			733vs
763vs	755vs	765vs	766vs	770vs
			777s	
788w	788vw		792s	787vs
		825s		
	837i	838m	820w	
	859i		837s	
890w				
		908s		
946w	944w	952w	953w	964m
				979m
988m		986m		
1004m		998w		
1028m	1032m	1020s		1009s
		1026msh		1038s
	1055vs		1063m	1049vs
1088s	1087m	1086s		1088s
1093s				
		1100msh	1100s	
1137w			1140m	
	1151w		1148m	1159vs
1161vw		1160s	1166vs	
			1177vs	1174s
		1192vs		1193vs
1231m	1232w	1222ssh	1220w	1216m
			1240vs	
1274vs	1280w	1264s	1269s	1266s
		1281wsh	1274ssh	1277m
	1301m		1306wsh	1294m
1318mw		1327s	1327vs	

Califano has reported the following absorption frequencies for the NH deformations:







~ 1620	1050-90	1260-90	~1150	~800	NH_2
1080-1163	1191	1300-20	-	~600	ND_2
A	B	C	D	E	

The assignment of these frequencies was determined by deuteration of the amino hydrogens and noting which bands shifted or disappeared.

TABLE IV

3, 5-Me_2 -ND_2	2, 6-Me_2 -ND_2	2, 6-Br_2- 4-Me-ND_2	2, 4,6-Cl_3 -ND_2
687vs			
		705w	710m
			719m
	735s	727vs	
752w	763vs	767s	771vs
		789vw	787s
826vs	819w		806w
845w	853vw	852vs	858vs
857s		873vs	
		890s	900vs
912w			
			928w
938w	946m	944m	
967vw			959m
995w	988m		
	996wsh	1004w	
1022wsh	1028m		
1035s		1039wsh	
		1051vs	1067s
	1088s		
1140s	1150m	1157s	1165m
1175vs		1190w	
			2102w
1218vs	1226w	1214m	
	1231m	1231w	
	1248w		
1274w		1274vs	1276vs
	1285vs		
	1307s	1307vs	1307vs
1312s			
1330vs			
1340vs			1386m

Table IV shows the spectra of some of the anilines whose deuterated spectra were investigated. These spectra are compared with the spectra of the anilines as listed in Tables I, II and III. As an example from the data given, compare the spectra of the deuterated and undeuterated 2, 6-dibromo-4-methyl aniline.

The symmetrical deformation mode (A) absorption at 1620 $cm.^{-1}$ has not been observed by us because the solvents employed interfere at this frequency. A study of this band will be made when we in-

vestigate the CaF_2 region of the spectra. However a strong new band occurs in the deuterated spectra at 1157 cm.$^{-1}$. The asymmetrical deformation mode (B) appears as a medium band in the undeuterated compound at 1088 cm.$^{-1}$. This band occurs only as a very weak shoulder in the deuterated spectra. We find a strong new band occurring at 767 cm.$^{-1}$ which is somewhat lower than Califano has reported.

The carbon-nitrogen stretching mode (C) appears as a strong band at 1294 cm.$^{-1}$ in the aniline. On deuteration a very strong new band appears at 1307 cm.$^{-1}$. This is in very good agreement with Califano's data.

We observed no absorption at 1150 cm.$^{-1}$ for the wagging deformation (D) of this compound. Califano has assigned this frequency by correlations with other compounds. Note that the methyl substituted anilines have an intense absorption band at 1175 to 1150 cm.$^{-1}$. Additionally, several of the halo substituted anilines exhibit weak absorption in this region. We are inclined to assign this frequency to the CH in plane bending vibration. For example mesitylene, whose spectra is well known, has an intense absorption at 1160 cm.$^{-1}$ (Table II) which is attributed to this CH in plane bending motion. We have not yet assigned a frequency to this amino wagging motion.

Our studies on the twisting motion (E) are not, as yet, complete.

Similar correlations between the other deuterated and undeuterated anilines can be drawn by comparing the data in Table IV to that in Tables I, II, and III.

Our investigation, therefore, shows that the assignments made by Califano are, for the most part, quite accurate. Further investigations of anilines and deuterated anilines are in progress in our laboratory at the present time.

As Table IV shows, the spectra of the deuterated anilines are more complex than that of the undeuterated anilines. We prepared the deuterated anilines by shaking a saturated CS_2 solution of the amine with a double mole ratio of D_2O for twelve hours. The spectrum was then taken of this solution. Then the solution was shaken with a fresh batch of D_2O and the spectrum taken again.

We found that the second spectrum was less complex than the first. This is because many of the bands that were weaker after the first shaking disappeared entirely after a second shaking. However, it is doubtful if the amine is more than 75 per cent deuterated even after the second shaking.

SUMMARY

A series of 1, 2, 3, 5-tetra-substituted and 1, 3, 5- and 1, 2, 3-trisubstituted benzenes have been investigated by infra-red analysis in the 1600 cm.$^{-1}$ to 400 cm.$^{-1}$ region. The following conclusions have been reached regarding these compounds:

1. A tentative assignment of absorption frequencies of CH vibrations, skeletal vibrations, NH deformations, and frequencies attributed to substituent groups are given.

2. Procedures for distinguishing between various substitution patterns are given.

3. Procedures for distinguishing between substituent groups with some degree of certainty are given.

4. The need for discrimination in employing and analyzing infrared spectra is emphasized.

ACKNOWLEDGMENTS

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MORPHOLOGY AND ANATOMY OF THE MATURED FLORET OF WILD OAT

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Wild oat **(Avena fatua L.)** is justly reputed to be the most troublesome weed of the wheat raising areas of the north central states and Canada. Since it closely resembles the economic plants of the region and since the "seeds" are dormant for about four months following abscission from the mature plant, the annual weed has been resistant to control. Some effort has been made to define certain phases of the life cycle and the structure of wild oat. A study performed by Zade (9) is not readily available, and the work performed by Korsmo (7) is rather fragmentary. Cannon (5) and Kandeler (6) have reported detailed studies of the development of the

embryo and abscission of the mature floret, respectively. The study reported in this paper is a portion of a study of the developmental morphology and anatomy of wild oat. Since wild oat is an annual a study of the life history of the plant begins logically with a consideration of the "seed", a caryopsis enveloped in a hull.

MATERIALS AND METHODS

A caryopsis enveloped in a hull, the "seed" used in this study was harvested on July 27, 1957, at the end of a normal growing season. The seed bettered the 95 percent viability level.

For the studies in morphology, the seeds were dissected into major components. In addition, the seeds were sectioned into one milimeter pieces cut either perpendicular or parallel to the axis of the floret.

Paraffin embedding methods for seed studies are tedious and time consuming; consequently, a microtome fitted with a freezing attachment was used to cut sections from the seeds in the manner used by Bradbury, et. al. (1, 2, 3, 4). Intact florets sectioned satisfactorily at about 15 percent moisture content and the caryopsis cut best at about 25 percent moisture content. Although several methods of handling sections were tried, the most satisfactory method consisted of mounting the "seeds" in gum arabic, cutting them at 30 to 35 microns with a precooled knife, and placing the cut sections individually in a drop of water on a slide. Temporary mounts were made by staining the sections with 0.1 percent congo red and mounting them in glycerol after the manner described by Bradbury, et. al. (1, 2, 3, 4). Permanent mounts were made by staining the sections with either a safranin-aniline blue or safranin-fast green series described by Sass (9) and mounting them in "picolyte."

The seed of wild oat is borne in a spreading panicle, the unit of the inflorescence being the spikelet. In wild oat, the florets are enclosed by two nearly equally developed glumes until maturity. Each spikelet contains three florets; but in many instances, the third floret is sterile, staminate, or rudimentary. The florets are borne on a rachilla which disjoints at maturity, a segment of the rachilla accompanying each floret when the mature florets are abscissed from the parent plant and from each other.

MORPHOLOGY

The caryopsis is enclosed at maturity by a hull consisting of the lemma and palea and the attendant rachilla segment. The tip of the hull becomes lacerate as the hull dehydrates at maturity. A divergent awn originates from the mid-point of the lemma. A characteristic "sucker mouth" callus constitutes the basal portion of the "seed."

The lemma varies in color and in degrees of pubescence. Lindsay (8) and other researchers have characterized the four varieties of wild oat by the combination of coloration and pubescence. The lem-

ma is faintly five nerved, not keeled and rather tough, though not indurate. The once-flexed awn is twisted below the point of flexure, minutely barbed above the point of flexure, and breaks rather easily at the point of flexure. The awn is an aid to dissemination and to natural planting of the seed, but it is reported to be injurious to livestock.

The bi-keeled, rather membranous palea is nearly enclosed by the overlapping margins of the lamma. The rachilla originates from the callus of the floret and has a callus at its tip composed of part of the tissues of the abscission zone. The rachilla extends to the midpoint of the palea and is closely appressed to it. Hairness of the rachilla varies considerably.

The callus forms an angle of 30 degrees with the floret axis. The callus consists of the modified tissues of the abscission zone appearing as a circular ridge about a hollow containing traces of vascular tissue.

The hull encloses the caryopsis, a true fruit characteristic of most of the grasses. The golden hued kernel of wild oat is densely hairy and terminates in a brush. The embryo may be seen through the percarp and seed coat on the dorsal side of the caryopsis which lies adjacent to the lemma. The kernel is deeply creased on the ventral side. At the tip of the caryopsis, two stylar scars and remnants of stylar tissue appear; and at the base of the grain, an attachment scar is evident.

ANATOMY

In section, the lemma resembles the true leaf of the parent plant. The cells of both the inner and outer epidermis of the lemma are small with thickened walls. The hairs which appear on the lemma in some varieties are unicellular epidermal appendages with a lumen approximately equalling the thickness of the wall of the hair. Immediately adjacent to the outer epidermis lie three to five layers of collenchymatous cells which appear elongate in longisection. Two layers of crushed parenchyma cells lie next to the inner epidermis of the lemma. Vascular bundles with phloem and xylem elements appear coincidental to the nerves of the lemma but adjacent to the inner epidermis. The cells of the point of origin of the awn are highly lignified, a condition which apparently characterizes the awn itself. The palea resembles the lemma in structure; however, the amount of collenchyma is reduced and vascular bundles occur only at the keels. The vascular bundles at the keels contain both phloem and xylem elements, and the epidermis of the keep bears hair like appendages.

The rachilla arises from the callus and contains a central vascular system surrounded by lignified fibers. Cell walls of the tissues of the rachilla evidence prominent pitting and the vascular bundle contains phloem elements and pitted, annualarly and spirally thickened vessels.

The callus contains remnants of a profusely anastimosed vascular system similar to that of the nodal plate of the grasses. Vascular bundles may be traced to the lemma, palea, caryopsis, and the rachilla. The vascular bundle which goes to the caryopsis branches into strands which proceed to the various floral organs no longer evident in the mature floret. The tissue of the ridge appears to be collenchyma, although a few highly lignified cells and a few crystals appear in the abscission zone. The epidermis of the callus is composed of very thick walled cells, many of which give rise to the epidermal hairs which are found on the callus.

The pericarp encases the entire seed. In wild oat the pericarp is rather poorly developed except in the crease. In cross and longisection, the epidermal cells are barely definable over much of the caryopsis but are more prominent in the crease. The remainder of the pericarp is made up of a layer or layers of crushed and fused cells of indeterminate form. The pericarp is modified at the brush end of the caryopsis, in the crease, and at the base of the kernel.

At the brush end of the caryopsis, the pericarp separates from the seed coat to enclose an air space. In the stylar scar a peak occurs in the seed coat and a suture in the pericarp. The tissue of the stylar scar appears to be composed of degenerate parenchyma. Epidermal cells of the pericarp give rise to the hairs of the brush which average about one milimeter in length, are hollow, and are bulbous at the base. In the crease, the pericarp thickens slightly and encloses two air spaces. A vascular bundle runs through the pericarp from the base of the caryopsis to near the tip of the kernel. Xylem vessels with annualar and spiral thickening appear throughout the length of the vascular tissue. The attachment region of the kernel consists of a mass of slightly crushed parenchyma with some annularly and spirally thickened vessels associated with some pitted vessels and tracheids. The cells at the abscission zone appear to be slightly lignified and seem to be continuous with the epidermis.

Although the seed coat forms a complete covering around the seed, it reaches its maximum development in the crease. Over much of the seed, the seed coat and the nucellar tissues appear as a fused layer of indeterminate structure. In the crease, the nucellar layer is much thickened and resistant to staining. A nucellar projection runs nearly the full length of the crease.

The endosperm is composed of two basic tissues, the aleurone layer and the starchy endosperm. The aleurone layer, a layer of cells adjacent to the nucellar tissues, encloses the endosperm tissue except at the scutellum and at the point of attachment. At the stylar scar, the aleurone layer becomes mildly proliferate. Occasionally, the cells of the aleurone layer may be reduced in length and paired centripetally. Over the embryo, the cells diminsh in size merging into the parenchyma of the attachment zone. In the crease, the

aleurone layer remains continuous, but the cells of the tissue appear to be somewhat more parenchymatous in nature.

With rather thick walls, the cells of the aleurone tissue resemble collenchyma in appearance. No intercellular spaces occur and the middle lamella appears rather prominent. Minute canals may occur between cells, but they could not be positively demonstrated. The cytoplasm of the aleurone cells is very dense containing proteinaceous aleurone grains and possible some lipid materials. The nuclei of the cells stain readily with fast green or aniline blue.

Peripheral parenchyma cells of the starchy endosperm appear in aggregates, but most of the endosperm cells adjacent to the aleurone layer are columnar or prismatic in appearance. Toward the center of the kernel, the endosperm cells become larger. The cells of the endosperm are thin walled and filled with starch grains of varying size. Nuclei may be demonstrated in some of the peripheral cells of the endorsperm but not in the other cells of that tissue.

The embryo consists of the scutellum, a storage and digestive organ; the embryonic axis, the living embryonic plant; and the epiblast, a leaf like appendage attached to the embryonic axis opposite to the scutellum. The embryo is oriented with the scutellum toward the central axis of the kernel and the plumule of the embryonic axis toward the brush end of the kernel.

The outermost tissue of the scutellum is an epithelium composed of secretory cells possessing a rather dense cytoplasm. The bulk of the tissue of the scutellu consists of parenchyma cells with a granular material and deeply staining nuclei. A provascular strand arising from the scutellar nodal plate composes the central axis of the scutellum. In one case, a spirally thickened xylem vessel appeared in the provascular strand. A ventral scale appears near the tip of the scutellum adjacent to the embryonic axis.

The radicle of the embryonic axis consists of a primary seminal root enclosed by a sheath like structure, the coleorhiza. The coleorhiza is formed of parenchyma tissue which is modified to form an epidermis on the exterior of the organ and is devoid of vascular tissue. The root cap and calyptrogen appear at the tip of the encased embryonic root. In addition, the periblem-dermatogen which gives rise to the epidermis and cortical tissues and the plerome which gives rise to the tissues of the stele appear at the apex of the root. In cross section, the epidermis, cortex and pericycle of the root can be distinguished, but the vascular tissues of the stele resemble parenchyma. The cells in the center of the vascular cylinder which will become a metaxylem vessel are slightly larger in diameter than adjacent cells of the stele. The provascular tissues of the radicle anastimose with other provascular tissues at the scutellar node. The initials of two lateral secondary seminal roots appear in the region of the scutellar node.

The epiblast appears as a leaf like appendage to the embryo in

the region of the scutellar node. The epiblast is composed of compact parenchyma and is devoid of provascular tissue.

The plumule is composed of a sheath, the coleoptile, which encloses the embryonic leaves which enclose the stem apex. A bud primordium appears in the axil of the coleoptile adjacent to the scutellum. The cells of the coleoptile are parenchymatous but are differentiated into an inner and an outer epidermis. Two strands of provascular tissue originate from the scutellar node and enter the coleptile. A pore may be discerned near the apex of the coleoptile.

Three true leaves representing three nodes of the seedling are enclosed by the coleoptile. The true leaves arise spirally from the stem axis in a distichous manner, the first true leaf arising opposite to the scutellum. In the first two true leaves, an inner and outer epidermis are formed which enclose a densely compacted parenchyma. Seven provascular strands occur in the first true leaf. The provascular strands of the second true leaf are not discernible. The third true leaf is little more than a small protuberance from the stem apex.

The stem apex is composed of a small, rounded mass of very compact cells with nuclei which stain deeply. The cells are thin walled and isodiametric, conditions typical of meristematic tissues.

The "seed" of wild oat does not differ significantly from the caryopsis of other grasses. No anatomical or morphological basis for seed dormancy can be postulated from the structure of the caryopsis.

SUMMARY

1. A study of the morphology and anatomy of the mature floret of wild oat is reported. Gross morphology was studied through dissection of "seed" and from sections one mm. thick. Sections for anatomical studies were cut with a microtome fitted with a freezing attachment, stained with congo red and mounted in glycerol or stained with safranin-aniline blue or safranin-fast green and mounted in "picolyte."

2. The caryopsis is enfolded by the hull composed of the lemma and palea of the floret accompanied by a segment of the rachilla. The lemma is awned from the back, and the base of the floret is composed of a callus presenting a "sucker mouth" appearance.

3. The hairy caryopsis is composed of an outer covering consisting of the pericarp, seed coat, and nucellar tissues; an endosperm composed of an aleurone layer and starchy endosperm; and an embryo composed of the scutellum, the epiblast and the embryonic axis. The plumule, the radicle, and the initials of two lateral secondary seminal roots compose the embryonic axis. The various parts of the embryo are interconnected by provascular tissue.

4. No relationship between "seed" dormancy and the anatomy and morphology of wild oat "seed" could be established.

ACKNOWLEDGEMENTS

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AN EVALUATION OF THE AVAILABLE NITROGEN PRODUCING CAPACITY OF SOILS IN A LONG-TIME FERTILITY TRIAL

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Most North Dakota soils do not supply available nitrogen in amounts adequate for maximum production of farm crops. This is attested to by the great increase in usage of nitrogen fertilizer in recent years. It is noted that some soils require much more nitrogen fertilizer than others. While some of this variation may be due to

very recent management practices, much of it no doubt is due to the integrated effects of past management practices. It is well known that some management systems cause a more rapid loss of soil organic matter than others. Since the ultimate source of most available soil nitrogen is soil organic matter, it is reasonable to expect that nitrogen releasing capacity of soils may be related to their past management.

This paper reports the results of a greenhouse pot culture trial in which relative nitrogen releasing capacities of soil samples from various plots of a long-time fertility experiment at Fargo were determined.

MATERIALS

Experimental materials consisted of surface soil samples taken in 1953 from a soil fertility experiment on Fargo Clay at the North Dakota Agricultural Experiment Station. This experiment had been laid out in 1913 to test two major systems of farming—livestock and grain—each with and without regular additions of manure or residues and various fertilizers and lime (4). Treatments selected for this study were check, manure, and manure + phosphorus from the livestock system, and check, crop residues, and crop residues + phosphorus from the grain farm system. The manure plots had received about nine tons of manure every fourth year. Crop residue plots had received all small grain residues and the second crop of clover. Phosphated plots were treated with 60# P_2O_5 every fourth year. Each of the six selected treatments was represented by 12 soil samples (3 sub-samples from each of 4 field plots).

METHODS

Each of the 72 soil samples from the six treatments were potted as follows: A 1200-gram portion of each soil sample which had been ground to pass a 4 mm. seive was mixed with 2400 grams of quartz sand and treated with 50 ml. of a solution containing phosphoric acid, potassium sulfate, and trace elements. The amounts added were equivalent to 180 mgm. P_2O_5, 120 mgm. K_2SO_4, and 60 mgm. "Es-Min-El" per pot. The sand, soil and fertilizer solution were mixed and placed in a number 10 can, the interior of which had been painted with black asphaltum. Piper sudan grass seeds were planted on February 18, 1957. Demineralized water was added to bring the moisture content up to field capacity (previously estimated by determining ⅓ atm. percentage using the method outlined in reference number 2).

The pots were placed on benches in a greenhouse in a random arrangement. At each watering, a systematic shift of pot location was made to eliminate the effects of non-uniformity of light and temperature. Demineralized water was regularly added in amounts to bring each plot up to the correct weight.

After the seedlings were well established, they were thinned to eight per pot. Artificial lighting was used from sunset to 10:00 p.m.

each night. The thermostat was set to maintain a minimum of 80° F. On sunny days temperature often exceeded this but was kept below 100° F. by ventilation.

On March 28, 1957, 38 days after planting, the plants were clipped one inch above the soil level. The shoots were dried in a forced air oven at 70° C. and weighed. They were ground in a Wiley Mill using a 40 mesh screen and analyzed for total nitrogen using a semi-micro Kjeldahl method (1).

The second crop was harvested on May 11, 1957, 44 days after the first cutting, and handled in exactly the same manner. Yields of dry matter, nitrogen content and yield of nitrogen were calculated, and the data were analyzed by standard statistical techniques (3). insure adequate amounts of these essential elements. The soils are naturally well supplied with calcium and magnesium. It is assumed, then, that the performance of the test crop is a measure of nitrogen supplying capacity of the soil.

Results of both cuttings are summarized in Table 1.

TABLE 1—Dry Matter Production, Nitrogen Content, and Yield of Nitrogen by Sudan Grass Shoots in the Greenhouse.

