

PROCEEDINGS
of the
NORTH DAKOTA
ACADEMY OF SCIENCE

Founded December, 1908

VOLUME X
1956

PUBLICATION COMMITTEE

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*

July, 1956
GRAND FORKS, NORTH DAKOTA

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OFFICERS

President W. E. Cornatzer, University
President-Elect Warren Whitman, NDAC
Secretary-Treasurer - Ben G. Gustafson, University
Historian - - - - G. A. Abbott, University
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Harry B. Hart, Ex-officio, Jamestown College
William L. Downing, Jamestown College
John C. Thompson, Teacher's College, Dickinson

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NORTH DAKOTA ACADEMY OF SCIENCE

ACTIVE MEMBERS

- Abbott, G. A. (Chemistry), University, Charter Member. 1908.
 Aho, Donald T. (Conservation), U. S. Soil Conservation Service, Bismarck. 1954.
 Anderegg, L. T. (Chemistry), Agricultural College. 1955.
 Anderson, Robert N. (Agronomy), Agricultural College. 1954.
 Anderson, Sidney B. (Geology), North Dakota Geological Survey. 1953.
 Arnason, A. F. (Forestry), Commissioner, State Board of Higher Education, Bismarck. 1939.
 Aulesbrook, Kenneth A. (Physiology), Agricultural College. 1955.
 Bale, Harold D. (Physics), University. 1954.
 Banasik, Orville J. (Cereal Chemistry), Agricultural College. 1954.
 Bauer, Armand (Soils), Agricultural College. 1955.
 Bell, Gordon L. (Geology), University. 1954.
 Bitzen, Edward F. (Chemistry), U. S. Bureau of Mines. 1952.
 Bliss, Harold N. (Ornithology), Grafton. 1951.
 Bo, Walter J. (Anatomy), University. 1954.
 Bolin, Donald W. (Biochemistry), Agricultural College. 1946.
 Eolin, F. M. (Veterinary Science), Agricultural College. 1948.
 Bosch, Wouter. (Chemistry), Agricultural College. 1948.
 Bosch, Mrs. Wouter. (Chemistry), Agricultural College. 1949.
 Bothun, Robert E. (Plant Genetics), Agricultural College. 1954.
 Brezden, William. (Chemistry), State Mill and Elevator, Grand Forks. 1945.
 Briggie, Leland W. (Agronomy), Agricultural College. 1950.
 Broberg, Joel W. (Chemistry), Agricultural College. 1948.
 Brody, Harold. (Anatomy), University. 1954.
 Brown, Leonard W. (Chemistry), Armour and Company, Fargo. 1952.
 Bryant, Reece L. (Poultry Genetics), Agricultural College. 1948.
 Buchanan, M. L. (Animal Husbandry), Agricultural College. 1950.
 Buegel, Hermann F. (Psychology), University. 1955.
 Burr, Alex C. (Chemical Engineering), N. D. Research Foundation, Bismarck, 1940.
 Callenbach, John A. (Entomology), Agricultural College. 1954.