Treatment	First Cutting			Second Cutting		
	Yield of Sudan Grass	Nitrogen Content	Yield of Nitrogen	Yield of Sudan Grass	Nitrogen Content	Yield of Nitrogen
	gms./pot	%	Mgms. N /1000 gms. soil	gms./pot	%	Mgms. N /1000 gms. soil
Livestock Series						
Manure	7.42	1.29	79.5	4.38	0.56	20.5
Manure + P	7.31	1.25	76.6	4.34	0.56	20.1
Grain Farm Series						
Check	6.83	1.12	63.6	3.47	0.55	15.6
Crop Residues	7.38	1.20	73.4	4.11	0.53	17.8
Crop Res. + P	7.59	1.15	73.0	4.04	0.54	17.8
1sd. (.05)	.57	.09	3.5	NS	NS	2.2
1sd. (.05)	NS	.12	4.9	——	——	3.1
Check	6.61	1.14	63.0	3.52	0.56	16.2

RESULTS AND DISCUSSION

In this greenhouse trial, sand was mixed with the soil to eliminate differences in soil physical condition due to past management. Phosphorus, potassium, sulfur and the trace elements were added to

FIRST CUTTING

Yield of sudan grass shoots on soils from check plots was significantly less than that on soils from plots which had been treated with manure, crop residues, manure plus phosphorus or crop residues plus phosphorus.

Nitrogen content of sudan grass from manure and manure plus phosphorus plots was higher than that from check plots. Also it appears that manure resulted in higher nitrogen content than did crop residues.

Uptake of nitrogen by sudan grass shoots (yield of nitrogen) was greater from soils having a history of manure than from those treated in the past with residues. These, in turn, gave a greater yield of nitrogen than did soils from check plots. The differences between manure and manure plus phosphorus and between crop residue and crop residue plus phosphorus were not significant.

SECOND CUTTING

Yields of this cutting were much smaller than those of the first and nitrogen contents also were lower, resulting in smaller yields of nitrogen. This was expected because the soils at potting time contained some available nitrogen, while the second crop had to rely entirely on the nitrogen released while it was growing. For this reason, it is thought that the yield of nitrogen from the second cutting is the better measure of the inherent capacity of the soil to release nitrogen.

Treatment did not have significant effect on dry matter production or nitrogen content of sudan grass. The greatest yields of nitrogen were from the manure and manure plus phosphorus plots. They were significantly greater than those from the residue or residue plus phosphorus plots and these in turn were greater than the grain-farm check.

SUMMARY

Results of a greenhouse trial designed to meaure nitrogen releasing capacity of soils from a long-time soil fertility trial indicate the following:

1. Soil from plots to which crop residues have been returned for 40 years now has greater nitrogen capacity than soil from plots to which no additions have been made.
2. Soils from manured plots have greater nitrogen releasing capacity than soils from plots treated with crop residues.
3. The long-time use of phosphorus fertilized appears to have little influence on the present day capacity of these soils to release available nitrogen.

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AN INVESTIGATION OF WHEAT GLUTEN FRACTIONS BY CHROMATOGRAPHIC METHODS[1]

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Gluten, a protein found in wheat and, to a lesser extent in rye, has been of interest to cereal chemists for a long time. Many investigations have been made on the physical and chemical properties of this substance in relation to breadmaking without complete success. C. H. H. Bailey (2) summed up the work done in this field up to 1944 in his monograph "The Constituents of Wheat and Wheat Products."

Aitken and Geddes (1) in 1938 illustrated the relationship between protein content and baking quality of flour. While for most flours of average quality, the baking quality was definitely correlated with the protein content of the flour, the results from some weak and strong flours indicated that there was a definite effect due to the gluten characteristics or quality.

Harris and Frokjer (6) in 1952 divided the gluten from a hard red spring wheat into three fractions by dispersion and precipitation methods. This involved washing the gluten from the flour by the method of Dill and Alsberg (4) dispersing in 0.013N lactic acid, and then adjusting the pH level with saturated hydroxide solution. The levels chosen were 5.0, 5.5 and 6.8. At each of the pH levels a fraction of the protein was precipitated, removed by centrifugation, and designated as Fractions I, II, and III respectively.

These fractions, and the crude and purified crude gluten, were incorporated with a standard flour, to bring the protein level up to 13.0% (13.5% moisture basis) in each case. The fortified flours were baked, along with an unfortified control, and the results were compared.

It was found that the addition of the crude or the purified gluten improved the mixing and baking characteristics of the flour over those of the control. The addition of Fraction II also improved flour quality; however, the addition of Fraction I to the flour resulted in definitely poorer mixing and baking properties, while Fraction III caused poorer mixing curves, but did not alter the baking strength of the flour.

The terms strong, medium, or weak flours refers to the strength of the gluten as shown by the mixing curves. Thus, in a strong flour, the gluten is strong and elastic showing a relatively long mixing time and tolerance, associated with a very wide mixogram. In a weak flour, the gluten is weak and nonelastic, resulting in a narrow mixogram with a short mixing time and tolerance.

Harris and Sullivan, (7) in subsequent experiments along these

lines, changed the pH levels slightly, to increase the yield of protein precipitated. The levels employed in this study were 5.2, 5.8, and 6.8.

The present investigation was undertaken to determine the differences in amino acid composition of crude gluten, purified crude gluten, and Fractions I, II, and III. In addition five protein preparations were made from a strong, a medium, and a weak flour, and the amino acid compositions of each were determined, to detect possible differences between these three types of flour.

EXPERIMENTAL

Chromatographic methods of separation and analysis were employed. We used two-dimensional paper chromatography to separate all of the amino acids into distinct spots. The solvents described by Davies, Harris, and Parsons (3) were selected. These are: the organic layer from a mixture of n-butanol, glacial acetic acid, and water (in the proportions 25:6:25) for the first direction; and a mixture of 9 parts of 95% ethanol and 1 part 2N NH_4OH for the second direction development. These solvents are relatively inexpensive, and do not require the special atmosphere and redistillation connected with the use of phenol. Also, and more important, the amino acid separation was excellent with this solvent air. Spot color was developed as usual by treatment with a solution of ninhydrin in actone, giving purple spots at the location of various amino acids.

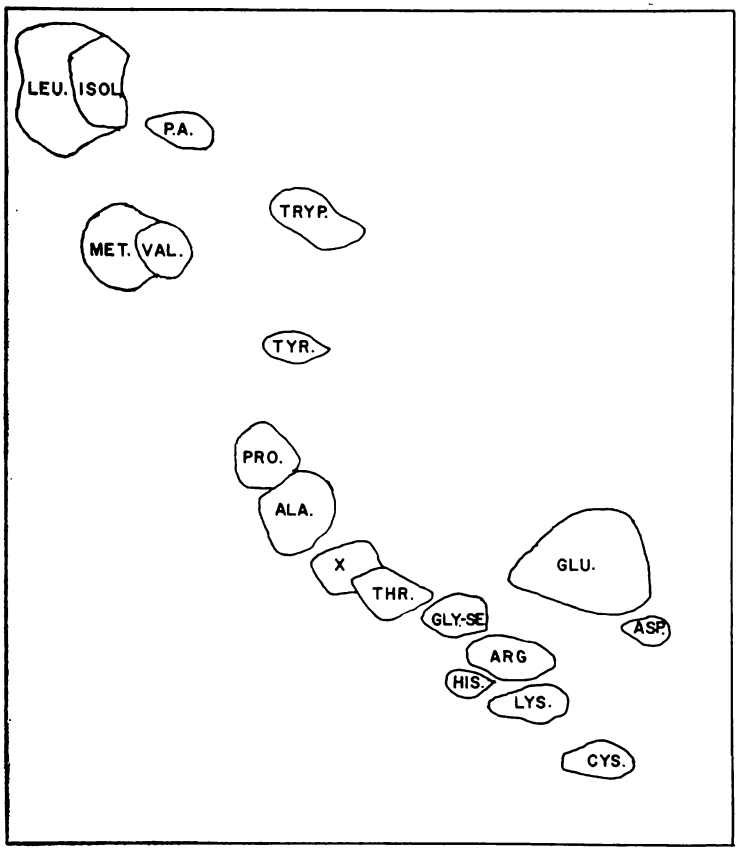
Four chromatographic methods were investigated. The first two procedures differed in the manner of handling the paper after treatment with ninhydrin, while in the third method another technique for developing of the chromatograms was employed. The fourth method used a different means of spot measurement for quantitative estimation.

For the first two methods, the papers were initially developed by allowing the butanol-acetic acid-water solvent to flow down the length of the paper for 30 hours. This meant that the solvent front moved off the paper. The paper was rotated 90° for the second run with the ethanol-ammonia solvent which again ran off the paper during the 21 hour irrigation period.

After drying for 24 hours, the papers were dipped in a 0.5% (w/v) ninhydrin in acetone solution. For method two, after a short drying period, the papers were heated in a forced-draft oven for 10 minutes at 70°. This is one of the usual methods of development. However Wellington (8,9) has investigated the effects of humidity and temperature upon the color-development of the treated chromatograms, and recommends control of these factors. Method one involved placing the chromatograms, after dipping, in a cabinet with the humidity controlled to 45% ± 4%, and the temperature at 35° ± 1°. They were then allowed to develop for 30 hours.

The third method used a different sequence of solvent runs as compared to the first two methods. The first run was the same, but the development in the second direction was different. The solvent

was allowed to go only to the bottom of the paper, a matter of 12 hours, and then the chromatogram was removed from the developing tank and dried. Then it was returned to the tank, and run in the same direction, with the same solvent, for a second 12-hour period. This doubling of the second run resulted in better separation of many of the amino acids, notably the three basic acids lysine, arginine, and histidine. This type of multi-development has been used in one-dimensional carbohydrate chromatography, but this is the first time, to our knowledge, that it has been applied to amino acid chromatography. (Figure 1. Chart showing the two dimensional chromatographic separation).



CHROMATOGRAM - METHOD THREE

The quantitative estimation of the amino acids in the first three methods followed the usual method; cutting out the colored spots from the paper, eluting the color with a solvent, and determining the optical density of the eluate. This optical density, ideally, is directly proportional to the amount of amino acid which was present on the spot.

The fourth procedure employed a method of estimation suggested by Fischer; (5) that of measuring the area of the spot. The area of the spot should be proportional to the amount of amino acid in the spot. The chromatograms which were prepared for method three were used. After the color was developed, contact prints of the chromatograms were made on Contoura paper. The areas of the spots were outlined, and measured with a planimeter.

RESULTS AND DISCUSSIONS

Standard curves were prepared, using each of these methods. This involved running six concentrations of an amino acid mixture of known composition, containing the sixteen amino acids generally found in wheat gluten. Four replicates were run at each of the concentrations.

The data from each of the four methods was subjected to statistical analysis. The variance components which resulted indicate the percentage of variability in the optical density readings, within a given method, contributed by the three main sources of variation. (Table I).

TABLE I—Variance Components[1] for the Four Methods

Variance Component	Method 1	Method 2	Method 3	Method 4
Replications	0.0	0.3	0.2	0.5
Amino Acids	82.9	83.8	91.4	98.8
Concentrations	17.1	15.9	8.4	0.7
Standard Error of a Single Determination	±0.0239	±0.0263	±0.0258	±0.1901

1. Percent of variance contributed by main sources of variance.

The low variability contributed by the replications indicates good reproducibility of the readings.

The high percentage of variability due to amino acids is to be expected, since the amino acids are present in varying amounts, from 2 to 200 micrograms. Also, the molar color yield of an amino acid with ninhydrin is characteristic of that acid.

The percentage of concentration variance may be roughly correlated with the slope of the standard curves. A rather steep slope is desirable, to differentiate easily between, for example, 5.5 and 5.6 micrograms of acid. In this respect method one is the best, while the standard curves for method four would have almost zero slope, and so would be of little value.

The standard error of a single determination is approximately the same for each of the methods. A statistical analysis showed that the differences in the standard error for the first three methods are not significant at the 5% level. The units in the fourth method were greater by a factor of ten as compared to the others, so that the error in this method is also in the same general range.

For analytical work on the wheat glutens method three was chosen. This method gave better separation than the other two methods, making it easier to select the spots. Also, the standard curves had a somewhat higher coefficient of correlation. All standard curves of method three, with the exception of histidine and methionine, had coefficients of correlation between concentration and optical density greater than 0.9.

For the flours, three were selected which more or less covered the spectrum of baking qualities. The first was a medium strength baking standard. The gluten from this flour had been isolated and fractionated by Sullivan in 1955, so the fractions were available for use. A weak flour, of poor baking characteristics was chosen, and also one with strong qualities. The protein content of these flours was appromiately the same in all three cases. The glutens from the latter two flours were isolated and fractionated in accordance with Harris and Sullivan's procedures. (7).

The proteins were hydrolyzed by refluxing in 6N hydrochloric acid for 28 hurs. The hydrolysis of gluten in HCl was followed by using both the biuret reaction for peptide bonds, and the ninhydrin reaction for free amino acids. The results in both cases were the same: 28 hours were sufficient for essentially complete hydolysis.

A total of fifteen hydrolyzates were prepared from the crude gluten, the purified crude gluten, and Fractions I, II, and III of each of the three flours. The humin was removed from the hydrolyzates by adusting the pH of the solution to 4 and removing the separated humin by centrifugation.

Four replicate papers were run for each of these hydrolyzates. Method three was used, and the amounts of amino acids present were calculated from the optical density readings and the data from the standard curves.

The resulting data are expressed as the percentage of the total amount of amino acid nitrogen contributed by each amino acid. Histidine, while definitely present in the hydrolyzate, was not included in the total, since the poor characteristics of the standard curves for this amino acid indicated doubtful accuracy.

The results which are presented here did not have the level of precision that we had hoped for, because of inherent inaccuracies of paper chromatographic methods and accumulative errors of an investigation as broad in scope as the present one. Table II indicates the salient features of the amino acid percentage levels.

TABLE II—Amino Acid Distribution in Wheat Gluten Fractions

Amino Acid	Strong Flour			Medium Flour			Weak Flour		
	Fraction			Fraction			Fraction		
	I	II	III	I	II	III	I	II	III
Aspartic Acid	H	M	L	H	M	L	H	M	L
Lysine	H	M	L	H	M	L	H	M	L
Arginine	H	M	L	H	M	L	H	M	L
Alanine	H	M	L	H	M	L	H	M	L
Glycine + Serine	H	M	M	H	M	M	M	H	H
Proline	L	H	L	L	L	M	L	L	H
Glutamic Acid	L	M	H	L	M	M	L	M	L
Leucine± Isoleucine	H	M	L	H	M	M	H	M	H

In this table letters represent the relationship of the amino acid level to the crude and purified gluten level: H means a higher level of amino acid in the fraction, M the same level, and L a lower level of amino acid in the fraction than in the crude and purified glutens. A blank space represents a medium level of the amino acid.

One of the most noticeable features is the preponderance of high levels of amino acids in the first fraction, the weakest fraction of the three as far as gluten strength is concerned. However, this is reversed in the cases of proline and glutamic acid, the two major amino acids of the gluten protein. Their lowest level is in the first, weak, fraction.

The correspondence between glutamic acid levels and gluten characteristics is most marked in the first and third fractions. While the glutamic acid level is low in the first fractions of all three flours, it is approximately the same as the crude gluten level in the third fraction of the flour of medium strength, higher than the crude gluten level in Fraction III of the strong flour, and lower in Fraction III of the weak flour. The glutamic acid levels in Fraction II of all three flours is equal to that of the crude gluten preparation. It must be kept in mind that Harris and Frokjer (6) showed that the addition of Fraction I to a flour decreased the gluten strength of the flour, while Fraction II improved the baking characteristics greatly, and Fraction III was without effect. However, the flour these workers used was very similar to the medium strength flour employed in this investigation.

The second amino acid of importance is proline. Again, the level of proline in all three first fractions is low, but the characteristics of the flour seem to have a relationship to the distribution of proline between Fractions II and III.

In the medium strength flour, the proline level in Fraction II is low, while in Fraction III it is medium. This is a more even distribution than in either the strong or the weak flour. Thus, in the

strong flour, the greater portion of the proline has remained in Fraction II, and Fraction III has only a low level of proline, whereas in the weak flour this relationship is reversed.

Another feature worth mentioning in connection with these two levels is that of the level of leucine and isoleucine present. These two amino acids make up the third large portion of the gluten protein, along with glutamic acid and proline. It should be noticed that in Fraction III the leucine+isoleucine maintains its proportionality to glutamic acid, but does not follow the proline fluctuations.

Glycine and serine are present in a relatively high concentration in the first fraction, the weak fraction, of the strong and medium flours, but they also have a high value in Fractions II and III of the weak flour.

The amino acid levels of lysine are interesting in that they decrease consistently with the fractions, i.e., high in Fraction I, medium in Fraction II, and low in Fraction III. Since lysine is a basic acid, it affects the isoelectric point of a protein by virtue of its free group. It is thought that the descending relationship of lysine is related to the fractionation of the gluten.

SUMMARY

1. Glutamic acid levels are low in the weak first fraction of all flours, but in the third fraction they parallel the strength of the flours, being low in the weak flour, medium in the medium strength flour, and high in the strong flour.

2. Flour strengths show a relationship to the distribution of proline between Fractions II and III. In the weak flour the proline level is high in Fraction III and low in Fraction II; in the strong flour Fraction II contains the higher level of proline while Fraction III has a low level; and in the medium strength flour proline is more evenly distributed between the two fractions.

3. Leucine+isoleucine concentration is inversely proportional to that of glutamic acid throughout the fractions.

4. The lysine levels in the three fractions may contribute to the isoelectric point of the proteins, and be controlled by the pH at which precipitation is effected.

CONCLUSIONS

From the facts, the data indicate a trend in the variation of the amino acid levels among the different fractions and the different flours. Since the main differences in glutamic acid levels between the three flours occur in the third fraction, and the differences in proline distribution are in Fractions II and III, it appears that the variations in flour strengths and baking characteristics may be due in part to the composition and physical characteristics of Fraction III.

It would be desirable to examine this third fraction of various flour glutens more closely, using more accurate developments of the

methods described in this paper, or other methods. The relationship between the characteristics of Fraction III and those of the parent flour should be clarified.

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DIRECTION IN ADULT LOCOMOTION WITHOUT BENEFIT OF VISION

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In the aftermath of unusual life experiences people sometimes reminisce about how they "got lost in the woods," or couldn't find their way through a deep fog, or how their "sense of direction" failed them in a blinding storm. Assuredly, the implications and applications become especially realistic under blizzard conditions. Red River Valley folk will recall that no ominous forewarding augured the tragic Ides of March in the 1941 blizzard. Although other sensory cues may help, such as auditory, cutaneous (cold, pressure, pain), and, of course, static and kinesthetic sensitivity, it can be safely assumed, if not self-evident, that man depends in large measure upon visual sensitivity in situations involving direction and distance in locomotion toward given destinations.

The above approach was used to provide orientation and motivation in an experiment dealing with locomotion without benefit of vision. Obviously, to simulate conditions involving the adversities and perils of prairie weather was impossible, and caution was advised against over-generalization of the findings. However, each **S** was blindfolded (simulating zero visibility) and directed toward four specific destinations of varying directions and distances, and individual patterns of actual performance in an outdoor area were recorded on scaled charts designed for the experiment. It was assumed that a football field approximates the area of a typical farm-

stead, thereby facilitating the quantification of data by plus-minus measurements from the ten-yard lines, side-lines, and goal-lines.

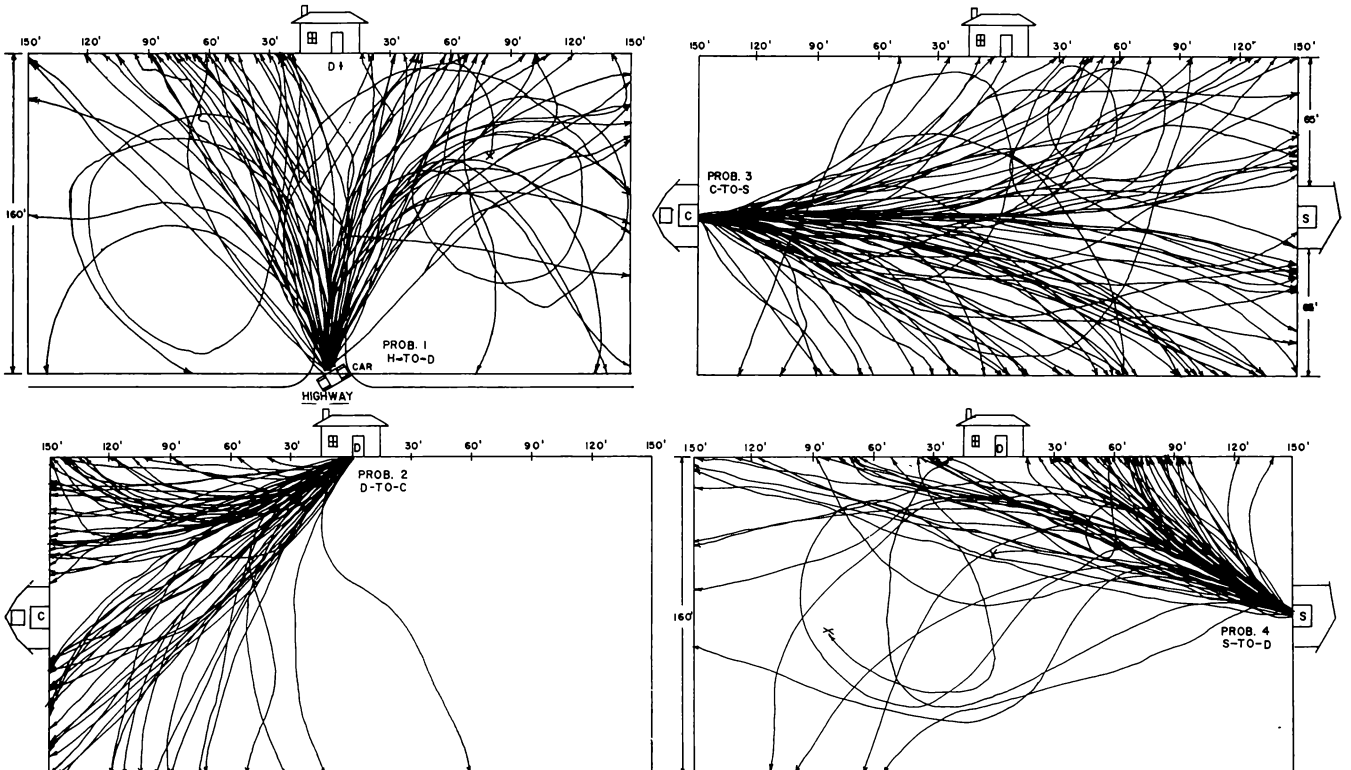
At the outset, no hypotheses were attempted. Naturally, however, questions arose among the Ss, such as: Would they reach their destinations? Would they reveal patterns such as rotary, zig-zag, etc.? Does direction make a difference? Is distance a factor? Could one rely upon kinesthesis and static sensitivity to guide a person to his destination? Are patterns purely those of chance? In other words, is a null hypothesis indicated?