 Cary, James D. (Pathology), University. 1950.
 Carter, Jack F. (Agronomy), Agricultural College. 1950.
 Cassel, J. Frank. (Vertebrate Ecology), Agricultural College. 1954.
 Challey, John R. (Vertebrate Ecology), Agricultural College. 1954.
 Christoferson, Lee A. (Neurological Surgery), Fargo. 1952.
 Clagett, Carl O. (Biochemistry), Agricultural College. 1949.
 Comita, Gabriel W. (Zoology), Agricultural College. 1954.
 Conlon, Thomas J. (Agronomy), Dickinson. 1950.
 Cooley, A. M. (Chemical Engineering), University. 1938.
 Coon, Ernest D. (Chemistry), University. 1923.
 Corbus, Jr., Budd C. (Urological Surgery), Fargo. 1952.
 Cornatzer, William E. (Biochemistry), University. 1952.
 Davis, Mildred L. (Nutrition), University. 1951.
 DeBoer, Benjamin (Pharmacology), University. 1952.
 Dillard, J. R. (Gynecology), Fargo. 1954.
 Dinusson, William E. (Animal Nutrition), Agricultural College. 1950.
 Dixon, John D. (Electrical Engineering), University. 1955.
 Donat, Theodore L. (Medicine), Fargo. 1954.
 Doubly, Mrs. Elma K. (Bacteriology), Agricultural College. 1950.
 Doubly, John A. (Bacteriology), Agricultural College. 1950.
 Douglas, Raymond J. (Animal Husbandry), Agricultural College. 1950.
 Downing, William L. (Biology), Jamestown College. 1952.
 Dunbar, Ralph E. (Chemistry), Agricultural College. 1938.
 Ebeltoft, David (Plant Breeding), Agricultural College. 1955.
 Ederstrom, Helge E. (Physiology), University. 1953.
 Erickson, Roland I. (Mining), University. 1953.
 Estensen, Ernest V. (Psychology), Agricultural College. 1951.
 Eveleth, D. F. (Veterinary Science), Agricultural College. 1944.
 Facey, Vera (Botany), University. 1948.
 Ferris, Leslie M. (Chemistry), Agricultural College. 1954.
 Fischer, Robert G. (Bacteriology), University. 1948.
 Fleetwood, Charles W. (Chemistry), Agricultural College. 1948.
 Flor, Harold H. (Plant Pathology), Agricultural College. 1943.
 Folsom, Clarence B. (Petroleum Engineering), University. 1954.
 Fordyce, Ira V. (Chemistry), Am. Crysl. Sg. Co., East Grand Forks, Minn.
 Forster, Theodore L. (Dairy Technology), Agricultural College. 1950.
 Fox, Adrian C. (Conservation), Soil Conservation Service, Bismarck. 1954.
 Frank, Richard E. (Chemistry), University. 1949.
 Fredrickson, Ronald L. (Chemistry), Abbott Laboratories, North Chicago, Ill. 1951.
 Freeman, Andrew L. (Electrical Engineering), Grand Forks. 1955.
 French, Harley E. (Anatomy), Dean Emeritus, University. 1911.
 Fromm, Herbert J. (Biochemistry), University. 1955.

- Gault, Alta R. (Physiology), University. 1949.
- Geiszler, Gustav N. (Agronomy), Agricultural Experiment Station, Minot. 1950.
- Giles, Ray (Petroleum Chemistry), Standard Oil Co., Mandan. 1954.
- Graham, Charles M. (Internal Medicine), Grand Forks. 1951.
- Grimes, Ruby (Mathematics), Agricultural College. 1946.
- Gustafson, A. A. (Bacteriology), Public Health Lab., University. 1950.
- Gustafson, Ben G. (Chemistry), University. 1939.
- Hamre, Christopher J. (Anatomy), University. 1950.
- Hanson, Dan E. (Geology), University. 1954.
- Hansen, Miller. (Geology), N. D. Geological Survey. 1952.
- Haraldson, Harold C., (Geology), University. 1952.
- Harris, Rae H. (Agricultural Biochemistry), Agricultural College. 1938.
- Hart, Harry B. (Chemistry), Jamestown College. 1929.
- Harwood, Theodore H. (Internal Medicine), University. 1954.
- Haugen, Kenneth (Geology), University. 1954.
- Hauz, Edgar A. (Internal Medicine), Grand Forks. 1951.
- Hazen, Arlon (Agricultural Engineering), Agricultural College. 1950.
- Heermann, Ruben M. (Agronomy), U. S. Dept. of Agriculture, Fargo. 1950.
- Helgeson, E. A. (Botany), Agricultural College. 1936.
- Henderson, J. Donald (Physics), University. 1945.
- Higgins, Edith C. (State Seed Department), Agricultural College. 1950.
- Hill, A. Glenn (Mathematics), Agricultural College. 1946.
- Hoepfner, Jerome J. (Chemistry), Bureau of Mines, University. 1949.
- Hoffman, Glenn L. (Parasitology), University. 1951.
- Holm, Glenn C. (Veterinary Science), Agricultural College. 1950.
- Holmes, Richard R. (Chemistry), University. 1953.
- Horner, Oscar (Vertebrate Ecology), Agricultural College. 1954.
- Hoyman, William G. (Phytopathology), Agricultural College. 1950.
- Hultz, Fred S. (Agriculture), President, Agricultural College. 1950.
- Hundley, John L. ((Physics), University. 1930.
- Jacobs, Francis A. (Biochemistry), University. 1955.
- Jensen, C. (Dairy Husbandry), Agricultural College. 1927.
- Kaufman, Victor (Physics), University. 1951.
- Keefer, Daryle E. (Psychology), University. 1953.
- Keith, Eaden F., Jr. (Pharmacology), University. 1953.
- Kingsley, Allan F. (Agricultural Chemistry), Agricultural College. 1950.
- Kjersstad, C. L. (Philosophy and Psychology), University. 1937.
- Klosterman, Harold J. (Agricultural Chemistry), Agricultural College. 1948.
- Knudson, Walter L. (Biology), School of Forestry, Bottineau. 1950.
- Kohanowski, Nicholas (Geology), University. 1949.
- Koons, Melvin E. (Bacteriology), Public Health Lab., University. 1943.
- Koth, Arthur W. (Metallurgy), University. 1939.
- Krong, Norman L. (Psychology), Agricultural College. 1955.
- Kruschwitz, Earl H. (Physics), Valley City. 1947.
- Kube, Wayne R. (Chemical Engineering), Bureau of Mines, University. 1949.
- Laird, Wilson M. (Geology), University. 1941.
- Langford, Larkin H. (Animal Husbandry), Agricultural College. 1950.
- Larson, Edith E. (Biology), University. 1947.
- Lawson, Edward C. (Mechanical Engineering), University. 1955.
- Lebsock, Kenneth L. (Agronomy), Agricultural College. 1954.
- Lium, Elder L. (Civil Engineering), University. 1953.
- Loomis, Fred H. (Cereal Chemistry), Loomis Laboratories, Grand Forks. 1947.
- Lundy, John S. (Anesthesiology), Mayo Clinic, Rochester, Minn. 1940.
- Luper, Miltza (Medical Technology), Deaconess Hospital, Grand Forks. 1951.
- McCauley, Howard W. (Civil Engineering), Agricultural College. 1954.
- McMillan, William W. (Chemistry), N. D. Research Foundation, Fordville. 1947.
- MacDonald, John H. (Biology), Teachers College, Dickinson. 1951.
- McClelland, John E. (Soils), Agricultural College. 1955.
- McMurtrie, Robert (Chemical Engineering), Bureau of Mines. 1955.
- Magnusson, Adelynn M. (Chemistry), University. 1951.
- Manz, Oscar E. (Ceramic Engineering), University. 1953.
- Marwin, Richard M. (Bacteriology), University. 1949.
- Mason, Harry. (Physics), Jamestown College. 1951.
- Miller, Clifton E. (Pharmaceutical Chemistry), Agricultural College. 1947.
- Minnear, F. L. (Chemistry), Agricultural College. 1954.
- Mohlberg, Joyce. (Vertebrate Morphology), 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, Walter H. (Chemistry), University. 1931.
- Moreng, Robert E. (Poultry Physiology), Agricultural College. 1955.
- Murphy, H. E. (Chemistry), Teachers College, Dickinson. 1940.
- Nelson, Edward O. (Mathematics), University. 1955.
- Norum, E. B. (Soils), Agricultural College. 1948.
- Nungessor, William C. (Physiology), University. 1954.
- Oakey, John A. (Civil Engineering), Agricultural College. 1954.
- Oehler, Mrs. Alma. (Nutrition), State Mill and Elevator, Grand Forks. 1945.
- Olson, Ordell P. (Agronomy), Agricultural College. 1955.