In 1955 a study of the magnitude of error (footage to left or right of destination) was attempted. (2) But the computations were based upon measurements from zero-point goals, which in real-life situations would be highly unrealistic; moreover, about one-fourth of the *S*s failed to reach measurable points on opposite boundary lines. However, measurable footages for 73 *S*s were obtained, showing the total to the left of zero-point to be 4560 feet; total to right, 8209 feet, or a dextral ratio of 62:112 per S in magnitude of error. Incidentally, it had been the writer's guess, later proved erroneous, that right-handed people would favor left-rotary patterns of locomotion because of longer strides with the right foot. (Of such is the nature of "basic research," if by "basic research" is meant doing what one does not know for sure what one is doing!)

The present report is based upon the charted performances of 152 Ss, showing individual patterns and measurement in the following specific situations: 1. from South to North across the middle of the gridion (H to D on the chart, simulating highway to dwelling); 2. diagonally from North to Southwest (D to C, dwelling to cattle barn); 3. lengthwise of the field (C to S, cattle to sheep); and 4. diagonally from East to Northwest (S to D, or back to the dwelling). Since zero-point goals would be quite unrealistic in that it would be difficult enough to hit even the broad side of a barn, the width of each destination was arbitrarily set at 30 feet (15 feet on either side of zero-point), simulating the side of a building.

From the charted reports of the 152 Ss, composite drawings were made, including film slides as well as tracings of individual patterns (done by R. T. Myers, engineer), for each of the four problems as reproduced in Fig. 1. As already stated, the main purpose was to make an analysis of the data to determine the chances of arrival at a 30-foot-wide goal without aid of vision (simulating zero visibility); or, failing to arrive, whether the errors were predominantly to the left or right of destination. Appropriate statistical formulae (1,3) were applied to determine the reliability of percentages and the significance of differences between percentages. Incidental notations were made as to unusual deviate patterns and mental-emotional confusions and tensions reportedly experienced during the the trials.

Despite the usual cautions against over-generalization in psychological experimentation, some conclusions and/or hypotheses


150' 120' 90' 60' 30' D 30' 60' 90' 120' 150'
160'
PROB. 1
H-TO-D
CAR
HIGHWAY
PROB. 3
C-TO-S
C
S
65'
85'
PROB. 2
D-TO-C
PROB. 4
S-TO-D

seem to emerge from an examination of the tabulated data and summaries as presented in Tables 1 to 4.

TABLE 1

Summary of Frequencies and Percentages of Error in Four Problems of Locomotion-without-Aid-of-Vision

152 Ss 608 trials	Errors to left 15 ft. or more freq.	 pctg.	Less than 15 ft. from destination freq.	 pctg.	Errors to right 15 ft. or more freq.	 pctg.
Prob. 1: S to N	52	34.2	37	24.3	63	41.5
Prob. 2: N to SW	40	26.3	31	20.4	81	53.3
Prob. 3: W to E	53	34.9	26	17.1	73	48.0
Prob. 4: E to NW	38	25.0	34	22.4	80	52.6
All 4 trials	183	30.1	128	21.1	297	48.8

Table 1 presents the frequency and percentage of errors to left or right of destination as well as successful arrivals in each of the four problems. As revealed in the totals for all four trials, the evidence is conclusive that the chances of reaching destinations are meager (about one chance in five) as compared with errors to left and right, the total for all four trials showing that only 21.1 per cent arrived at destinations as against 30.1 per cent to the left and 48.8 per cent to the right of destinations. Assuredly, a null hypothesis of a true difference of zero would be untenable.

The data for problems 2 and 4 in Table 1 offer specific evidence as to the factor of direction because the distances in these two trials were held equal but the directions were not only diagonal but in two directions, from North to Southwest and from East to Northwest. No reliable statistical difference was found, since the percentages to the left (26.3 and 25.0), center (20.4 and 22.4), and right (53.3 and 52.6) remained practically unchanged in each direction, a very slight difference of only 2 per cent (center) arising perhaps from the "practice effect" of the previous trial.

TABLE 2

Missed Destinations and Left-Right Error Patterns

Missed Destinations (15 ft.+)

152 Ss	freq.	pctg.
All 4 goals	68	44.7
Missed 3 goals	47	30.9
Missed 2 goals	28	18.4
Missed 1 goal	8	5.3
Missed none	1	0.7
	152	100.0

Dominance of Left-right Errors (from zero)

Sinistral		Dextral	
LLLL	4	RROL	8
LLLO	3	RROO	1
LLLR	24	RRRL	41
LLOO	2	RRRO	5
LLOR	5	RRRR	26
	38 (25%)		81 (53.3%)

Ambitendent (LLRR)
33 (21.7%) Total: 152 Ss

The **distance** factor is involved in the recordings for problems 1 and 3 in Table 1. Whether the cardinal directions are more readily sensed than are the diagonal directions remains unanswered, though one may logically assume that South-to-North or West-to-East directions would be no less difficult, perhaps more accurately traversed, than the diagonals involved in problems 2 and 4. Logically, therefore, the differences shown for problems 1 and 3 (34.2 to 34.9 per cent to the left, 24.3 to 17.1 to center, and 41.5 to 48.0 to the right) would be ascribable to the **distance** factor; that is, 300 feet as against 160 feet, where 11 **Ss** failed to reach the more distant goal, ten of whom, incidentally, went to the right of destination.

Table 2 shows the distribution of missed goals, with 68 **Ss** (or 44.7 per cent) missing all four goals by 15 feet or more, and only one **S** arriving at all four goals. As further indicated in Table 2, the returns provide evidence as to dominance of left or right patterns, measured in this lone computation from zero-point destinations. Al-

TABLE 3

Standard Error and Confidence Limits of Percentages

152 Ss	Pctg.	Sigma	5% Level (σp) (1.97)	1% Level (σp) (2.61)	3 sigmas & limits (virtual certainty)	
Prob. 1[a]						
Left	34.2	3.8	7.5	9.9	11.4	22.8-45.6
Goal	24.3	3.5	6.9	9.1	10.5	13.8-34.8
Right	41.5	4.0	7.9	10.4	12.0	29.5-57.5
Prob. 2[a]						
Left	26.3	3.6	7.1	9.4	10.9	15.5-37.1
Goal	20.4	3.3	6.5	8.6	9.9	11.5-30.3
Right	53.3	4.0	7.9	10.4	12.0	41.3-65.3
Prob. 3[a]						
Left	43.9	3.8	7.5	9.9	11.4	23.5-46.3
Goal	17.1	3.0	5.9	7.8	9.2	7.9-26.3
Right	48.0	4.1	8.1	10.7	12.2	35.8-60.2
Prob. 4[a]						
Left	25.0	3.5	6.9	9.1	10.5	14.5-35.5
Goal	22.4	3.4	6.7	8.9	10.1	12.3-32.5
Right	52.6	4.0	7.9	10.4	12.1	40.5-64.7
Total[a]						
Left	30.1	3.7	6.3	9.7	11.1	19.0-41.2
Goal	21.1	3.3	6.5	8.6	9.9	11.2-31.0
Right	48.8	4.0	7.8	10.4	12.0	36.8-60.8
Diagonal[a]	22.4	3.4	6.7	9.3	10.2	12.2-32.6
Diagonal[a]	20.4	3.2	6.3	8.4	9.6	10.8-30.0
Sinistral[b]	25.0	3.5	6.9	9.1	10.5	14.5-35.5
Ambi[b]	21.7	3.4	6.5	8.6	10.0	11.7-31.7
Dextral[b]	53.3	3.1	6.1	8.1	9.2	50.2-56.4

a. From Table 1
b. From Table 2

though 33 **Ss** (or 21.7 per cent) were recorded as ambitendent, that is, twice to the left and twice to the right of the four goals, the important finding would seem to be that sinistral dominance appeared in only 38 (exactly one-fourth) of the cases as against dextral dominance in 81 cases (or more than both the ambi-dextral groups put together). Again, as in Table 1, a null hypothesis of a true difference of zero is untenable.

Table 3 presents the results of computations in line with accepted statistical formulae (1,3) covering the standard error (sigma) of the percentages and the confidence limits at 5% and 1% levels, together with 3 sigmas computed to indicate the limits of virtual certainty. The formula employed for standard error was:

$$\sigma p = \sqrt{pq/N};$$

for the 5% level: (σp) (1.97); for the 1% level: (σp) (2.61). Using the item **Total Right** as a sample, the reading would be: percentage to right 48.8, sigma 4.0, limits 44.8 to 52.8; 5% level, 7.8, limits 40.9 to 56.1; 1% level, 10.4, limits 38.4 to 59.2; and 3 sigmas, virtual certainty, 12.0, limits 36.8 to 60.8.

Table 4 reveals the significance of the differences between percentages, which involved (3) computation of D/σD. The formula used for σD is: $\sqrt{\sigma^2 p_1 + \sigma^2 p_2}$. Using the item **Total Right** as a sample, the reading would be: percentage right 48.8 minus percentage left 30.1 = 18.7; sigma, 5.4; and the percentage difference

TABLE 4

Significance of Percentage Differences

	Pctg. right	Pctg. left	Difference in pctgs.	σ/D	D/σD	Chances in 100
Prob. 1	41.5	34.2	7.2	5.5	1.3	90+
Prob. 2	53.3	26.3	27.9	5.3	1.3	99.9
Prob. 3	48.0	34.9	13.1	3.9	3.4	99.9
Prob. 4	52.6	25.0	27.6	5.3	5.2	99.9
Total	48.8	30.1	18.7	5.4	3.5	99.9
Dextral[b]	53.3	25.0	28.3	4.9	5.8	99.9
Ambi[b]	78.3 R+L	21.7	56.6	4.6	12.3	99.9
Diagonal[a]	22.4	20.4	2.0	4.6	.4	65
Distance[a]	24.3	17.1	7.2	3.2	2.3	98.9

a. From Table 1
b. From Table 2

of 18.7 divided by the sigma of the difference 5.4 = 3.5, which, according to the Table of Probabilities (3), shows the chances to be 99.9+ in a 100 that a true difference exists; in this case, dextral dominance.

Since **3** is regarded as the margin of virtual certainty (3), it will be noted from Table 4 that in problem 1 the chances are 90+ out of a 100; that, quite importantly, in diagoanl directions (problems 2 and 4) little beyond a chance difference is indicated; and that for

the distance factor, the chances are 98.9 in a 100. All other items are well above the margin of 3, indicating virtual certainty.

Despite the artificial and arbitrary limitations apparent in the design of the four problems, comments by individual Ss indicated realistic applications to life situations as "visualized" from their performances in this experiment.

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WHEAT STEM RUST RESEARCH AT NDAC

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ABSTRACT

A running comentary of a moving picture in color illustrating wheat breeding experiment.

1. Red durum—stem rust infected, 1950—new race-15B.
2. Resistant vs susceptible contrast—(resistance gene necessary).
3. L. R. Waldron, wheat breeder at NDAC, 1916-1953 (37 years).
4. Wheat rust nursery—many different types, and characters.
5. Recording observations in the field.
6. Use of greenhouse for speeding up wheat increase.
7. Wheat hybridization to produce new recombinations.
8. Harvesting and threshing new crosses.
9. F_1 generation of cross with new rust resistant wheat from Africa.
10. Planting 400 F_1 seeds for stem rust reaction test.
11. Preparation of artificial stem rust culture.
12. Inoculation of seedlings for artificial epidemic.
13. The contrast between resistant and susceptible reactions.
14. Harvesting the greenhouse crop.
15. Planting greenhouse material in the field nursery.
16. International cooperative testing.
17. Nursery harvest, procedure and equipment.
18. Wheat variety plots.
19. Increasing new wheats in the South.
20. A small increase plot of new rust resistant wheat.

THE HEART IN PORTAL CIRRHOSIS

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ABSTRACT

In order to assess the incidence and type of heart disease in patients with portal cirrhosis, 108 patients who died with portal cirrhosis and were autopsied were studied. These patients died with clinical and laboratory evidence of moderate to severe portal cirrhosis and not necessarily complications of portal cirrhosis. Age range of these patients was 26 to 83 years, with a mean age of 57.4 years and a standard deviation of 13.7 years. 26 were females and 82 were males.

52 (48%) of these patients had associated serious heart disease. Of these, 26 had arteriosclerotic heart disease, 9 had hypertensive heart disease, 5 had valvular heart disease, 12 had cardiac hypertrophy with congestive failure not classifiable in the usual classification of heart disease.

These patients with cardiac hyertrophy associated with portal cirrhosis had signs and symptoms of heart failure characterized by cardiac enlargement, tachycardia, apical systolic murmurs, and electrographic evidences of premature auricular and ventricular contractions and varying degrees of intraventricular conduction defects. Pathological study of the heart and liver of these patients with cardiac hypertrophy showed that in 11 of the 12 patients the accompanying portal cirrhosis was early or only moderately advanced.

Histologically these hearts showed nuclear and cystoplasmic vacuolization and perinuclear brown pigmentation with lipofuscin. Delicate and diffuse fibrosis often involving only segmental portions of the fiber was observed. In some areas collagen was deposited on a framework of denuded myofibrils. The bridging between the transversely ruptured fibers indicated that muscle fregmentation resulted before the agonal state. In 2 of the 12 cases the predominantly lymphocytic and histocytic exudate of diffuse interstitial myocarditis was found which was similar to that reported in cases of beri-beri heart disease.

This study suggests that patients with portal cirrhosis have not only the common types of heart disease but are also prone to develop an idiopathic type of heart disease associated with portal cirrhosis **per se.**

INFLUENCE OF STRAW, METHOD OF INCORPORATION, AND NITROGEN FERTILIZATION ON AVAILABLE NITROGEN STATUS OF SOIL AND YIELD AND NITROGEN CONTENT OF WHEAT

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ABSTRACT

Field trials were conducted at Edgeley in 1955 and 1956 and at Casselton in 1956 and 1957 to gain additional information on the influence of straw, method of incorporation, and nitrogen fertilization on the distribution of available nitrogen in the soil at various times during the growing season and on yield and nitrogen content of hard red spring wheat.

At Edgeley different methods of incorporation of straw were accomplished by using a oneway disk and a moldboard plow. At Casselton, tillage was kept uniform, but straw incorporation variables were obtained by adding straw before and after rototilling. Rototilling was followed by plowing.

Nitrogen fertilization gave no yield increase in two trials, a small increase in one and a very large increase in one. Nitrogen content of wheat grain was increased by nitrogen fertilization in the two trials which did not give yield responses. Fall fertilization at Casselton resulted in increased available soil nitrogen at seeding time. Nitrogen fertilization did not produce significant increases in available soil nitrogen in any trial at sampling dates of 40 days or more after seeding. In most cases, nitrogen fertilization increased the amount of nitrogen removed by above-ground growth.

Straw had no influence on yield except in one trial where it reduced both stand and yield. Nitrogen content of grain and nitrogen removed by above-ground growth were not affected significantly by added straw. In no case did added straw reduce the available nitrogen content of the soil.

Wheat on plowed plots yielded more than on onewayed plots at Edgeley in both years. In 1956 much of the difference could be attributed to poor stands on onewayed plots. Tillage method did not significantly affect nitrogen content of grain, available nitrogen content of soil or nitrogen removal by above-ground growth.

In these four trials, strawy residues did not exert as much influence on availability of nitrogen as would be predicted from results of laboratory and field investigations elsewhere.

BIRD LIFE OF GRAND FORKS COUNTY, NORTH DAKOTA

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In his monograph on bird life in Britain[1], James Fisher points out that while some 424 bird species appear on the British list, only about 200 of these participate regularly in the season-by season natural life of the islands. So it is in any geographical region, including Grand Forks County. A complete "bird list" for this county might include about 225 species. Of these, many will seldom be noticed except by professional biologists or the most incorrigible amateurs, and do not play prominent roles in our bird life. Some may be with us in sparse numbers, perhaps only for a day or two a year—some may be records of wind-blown waifs flung into this area once in history—some may belong to species now gone, or almost gone, from the earth. There remain perhaps 125 species whose year-by-year activities form the pattern of avain life in this region. About 75 of the most prominent of these species are here listed, with some comment added in most cases.

This, therefore, will not be a complete species list for this county[2]. The species listed here are birds any observer may *expect* to see, if he goes to the right sort of place at the right time of year, and if he will learn to identify them. It is my thought that many who are interested in bird study may find such an annotated list of our basic species more useful, and perhaps less discouraging, than a complete list of recorded occurrences.

Grand Forks County lies mostly within the Red River Valley region of North Dakota[3]. This region is flat prairie once the bed of a great glacial lake, from which the fertile lacustrine soils were deposited. The land is essentially all farmed; practically all tillable land is under cultivation, and the remainder is in hay or pasture. Wooded areas are restricted to very narrow borders along the few rivers, and to shelter belts and "tree claims". The woodlands are deciduous, except where conifers have been planted, as in shelter belts. The very level Valley region does not present the rolling topography, with numerous depressions between low rises, characteristic of the glacial drift plains of central North Dakota. This means to the bird student that the Valley is not slough or pothole country, and wetland areas are few. The main such area in the county lies ten or fifteen miles northwest of Grand Forks. Much of it is contained in the Kelly Slough National Wildlife Refuge.

The bird species of this part of North Dakota are on the whole eastern, rather than western, birds. We see the Yellow-shafted (not Red-shafted) Flicker, the Baltimore (not Bullock's) Oriole, and so

on. In this matter, there is no rigid dividing line. Some typical western species (Brewer's Blackbird, Western Kingbird) are numerous here, and some typical eastern ones are missing. But on the whole our birds belong to the group of associated forms that spreads from New England through the northern states to about the middle of the great plains. Our species also include a number which are inland forms (Clay-colored Sparrow, Black Tern, etc.) rather than eastern or western. However, the highly characteristic great plains birds such as Baird's Sparrow or Sprague's Pipit are rare or missing here.

Sparrows and Finches. Savannah Sparrow, Vesper Sparrow, Clay-colored Sparrow, Chipping Sparrow, and American Goldfinch. There are four common species of native sparrows. The Chipping Sparrow I have seen only in the town of Grand Forks, around lawns and parks. The other three are numerous on the prairie, the Savannah on the lower land, the Vesper along roadsides and in similar areas, and the Clay-colored on dry brushy higher land. The latter also nests in brushy vacant lots at the edge of towns. The American Goldfinch is a common nesting species.

Lapland Longspur, White-throated Sparrow, Slate-colored Junco, Tree Sparrow. These are spring and fall migrants—they do not winter here. The White-throated Sparrow and the Junco are the most prominent of the sparrow migrants in town, and around shelter belts, parks, and farmsteads. The Lapland Longspur is found in the open prairie by thousands. They possibly occur in greater numbers than any other species in this region, although they are migrant and do not remain to nest. In midwinter, also, most of the Longspurs move farther south, to be replaced by Snow Buntings.

Lincoln's Sparrow is a shy and furtive migrant, but regular in fair numbers in brushy or wooded areas. The bold and prominent Harris' Sparrow is here briefly during every migration.

Icterid Western Meadowlark, Redwinged Blackbird, Brewer's Blackbird, Common Grackle, Brown-headed Cowbird, Baltimore Oriole, Bobolink. Summer breeding species, all very common except the Bobolink, which occurs in small flocks. The Baltimore Oriole is numerous in Grand Forks and elsewhere around human settlements. The common blackbird in town is the Grackle, which is replaced on the prairie by Brewer's (in fields or pastures) and the Redwinged (in wet locations).

Wood Warblers. Yellow Warbler. The only common nesting warbler, in town and wooded areas.

Myrtle Warbler. Of our twenty-odd species of migrant warblers, this is by far the most prominent. During their relatively long stay here, they may be seen not only around all lawns, parks, and streets of the town, but also on the open prairie near coulees or sloughs. The next most numerous migrants, the Tennessee and Orange-

crowned Warblers, are much less prominent and are difficult to identify without binoculars.

Waxwings, Kinglets, Thrushes, Mockingbirds, Wrens. Robin, Brown Thrasher, Catbird, House Wren. Common nesting species in town or in wooded areas. The Cedar Waxwing also nests.

Golden-crowned Kinglet, Swainson's Thrush. Migrants. This Kinglet is rather numerous during migration periods. The Swainson's is the most common of our four migrant thrushes.

Corvids, Swallows, Larks, Tyrant Flycatchers. Common Crow, Blue Jay, Purple Martin, Barn Swallow, Bank Swallow, Eastern Wood Peewee, Western Kingbird, Eastern Kingbird. Common nesting species. The Crow and Jay do not winter here. The Purple Martin is seen only in town, where nesting boxes are supplied. The Peewee nests in parks and wooded areas. The two Kingbirds occur on the prairie, up to the edge of towns, and in almost exactly equal numbers according to my counts.

Horned Lark, Empidonax flycatchers. Migrants. If the Horned Lark nests here, it must be in numbers very small compared to the migration numbers. Mostly they are seen on roads or on bare fields in spring and fall. Our Horned Larks are "pale-faced" races, not bright yellow on the face. The little green flycatchers of the Empidonax group are regular and sometimes quite prominent migrants.

Woodpeckers, Kingfishers, Swifts. Yellow-shafted Flicker, Belted Kingfisher, Chimney Swift, Common Nighthawk. Nesting species. Chimney Swifts are not numerous. I have not seen them except in Grand Forks, and I believe that those present through the summer here represent just one small flock. The other species are common, although large flocks of Nighthawks are not seen except during migration.

Doves, Mourning Dove. Nesting species, numerous both in and out of town.

Terns and Gulls. Black Tern, Franklin's Gull. The Black Tern may be seen at Kelly Slough in the summer. Forster's Tern is seen here also, although erratically (the Common Tern is uncommon; the swallow-tailed terns are Forster's). Franklin's Gulls follow the plows in spring and fall, but I have seen less of them in recent years. The common mantled gull is the Ring-billed (not the Herring Gull or California Gull).

Shorebirds. Killdeer, Spotted Sandpiper. Nest. The Killdeer is a numerous and well-known prairie species. The Spotted Sandpiper occurs in small numbers, but can be seen regularly along the Red or especially the Turtle River, in the woods.

Greater and Lesser Yellowlegs. Migrant shorebirds are numerous, but erratic in occurrence. The Yellowlegs, however, can always be seen in season. They nest farther north, but their absence for the purpose is so brief that they are scarcely missed. Of others, the

Marbled Godwit, Willet, and Wilson's Phalarope are to be expected in the spring. Among smaller sandpipers, the Pectoral Sandpiper (with light yellow legs, a point not mentioned in some field guides) is our most common.

Coots and Rails. American Coot. Coots are only migrant at Kelly Slough, although they nest in this latitude. The Sora Rail is seldom seen, where it is present in numbers, and I am not sure of its status here.

Hawks. Marsh Hawk, Red-tailed Hawk. The former is a prominent nesting species. The Red-tailed also nests in this area, but is much more prominent during migration, when large flights pass over.

Waterfowl. Blue-winged Teal, Mallard, Pintail, Shoveler, Gadwall, American Widgeon. These are the breeding waterfowl at Kelly Slough, all dabbling ducks, given here in order of decreasing numbers, the Blue-winged Teal most numerous. These species can ordinarily be seen throughout the summer.

Lesser Scaup, Canvasback, Redhead, Ruddy Dick, Ring-necked Duck, common Goldeneye. Diving ducks are migrant here, although some of these nest at this latitude in North Dakota. The species named are dependable at Kelly Slough during spring and fall migration. Of these, the Lesser Scaup (or Bluebill) are most common. Other regular migrants include small numbers of Canada Geese and Whistling Swans.

Herons and Grebes. Great Blue Heron, Pied-billed Grebe. Both nest in the county. The Horned Grebe is a regular spring and fall migrant at Kelly Slough.

Winter Birds and Resident Species. Snow Bunting, House Sparrow, Starling, White-breasted Nuthatch, Black-capped Chickadee, Downy Woodpecker, Hairy Woodpecker, Great Horned Owl, Gray Partridge ("Hun"). The number of winter species in this region is small. Many colorful species typical of winter in milder climates do not occur here, or move south for the winter. The nine species listed are the ones that can be regularly seen. Of these, all but the Snow Bunting are permanent residents, and can of course be observed in summer also. The Great Horned Owl is resident, although in view of its nocturnal habits the daytime bird watcher can scarcely depend on observing it at will. The Snow Bunting is a winter visitor, never seen in town, but present in hundreds on the prairie during most winters. I believe that their maximum concentration in United States, in an ordinary winter, is probably reached in our latitude. In a particularly mild year the numbers may be small, presumably because they then stay farther north.

In addition, in the winter, the more glamorous erratic wanderers such as grosbeaks, crossbills, and the Arctic hawks and owls may appear. Of these species, one which is regular enough in Grand Forks to be listed here is the Bohemian Waxwing. Although one

can scarcely depend on observing them when desired, they can be expected to appear in the town at some time during every winter.

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XANTHOMONAS SP. OF BACTERIA IN WHEAT WITH SYMPTOMS OF A BLACK CHAFF DISEASE

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INTRODUCTION

In the summer of 1956, studies were undertaken to determine if any microorganisms were associated with a "black chaff" disease of Conley wheat. In that summer, large numbers of bacteria in the genus **Xanthomonas** were repeatedly isolated as the predominant type. In as much as **Xanthomonas transluscens** var **undulosa** has been reported by Hagborg[1] as the cause of a "bacterial black chaff" disease of wheat, it was considered quite desirable to compare the Conley isolates with Hagborg's and to determine if these isolates played any part in the "black chaff" disease of Conley wheat. The studies reported and in progress include; (1) Isolations of exanthomonas bacteria from Conley (susceptible) and Lee (resistant) wheat, (2) Determinations of biochemical characteristics of these bacterial isolates as well as those of **X. transluscens** var. **undulosa** of Hagborg, (3) Comparison of the growth supporting ability of ground glumes from the heads of Conley and Lee wheat for these xanthomonas isolates, (4) Search for bacterial growth stimulators or inhibitors in extracts of ground glumes of Conley and Lee wheat, (5) Comparisons of the free amino acids and sugar types in the glumes of the Conley and Lee wheat, and (6) Inoculation experiments using the **Xanthomonas** sp. isolates.

Isolations of Xanthomonas sp. from Conley and Lee Wheat

In the bacterial isolations made in 1956 on glumes and stems of Conley, only plants with symptoms gave numerous bacterial isolates of the xanthomonas type. A few pink isolates of corynebacterium were also found. The fact that most of the bacterial isolates were

xanthomonas types was taken to indicate that these bacteria were probably not just chance contaminants.

In the summer of 1957, bacterial counts were made on Conley and Lee wheat. Lee was found also to show a few plants with "black chaff" like symptoms. The results of these counts were rather surprising in that for the most part Lee gave higher counts than did Conley except for isolations made from the stem samples. (see table I).

TABLE I

Numbers of Bacteria Isolated from Wheat Plant
Bacteria Per Gram Dry Plant Tissue

Wheat	Glumes	Stems	Leaves
Conley "Infected"	130,000	240,000	33,000,000
Conley "Non-Infected"	14,000	80,000	400,000
Lee "Infected"	540,000	26,000	54,000,000
Lee "Non-Infected"	50,000	20,000	8,000,000

These results indicate that the plants with symptoms have counts considerably higher than the plants without symptoms. This is true for all tissues examined except the stems of Lee which showed no significant difference in counts.

Determination of the Biochemical Characteristics of the Xanthomonas sp.

Twelve cultures of **Xanthomonas** sp. isolated from "black chaff" plants during the summer of 1956 and 11 cultures isolated in the summer of 1957, were compared biochemically to a culture of **X. transluscens** var **undulosa** received from Hagborg. These xanthomonas bacterial isolates represented at least 13 different biochemical groups and all differed from **X. transluscens** var. **undulosa** of Hagborg in at least 3 biochemical tests. A comparison of these groups is given in table II.

In another series of tests 8 isolates were compared in their abilities to produce acid from various source of carbon. Representative results of these tests are shown in table III.

The results of the biochemical tests demonstrate that the **Xanthomonas** sp. isolates are a heterogeneous group and are different than **X. transluscens** var. **undulosa** of Hagborg.

Wheat Plant Tissue as Growth Medium for Xanthomonas sp. Isolates

If the bacterial isolates from wheat with "black chaff" symptoms find the nutritional environment favorable for growth in the Conley variety but less favorable in Lee, then media made from the 2 plant varieties might show a difference in amounts of bacterial growth.

Media were made using ground glumes in distilled water to give a 10 per cent concentration with the pH adjusted to neutrality with sterile potassium hydroxide both before and after autoclaving. The bacterial growth in these media was determined by bacterial counts which are shown in table IV.

TABLE II

Biochemical Tests on Xanthomonas Sp.

Isolates		Tests							
		Starch	Gelatin	Indole	*A-Methyl Carbinol	Methyl Red	H_2S	Nitrate	Litmus Milk
Hagborg	C- 2	—	+	—	—	—	+	—	ALK
	C- 3	—	+	+	+	—	—	+	ACG
	C- 4	—	+	+	+	+	—	—	ACG
	C- 5	—	+	—	—	—	—	+	H
	C- 6	—	+	—	—	—	—	—	A
	C- 7	—	+	—	—	—	—	+	AC
Conley	C- 8	—	+	—	+	—	+	+	A
	C- 9	—	+	—	+	—	—		A
	C-10	—	+	+	+	—	—	—	AC
	C-12	—	+	+	+	—	—	—	ACG
	C-14	—	+	—	+	—	—		AC
	CO- 2	—	+	—	+	—	+	+	ACG
	CO- 5	—	+	+	+	—	+	+	AC
	CO-11	—	+	—	—	—	+	+	A

\+ = Positive Reaction
— = Negative Reaction
A = Acid Production
ALK = Alkaline Reaction
C = Coagulation of Milk
G = Gas Production
H = Hydrolysis of Casein
* = Acetyl

TABLE III

Acid Production* from Carbon Compounds

		Glucose	Mannose	Galactose	Fructose	Rhamnose	Sucrose	Maltrose	Raffinose	Mannitol	Dulcitol	Inositol	Starch	Inulin	Salicin
Hagborg	C-2	A	A	A	A	A	A	A	A	A	—	A	—	—	—
	C-3	—	—	—	—	—	—	A	—	—	—	—	A	—	—
	C-4	A	A	A	A	—	A	A	A	A	—	A	—	—	—
Conley															
	C-5	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C-8	A	A	A	A	A	A	A	A	A	—	A	A	—	A

* = Acid Production pH Below 5.5
A = Acid
— = No Acid

TABLE IV

Growth of Bacteria in Wheat Plant Media

Billions of Bacteria Per ML

Glumes of	CO-6	CO-11	CO-13	AVE.
Conley	11.6	11.5	5.6	10.1
	10.0	13.6	8.2	
Lee	8.4	6.5	7.3	9.4
	14.4	14.0	5.6	

From these results it is quite evident that the ground glumes from either variety of wheat supports the growth of large numbers of bacteria.

Search for Bacterial Growth Stimulators or Inhibitors in Extracts of Conley and Lee Wheat

Since the above growth experiments did not show any differences between the 2 wheat varieties when the total ground glumes were used and since local tissue differences might not show in such experiments, it was decided to use paper chromatrographic methods to concentrate specific components. By paper chromatography of water extract of the ground glumes, amino acids and sugars as well as other chemicals would move on the paper in compact zones and as such a concentrating action would result in contrast to the diluting effect obtained by grinding the glumes. Paper chromatograms of extracts of ground glumes of Conley and Lee wheat were placed on large plates of agar medium seeded with the xanthomonas bacteria and left 25 minutes for diffusion of plant components from the paper into the agar medium. In this method, stimulatory and especially inhibitory substances would be indicated by either a heavier growth of bacteria or zones of diminished growth. No stimulation or inhibition of the bacterial growth was obtained.

Comparison of Amino Acids and Sugar Composition of Conley and Lee

Since the previous experiments, based on microbiological methods did not show any nutritional differences between the 2 wheats, experiments were initiated to compare the free amino acids and sugars in the 2 wheats. In preliminary experiments no significant differences have been found in the free amino acids and sugars in extracts of the 2 wheat varieties.

Plant Inoculations

In numerous greenhouse experiments, inoculations of Conley wheat with **Xanthomonas** sp. isolates have given negative results and no xanthomonas bacteria could be reisolated. There is always the question, however, whether plants grown in the greenhouse have an altered physiology which in this case makes the plant an unsuitable host for the bacteria. In experiments on temperature and humidity, it was found that if the plants were held at temperatures of 90 F and above, moderate "black chaff" symptoms developed

in a majority of the plants in the greenhouse. Experiments are now in progress to determine if the xanthomonas bacteria will multiply in the plant tissues if inoculations are made after preliminary symptoms develop following heat treatments. Histological sections indicate a disintegration of the plant cells in the areas showing symptoms. It may be that the bacteria cannot grow in the plant until there is some initial cell breakdown. Once this has occurred they may be able to grow on the nutrients thus released. The fact that they grow luxuriantly in media made with ground glumes may support this. Thus injury to the plant by environmental factors may make the conditions favorable for bacterial growth. The growth of bacteria in such damaged tissue may increase the damage and severity of the black symptoms.

ADDITIONS OF AMINO ACIDS TO RATIONS FOR WEANLING PIGS

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ABSTRACT

Four trials each with four paired weanling pigs were used to study the effect of amino acid supplementation to a basal barley ration.

Rate of gain and feed efficiency were used to measure the effect of amino acid additions. Trytophan and lysine in combination gave a slight increase in rate of gain and feed efficiency over the control. Methionine retarded the average daily gain and feed efficiency in all cases except when fed in combination with lysine the feed efficiency was increased. Lysine alone at various levels and in combination with methionine and trytophan gave an increased rate of gain and feed efficiency. In this study lysine appeared to be the limiting amino acid.

Slides were shown in the presentation of data.

BREAKING THE DORMANCY OF BUDS IN LEAFY SPURGE WITH GIBBERELLIC ACID

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Dormant or latent buds constitute a major problem in the control of many of our serious perennial weeds. Leafy spurge has an

extensive and deep root system equipped with numerous buds. Removing the above ground stems causes a few of these buds to send up shoots while many buds still remain dormant.

An effort has been made to use hormone-like chemicals to break the dormancy of all such buds so that a single herbicidal spray may be used to obtain complete killing and eradication of this weedy pest.

Among the more promising chemicals tried is gibberellic acid or its salts. In green house tests we have been able to break the dormancy of from 1/3 to 2/3 of the dormant buds together with a striking stimulation of shoots produced. In a number of instances flowering appears to be stimulated as well as abnormal vegetative growth.

INTERSEXUALITY IN DIPODOMYS

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ABSTRACT

Observations on the adult and developmental anatomy of the reproductive tracts of over one hundred **Dipodomys** reveal that this rodent exhibits in the normal female an intersexuality similar to that described in certain other mammals. In addition to the vaginal opening, the female external genitalia consists of a penis-like clitoris which contains a "penile" urethra conducting urine to the tip of the organ. The epithelium of this urethra is greatly hypertrophied in the anestrous and ovariectomized female, but atrophied in the sexually active female. The epithelium of the membranous urethra does not change.

Studies of the development of the reproductive tracts in embryos and fetuses suggest the presence of a masculinizing influence during gestation. Testes in male term fetuses have well-developed seminiferous tubules, but there are no primary follicles in fetal ovaries. The bulbo-urethral glands are equally developed in the male and female term fetuses, but are vestigial and non-functional in adult females. Prostate glands do not develop in females and there are no Wolffian duct derivatives.

Implications of the above observations are discussed with respect to current concepts about sexuality

DEVELOPMENT OF AIRSACS IN ANAS PLATYRHYNCHOS

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ABSTRACT

White Pekin Duck embryos from three and one-half to eighteen days incubation were prepared by serial section for study with the microscope. Older embryos were studied by means of latex injections of the respiratory system and dissection, or digestion of the tissues to produce hardened rubber casts of the respiratory system.

Each cervical airsac arises from the first secondary bronchus as it does in the chicken. The mesial moiety of the interclavicular airsac is a direct continuation of a branch of the first secondary bronchus while its counterpart in the chicken comes from the airsac primordium which originates the intermediate airsac. The lateral moiety of the interclavicular airsac is a development of the second secondary bronchus while its likeness in the chicken is a continuation of a branch of the first secondary bronchus. The intermediate airsac develops from the mesial surface of a ventrally directed tertiary bronchus derived from the third secondary bronchus; it has a primary and secondary ostium. The anterior abdominal airsac develops from the curved distal end of a second bronchus and possesses a primary and secondary ostium. The posterior abdominal airsacs develop from the origins similar to that described for the posterior intermediate and abdominal airsacs in the chicken.

The secondary ostia for each intermediate and anterior abdominal airsac correspond to the respective loci of recurrent bronchi cited for the chicken (Locy and Larsell) 1916. The gradual expansion of the airsacs and migration of the mouths of the secondary, tertiary or quarternary bronchi located around the primary or secondary ostia of the lateral moiety and the three diaphragmatic airsacs from the lung side of the ostia to the airsac side of the ostia is in direct contrast to the growth of "recurrent" bronchi from the airsacs to the lungs.

FORAGE PRODUCTION AND ANIMAL GAINS ON SUPPLEMENTARY EARLY SEASON PASTURES IN WESTERN NORTH DAKOTA[1]

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ABSTRACT

Tame grass pastures, particularly crested wheatgrass pastures,

have been used to great advantage to supplement native grass pastures and ranges in the spring period in the Northern Great Plains. The use of a simple rotation of tame grass pasture for the early part of the season and native grass pasture for summer and fall grazing has resulted in some cases of increases in overall grazing capacity of 30 to 35 percent.

A quantitative evaluation of the performance of supplementary spring pastures using crested wheatgrass and crested wheatgrass-alfalfa pastures was begun at the Dickinson Experiment Station in southwestern North Dakota in 1955. Forage production and consumption on replicated pastures were determined by means of standard pasture cages. The relative grazing value of the pastures was determined by means of yearling steers.

Crested wheatgrass-alfalfa pastures have proven to be superior to straight crested wheatgrass pastures for early season grazing. The yearling steers have grazed both sets of pastures for an average period of 52 days beginning early in May and terminating about the end of June. During the three years of the trial (1955-57) the crested-alfalfa pastures have carried a one-third heavier grazing load than the straight crested pastures, have produced 26 percent more forage per acre, and have produced 38 percent more beef per acre. Tables I and II show forage production and beef production on the pastures during the three years of the grazing trial.

TABLE I. Three-year average forage production and utilization on crested wheatgrass and crested-alfalfa pastures grazed by yearling steers. Dickinson Experiment Station, 1955-57.

Pasture	Forage Prod. (lbs./a.)	Forage Util. (lbs./a.)	Percent Util.
Crested wheatgrass	913	740	81
Crested-alfalfa	1264	987	78

Pastures grazed for average of 52 days in May and June.

TABLE II. Gains per acre (lbs. of beef) by yearling steers grazing crested wheatgrass and crested-alfalfa pastures for an average of 52 days in May and June. Dickinson Experiment Station, 1955-57.

Pasture	1955	1956	1957	Average
Crested wheatgrass	64.3	60.3	109.8	78.1
Crested-alfalfa	92.2	96.3	158.1	115.1

THE OCCURRENCE OF A WAXY DEPOSITION ON THE CELL WALLS OF THE LEAVES OF PICEA GLAUCA (WHITE SPRUCE)

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ABSTRACT

In the course of a detailed study of the anatomy of the leaves of white spruce, **(Picea glauca** (Moench.) **Voss** in relation to resistance to desiccation, the walls of the cells of the internal tissues showed varying degrees of thickening. Microchemical tests indicated that the cell walls were separated by a wax-impregnated lamella. The innermost surface of the cell walls also showed a waxy lining with similar staining reaction. Both waxy layers appear to be quite uniformly deposited and are approximately 1 micron in thickness.

Microchemical tests with cupra-ammonium, Sudan IV, chromic acid, IKI and hydrochloric acid all showed a positive indication of the waxy nature of the layers. Leaf sections were exposed to mild saponification with 10% KOH at 60° C. and after treatment gave similar staining reactions, indicating that the waxy material is relatively stable.

Similar layers, variously described as suberized or lignified have been observed by other workers in plant materials far removed genetically from **Picea glauca,** suggesting that this internal wax deposition may be more widespread through the vascular plants than is suspected.

SOME ASPECTS OF PERMAFROST AND FROST ACTION IN SUB-ARCTIC FOREST-TUNDRA

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ABSTRACT

The area of study reported is located in the Severn River area of the Hudson Bay Lowland above 56° latitude and within the zone of discontinuous permafrost. Beach ridge and inter-beach topography with soils of gravel, sand, silt, and organic matter greatly influence drainage and frost phenomena. The active zone, or climafrost, was determined in several sites.

On sandy beach ridges the midsummer climafrost exceeded three feet, while on the lower slopes it was only eight inches. Within inter-beach areas the soils were entirely organic. Variation in vegetative cover ranged from spruce, larch, and ericaceous shrubs growing on the lichen mat of raised organic hummocks to surrounding,

low-lying sedge mats. Across the hummocks the climafrost depth was 10-12 inches. At the level of the water table of the surrounding ponds climafrost depths dropped sharply to five to nine feet or more.

Across shallow drainage basins, ridges were formed by frost action. Here the vegetative cover and organic mat increased with resulting surface insulation. Lateral and vertical pressures from differential freezing force underlying clay up into the unfrozen ridges.

The insulating properties of dry, organic peat are illustrated by the very shallow thawing on a south-facing cut bank along the river.