- Oppelt, Walter H. (Fuels), Bureau of Mines, University. 1949.
 Overbo, Gerhard O. (Physics), Teachers College, Valley City. 1947.
 Owens, Paul R. (Floriculture), Owens Floral Co., Grand Forks. 1945.
 Peterson, Harvey J. (Veterinary Medicine), Grand Forks. 1954.
 Peterson, Charles B. (Surgery), Grand Forks. 1951.
 Porter, Charles B. (Surgery), Grand Forks. 1951.
 Posin, Daniel Q. (Physics), Agricultural College. 1948.
 Potter, Loren. (Botany), Agricultural College. 1948.
 Randall, Robert N. (Wildlife Management), U. S. Fish and Wildlife Service, Bismarck. 1954.
 Redmond, Charles E. (Soils), Agricultural College. 1955.
 Reid, Russell (Natural Science), State Museum, Bismarck. 1940.
 Richards, Stephen H. (Wildlife Management), Agricultural College. 1954.
 Riedesel, Mildred (Home Economics), University. 1955.
 Riley, Kenneth W. (Chemistry), Marietta, Ohio. 1936.
 Robinson, Hugh M. (Botany), Teachers College, Valley City. 1948.
 Robinson, Roy N. (Physics), Public Schools, Minot. 1951.
 Roglnie, Philip A. (Mathematics), University. 1946.
 Rolzinski, Julian J. (Biology), Junior College, Devils Lake. 1950.
 Saiki, Arthur K. (Pathology), University. 1949.
 Sandal, Paul C. (Plant Breeding), Agricultural College. 1955.
 Sands, F. H. (Chemistry), Agricultural College. 1946.
 Saugstad, Stanley. (Entomology), Minot. 1939.
 Schmitz, Emmett R. (Geology), University. 1954.
 Scott, George M. (Cereal Chemistry), Agricultural College. 1952.
 Sebens, William P. (Agriculture), Greater North Dakota Association, Fargo. 1948.
 Severson, Donald E. (Chemical Engineering), University. 1949.
 Shoesmith, Lloyd (Soils), Agricultural College. 1950.
 Shrader, Ruth. (Anatomy), University. 1951.
 Shumard, Raymond F. (Parasitology), Agricultural College. 1954.
 Sibbitt, L. D. (Cereal Technology), Agricultural College. 1946.
 Simonson, Gerald H. (Soils), Agricultural College. 1955.
 Sleeper, Bayard P. (Bacteriology), Agricultural College. 1952.
 Smith, Glenn S. (Plant Breeding), Agricultural College. 1930.
 Snook, Theodore. (Anatomy), University. 1954.
 Spier, Jack J. (Pathology), St. John's Hospital, Fargo. 1952.
 Staley, Raymond C. (Mathematics), University. 1946.
 Stallings, H. Dean. (Library), Agricultural College. 1951.
 Starcher, George W. (Mathematics), President, University. 1954.
 Stevens, O. A. (Botany), Agricultural College. 1910.
 Stewart, Donald L. (Chemistry), Am. Cryst. Sg. Co., E. Grand Forks, Minn., 1943.
 Stoa, Theodore E. (Agronomy), Agricultural College. 1950.
 Stockdale, Thomas E. (Petroleum Refining), Standard Oil Co., Mandan. 1954.
 Sudro, W. F. (Pharmacy), Agricultural College. 1911.
 Sullivan, John W. (Biochemistry), Agricultural College. 1954.
 Summers, Lawrence. (Chemistry), University. 1951.
 Svore, Jerome H. (Sanitary Engineering), State Health Dept., Bismarck. 1943.
 Thompson, John C. (Mathematics), Teachers College, Dickinson. 1948.
 Timian, Roland G. (Plant Pathology), Agricultural College. 1954.
 Towse, Donald F. (Geology), Dickson. 1952.
 Traverse, Alfred. (Plant Paleontology), U. S. Bureau of Mines. 1952.
 Treumann, William B. (Chemistry), Fargo. 1946.
 Tsumagari, Yukio. (Pathology), University. 1951.
 Turelle, Joseph W. (Agronomy), U. S. Soil Conservation Service, Bismarck. 1954.
 Van Heuvelen, W. (Chemistry), State Health Dept., Bismarck. 1945.
 Vergeer, Teunis. (Physiology), University. 1954.
 Walster, H. L., (Director of Experiment Station), Agricultural College. 1920.
 Watkins, John B. (Veterinary Medicine), Grand Forks. 1954.
 Weers, Walter A. (Civil Engineering), Agricultural College. 1954.
 Welte, Arden F. (Biology), Grafton. 1954.
 Wendland, Ray T. (Chemistry), Agricultural College. 1948.
 Whalin, Edwin A. (Physics), University. 1955.
 Wheden, Arthur D. (Zoology), Danbury, Connecticut. 1924.
 Wheeler, George C. (Biology), University. 1924.
 Whitman, Warren. (Botany), Agricultural College. 1950.
 Wiidakas, William. (Agronomy), Agricultural College. 1946.
 Wills, Bernt L. (Geography), University. 1949.
 Witmer, Robert B. (Physics), University. 1925.
 Young, Ralph A. (Agronomy), Agricultural College. 1954.
 Zubriski, J. C. (Soil Physics), Agricultural College. 1955.