A CHROMATOGRAPHIC STUDY OF STARCH HYDROLYSIS

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ABSTRACT

Differences between barley and malt extract values may be partly attributed to starch granule damage, however, this does not entirely explain varietal differences. In the malting process it appears that the amylopectin undergoes enzymatic digestion whereas the amylose component is degraded only slightly. Since the rate of hydrolysis tends to slow down as the point of branching is approached it would be interesting to follow the hydrolysis of starch and determine if the rates of hydrolysis differed appreciably between different varieties of barley and their malts.

This is a study of starch hydrolysis. The starches from several barley varieties and their malts were prepared by a non-chemical method. The starches were gelatinized by heating prior to hydrolysis and alpha amylase was used as the enzyme source. Aliquots were removed from the hydrolysate and analyzed at intervals during the hydrolysis. A quantitative paper chromatographic method was used to analyze the oligosaccharides produced. The weights of the oligosaccharides were calculated by referring to a standard glucose curve and the identity of the oligosaccharides was obtained by hydrolyzing with beta amylase.

A COMPARISON OF THE SMOOTH MUSCLE REACTIVITY OF ARTERIES AND VEINS FROM CATTLE*

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ABSTRACT

Coronary and systemic arteries and veins were removed from freshly slaughtered beef, and strips of smooth muscle prepared for

in vitro observation. Coronary artery smooth muscle relaxed in response to epinephrine, norepinephrine, excess CO_2, and low O_2. Serotonin, acetylcholine, and histamine contracted this muscle. Coronary vein strips were much less responsive than the corresponding artery, and differed in that they were constricted by all the agents listed, and were not responsive to CO_2 and low O_2.

Systemic artery strips were much more sensitive to various stimuli than coronary arteries. They differed in response in that they contracted in the presence of all the agents listed, except CO_2 and low O_2, which gave no response. Systemic vein preparations were more responsive than coronary veins, but otherwise reacted in a similar manner.

Histological sections of the vessels indicated that the amount of smooth muscle was greater in arteries than in veins, but this did not account for all of the differences in response that were encountered. Qualitative differences between the smooth muscle of coronary and systemic vessels were apparently more significant in determining responses than the total amount of muscle.

(*Supported by American Heart Association).

RESPIRATION OF ASCITES TUMOR CELLS

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ABSTRACT

Tumor cells characteristically possess a high anaerobic and aerobic glycolytic potential. In the presence of high levels of glucose, the respiratory rate of tumor cells in Krebs Ringer Phosphate Buffer possess a diminished respiratory rate when compared with tumor cells in medium containing low levels or no glucose. This apparent regulation of tumor respiratory rate by glucose has been investigated. The ogygen consumption, glucose utilization, lactic acid production and synthetic rates of cellular phosphorus compartments through isotopic labeling has been determined under a variety of experimental conditions. Experimental data of the effect of buffer capacity, pH, amino acids and protein upon the respiratory and glycolytic rate of tumor cells will be presented and discussed.

PURIFICATION AND KINETIC STUDIES ON RAT LIVER THETIN-HOMOCYSTEINE TRANSMETHYLASE*

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It has been demonstrated that homocysteine is irreversibly methylated to methionine in the presence of dimethylthetin (thetin) and the enzyme thetin-homocysteine transmethylase. Other investi-

gators have obtained a 100-fold purification of the enzyme from horse liver acetone powders. Their preparation appears to be essentially homogenous, based on the criteria of ultracentrifugation and electrophoresis.

We have obtained a preparation of the rat liver enzyme by ammonium sulfate fractionation and heat denaturation which appears to be at least as pure as those obtained by other investigators. The enzyme migrates as a single component when subjected to electrophoresis, and is incapable of catalyzing methionine and methylmercaptoacetate synthesis in the absence of either thetin or homocysteine.

Kinetic studies were initiated in an attempt to elucidate the transmethylation mechanism. Initial reaction velocities were determined on assay mixtures containing DL-homocysteine, thetin, 0.02 M $NaHCO_3$ buffer (pH 7.4) and enzyme. The reactions were carried out in Warburg manometric flasks under 95% N_2-5% CO_2 at 37°. Reactions were initiated by tipping in enzyme and later terminated by the addition of 6 N HCl. Methylmercaptoacetic acid was extracted with ether and estimated spectrophotometrically at 500 mu by a microadaption of Horn's method for methionine. The chromogenic intensity of methylmercaptoacetate was 62% of that for methionine at 500 mu. Corrections were made for "unavailable" homocysteine (lost through oxidation).

The apparent Michaelis constants (Km) were determined for each substrate at 4 different levels of the second substrate. Reciprocal plots of initial velocity versus substrate concentration were found to be linear, however, dissimilar slopes and intercepts on the 1/v axis were obtained when the second substrate was varied. The data appear to fit the kinetic equation of the type:

$$\frac{V_{max}}{v} = 1 + \frac{K_A}{A} + \frac{K_B}{B} + \frac{K_{AB}}{AB}$$

where V_{max} is the maximal initial velocity, v the initial observed velocity, K_A and K_B the Michaelis constants, A and B the concentration of substrates, and K_{AB} a complex constant.

The transmethylase system appears therefore to involve either a compulsory pathway (steady state) or a random sequence (equilibrium state) of enzyme substrate binding. Some of the kinetic data obtained from these studies are as follows:

$V_{max} = 5.3 \times 10^{-1}$ M/25 min, $K_{thetin} = 1.0 \times 10^{-2}$ M, $K_{L\text{-homocysteine}} = 2.1 \times 10^{-1}$ M

It is not possible to choose between either of these pathways on the basis of the data presented. Such a choice may be made, however, from enzyme-substrate binding studies which are now in progress.

INFLUENCE OF PYRIDOXINE ON METHIONINE ABSORPTION

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ABSTRACT

We have shown that deoxypyridoxine inhibits the intestinal absorption of both D- and L-methionine from perfused segments of the small intestine of the rats (J. Biol. Chem., in press). The inhibitory effect of a single intraperitoneal injection of 0.5 mg. of deoxypyridoxine hydrochloride was reversed upon the administration of a similar amount of pyridoxine hydrochloride. Animals treated with pyridoxine but no antivitamin exhibited a greater ability to absorb L-methionine than did control rats fed an otherwise adequate diet. Pyridoxine depletion by dietary means likewise demonstrated a depression in the ability to absorb the amino acid. These latter findings were related directly to the degree of deficiency. These have been demonstrated by both continuous absorption and the net load exchange from the perfused intestinal segment.

EFFECT OF ANALGESIC AGENTS ON PROTOZOAN CARBOHYDRATE METABOLISM

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ABSTRACT

Relatively little information is available on the effects of analgesic agents at the cellular level. Morphine and related agents have been shown to produce hyperglycemia in experimental animals. Nalorphine, an opiate antagonist, has been shown to inhibit hyperglycemia.

A ciliated protozoan, **Tetrahymena pyriformis,** strain S, was used in these studies to determine the effects of analgesic agents on carbohydrate metabolism. The Warburg apparatus was used to determine oxygen uptake, which was taken as an index of increased or decreased carbohydrate metabolism. Organisms were grown at 28°C in a simple peptone-yeast extract-glucose medium for 2 to 7 days. In certain experiments, the protozoa were placed in a glucose-free medium for 1 to 4 days in an attempt to deplete the carbohydrate reserves. Preparations for manometric studies were washed free of medium constituents in a dilute phosphate buffer (pH 7.0) and finally resuspended to a given optical density in phosphate buffer. Double side-arm flasks were charged with cells in the re-

action vessel, glucose or buffer in one side-arm and the analgesic agent in the other side-arm. Potassium hydroxide in the center well of the vessel absorbed any liberated carbon dioxide.

Preliminary results suggest that morphine, dihydromorphinone and meperidine decrease utilization of exogenous glucose. Controls showed that endogenous metabolism was also slightly decreased with these analgesic agents. Nalorphine, the opiate antagonist, acted in a manner similar to morphine. Also, nalorphine did not antagonize the effects of morphine when both were added to the reaction vessels.

THE ORIGIN OF THE AIRSACS IN THE WHITE PEKIN DUCK: *Anas platyrhrynchos, Linnaeus*

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INTRODUCTION

The gross morphology of the airsacs in the domestic duck has been known since the work of Sappey (1847). The only developmental studies on the airsacs in any species are the work of Selenka (1866) and the more complete study of the development of the lungs and airsacs by Locy and Larsell (1916) for the common fowl. The terminology of the bronchial subdivisions and the airsacs in the present paper is derived from Locy and Larsell (1916), Delphia (1950) and Gier (1952).

MATERIALS AND METHODS

White Pekin Duck embryos from three and one-half days incubation through eighteen days incubation were prepared routinely for histological sectioning. The serially sectioned specimens were studied by means of photomicrographs, camera lucida tracings, direct projections, and diagrammatic reconstructions.

OBSERVATIONS

Lungs

The initial steps in development of the lung in this species is similar to that given for the chicken by Locy and Larsell (1916). The first ectobronchus and first and third entobronchi arise by seven days incubation. Elements of each of the four groups of secondary bronchi (ecto-, ento-, dorso- and latero-bronchi) can be seen by ten days incubation. At this time numerous tertiary bronchi are seen from each of the larger secondary (Plate II, Fig. 7). The air capillaries arise as projections from the walls of the various bronchi at about seventeen and one-half days incubation.

The Airsacs

The Cervical Airsacs: This pair of airsacs is first observed in the nine day duck as thumb-like projections from the first entobronchi slightly posterior and ventral to the anterior tip of the lung (Plate I, Fig. 1). The cervical airsacs give rise to dorsal projections on their lateral margins between thirteen and fourteen days incubation. These projections are the homologs of the pars ovalis of the pigeon. The cervical and thoracic systems of diverticula arise before hatching.

The Interclavicular Airsacs: These airsacs in the White Pekin Duck consist of mesial and lateral moieties or components. The mesial moiety of each lung originates at nine days as a projection from the first entobronchus immediately anterior and mesial to the entrance of the primary bronchus into the lung (Plate I, Fig. 1). The mesial moiety pushes into the thoracic mesenchyme medial and ventral to the bronchus. By eleven days it reaches the lateral margin of the esophagus; by fifteen days each moiety extends to the median line ventral to the esophagus. The sub-cordal, humeral and anterior half of the subscapular lobes arise later from these moieties.

Each lateral moiety originates as a direct continuation of the distal end of the lateral ramus of the second entobronchus at ten days (Plate I, Figs. 1, 2). It pushes into the thoracic mesenchyme by thirteen days and expands anteriorly. The anterior expansion gives rise to numerous diverticula in the anterior and lateral thoracic region. The mouth of each lateral moiety at the time of its origin shows a number of quaternary bronchi whose mouths or proximal portions are intra pulmonary. (Plate I, Fig. 2). These mouths become located on the airsac side of the ostium by sixteen days as a result of a very gradual expansion of the mouth region of the moiety. These auxiliary connections correspond by position to recurrent bronchi of previous authors.

The Intermediate Airsacs: Each intermediate airsac arises on the ninth day as the extra-pulmonary expansion of the middle portion of a tertiary bronchus from the third entobronchus while the proximal and distal ends of this tertiary bronchus remain within the lung (Plate II, Figs. 1, 2, 3). Each airsac, thus, has a primary ostium located mesial and posterior to the entrance of the bronchus into the lung and a secondary ostium located ventral and lateral to the entrance of the bronchus into the lung. Quaternary bronchi occur along the mesial margin and at the distal end of the original tertiary bronchus prior to the exit of its middle portion from the lung as the intermediate airsac. By eleven days a primary, secondary and tertiary ostium exist. The latter ostium is the result of the mouth of the mesially located quaternary bronchus being carried out of the lung. The further expansion of the airsac results in the gradual pulling of the mouths of the quaternary bronchi around the original secondary ostium from the lung side of the ostium to the airsac side of the latter ostium. Numerous auxiliary connections are thus estab-

lished around the original source of the secondary ostium. These auxiliary connections correspond by position to recurrent bronchi of previous authors.

The Anterior Abdominal Airsacs: These airsacs originate at nine days as the extrapulmonary expansion of the mesial surface of the curved distal end of the third latero-bronchus. The distal end of this secondary bronchus shows tertiary bronchi prior to the formation of the airsac. The airsac has a primary (Plate II, Figs. 7, 8) and a secondary ostium (Plate I, Figs. 3, 4; Plate II, Fig. 9). The behavior of the tertiary bronchial mouths on the distal end of the secondary bronchus (or secondary ostium) is as described for the quaternary bronchi around the secondary ostium of the intermediate airsac. The numerous auxiliary connections established for the secondary ostium of this airsac correspond by position to the recurrent bronchi of previous authors. Numerous tertiary bronchial outgrowths around the primary ostium have their mouths carried from the lung side to the airsac side of the ostium by the gradual expansion of the proximal portion of the airsac (Plate 1, Fig. 4).

The Posterior Abdominal Airsacs: These airsacs originate from the posterior tip of the mesobronchus at nine days. The minute secondary bronchi (three posterior latero-bronchi and three posterior dorsobronchi) (Plate I, Fig. 3) are involved in the formation of the auxiliary connections between these airsacs and the lungs. The secondary bronchi (above) have their proximal portions or mouths carried from the lung to the airsac side of the ostium gradually from ten through fifteen days incubation. The establishment of these secondary bronchial mouths outside the lung provides auxiliary connections which correspond by position to recurrent bronchi of previous authors.

DISCUSSION AND SUMMARY

Each interclavicular airsac in **Anas platyrhrynchos** is composed of two components or moieties as described in the chicken (Locy and Larsell, 1916). The mesial moiety is the homolog of the interclavicular airsac described for the duck by Juillet (1912). The lateral moiety in the White Pekin Duck originates from the second rather than the first entobronchus. The origin of the intermediate and anterior abdominal airsacs from the mesial surface of the tertiary bronchus and secondary bronchus respectively provide primary and secondary ostia for each airsac; the secondary ostia for these two airsacs are the sources of the auxiliary connections to the lung. The auxiliary connections, being bronchial tubes whose mouths are carried from the lung to the airsac, correspond by location to recurrent bronchi of previous authors but are of different origin. Recurrent bronchi are said to grow from the airsacs to the lung. The gradual shifting of the mouths of the quaternary bronchi around the ostium of the lateral moiety, the mouths of tertiary bronchi around the primary ostium of the anterior abdominal airsac and the mouths of the pos-

terior secondary bronchi around the ostium of the posterior abdominal airsac from the lung side of the ostia to the airsac side of the ostia provides auxiliary connections that correspond by location to recurrent bronchi of previous authors. Recurrent bronchi as defined by Juillet (1912) and Locy and Larsell (1916) do not exist in the White Pekin Duck. The auxiliary connections grow from the lungs to the airsacs.

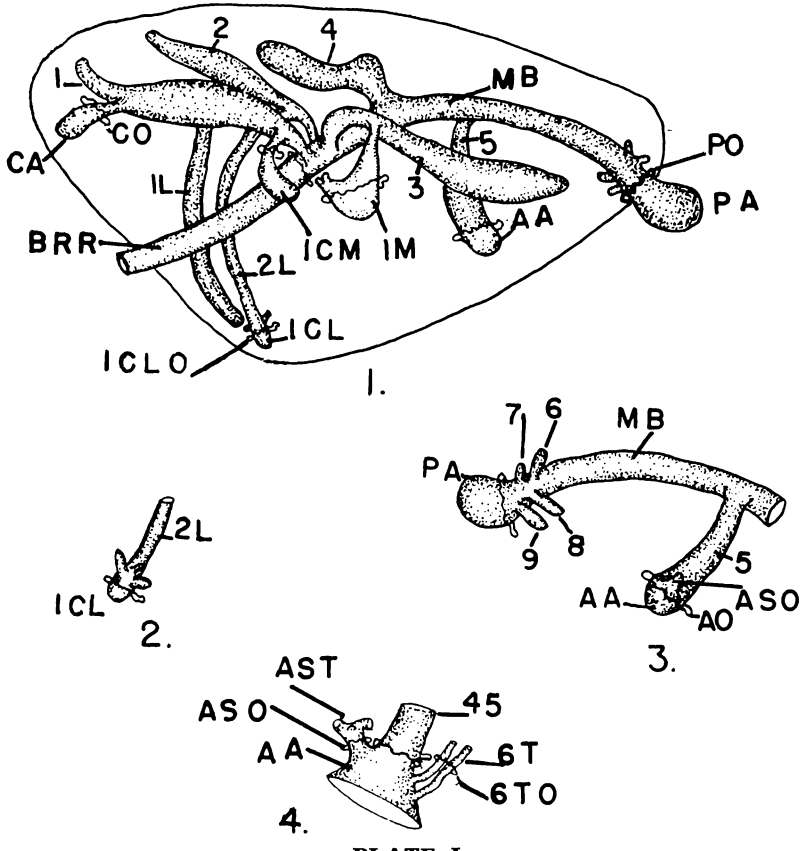

PLATE I

Figure 1. Diagrammatic reconstruction, left lung, ten day embryo. Mesial view.

Figure 2. Diagrammatic reconstruction, lateral ramus of second entobronchus, left lung, eleven day embryo. Lateral view.

Figure 3. Diagrammatic reconstruction, posterior region of left lung, eleven day embryo. Lateral view.

Figure 4. Diagrammatic reconstruction, ostial regions of anterior abdominal airsac, left lung, sixteen day embryo. Lateral view.

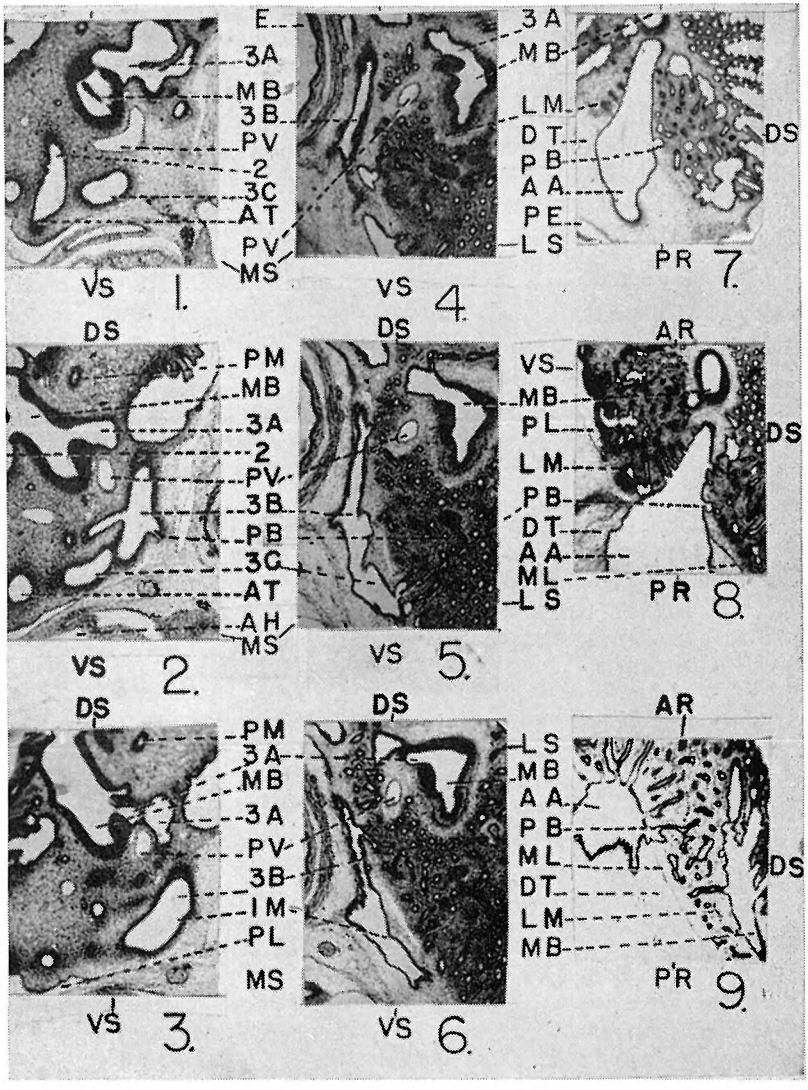

PLATE II

Figures 1, 2, 3. Photomicrographs, transverse sections at 100 micron intervals. Forty-five magnifications. Ten day embryo, left lung.

Figures 4, 5, 6. Photomicrographs of transverse sections at 100 micron intervals. Forty-five magnifications. Eleven day embryo, left lung.

Figure 7. Photomicrograph, sagittal section, 45 maginfications. Eleven day embryo, left lung.

Figure 8. Photomicrograph, sagittal section, 45 magnifications. Thirteen day embryo, left lung.

Figure 9. Photomicrograph, sagittal section, 45 magnifications. Fourteen day embryo, left lung.