MEMBERS ELECTED IN 1956

- Bieber, Loran L. (Biochemistry), Agricultural College. 1955.
 Bradley, Robert. (Civil Engineering), Highway Dept., Bismarck. 1955.
 Busch, George. (H. S. Science), Rugby. 1955.
 Denison, A. Rodger. (Petroleum Geology), Amerada Corp., Tulsa. 1955.
 Edgerly, Charles G. M. (Dairy Husbandry), Agricultural College. 1955.
 Gajmerac, Walter L. (Entomology), Agricultural College. 1955.

- Holland, Neal S. (Horticulture), Agricultural College. 1955.
Johansen, Robert H. (Horticulture), Agricultural College. 1955.
Kirby, Joseph. (Civil Engineering), Highway Dept., Bismarck. 1955.
Lindseth, Joseph M. (Agriculture), Teachers College, Dickinson. 1955.
Lockhart, William. (Poultry Nutrition), Agricultural College. 1955.
Miller, Wilford. (Biology), State Game & Fish Dept., Bismarck. 1955.
O'Reilly, Edward J. (Chemistry), University. 1955.
Peterson, Norman C. (Chemistry), Agricultural College. 1955.
Rathman, Franz H. (Chemistry), Agricultural College. 1955.
Schnell, Richard D. (Vertebrate Anatomy), Agricultural College. 1955.
Vick, James A. (Physiology), University. 1955.
Youngs, Vernon. (Chemistry), School of Forestry. 1955.

NORTH DAKOTA ACADEMY OF SCIENCE

Minutes of the Forty-Eighth Annual Meeting

FRIDAY, MAY 4, 1956

President Harry B. Hart called the meeting to order at 9:03 a.m. with 22 members present in Room 27 of Or lady Hall on the Campus of Jamestown College. After brief introductory remarks by the president the nine papers listed on the morning program were read and discussed.

At 11:32 a.m. the first business session was called to order. Dr. W. E. Cornatzer reported for the committee on revision of the constitution. Other members of his committee were Dr. W. M. Laird and Dr. G. C. Wheeler. The report recommended that our constitution be revised to include the following articles and by-laws. Each section was voted on separately and each passed unanimously.

ARTICLE II—Membership

Section III. Sustaining members may be elected in the same manner as active members. Sustaining members may be of two types, individual or corporate.

ARTICLE III—Officers

Section I. The officers of the Academy of Science shall be a President, President-Elect, and Secretary-Treasurer who shall perform the duties usually pertaining to these offices. The officers shall be chosen by ballot at the Annual Meeting and shall hold office for one year, or until their successors are duly elected. They shall take office at the close of the Annual Meeting. In the event of a vacancy in the presidency, the President-Elect shall automatically assume the duties of that office.

Section II. The Executive Committee, consisting of the above named officers the Retiring President and two other members elected for one year, shall have charge of the ordinary executive duties such as the preparation of programs, selection of meeting place, and arrangement of details of the meeting.

BY-LAWS OF THE NORTH DAKOTA ACADEMY OF SCIENCE

8. The annual dues of the Academy: Active member — \$2.00.

Sustaining member (individual—\$10.00) (corporate—\$25.00).

The nominating committee composed of Prof. Harry Mason, chairman; Dr. C. J. Hamre, Dr. R. E. Dunbar, Mr. Roy Robinson, and Prof. John H. MacDonald presented their report which included Dr. Richard Frank as a candidate for secretary-treasurer. Because of

other duties Dr. Frank asked that his name be withdrawn and Prof. Ben G. Gustafson was nominated from the floor. With this change the slate of candidates presented was as follows:

President	W. E. Cornatzer*
	J. Frank Cassel
President-Elect	Warren Whitman*
	Cyril Moore
Secretary-Treasurer	Harald Bliss
	Ben G. Gustafson*
Historian	G. A. Abbott*
Executive Committee	William Downing*
	John Thompson*
	Earl Kruschwitz

Members were instructed to cast their ballots between 1:00 and 4:00 p. m. at the registration table. The candidates whose names are marked* in the above slate were elected.

This morning session adjourned at 12:00 noon and was followed by luncheon in the College Commons. Visitors were guests of Jamestown College.

The Academy reconvened at 1:40 p. m. in Room 27 of Orlady Hall. The eleven papers listed on the afternoon program were read and discussed. The meeting adjourned at 5:45 p. m.

The Academy Dinner was a joint meeting with the Red River Valley Section of the American Chemical Society held in the College Commons. Eighty-seven members and guests were present. Dr. Harry B. Hart presided at the dinner and presented the following program: Musical numbers by Janice Peterson and Lew White, students at Jamestown College. Greetings from Jamestown College by its President, Dr. Edwin H. Rian. Announcements relative to officers for the Red River Section of A.C.S. by Dean R. E. Dunbar. New Officers of the Academy were introduced by Mr. J. Donald Henderson. Dr. Rae H. Harris announced the winners of the Student Research Prizes as follows: First Place—Mr. G. A. Sweeney; Second Place—Mr. Loran Bieber; Third Place—Mr. Jerome E. Bakke; and Honorable Mention—John Gordon, Carleton L. Lohse, and Roger C. Zejdlik.