LEGEND

AA	Anterior abdominal airsac
AH	Auricle
AO	Orifice of primary connection of anterior abdominal airsac
AR	Anterior region of body
AR	Secondary ostium of anterior abdominal airsac
AS	Orifice of secondary connection of anterior abdominal airsac
ASO	Primordium of lateral moiety of interclavicular airsac
AT	Primary bronchus, right
BR	Primary bronchus, left
BRR	Cervical airsac
CA	Orifice ofcervical aisac
CO	Dorsal surface of body
DS	Diaphragmatic tissue
DT	Orifice of lateral moiety of interclavicular airsac
ICLO	Lateral moiety of interclavicular airsac
ICL	Mesial moiety of interclavicular airsac
ICM	Intermediate airsac
IM	Lung mesoderm
LM	Lateral surface of body
LS	Mesobronchus
MB	Mesonephric duct
MD	Muscle layer
ML	Mesial surface of body
MS	Posterior abdominal airsac
PA	Tertiary bronchus
PB	Pericardial cavity
PC	Pericardium
PE	Pleural cavity
PL	Pulmonary artery
PM	Orifice of posterior abdominal airsac
PO	Posterior region of body
PR	Pulmonary vein
PV	First entobronchus
1	Lateral ramus of first entrobronchus
1L	Second entobronchus
2	Lateral ramus of second entobronchus
2L	Third entobronchus
3	Proximal portion of tertiary bronchus giving rise to intermediate airsac

3A	Middle portion of tertiary bronchus giving rise to intermediate airsac
3B	Distal portion of tertiary bronchus giving rise to intermediate airsac (secondary ostium of intermediate airsac)
3C	First ectobronchus
4	Pre-airsac region of second laterobronchus
45	Second laterobronchus
5	Second-most posterior dorsobronchus
6	A tertiary bronchus with mouth on airsac side of ostium of
6T	anterior abdominal airsac
6TO	Orifice of 6T
7	Most posterior dorsobronchus
8	Second-most posterior laterobronchus
9	Most posterior laterobronchus

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THE EFFECT OF BETA-CAROTENE AND CORTISONE EPITHELIUM OF VITAMIN A DEFICIENT RATS*

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ABSTRACT

From biochemical studies of the liver and kidney cortisone has recently been observed to impair the conversion of beta-carotene to vitamin A. The blocking of the conversion of beta-carotene to vitamin A by cortisone may result only in a quantitative reduction of

the vitamin A stored in body depots and may not produce pathological changes in organs sensitive to vitamin A deficiency. With this question in mind, and by utilizing cornification of the vaginal epithelium of the rat as the criterion of vitamin A deficiency, the present investigation was undertaken to determine whether beta-carotene would in the presence of cortisone treatment cause the cornification of the vaginal epithelium of vitamin A deficient rats to disappear.

The vitamin A deficient animals showing abnormal cornification of the vagina were treated with either beta-carotene or cortisone or beta-carotene and cortisone. For microscopic study the sections of the vagina of each animal were stained with hematoxylin and eosion.

Abnormal cornification of the vagina in the animals that received beta-carotene alone or beta-carotene and cortisone disappeared. The superficial layer of the stratified epithelium of the vagina was found to be replaced by columnar and cuboidal shaped cells. In the animals that received cortisone alone the cornified epithelium of the vagina continued without change.

Since the rats receiving cortisone alone gave no indication of alterations in the vaginal smear, it seems to be clearly evident that the changes observed in the beta-carotene or the beta-carotene-cortisone treated animals must have been the result of the conversion of beta-carotene to vitamin A. Cortisone, therefore, had no demonstrable effect on the conversion of beta-carotene to vitamin A.

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Lockhart, William C. (Poultry Husbandry), Agricultural College. 1955.
Loomis, Ferd H. (Cereal Chemistry), Loomis Laboratories, Grand Forks. 1947.
*Love, Janet (Botany), Agricultural College. 1958.
Lundy, John S. (Anesthesiology), Mayo Clinic, Rochester, Minn. 1940.
*Lunseth, John H. (Pathology), University. 1958.
*McBride, Woodrow H. (Mathematics), University. 1958.
McMillan, William W. (Chemistry), N. Dak. Research Foundation, Fordville. 1947.
MacDonald, John H. (Biology), Teachers College, Dickinson. 1951.
*MacDonald, Wittmer (Basic Science), Teachers College, Minot. 1958.
*MacKichan, Ruth B. (Mathematics and Astronomy), University. 1958.
*Magill, John W. (Biological Chemistry), Agricultural College. 1958.
Magnusson, Adelynn M. (Chemistry), University. 1951.
*Manning, Francis P. (Medicine), Union Laboratories. Minot. 1958.
Manz, Oscar E. (Ceramic Engineering), University. 1953.
Marwin, Richard M. (Bacteriology), University. 1949.
Mason, Harry (Physics), Jamestown College. 1951.
Matson, Charles F. (Biochemistry). Veteran's Adm., Fargo. 1957.
*Meighan, John N. (Mathematics). Teachers College. Dickinson. 1958.
*Meintzer, Roger B. (Biological Chemistry), Agricultural College. 1958.
Meldrum, Alan H. (Petroleum Engineering), University. 1957.
Middleton, Herman F. (Geology), Amerada Petroleum Corp., Williston. 1957.
Miller, Wilford L. (Biology), State Game Fish Dept., Bismarck. 1955.
Minnear, F. L. (Chemistry), Agricultural College. 1954.
Mogen. Clinton A. (Soils), Soil Conservation Service. Fargo. 1955.
Moir, David R. (Botany). Agricultural College. 1954.
Moore, Cyril C. (Chemistry), Teachers College, Minot. 1948.
Moran, W. H. (Chemistry), University. 1931.
*Mulkern, Gregory B. (Entomology), Agricultural College. 1958.
Murphy, H. E. (Chemistry), Teachers College, Dickinson. 1928.
*Naismith, Donald P. (Mechanical Engineering), University. 1958.
*Nallaperumal, Ulaganathan (Chemical Engineering), University. 1958.
*Newgard, Vernon H. (Histo-chemistry), University. 1958.
Norum, E. B. (Soils), Agricultural College. 1948.
Nungesser, William C. (Physiology), University. 1954.
Nedom, H. A. (Petroleum Engineering), Amerada Petroleum Corp., Tulsa, Okla. 1957.
Oakey, John A. (Civil Engineering), Agricultural College. 1954.
Oehler, Mrs. Alma (Nutrition), State Mill and Elevator. Grand Forks. 1945.
*Olmstead, Edwin G. (Internal Medicine). University. 1958.
Olson, Ordell P. (Agronomy), Agricultural College. 1955.
*Omodt, Hollis W. (Soils), Agricultural College. 1958.
Oppelt, Walter H. (Fuels), Bureau of Mines, University. 1949.
O'Reilly, Edward J. (Chemistry), University. 1955.
*Orseth, Melvin M. (Electrical Engineering), University. 1958.
*Owen, Shubel D. (Education-Agricultural), Agricultural College. 1958.
Ovrebo, Gerhard O. (Physics), Teachers College, Valley City. 1947.
Owens, Paul R. (Floriculture), Owens Floral Co., Grand Forks. 1945.
Parsons, Jesse L. (Bacteriology), Agricultural College. 1951.
Peterson, Norman C. (Chemistry), Agricultural College. 1957.
Peterson, Robert H. (Organic Chemistry), Agricultural College. 1951.
Pike, George M. (Hydraulic Engineering), U. S. Geol. Survey, Grand Forks. 1957.
Posin, D. Q. (Physics), Agricultural College. 1950.
Porter, Charles B. (Surgery), Grand Forks. 1951.
Porter, Robert B. (Chemical Engineering), U. S. Bureau of Mines, Grand Forks. 1957.
Potter, Loren (Botany), Agricultural College. 1948.
*Promersberger, William J. (Agricultural Engineering) Agricultural College. 1958.
Randall, Robert N. (Wildlife Management), U. S. Fish and Wildlife Service, Bismarck. 1954.
Ranz, Robert (Chemistry), University. 1957.
Rathmann, Franz H. (Chemistry), Agricultural College, 1955.

Redmond, Charles E. (Soils), Agricultural College. 1955.
Reid, Russell (Natural Science), State Museum, Bismarck. 1940.
Richards, Stephen H. (Wildlife Management), Agricultural College. 1954.
Reiten, Palmer J. (Mechanical Engineering), University. 1957.
Riedesel, Mildred (Home Economics), University. 1955.
Riley, Kenneth W. (Chemistry), Marietta, Ohio. 1936.
Robinson, Hugh M. (Botany), State Teachers College, Valley City. 1948.
Robinson, Roy N. (Physics), Public Schools, Minot. 1951.
*Rogers, Riley (Pharmacy), Agricultural College. 1958.
Rognlie, Philip A. (Mathematics), University. 1946.
Rolzinski, J. J. (Biology), Junior College, Devils Lake. 1950.
Roth, Kingsley W. (Geology), Amerada Petroleum Corp., Denver, Colorado. 1957.
*Rudesill, James T. (Chemistry), Agricultural College. 1958.
*Russell, Seth (Sociology), Agricultural College. 1958.
Saiki, A. K. (Pathology), University. 1949.
Sandal, Paul C. (Plant Breeding), Agricultural College. 1955.
Sands, F. H. (Chemistry), Agricultural College. 1946.
Saugstad, Stanley (Entomology), Minot. 1939.
Schermeister, Leo J. (Pharmacy), Agricultural College. 1957.
Schnell, Richard D. (Zoology), Agricultural College. 1955.
Schneider, Clifford F. (Geology), U. S. Geol. Survey, Grand Forks. 1957.
Schooler, Arnold B. (Cytology), Agricultural College. 1957.
Scott, George M. (Cereal Chemistry), Agricultural College. 1952.
Sebens, William P. (Agriculture), State Soil Cons. Comm., Bismarck. 1948.
Severson, D. E. (Chemical Engineering), University. 1949.
Shoesmith, Lloyd (Soils), Agricultural College. 1950.
Shumard, Raymond F. (Parasitology), Agricultural College. 1954.
Sibbitt, L. D. (Cereal Technology), Agricultural College. 1946.
Silverman, Louis B. (Pediatrics), Grand Forks Clinic, Grand Forks. 1957.
Sleeper, Bayard P. (Bacteriology), Agricultural College. 1952.
Smith, Glenn S. (Plant Breeding), Agricultural College. 1930.
Snook, Theodore (Anatomy), University. 1954.
*Sommerfeldt, Therom G. (Soil Science), Agricultural College. 1958.
Spier, Jack J. (Pathology), St. John's Hospital, Fargo. 1952.
*Splies, Robert G. (Organic Chemistry), University. 1958.
Staley, Raymond C. (Mathematics), University. 1946.
Stallings, Harris D. (Library), Agricultural College. 1951.
Starcher, George W. (Mathematics), President, University. 1954.
Stevens, O. A. (Botany), Agricultural College. 1910.
Stewart, Donald L. (Chemistry), Am. Cryst. Sugar Co., E. Grand Forks, Minn. 1943.
Stoa, Thecdore E. (Agronomy), Agricultural College. 1950.
Stockdale, Thomas E. (Petroleum Refining), Standard Oil Co., Mandan. 1954.
Sullivan, John W. (Biochemistry), Agricultural College. 1954.
Summers, Lawrence (Chemistry), University. 1951.
Svore, Jerome H. (Sanitary Engineering), Columbia Basin Inter-Agency Comm., Portland, Oregon. 1943.
Thompson, John C. (Mathematics), Teachers College, Dickinson. 1948.
Timian, Roland G. (Plant Pathology), Agricultural College. 1954.
Towse, Donald F. (Geology), Dickinson. 1952.
Treumann, William B. (Chemistry), Agricultural College. 1946.
Turelle, Joseph W. (Agronomy), U. S. Soil Conservation Service, Bismarck. 1954.
Turn, Jenny (Bacteriology), Agricultural College. 1957.
*Turner, Robert C. (Medicine), Grand Forks. 1958.
Van Heuvelen, W. (Chemistry), State Health Dept., Bismarck. 1945.
*Vasey, Edfred H (Soils), Agricultural College. 1958.
Vennes, John W. (Bacteriology), University. 1957.
Vergeer, Teunis (Physiology), University. 1954.
Vick, James A. (Physiology), University. 1955.
Vincent, Muriel C. (Pharmacy), Agricultural College. 1957.
Waldron, Howard L. (Mining Engineering), University. 1957.
Walster, H. L. (Director of Experiment Station, Dean Emeritus), Agricultural College. 1920.
*Wardner, G. A. (Chemistry), University. 1958.
Watkins, John B. (Veterinary Medicince), Grand Forks. 1954.
Weck, Herman I. (Chemical Engineering), Standard Oil Refinery, Mandan. 1957.
Weisser, Wilbur O. (Mathematics), State Teachers College, Dickinson. 1957.
Whalin, Edwin A. (Physics), University. 1955.
Wheeler, Jeanette N. (Biology), University. 1957.
Wheeler, George C. (Biology), University. 1924.
Whitman, Warren C. (Botany), Agricultural College. 1950.
Wiidakas, William (Agronomy), Agricultural College. 1946.
Wills, Bernt L. (Geography), University. 1949.
Witmer, Robert B. (Physics), University. 1925.
Yeager, Vernon L. (Anatomy), University. 1957.

*Young, Duane E. (Natural Sciences), Teachers College, Minot. 1958.
Young, Ralph A. (Agronomy), Agricultural College. 1954.
Youngs, Nelson A. (Otolaryngology), Grand Forks. 1957.
Youngs, Roger W. (Chemistry), U. S. Bureau of Mines, Grand Forks. 1957.
Youngs, Vernon (Chemistry), School of Forestry, Bottineau. 1955.
Zubriski, J. C. (Soil Physics), Agricultural College. 1955.
*Members elected in 1958.

CORPORATE SUSTAINING MEMBERSHIPS

*American State Bank of Minot, Minot, North Dakota. 1958.
*First Federal Savings and Loan Association, Grand Forks, North Dakota. 1958.
*First National Bank, Grand Forks, North Dakota. 1958.
*First National Bank, Minot, North Dakota. 1958.
*Minot Federal Savings and Loan Association, Minot, North Dakota. 1958.
*North Dakota Farmers Union, Jamestown, North Dakota. 1958.
*Red River National Bank, Grand Forks, North Dakota. 1958.
*Valley Bank, Grand Forks, North Dakota. 1958.
Truax-Traer Coal Company, Minot, North Dakota. 1957.

THE FIRST FIFTY YEARS

By Dr. G. A. Abbott *

Professor Emeritus, (Chemistry), University of North Dakota

A Brief History of the North Dakota Academy of Science, presented at the Semicentennial Meeting, at the Agricultural College, Fargo, North Dakota, May 2 and 3, 1958.

Early Attempt to form an Academy of Science in North Dakota

As early as 1893, when the State was only three years old, an attempt was made to organize an Academy of Science. This fact became known in 1942, when a letter found among the writings of the late President Webster Merrifield told of this early, but evidently unsuccessful attempt. That letter was brought to the attention of G. A. Abbott, then Secretary of the Academy, by the late Dean William G. Bek, of the University. It read as follows:

"RED RIVER VALLEY UNIVERSITY
Wahpeton, N. D.

Wahpeton, N. D.
Nov. 13, 1893

President Merrifield:

Dear Sir:

I have for some time contemplated writing a suggestion to you. It is this—if an Academy for Sciences for North Dakota could not be formed to advantage. A union of the colleges in such a thing would serve to unify the educational work of the state, do good to science by making and publishing lists of the fauna and flora, study agricultural pests and helps, and in other ways do good, it seems to me, to this new state. I worked several years in such a one in Kansas in 1872-7, and we deemed it of much worth. I have spoken to President Beard of the Fargo Cong'l College, and also Pres't McFarland of Valley City Normal. Both favor it. What do you say? Ex-Gov. Miller thinks the Ag. Dept. would take us under its wing.

Very truly yours,
(Signed) M. V. B. Knox."

*Charter Member, and one of the six Founders. Annually re-elected Secretary for 40 consecutive years. Since then, Historian. He has attended every annual meeting.

The "Red River Valley University" was a Methodist College; later transferred to Grand Forks to become the present "Wesley College" affiliated with the University. M. V. B. Knox was President Martin Van Buren Knox, a fine scholar, who came from New England. He held a Ph.D. degree in Philosophy, and Mrs. Knox, also, is said to have held the Ph.D. degree.

We can only speculate as to why the organization was not formed at that time; but it is very probable that President Merrifield did not favor it. He was a classics scholar of the old school, which at that time was actively opposing the rapid introduction of scientific and technical courses into college curricula. This general attitude was reflected by President Merrifield's reply when told that efforts were being made to transfer science and engineering from the University to the Agricultural College. He calmly said: "Very well, let them take the science and engineering; we'll have a gentleman's school."

The Founding of the North Dakota Academy of Science

Fifteen years had elapsed after that early, abortive attempt, before the Academy of Science finally was established in North Dakota. Although at that time the State was only eighteen years old, the North Dakota Academy actually is much older than those of many older States, such as Virginia, Kentucky, Minnesota, and many others.

The North Dakota Academy is proud to trace its origin to the illustrious Indiana Academy of Science, which for a century has numbered among its members so many of the most distinguished scientists of America. Such men as David Starr Jordan, eminent biologist, and President of Leland Stanford University; Harvey W. Wiley, of pure foods fame; John and Stanley Coulter, Arthur, Barnes, Stone, chemist and President of Purdue University, Nef, Alexander Smith, later of Chicago and Columbia, Evermann, Eigenman, Underwood, Holmes, Baker, Lyons, Moore, McDougal, W. A. Noyes, Butler, Foley, Goss, and many others—leaders in their day who contributed so much to the advancement of science in America.

The North Dakota Academy of Science was founded by a small group of former members of the Indiana organization. Men who missed the stimulating associations with that Academy after coming to North Dakota. The idea of organizing a similar science group in North Dakota appears to have been activated during a conversation between Lynn Banks McMullen and Melvin A. Brannon, then Dean of the School of Medicine at the University of North Dakota, later President of the University of Idaho, and afterwards Chancellor of Higher Institutions of Learning in Montana for ten years. McMullen had served as Secretary of the Indiana Academy before coming to the State Normal at Valley City, as Professor of Physics, in Septem-

ber, 1908. These men often remarked that the inspiration had come from their former association with the Indiana Academy.

Organization Meeting

At the meeting of the State Educational Association, held at Valley City, December 31, 1908, McMullen and Brannon called together a small group informally to consider organizing a North Dakota Academy of Science. Prominent in this group were two other former "Hoosiers," Professors H. L. Bolley and C. B. Waldron, members of the faculty of the Agricultural College at Fargo.

Very meager records were made at that meeting, and they do not list the names of all who were present. The brief minutes read as follows: "Moved and carried that Professor Brannon be elected Chairman of the organization. Morris Johnson appointed Secretary. Moved that those present organize as the North Dakota Academy of Science. Moved, seconded and carried that the Chairman of the meeting (Professor M. A. Brannon) be empowered to appoint officers for the year, and that he act as President of the Executive Committee of five. Motion to adjourn. Carried. (Signed) Morris Johnson, Secretary Protem."

Meeting of the Executive Committee

The next record is that of the minutes of the Executive Committee meeting held in Professor Daniel E. Willard's office at the Agricultural College, February 1, 1909. Two new members had been added to the Executive Committee by President Brannon: Daniel E. Willard, Professor of Geology at the Agricultural College, and G. A. Abbott, who had arrived at the Agricultural College the day following the Valley City meeting, to become Assistant Professor and Chemist in the Experiment Station. He had served as Press Secretary of the Indiana Academy, and was immediately made a member of the Executive Committee.

The minutes of that meeting are as follows:

"Those present:—C. B. Waldron, M. A. Brannon, D. E. Willard, L. B. McMullen, and G. A. Abbott. The Secretary (L. B. McMullen) was instructed to write to SCHOOL SCIENCE AND MATHEMATICS, SCIENCE, and POPULAR SCIENCE MONTHLY. It was decided to hold the first regular meeting of the Academy at Grand Forks, May 21, 1909. Moved by McMullen, second by Waldron to have President Brannon prepare a program on the general topic: What can Biology do for North Dakota. Willard to prepare a similar program for Geology, Stewart for Physics, and Babcock for Chemistry. Voted to pay railroad expenses of members of the North Dakota Academy of Science attending this committee meeting. Brannon, $3.90; McMullen, $2.90."

Notice of the First Regular Meeting of the Academy

"Valley City,
May 3, 1909

Dear Sir:

There will be a meeting of the newly organized North Dakota Academy of Science at Grand Forks during the week of the High School Conference and Athletic meet.

Your name has been proposed for membership in the Academy and the Executive Committee would like to know which date—May 19th or 21st—would enable you to be present..

Kindly send this information to the Secretary by return mail, stating also how you feel in regard to the movement.

At this meeting the work which the Academy can do will be discussed. M. A. Brannon has charge of the discussion of the work of Biological Sciences, G. W. Stewart that of Physical Sciences, and D. E. Willard that of Geology.

The purpose of the Academy is (quoting from the Constitution), the encouragement and prosecution of scientific research and the diffusion of knowledge of science.

Yours very truly,
(Signed) Lynn B. McMullen,
Sec.-Treas."

Minutes of the First Regular Meeting

"The first regular meeting of the North Dakota Academy of Science was called to order May 21, 1909, in the Biology Department of the State University at 2 P.M., with President Brannon in the Chair. After preliminary remarks by the Chairman, President-elect of the University, Franklin McVey, made a short talk expressing his interest in the organization. Following this, a short business session was held. The purpose of the Academy was discussed at some length, as was also the feasibility of publishing Proceedings. A committee was appointed by the Chairman, upon motion of Mr. Waldron, to take up the question of publication. This committee consisted of Mr. Bolley, Chairman; Mr. Ruediger, and the Secretary (L. B. McMullen). By consent it was understood that the officers elected at the prelimnary meeting at Valley City were to hold office until the next regular meeting. (These ofifcers were President M. A. Brannon, Vice President C. B. Waldron, Secretary-Treasurer L. B. McMullen.) The Academy then proceeded with the Program as printed—a copy of which being hereto attached. The Academy adjourned at 6 P.M. to meet at the call of the Executive Committee. No evening meeting was held."