Dr. Wilson Laird introduced the guest speaker, Dr. A. F. Beale, Jr., of Dowell, Incorporated who presented his beautifully illustrated lecture on "The Stimulation of Oil Wells." Meeting adjourned at 9:00 a. m.

SATURDAY, MAY 5, 1956

The meeting was called to order at 9:12 a. m. in Room 27 of Orlady Hall by Dr. Harry B. Hart. The seven papers listed in the morning program were read and discussed. Between the presentations of papers numbered 22 and 23 Dr. W. E. Cornatzer gave a report on the current status of the Engineering and Science Scholarship Foundation.

The ANNUAL BUSINESS SESSION was called to order at 11:40 a.m. The minutes of the 1955 Annual Meeting were approved as printed in the 1955 **Proceedings**. The treasurer's report was presented. Mr. Henderson moved that the report be accepted subject to approval by an auditing committee after the bills for the annual meeting have been paid. Motion seconded and passed. President Hart appointed an auditing committee composed of Dr. G. C. Wheeler, chairman; Dr. E. D. Coon, and Dr. C. J. Hamre.

Dr. R. F. Shumard reported on the meeting of the Academy Conference held at the AAAS meeting in Atlanta, Georgia, in December of 1955. His report was accepted. Secretary Henderson read a communication from Mr. John Behnke of the AAAS and following some discussion, Dr. Clagett moved that the Executive Committee be empowered to act on the suggested appropriation of \$25.00 to help pay the expenses of AAAS Representatives when attending the Academy Conference. Motion seconded and carried.

Dr. Gabriel W. Comita presented the report of the Resolutions Committee.

MAY 5, 1956

THE COMMITTEE ON RESOLUTIONS PRESENTS THE FOLLOWING REPORT:

1. We express our appreciation to President Rian, the administration, faculty and Science students of Jamestown College for extending the facilities of the College to the Academy, and for the luncheons provided; and to the Press for giving excellent publicity to our meetings.
2. We are grateful to the Red River Valley Section of the American Chemical Society for its cooperative participation at our meeting.
3. Our thanks are extended to Jamestown College for its splendid efforts in preparation of the Academy Dinner.
4. We are particularly grateful to the Administrations of the Agricultural College, the University and Jamestown College for continuing their policy of financing the publication of the Proceedings of the Academy; and to the members of the Committee on Publication for the excellent work they have done.
5. To the Officers and Committees of the Academy, we express our thanks for their hard work in arranging and providing the excellent program of papers, the comfortable arrangements, and the successful conduct of this very interesting and profitable meeting of the Academy, especially to President Hart and Secretary Henderson, both of whom assumed the larger share of responsibility in staging the meetings.
6. The members of this Committee are conscious that the scientists of institutions of higher learning of this State are not using the Academy as fully as they should. In order that better expression of scientific activity by all institutions in the State be encouraged, greater effort should be made to invite members from widely-scat-

tered institutions to present invited papers. As a recommendation we urge that papers be invited from members at institutions other than the ones at which the meetings are being held. In addition, the members of this Committee recommend that greater participation be urged upon graduate students, and in particular undergraduate students should be spurred to become members of the Academy and to present the results of their original work which in many cases is not being reported. Notification should be made to all undergraduates in the State that they are eligible for membership, and that their participation in Academy activities is invited.

7. We are very grateful to A. Rodger Denison, Vice-President of the Amerada Petroleum Corporation, for his gift of \$190.00 for student research prizes and the publication costs involved. This kind of support makes student participation more encouraging.

Respectfully submitted by the Resolutions Committee

Vera Facey,
William L. Downing,
Gabriel W. Comita, Chairman.

Prof. Ben Gustafson moved that the report be accepted. Motion seconded and carried.

The report of the Committee on Publications was given by its chairman, Dr. Rae H. Harris. Report was accepted.

In the absence of Dr. Harold Klostermann who was ill, Dr. Carl Claggett reported for the Membership Committee. In recognition of his service to the Academy through the sponsorship of the Student Research Contest, Dr. A. Rodger Denison was elected to honorary membership. Upon recommendation of the committee twenty-six nominees were elected to active membership subject to payment of their annual dues before June 1, 1956. Their names are given at the end of the list of active members in the **Proceedings**.

Dr. O. A. Stevens heading Necrology gave the report of the Necrology Committee had been submitted to the secretary.