Program of the First Regular Meeting

The programs of the first six Annual Meetings of the Academy were printed on "vest-pocket" size folders, 3½x6 inches. The program of the first regular meeting read as follows:—On the title page: "North Dakota Academy of Science. State University. May Twenty-first, 1909. Sessions at 2 P.M. and 8 P.M. in the Biology

Department." The inside left page bore the single statement: "The principle thought of this meeting is What can the Academy do for the State of North Dakota." The inside right page carried the program of papers:

PROGRAM

Biology

Biological Opportunities in North Dakota
President M. A. Brannon
The Zoological Outlook in North Dakota
R. T. Young
Studies on the Purification of Streams
G. F. Ruediger
Some Scientific Aspects of the Forestry Problem in North Dakota
C. B. Waldron
The Obligation of the North Dakota Academy of Science in Relation to Soil Bacteria
T. D. Beckwith

Geology

The Geological Problems of the North Dakota Academy of Science
D. E. Willard

Chemistry

Chemistry Problems of the Academy
E. J. Babcock — G. A. Abbott

Physics

In what ways can those engaged in teaching and investigation in Physics be of service to the State?
L. B. McMullen — G. W. Stewart

The back side of the folder carried the single statement:—"There are more problems for an Academy of Science in North Dakota than in any other State in the Union. Can we solve them?"

Constitution and By-Laws

At the organization meeting at Valley City a tentative Constitution and By-Laws had been drafted. It was read at the first annual meeting and unanimously adopted at the second annual meeting held at the Agricultural College in 1910. It remained essentially unchanged until 1953 when it was revised as published in the Annual Proceedings, Volume VII (1953).

Roster of the Charter Members

It was voted to consider as Charter Members all qualified persons attending the first regular meeting who signified their wish to become members of the Academy. The following signatures were obtained:

*Abbott, G. A. (Chemistry), University.
Babcock, Earl J. (Chemistry), University.
Bassett, H. P. (Chemistry), Agricultural College.
Becker, A. J. (Applied Math.), University.
Beckwith, T. D. (Bacteriology), Agricultural College.
Bell, William B. (Biology), Agricultural College.

*Bolley, H. L.	(Biology. Plant Pathology.) Agricultural College.
*Brannon, M. A.	(Biology), University.
Burch, E. G.	(Sciences), State School of Science, Wahpeton.
Caldwell, G. H.	(Physiology), University.
Crouch, C. E.	(Mechanical Engineering), University.
Darner, R. W.	(Sciences), State School of Science, Wahpeton.
Eastgate, Alf	(Wild Life), Tolna, N. Dak.
Heyward, R.	(Science), Grand Forks, N. Dak.
Holgate, W. R.	(Science), Grand Forks, N. Dak.
Leonard, A. G.	(Geology), University. State Geologist.
McDonald, A. L.	(Science), University.
*McMullen, L. B.	(Physics), State Normal School, Valley City.
McVey, Frank L.	(Economics), President, University.
Ruediger, G. F.	(Hygiene and Sanitation), University.
Stewart, G. W.	(Physics), University.
*Waldron, C. B.	(Horticulture), Agricultural College.
White, H. L.	(Chemistry), Agricultural College.
*Willard, D. E.	(Geology), Agricultural College.
Young, R. C.	(Zoology), University.

**Member Organizing Committee*

Source of Academy Membership

North Dakota, a pioneer agricultural State, obtained membership for the Academy of Science almost entirely from the science faculties of the University, the Agricultural College, and the several State Normal Schools and Technical Schools. But Fargo College, a small Congregational Arts College, before it closed, furnished a few very capable and active members of the Academy. Notably Daniel Freeman who served as Vice President in 1921 and as President of the Academy in 1922. Jamestown College, a Presbyterian Arts College of high accredited rating, always has given valuable support to the Academy of Science. For many years the late Dr. W. B. Thomas was a very active member. From the beginning the Annual Meetings of the Academy had alternated between the University and the Agricultural College. Until 1956, when in compliment to Professor Harry B. Hart, Head Professor of Chemistry at Jamestown College and President of the Academy, the meeting was held on the campus of Jamestown College. This College also has contributed toward the publication of the Academy Proceedings. Through the years it has graduated scientists out of proportion to its enrollment, including some who are now active in the Academy, among them Dr. Alex Burr and the present Secretary of the Academy, Professor Ben Gustafson, of the University.

Larger High Schools have furnished a few members. The first Constitution encouraged persons actively interested in science and its promotion to join the Academy, and a number did so who were not affiliated with any institution of learning. Among them, Alf Eastgate of Tolna, actively interested in North Dakota Wild Life, and Emil Krauth of Hebron, who as a young man threatened with tuberculosis, came to western North Dakota to recover his health.

Like another frail eastern young man, Theodore Roosevelt, who came to western North Dakota, he was restored to magnificent health and vigor by the "healing influences of time and Nature" in rugged North Dakota. Emil loved the wide open prairies and often remarked that he regained his health by chasing butterflies in North Dakota. He exhibited his magnificent mounted collection of North Dakota butterflies at a meeting of the Academy, and older members will not forget the exquisite beauty of that collection, or the genial, German-born nature-lover who assembled it.

Another who prized highly her invitation to become a member of the Academy was Mrs. Fannie Heath. She became widely known for her active study of the native plants, especially the wild flowers, of North Dakota. She acquired recognition through her modest publications and was regularly called upon to ship plants to Harvard and to other eastern herbaria and Botanical Gardens. In her farm gardens, four miles southwest of Grand Forks, she collected and cultivated these plants. The work was heavy, but she continued her labor of love until age and failing strength forced her to give up her cherished lifelong hobby.

In this age of speed and specialization, not only have we seen the passing of the Pioneer, but also with him, the picturesque Naturalist—one "who in the love of Nature held communion with her visible forms," and to whom Nature "spoke" in a simple, satisfying language.

Preparation of the Programs

We have seen that the keynote of the very first meeting was to make the Academy the servant of the State. That objective has continued to characterize its activities throughout the fifty years of its existence; but this does not imply that its research always has been limited to applied science. Actually, without conscious intent or special concern, a remarkable balance has existed between "pure" or fundamental science, and applied science—often assumed by the public to be more "practical." In the preparation of programs, members have been encouraged to submit papers voluntarily in the belief that better programs are obtained in that way. Rarely, and only for special reasons, have papers been specifically solicited, with the exception of the invited guest speaker. At times the papers offered, even with the time limit imposed for their presentation, have been so numerous as to make it difficult to accommodate them on the program. Yet it seemed inadvisable to divide the session into sectional meetings. However, at the Sixteenth Annual Meeting, held at the Agricultural College, May 2 and 3, 1924, the experiment was tried. The Friday afternoon session was divided into two Divisional Meetings, attempting to classify the papers into biological and physical sciences respectively. But such a distinction could not clearly be defined. The members were not satisfied with the plan, and at the

business session they voted to discontinue it. Not until 1956 was the plan revived.

The first six Annual Meetings were one-day sessions, held on the last Saturday in April or the first Saturday in May. Two-day sessions began with the Seventh Annual Meeting, held at the University April 30 and May 1, 1915. Twenty-five papers were read at that meeting. It was also the first meeting featuring a dinner Guest Speaker. The informal dinner was held on Friday evening in the Commercial Club rooms downtown, and the Guest Speaker was Dean E. P. Lyons of the College of Medicine, University of Minnesota. His subject was "A Summer in Labrador." It was beautifully illustrated with slides. The Academy continued to hold informal dinners; but the custom of inviting a special Guest Speaker was not resumed until 1929. Since then it has continued practically without interruption.

Guest Speakers at the Academy Dinners

Year	Place	Speaker and Subject
1915	Univ.	Dr. E. P. Lyons, Dean of the College of Medicine, University of Minnesota. "A Summer in Labrador." Illustrated.
1929	Univ.	Dr. Charles Sheard, University of Minnesota. "The Color of the Skin and Factors Which Affect It." Illustrated.
1930	A. C.	Professor Howard E. Simpson, University of North Dakota. "The Geological Story of the La Brea Tar Pits." Illustrated.
1931	Univ.	Program of Entertainment by Local Musicians.
1932	A. C.	Dr. Albert Ernest Jenks, University of Minnesota. "Prehistoric Mimbres Culture—The Most Creative Ceramic Artists of Prehistoric Time." Illustrated.
1933	Univ.	Silver Anniversary Dinner. President of the Academy George Wheeler gave a breezy talk recalling customs and events when the Academy was founded. Secretary Abbott recounted the founding.
1934	A. C.	Dean E. M. Freeman, University of Minnesota. "The Evolution of Plant Life." Illustrated.
1935	Univ.	Professor D. E. Minnich, University of Minnesota. "The Mind of the Insect." Illustrated.
1936	A. C.	Professor William S. Cooper, University of Minnesota. "The Upper Mississippi River Since Glacial Times." Illustrated.
1937	Univ.	Dr. William Shimer, National Secretary, United Chapters of Sigma Xi. "The Synthesis of the Sciences."
1938	A. C.	Dr. Neal Weber, University of North Dakota. "Travelling the Courantyne River in Uninhabited Jungles of South America." Illustrated.
1939	Univ.	Dr. Herbert Freundlich, Kaiser Wilhelm Institute of Physical Chemistry, Berlin, Germany. Dr. Freundlich was a refugee from Nazi Germany, who spent five years in England before accepting a position on the faculty of the University of Minnesota. He was perhaps the world's authority on

Year	Place	Speaker and Subject
		Colloid Chemistry. "Developments in the Field of Colloid Chemistry in the past five years."
1940	A. C.	Dr. John S. Lundy, Department of Anesthesiology, Mayo Clinic, Rochester, Minnesota. "The Indispensable Value of the Fundamental Sciences in the Establishment of Anesthesiology—a New Medical Specialty."
1941	Univ.	Dr. Clyde C. Bailey, College of Agriculture, University of Minnesota. "Bread and Nutrition."
1942	A. C.	Dr. J. R. Swendeman, Moorhead State Teachers College. "The Geography of Hemispherical Solidarity." Illustrated.
1943	Univ.	Dr. Ernst C. Abbee, University of Minnesota. "A Botanical Expedition to the East Coast of Hudson Bay." Illustrated with beautiful colored moving pictures, and Kodachrome slides. He also displayed a collection of maps, specimens and Eskimo curios.
1944	A. C.	Dr. Ralph E. Dunbar, Acting Dean of the School of Chemical Technology, Agricultural College. "Science in the Post War World."
1945	Univ.	Mr. John A. Hutcheson, Associate Director of the Research Laboratories of the Westinghouse Company, Pittsburgh, Pa. "Industrial Research." Illustrated.
1946	A. C.	Professor H. W. Johe, Department of Architectural Engineering, Agricultural College. "Views of Hawaii." Also "his own colored sketches."
1947	Univ.	Dr. Herbert Hunter, Cambridge, England. Specialist in Plant Breeding, especially as applied to the improvement of Barley Culture. "Malting Barley in England."
1948	A. C.	Dr. J. A. Anderson, Chief Chemist of the Grain Research Laboratory at Winnipeg. He is accepted as an expert in the preparation of scientific papers for publication. His unique subject was: "Bridling the Editorial Nightmares."
1949	Univ.	First joint meeting with the newly chartered Red River Valley Section of the American Chemical Society, which sponsored the distinguished Guest Speakers: Dr. and Mrs. Jean Felix Piccard, famous balloonist, and Professor of Aeronautical Engineering at the University of Minnesota. Mrs. Piccard, herself an expert balloonist, and distinguished speaker in her own right.
1950	A. C.	Dr. E. C. Stakman, distinguished Plant Pathologist, University of Minnesota. "Science and its Sphere of Influence."
1951	Univ.	Dr. W. J. Breckenridge, Director, Museum of Natural History, University of Minnesota. "Becoming More Bird Conscious."
1952	A. C.	Dr. D. L. Tabern, Abbott Laboratories, North Chicago, Ill. "Radioactive Isotopes in Biology and Medicine."
1953	Univ.	Dr. A. Rodger Dennison, Vice President, Amerado Petroleum Corporation. "Prospecting for Petroleum —An Examination of the Application of Geology to Oil Finding."

Year	Place	Speaker and Subject
1954	A. C.	Dr. Laurence H. Snyder, Dean of the Graduate College, University of Oklahoma. "Human Heredity and its Modern Applications."
1955	Univ.	Dr. John S. Lundy of Mayo Clinic, Rochester, Minnesota. "Recent Progress in the Conquest of Pain."
1956	Jamestown College	Dr. A. F. Beale Jr., of Dowell, Incorporated. "The Stimulation of Oil Wells." Beautifully illustrated.
1957	Univ.	Dr. David E. Green, Chairman, Institute for Enzyme Research, University of Wisconsin. "Structure and Enzymatic Function of the Mitochondrion."

Research in America at the Turn of the Century

At the turn of the Century, not only this State, but the whole country had yet to learn the real nature and value of scientific research. It took the concussion of the First World War to awaken us to the realization that we had been shamefully dependent on Europe, especialy on Germany, not only for our knowledge of basic science but for most of the indispensable products of scientific research. If at that time we had been told that we would live to see the time when our "hard-boiled" Captains of Industry not only would cease to scoff at science; but would actually become the most enthusiastic supporters of research and development costing not merely millions, but even billions of dollars, we would have said with cynical scorn, that such a fantastic miracle never could happen; certainly not in our day. But we know it did happen—in less than a single generation. No other generation has lived to see such an amazing pageant in man's conquest of Nature.

Difficulties Encountered by Early Members of the Academy in Their Efforts to Carry on Research

In this day of generous research grants from Government agencies and endowed Foundations, as well as more adequate State appropriations, it is nearly impossible for younger men to appreciate the great difficulties and handicaps under which the early members struggled to carry on research. At that time most administrators and State officials merely "accepted research logically, without actually believing in it." Some openly opposed it, insisting that their professors were hired to teach, not to spend their time puttering with silly experiments; but if they must fool with such things it must be done after hours, on Sunday, or holidays—as indeed much of it was. One Dean told his faculty emphatically that educational institutions were established for the sole purpose of teaching students—not carrying on research. "Why," he said, "we don't need to discover any more knowledge; we've got so much knowledge now that we can't possibly teach it all in a lifetime." Addressing a faculty meeting, a prominent member of the Board, at that time, went so far as to say: "Gentlemen, so long as I am connected with this Board I will always favor the carrying on of research by the college pro-

fessor, (great applause) not because such research is worth a damn, gentlemen, but because the professor thinks it is, and it keeps him content to work on a lower salary."

Such statements sound utterly ridiculous today in this Atomic-Space Age; but in the early years of the Academy, such attitudes were by no means uncommon. It is against this background that we must judge the work of our Academy pioneers.

Perhaps the greatest discouragement was not so much the occasional outright opposition to research, as the wide-spread stoical indifference to it. As a result, teaching loads were unreasonably heavy, and often it was impossible to get necessary equipment, even for the most modest investigations. Small wonder, then, that for so many years the North Dakota Academy of Science was unable to obtain either institutional or State aid for the publication of its Proceedings. As a consequence many papers of outstanding value to the citizens of the State were lost or made useless for the lack of publication. Fortunately some members were able to find limited outlets for some of their contributions in the various scientific journals. The scope and variety of these unpublished contributions were indicated by the titles of the papers appearing on the programs of the Annual Meetings.

Periods of "Storm and Stress"

It is doubtful if any other State has suffered more severely from periods of economic and political "storm and stress." Yet the North Dakota Academy of Science has shown amazing "survival ability." It has weathered two World Wars, the Korean "Police Action," the deadly Flu Epidemic of 1918, the Great Depression, a decade of searing drouth, frequent violent political upheavals, and more than thirty years of inadequate State support of higher education. Through all of these vicissitudes it has steadfastly maintained an indominable morale, and carried on its activities, never once failing to hold its Annual Meeting—once, during the war when special Government permission had to be obtained. During these trying years, enrollment remained small, and membership turnover was rapid. Not until the Post-War period, has the Academy been able to hit its stride, and to enjoy rapid growth in numbers, interest, and prestige, reaching its present membership of about 320.

Value of the Academy to the State

In appraising the value of the Academy to the State, a distinction should be made between the activities of the organization as such, and the contributions of its members in their individual capacities. From its beginning, the organizaton has served to foster deep and endurng friendships among the active scientists of the State, acting as a powerful stimulus to their research and providing a forum for the helpful discussion of scientific problems. It has served in some

measure to bring science to the attention of the public; but perhaps its greatest service has been the development and maintenance of a high morale among its members, encouraging their simplicity to wonder, their zeal to investigate, under discouraging conditions, and their ambition to make known their own discoveries to their scientific colleagues, and to do their bit for the benefit of science and their fellowmen.

Obviously, in this brief account, it is impossible to catalog the contributions of the individual members of the Academy during the past half century. Even if that were possible, it would not truly represent their value; for like the germ plasm of life itself these contributions continue to live, grow, and multiply; because almost without exception early members were science teachers as well as investigators. There were very few scientists in the State who could devote their entire time to research. They were teachers who had been inspired by other great teachers—some the greatest in Europe and America—and they in turn were able to pass the "ever burning torch from hand to hand." Their "hand-picked" major students graduating from the State's institutions always have been brilliantly successful in advancing science and technology. Thus the "chain reactions" started by these members of the Academy through their inspiring teaching will continue enormously to multiply their own limited contributions to science as the years go by.

A Common Fallacy

Thoughtless critics often complain that because our brilliant young people leave the State after graduation, to seek their own careers, means a total loss to the taxpayers who have educated them. The implication is that this State could live in perfect isolation, and that only its own residents can contribute to its economy and culture. This fallacy should be obvious; for a pioneer agricultural State must of necessity import nearly all of its necessities and luxuries—even the very tools necessary to maintain its agriculture. These critics would be astonished if they but knew how many of the products used in their daily lives bear the "fingerprints" of these young people who have left the State after being trained by the members of the Acadmy of Science. A few examples may be cited.

Every time you get a clear telephone message, enjoy a sound movie, or a TV program, you are indebted to a North Dakota farm boy, who after graduation, left the State to go with "Big Business." His discoveries in Physics helped to improve telephone communication, and he cleverly put the sound track of the picture film so that sound and sight never can get out of step.

Another North Dakota farm boy walked to college and waited on tables to help earn his expenses. After graduating with high honors, he, too, left the State to seek his own fortune. He and his

associates in research invented the "modulater" that bears his name and makes possible the clear transmission of messages and music over long distance telephone wires and cables. His name is also associated with the "Walky-Talky," the "Ship-to-Shore," "Plane-to-Ground," and the "Pilot-to-Navigator" communications.

Another North Dakota graduate is now Executive Vice President of one of the largest companies manufacturing farm machinery and equipment, as well as heavy road-building machines. Their products are widely used in North Dakota. Still another is Director of Research and Development in a gigantic concern producing electric equipment, atomic driven engines for submarines, reactors for power production, railway equipment, and a great variety of household appliances. North Dakota men and women have contributed to the production of better paints and varnishes, useful plastics, new synthetic textile fibers, new soaps and detergents, miracle drugs, vitamins, cosmetics and perfumes. Others help to improve fertilizers, insecticides, plant hormones, and weed killers. These are only typical examples and a host of others could be cited. Have they been a total loss to North Dakota taxpayers? Perhaps they should have remained on the farm—to increase our agricultural surpluses.

Let us not forget that these creative minds were inspired and trained by the members of our Academy of Science. They represent every field of science and technology.

While we cannot review even the outstanding contributions of the present active members of the Academy, let us hope that the larger histories of the State will not overlook them; for we are gradually learning the hard way that it may be fully as important to record science as politics. References to individual accomplishments, therefore, must be limited to selected or typical examples relating to the early members. No attempt will be made to give complete biographies; for they can be found in such publications as "Who's Who In America," "Who's Who in Science," "American Men of Science," and similar Engineering records.

Some Contributions of Pioneer Members of the Academy

H. L. Bolley—one of the Founders of the Academy, Dean of Biology at the Agricultural College and State Seed Commissioner, contributed enormously to the early fame and fortune of the State. He wrote the North Dakota Pure Seed Laws and the Seed Certification Acts. But his greatest contributions were in the field of Plant Pathology. He discovered the parasitic origin of potato scab, and introduced the now world-wide use of corrosive sublimate in seed tuber disinfection. Likewise the use of formaldehyde in the disinfection of seed cereal grains. He traced the life cycle of the destructive black stem rust, and upon learning that the common Barbary served as winter host to the parasite, in 1916, he wrote the North

Dakota State Barbary Eradication Act, and was also active in promoting Nation-wide Barbary eradication. Later it was found that spores from the northern wheatfields find winter hosts in the wilds of Mexico, where they develop spring spores that return to the wheat carried by prevailing winds. He then abandoned Barbary destruction and turned to plant breeding in the hope of developing rust-resistant strains of wheat, and also wilt-resistant flax. Recognizing his work, the U. S. Department of Agriculture sent him as special investigator to the chief wheat and flax producing countries of Europe and Asia, to find strains that had survived under conditions of severe disease infection. This put him and his College on the World map. His investigations during the period from 1900 to 1928 made possible the commercial cropping of numerous varieties of rust-resistant wheat and wilt-resistant flax. A prolific publisher of Bulletins and other scientific papers, Professor Bolley was famous as a crusader for the maintenance of soil purity through proper seed breeding, seed selection, seed disinfection and crop rotation. He was also a pioneer in developing weed control by the use of chemical sprays and dusts. Thus his pioneer work and that of his brilliant successors have been of inestimable economic value to the State.