Joseph H. Schultz

Joseph H. Schultz was born on a farm in Richland County, North Dakota, November 3, 1915 and died December 17, 1955. He attended NDAC for three years where he was known as an earnest, industrious student. When Professor A. F. Yeager removed to Michigan, Schultz followed and received his B.S. degree at Michigan State College (now University) in 1939, his M.S. at the same place in 1941. Work for his Ph.D. was completed at Washington State College in 1944 and he returned to NDAC in 1948 as chairman of the Horticultural Department.

Dr. Schultz was interested in all branches of horticulture as well as in other related fields. Perhaps his outstanding accomplishment was the production of the Doublerich tomato with a high Vitamin C content. With Dr. Yeager he had assisted in the production of the

Early Chatham tomato. He was growing a number of improved potato varieties and had many trials with tree and other fruits under way. His death at an early age was a severe blow to horticulture in this area and he is greatly missed by his many friends.

Dr. O. A. Stevens moved that a committee be appointed and authorized to select and purchase a set of books on Science (not to exceed \$50.00) to deposit with the State Library Commission for circulation to high schools. Seconded by Dean Walster. Motion carried.

Dr. O. A. Stevens moved that a committee be appointed to canvass the Academy members for current magazines which they would be willing to forward to high schools and to contact the high schools to find those who would be most interested in securing such copies. Seconded by Mr. Knudson. Motion carried.

Dr. Alex. Burr moved that, upon the decision of the Executive Committee, the Academy join with other similar organizations in sponsoring a conference on mathematics; its being understood that there will be no financial obligation. Seconded by Dean Dunbar. Motion carried.

Dr. William Downing moved that the Academy empower the Executive Committee to investigate the possibility of inviting the North Dakota Psychological Society either to join with the Academy in joint meetings or in merging that society with the Academy. Motion seconded. Dr. Estensen, president of the N. D. Psychological Society, explained the role of the society in North Dakota and stated the need for such a society. Question was called for and motion carried.

The Academy adjourned at 12:35 p. m. and following adjournment luncheon was held in the Jamestown College Commons. Visitors were guests of Jamestown College.

Respectfully submitted,

J. Donald Henderson
Secretary

WINTER BIRD POPULATIONS IN THE DECIDUOUS FOREST ALONG THE RED RIVER IN NORTH DAKOTA

J. Frank Cassel

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ABSTRACT

Four annual counts have been made of the birds wintering on twenty-five acres of a small (about 40 A.), ungrazed peninsula in an oxbow of the Red River three miles north-northeast of Fargo on mixed-deciduous forest, with about six acres of open area, half on Edgewood Farm. The vegetation consists mainly of a river-terrace which is covered with grass and herbs and half with Wolfberry (*Symphoricarpos occidentalis*).

Fourteen species of birds have been recorded, mostly in the wooded areas. Only four of these have been seen on all four years. The population is composed mainly of Black-capped Chickadees, White-breasted Nuthatches, and Downy Woodpeckers. These species most frequently appear together in association groups which sometimes include additional species. The average total population in 1953 was 17 birds (density, 68 birds per 100 acres); in 1954, 13 birds (52/100 A.); in 1955, 24 birds (96/100 A.); and in 1956, 9 birds (36/100 A.).

POLYESTER RESINS OF TRIMESIC ACID (1)

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Trimesic acid (benzene-1,3,5-tricarboxylic acid) was first reported by Adolf Baeyer (2) in 1886 and was prepared by the sunlight polymerization of propiolic acid ($\text{HC}=\text{C}-\text{COOH}$) after a nine month exposure. Subsequent attempts to produce this acid in satisfactory yields or at a reasonable price in general have met with little success. The traditional recent method of preparation has usually involved the oxidation of mesitylene. But with mesitylene currently selling for \$20.00, and trimesic acid at \$240.00 a pound, both chemicals still remain in the semi-rare class. Furthermore, yields of trimesic acid, by the chemical oxidation of mesitylene, have usually ranged from 5 to a maximum of about 30 per cent. Recently, however, satisfactory laboratory methods have been developed (3), for this oxidation with yields ranging from 75 to 90 percent. This improvement in yield now makes trimesic acid more readily available for polyester formulation and study. The fact that trimesic acid contains three

carboxylic groups lends interesting possibilities for either a cross-linked or modified linear polymer.

EXPERIMENTAL

Trimesic acid was converted into its trimethyl-ester by the method of Pechmann (4). A 1 to 30 mole ratio mixture of trimesic acid and dry methanol containing 4 per cent by weight of dry hydrogen chloride was refluxed for 8 hours. The resulting solution was chilled to 0-5°, and the solid ester filtered. Concentration and cooling of the mother liquor yielded additional ester. The combined product was recrystallized from methanol yielding 70 to 80 per cent of the trimethyl ester of trimesic acid, melting at 143°. The use of sulfuric acid as a catalyst provided lower yields and a higher percentage of the mono- and di-methyl esters.