C. B. Waldron—one of the Founders, the first Vice President, and the second President of the Academy, had obtained his Ph.D. degree in Horticulture from the University of Michigan. He was one of the first four members of the faculty of the Agricultural College, a group afterward nicknamed the "Four Horsemen." Dr. Waldron was active in developing hardy varieties of trees and shrubs for farm shelterbelts. He demonstrated that apples and other fruits can be grown successfully in North Dakota. As an expert landscape gardener, he was called upon to lay out and landscape the grounds of the Agricultural College and those of most of the State's Educational, Penal, and Charitable Institutions, as well as historical sites and many of the city parks. Dr. Waldron was a member of the jury awards committee at the St. Louis World's Fair and chairman of that committee during the Exposition at Portland, Oregon. He also served as chairman of the Tri-State Grain and Stock Growers Association, and Head of the North Dakota Conservation Committee. He was active in fraternal and professional organizations and in the civic life of his community.

Edwin F. Ladd, another early member of the Academy, was a graduate of the University of Maine. He had worked at the New York Experiment Station before coming to North Dakota as Professor of Chemistry in the first faculty of the Agricultural College. He was a stocky man of tremendous energy and endurance. He soon became State Food Commissioner and in that capacity acquired national recognition for his cooperation with President Theodore Roose-

velt, and Dr. Harvey W. Wiley in the establishment and enforcement of the National Food and Drug Laws. Because North Dakota was almost exclusively a consumer State, it was easier to win test cases and establish legal precedents in North Dakota than in most other States. At first these fights were bitter, and Professor Ladd often remarked that he would not be able to sleep well without a 100,000 dollar libel suit hanging over his head. Many manufacturers of illegal foods and drugs saw to it that Ladd was able to get his sleep; but they soon learned through costly experience that they were fighting a losing battle; for Judge Amidon, of the Federal Court, gave Ladd his strong support. Professor Ladd then sought to correct other evils. He wrote the State Pure Paint Law and set up a chemical laboratory to enforce it. He wrote the specifications for petroleum products and the State Petroleum Inspection Law, designating ports of entry and providing for gravity, flash, and fire tests and for the complete analysis of samples in his Oil Testing Laboratory. In cooperation with the Paint Manufacturers Association, he set up elaborate paint durability tests, exposing panels painted with commercial paints to long exposure to weather. In his crusades, his chief weapons were his Bulletin through which he aroused public interest and support, and exposed violators, and his Regulatory Laboratories set up to support his police action in enforcing the laws. But his attempts to regulate the sale of patent medicines and to prevent the bleaching of flour met with unexpected strong resistance from the druggists and millers, respectively. Professor Ladd served a short term as President of the Agricultural College, before his election to the United States Senate.

A. Hoyt Taylor, trained at Wisconsin and Goettingen, Germany, came to the University of North Dakota as Professor of Physics, in September, 1909, soon after the charter meeting of the Academy, and his name was added to the list. Dr. Taylor was an enthusiastic pioneer in radio and is known as the "Father of Radar." With his own hands he built one of the earliest receiving sets. It occupied an entire large laboratory room in Science Hall arranged on large tables placed to form a giant U. This was before the invention of radio vacuum tubes. His detector was an ordinary sewing needle lying loosely across the sharpened edges of two parallel carbon plates. Later he used a small glass tube filled with powdered metallic silver, sealed at both ends and supplied with wire electrodes. A small cushioned mallot was used to jostle the silver particles. The induction coils were ten inches long and six inches in diameter, hand-wound with bell cord wire. The tuning condensers were huge, made of 18 inch sheet metal discs mounted on a central insulating hard rubber rod, the whole immersed in oil in a large glass doughnut jar. The tuning handle was a small garden spade handle. There were so many knife switches and other gadgets that Taylor himself was the only

person who could operate the set. Of course there was no loud speaker. Earphones were used. This set could not be called beautiful; but it worked. Contrast it with the modern trim little transistor sets you can carry in your pocket, and you have a striking illustration of the amazing progress made by science within the lifetime of the Academy. Taylor's transmitter used the sparks from a battery of Leyden jars, charged by a hand turned static machine. Of course his apparatus was a radio telegraph, not a telephone.

Dr. Taylor trained a group of teen-age boys within a radius of fifty miles of the University, to understand the Morse telegraph code and saw that they were provided with crystal receiving sets, then called "cat whiskers," and earphones. At definite times during the day he re-broadcast the time signals received from the powerful station at Arlington, Virginia, also the weather reports. Later one of those boys graduated in electrical engineering and built the University radio station KFJM.

At the beginning of World War I, Taylor was regularly picking up the code messages from Nauen, Germany. He invented a simple direction finder. It was an unpainted light wooden frame about the size of a door, wound with many turns of cotton-covered wire around the edges, the whole arranged to turn on a vertical axis. With this device he located ships on both oceans and in the Gulf of Mexico. At that time he was busy with the mathematical theories of radar waves, and planned to send a radar message to the moon as soon as a sufficiently powerful apparatus could be developed. Later at the U. S. Naval Research Laboratory at Washington, he had the satisfaction of assisting in the successful detection of the radio echo from the moon.

His publications on the mathematical theories of the radar waves are credited with making possible the invention of the altimeters used by the British night flyers in the "Battle of Britain." Later, during World War II, Dr. Taylor was cited by the President for conspicuous service to the Government through the development of Radar. Had he remained in North Dakota and received the recognition he should have received, this State might well have had the first commercial Radio Station in America.

Earl J. Babcock, a graduate of the University of Minnesota, came to the University as instructor in Chemistry in 1889, a year before North Dakota became a State. The University, then a Territorial institution, was only six years old. In 1891 he was made Professor of Chemistry and Geology, and in 1909 he became Dean of the School of Mines, a position which he continued to hold until his death. After the resignation of President Kane, and before the appointment of President West, he served a few months as acting President of the University.

He was a man of great physical energy and endurance, ambitious to develop the latent resources of a pioneer State, especially its lignite and clays. He established a brick factory at Hebron and many of the most beautiful buildings in the State are built or trimmed with Hebron brick. The remains of his early Cement mill are still to be seen near the village of Concrete. Cement was made in simple vertical kilns out of the local deposits of carboniferous shales. But the plant could not compete with the high grade Portland cement invading the State. At the University, he established the Ceramics Department which continues to demonstrate the high quality and artistic beauty of articles made from North Dakota's native clays. But his name is most closely associated with Dakota lignite. He worked tirelessly to improve its usefulness as a domestic and industrial fuel.

A commercial briquetting plant was built at Hebron and he carried on extensive research in the effort to find a suitable economical binder for these briquettes. He worked for many years in the closest cooperation with Dr. Fieldner, Director of the U. S. Bureau of Mines. After the death of Dean Babcock, his successor, Dean of Engineering L. C. Harrington continued the research on lignite and the close cooperation with the Government. A commercial unit pilot plant was built on the campus for the production of commercial hydrogen and "synthetic gas" from Dakota lignite. The long years of close cooperation with Dr. Fieldner culminated in the establishment of the modern Lignite Research Laboratory by the Bureau of Mines, adjacent to the University campus.

J. H. Shepperd, a graduate of Iowa State Agricultural College, had pursued graduate work at Wisconsin and Minnesota before coming to the Agricultural College in 1893 as Professor of Agriculture and Agriculturist in the Experiment Station. The service of Dr. Shepperd to North Dakota has been unusual. His work with plants, animals, and human organizations has been such as to win international recognition. His study of plants has given the State new varieties of grains, improved methods of tillage, and increased yields per acre. The livestock he developed and bred have been international champions, while the organizations he founded have abundantly demonstrated what can be done through cooperation. He was awarded a gold medal at the Paris World Exposition for his outstanding work in plant breeding. But livestock breeding through proper selection was Dr. Shepperd's greatest interest and in this he was conspicuously successful; for sheep and cattle bred on the college farm frequently won national and international grand championships. He was instrumental in organizing and fostering the famous New Salem Holstein Breeding Circuit, which in twenty-one years had become one of the leading Holstein centers in the United States.

To continue his studies of agriculture, and especially livestock,

Dr. Shepperd, accompanied by Mrs. Shepperd, made a round-the-world tour in 1925 spending months in England, Scotland, Denmark, and other European and Asiatic countries and gaining much first hand information of value. As Vice President for seven months he demonstrated his capable and far-seeing administrative ability and his appointment to the Presidency of the Agricultural College was inevitable. He was a most wholesome, genial and likeable man. Mrs. Shepperd was active in club work, a member of D.A.R. and Secretary of the State Women's Federation for many years. She was also an expert chemist and was associated with Dr. Ladd in the organization of his Pure Food Laboratory for twenty years.

Arthur G. Leonard, with A.B. and A.M. degrees from Oberlin and Ph.D. from Johns Hopkins, had taught Geology in Iowa and Missouri before coming to the University of North Dakota in 1903 as Professor of Geology and State Geologist. He was very active in his study of the geological formations of the region, especially with a view to their economic value. He recognized the great potential of the lignite and clays of the State and was able to map their approximate quantities and location. He was in close cooperation with the U. S. Geological Survey and a frequent contributor to its publications. In 1905-07 he served as Field Assistant to the U. S. Geological Survey, mapping the coal fields of North Dakota and Montana. He studied the occurrence of a humic acid material associated with lignite beds, and now called "Leonardite" in recognition of his work. He was naturally conservative about the possible occurrence of petroleum in North Dakota; for at that time the technique of very deep drilling had not been developed and Geologists were not aware of the existence of potential oil bearing rocks at great depths.

Howard E. Simpson, a graduate of Cornell College (Iowa), with a Master's degree from Harvard had served as instructor in Geology at Colby before coming to the University of North Dakota as Associate Professor of Geology. He was associated with Dr. Leonard and was soon promoted to Professor of Geology and Geography and Assistant State Geologist. Upon the death of Dr. Leonard, he became his successor as State Geologist and Field Assistant with the U. S. Geological Survey. He was also Special Weather Observer with the U. S. Weather Bureau.

Dr. Simpson's name is famous for his brilliant study of North Dakota's ground waters, lake levels, and the variations in the depth of the water table. He organized the well drillers of the State and from them obtained much of his knowledge of the ground waters. He gave special attention to the study of the artesian waters from the "Dakota Sandstone Artesian Basin" which is one of the most extensive artesian basins in the world. Alarmed at the rapid lowering of pressures and water levels in these wells he succeeded in get-

ting the Legislature to pass a Law forbidding owners to permit wells to run wild. He as State Geologist was required to enforce the law. But instead of becoming a "police officer" he tactfully aroused the interest of the public and obtained the voluntary cooperation necessary to conserve the water.

Later through Government relief set-ups, he sponsored a State-wide Survey of the Ground Waters, including a Fluoride Survey, which was carried out soon after his death by his successor, Frank Foley. When the National Resources Board appointed prominent Geologists to prepare a report on the Water Resources of America for the information of the President, Dr. Simpson was assigned the entire Mississippi Drainage Basin, and when the geologists assembled in Washington to draft the report, he was appointed to edit the entire report. He had an uncanny way of locating pre-glacial river and and stream beds, and from them obtaining satisfactory water supplies.

Academy Members Who Left the State

Many of the early members migrated from the State. Prominent among them was Dr. M. A. Brannon, one of the Founders and the first President of the Academy, who as previously stated became successively President of the University of Idaho and Chancellor of the Higher Institutions of Montana; but not before he had organized the School of Medicine of the University and served as Dean of the College of Science, Literature, and Arts and Professor of Biology. He was instrumental in establishing the State Biological Station at Devils Lake, which served as a miniature "Wood's Hole" for the students and biologists who studied there the flora and fauna of the region during the summer. The attempts to restore game fish to Devils Lake failed, but not for the reasons assumed by Dr. Brannon and his successor, Dr. Young. Daniel E. Willard, one of the Founders, was a pioneer in the study of the Geology of the State and of its soils. He is best remembered for the delightful, readable book: "The Story of the Prairie," which describes the features of the region and tells what they mean. His chapter on "Geology from the Car Window," means a railroad coach and not the automobile. His book was still popular twenty years after its first publication and at one time was required reading for high school students. He left to become Development Agent of the N. P. Railway. Lynn McMullen, Founder and first Secretary, soon left the State for graduate study at Columbia, taught in a number of States and finally served as President of the Eastern Montana State Teachers College until his retirement. He is the only other survivor of the Founders of the Academy besides the writer. Many others now distinguished in other States were former members of the North Dakota Academy.

Publication of the Proceedings

A new era began with the publication of the Academy Pro-

ceedings. In 1947, this became possible through the modest grants from the University and the Agricultural College. It enabled North Dakota to "save face" with other States in the exchange of publications and gave a new stimulus to the authors of papers. A Committee on Publications was appointed to edit the contents and supervise the publication and distribution of the Proceedings. This has resulted in a steady improvement in the quality of papers submitted, both in content and literary form. At once requests for some of the papers came from foreign countries, as well as from individuals and institutions in this country. Distribution and exchange of the Proceedings is now made through institutional libraries.

Student Participation in the Programs

With more liberal provisions for graduate students and research assistants, joint authorship of scientific papers with students has become more common. But a great stimulus to student participation in Academy programs began in 1953, made possible by the personal generosity of Mr. A. Rodger Dennison, Vice President of the Amerado Petroleum Corporation. He offers substantial cash prizes for the best papers presented by students on the programs of the Annual Meetings as determined by a competent board of judges and in addition generously defrays the expense of publishing student papers.

Junior Academies and High School Science Fairs

Many State Academies sponsor Junior Academies. The North Dakota Academy considered the matter; but at that time conditions seemed unfavorable for the establishment of a Junior Academy. The members voted against it, without prejudice, for they favored encouraging young people to become actively interested in science. Mr. Julien Rolzinski, teacher of Biology in the Junior College of Devils Lake, a member of the Academy, was a very energetic advocate of a Junior Academy. Failing in that attempt, he immediately set about the organization of State-wide annual High School Science Fairs, at which students compete for prizes for their exhibits featuring their intensive study of some carefully selected scientific project. These Fairs have been very successful not only in arousing student interest, but also that of the local communities who give them financial support. J. Donald Henderson, Associate Professor of Physics at the University and then Secretary of the Academy, gave Rolzinski his personal encouragement and cooperation but strongly insisted that these Fairs be sponsored and conducted by local communities rather than through State institutions or organizations. This plan has been very satisfactory and has stimulated much public interest in science.

Establishment of Scholarships

The North Dakota Academy of Science is cooperating with the North Dakota Society of Professional Engineers in the establishment

of Scholarships. They have established an incorporated group, North Dakota Foundation for Science and Engineering Scholarships, composed of representatives of the two organizations, empowered to legally solicit and collect funds for the establishment of scholarships in science and engineering in the higher institutions of the State. Through the cooperation of faculty members, the national standard examinations are given to High School seniors and the available scholarships are offered to students making the highest grades. The recipient is free to select either science or engineering and to enter any institution of his choice in the State. It is hoped that growing public interest and support may make it possible for increasing numbers of young people to become scientists and engineers, who otherwise might not be able to go to college.

Cooperation with the Red River Valley Section of the American Chemical Society and with Sigma Xi

Since receiving its charter in 1949, the Red River Valley Section of ACS has attended the Annual Dinners of the Academy, participating in the program and assisting substantially in securing guest speakers. The large overlapping membership of the two organizations insures the closest cooperation and fellowship. The same may be said of the Sigma Xi Chapter at the University and the Sigma Xi Club at the Agricultural College. They act as local hosts and sponsors of the Academy Dinners at their respective institutions, contributing also to the common expense.

The Need for Legal recognition of the Academy by the State

In the light of its half-century of brilliant performance and the enormous contributions of its members to the wealth and prestige of this commonwealth, it seems time that the State confer upon the Academy its recognition and legal status as the official North Dakota Academy of Science. Such recognition long has been given to the State Historical Society and it would seem that creative science upon which our very lives and the future of the State depend should be deemed equally worthy of official recognition.

A Glance at the Future in the Light of the Past

Within the life span of this Academy, the physical world, literally has been recreated. It is now a smaller world. We fly around it; we talk around it; we can even see around it; yet in another sense it is now a much larger world; for we know vastly more about it. This new world is the magnificent gift of science to humanity; for all that is strictly modern in the physical world is the contribution of science. We recognize it as the outstanding achievement of the race, and the most imposing monument to human reason.

But what of the future? Today the world presents the spectacle of a striking paradox. Through science man has now acquired the

intellectual stature of a god. He is literally Superman; but alas, with every new advance the gulf between the creative scientist and the masses grows ever wider and deeper. Herein lies the great danger to free society. One thing should be clear. If free nations are to survive, their citizens no longer can remain indifferent to science. It is not enough to train more technicians, or even to educate more scientists and engineers. We must make science an integral part of our modern culture. We must develop an intelligent thinking citizenry not easily stampeded by a few Sputniks or flying saucers—citizens able to apply the orderly methods of science to their individual and social thinking and acting—for science will continue to impose upon society its most baffling problems. A citizenry sensitive to the inspirational appeal of science and able to understand the part that we ourselves can play in shaping our own future, now that evolution is becoming more and more consciously directed by man. This is the great challenge of the future as the Academy faces the next fifty years.

PAST OFFICERS
NORTH DAKOTA ACADEMY OF SCIENCE

1908 Valley City. Organizing Committee, M. A. Brannon, Chairman.

Year	Place	President	Vice President	Sec'y-Treas.
1909	Univ.	M. A. Brannon	C. B. Waldron	Lynn B. McMullen
1910	A. C.	M. A. Brannon	C. B. Waldron	Lynn B. McMullen
1911	Univ.	C. B. Waldron	L. B. McMullen	G. A. Abbott
1912	A. C.	L. B. McMullen	H. F. Bergman	G. A. Abbott
1913	Univ.	Louis VanEs	A. G. Leonard	G. A. Abbott
1914	A. C.	A. G. Leonard	W. B. Bell	G. A. Abbott
1915	Univ.	W. B. Bell	Miss Lura Perrine	G. A. Abbott
1916	A. C.	Miss Lura Perrine	A. H. Taylor	G. A. Abbott
1917	Univ.	A. H. Taylor	R. C. Doneghue	G. A. Abbott
1918	A. C.	R. C. Doneghue	H. E. French	G. A. Abbott
1919	Univ.	H. E. French	J. W. Ince	G. A. Abbott
1920	A. C.	J. W. Ince	B. J. Spence	G. A. Abbott
1921	Univ.	L. R. Waldron	Daniel Freeman	G. A. Abbott
1922	A. C.	Daniel Freeman	Norma Pfeifer	G. A. Abbott
1923	Univ.	Norma Preifer	O. A. Stevens	G. A. Abbott
1924	A. C.	O. A. Stevens	David R. Jenkins	G. A. Abbott
1925	Univ.	David R. Jenkins	E. S. Reynolds	G. A. Abbott
1926	A. C.	E. S. Reynolds	J. G. Sinclair	G. A. Abbott
1927	Univ.	Karl H. Fussler	H. L. Walster	G. A. Abbott
1928	A. C.	H. L. Walster	G. A. Talbert	G. A. Abbott
1929	Univ.	G. A. Talbert	R. M. Dolve	G. A. Abbott
1930	A. C.	R. M. Dolve	H. E. Simpson	G. A. Abbott
1931	Univ.	H. E. Simpson	A. D. Wheedon	G. A. Abbott
1932	A. C.	A. D. Wheedon	G. C. Wheeler	G. A. Abbott
1933	Univ.	G. C. Wheeler	C. I. Nelson	G. A. Abbott
1934	A. C.	C. I. Nelson	E. A. Baird	G. A. Abbott
1935	Univ.	E. A. Baird	L. R. Waldron	G. A. Abbott
1936	A. C.	L. R. Waldron	J. L. Hundley	G. A. Abbott
1937	Univ.	J. L. Hundley	P. J. Olson	G. A. Abbott
1938	A. C.	P. J. Olson (Resigned)	E. D. Coon (Acting Pres.)	G. A. Abbott
1939	Univ.	E. D. Coon	J. R. Dice	G. A. Abbott
1940	A. C.	J. R. Dice	F. C. Foley	G. A. Abbott
1941	Univ.	F. C. Foley	F. W. Christensen	G. A. Abbott
1942	A. C.	F. W. Christensen	Neal Weber	G. A. Abbott
1943	Univ.	Neal Weber	E. A. Helgeson	G. A. Abbott
1944	A. C.	E. A. Helgeson	W. H. Moran	G. A. Abbott
1945	Univ.	W. H. Moran	J. H. Longwell	G. A. Abbott
1946	A. C.	J. H. Longwell	A. M. Cooley	G. A. Abbott
1947	Univ.	A. M. Cooley	R. H. Harris	G. A. Abbott
1948	A. C.	R. H. Harris	R. B. Witmer	G. A. Abbott
1949	Univ.	R. B. Witmer	R. E. Dunbar	G. A. Abbott
1950	A. C.	R. E. Dunbar	A. K. Saiki	G. A. Abbott
1951	Univ.	A. K. Saiki	Glenn Smith	J. Don. Henderson
1952	A. C.	Glenn Smith	Wilson Laird	J. Don. Henderson
1953	Univ.	Wilson Laird	C. O. Clagett	J. Don. Henderson
1954	A. C.	C. O. Clagett	G. A. Abbott	J. Don. Henderson
1955	Univ.	G. A. Abbott	H. B. Hart	J. Don. Henderson
1956	James-town	H. B. Hart	W. E. Cornatzer	J. Don. Henderson
1957	Univ.	W. E. Cornatzer	Warren Whitman (President Elect)	B. G. Gustafson