The conversion of trimesic acid, with a melting point of 380°, to its trimethyl ester, with a melting point of 143°, offered some real advantages in resin formation and at considerably lower temperatures. At temperatures above the melting point of the ester it was possible to maintain a homogeneous liquid phase for the reactions. Likewise, a more volatile by-product, methanol rather than water, was produced. Best results were obtained by using a 7.5 to 1 mole ratio of the polyhydric alcohol to ester, the excess alcohol serving as solvent. The reaction mixture was heated at 145° in a Claisen flask, equipped with mechanical stirrer, thermometer, heating mantle and condenser for the distillation of the by-product methanol. Specifically the trimethyl ester was reacted with glycerol, ethylene glycol, propylene glycol, 1,4-butanediol, dipropylene glycol and diethylene glycol. Tetra butyl titanate in concentration of 0.1-5.0 per cent by weight was used as a catalyst. As the reaction proceeded, the by-product methanol was distilled off. The reaction was deemed to be complete when no more methanol could be obtained. The system was then arranged for vacuum distillation and the excess polyhydric alcohol removed at 2 to 15 mm. pressure. When a viscous residue remained in the Claisen flask, the vacuum was removed and the contents poured into an evaporating dish. This material was cured at 120° in an oven for a period of 4 to 42 days. The final product in each case was a light colored, transparent, firm, attractive resin.

DISCUSSION

Far better results were obtained in the production of polyesters by the use of the trimethyl ester rather than with the trimesic acid itself. The use of inert solvents, such as dioxane, with the free acid did not offer any particular advantage. Considerable resistance was experienced in attempting to react solid polyhydric alcohols with trimesic acid or its trimethyl ester. In general trimesic acid appeared to be far more resistant to ester-resin formation than phthalic acid. Glycerol, under comparable conditions, gave the most satisfactory results of the several polyhydric alcohols studied. This investigation

is being continued with the idea of modifying and improving the products initially produced.

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VARIATIONS OF GASOLINE AND EFFECT OF ADDITIVES

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INTRODUCTION

A problem of the engineer in winter and in colder climates is to provide a fuel that will enable the gasoline engine to start easily and usually in less than ten revolutions. In the Grand Forks area in particular, and in northern states in general, the problem of starting an automobile in winter is quite evident. There have been many attempts to alleviate this problem such as head-bolt heaters, twelve-volt systems, gasoline additives and others.

The main purpose of this research was to attempt to determine the actual effectiveness of additives on starting, and also whether some gasolines are better for starting than others. In order to accomplish this purpose the American Society of Testing Materials Standard Distillation Test was used along with the ASTM Reid Vapor Pressure Test as a check. Four gasolines from Grand Forks were tested during the months of February, March and April of 1956. These gasolines were tested separately, and also with additives. The gasolines will be designated later by the letters A and B for two nationally known brands, and C and D for two cheaper local brands.

Since in the ASTM distillation test gasoline is evaporated in the presence of air, this test does not duplicate the evaporation characteristics of the actual engine. A test which comes closer to actual engine conditions is the Equivalent Air Distillation ASTM Test or EAD test in which gasoline is evaporated in the presence of its own vapor, and air-vapor and air-fuel ratios are controlled. Even with this close control in the EAD test, however, the conditions of the engine are not duplicated completely, since the flow of vapor in the engine manifold is much more rapid than in the EAD test. It is easily seen that the exact values needed cannot be obtained in these

tests. These tests are of value because they will give relative values which can be used in comparisons of gasolines. Graphs plotted with temperature versus per cent of gasoline distilled can be used to determine different gasoline characteristics including relative lowest starting temperature.

In running the ASTM distillation test four comparative qualities or characteristics are obtained. Starting, which is the ability of the engine to start in cold weather, is shown by the relative position of the ten per cent point on the distillation curve. If ten per cent of a fuel will be distilled at a lower temperature than ten per cent of another, then the first fuel contains more highly volatile ends, and consequently would have a lower starting temperature. Warm-up, which shows the relative speed at which the engine will reach its running temperature, is indicated by the relative area under the distillation curve between the twenty per cent and the seventy per cent points. The gasoline with a better warm-up characteristic would have a smaller area under the curve. The gasoline with better acceleration qualities would have smaller area under the distillation curve between the 158°F and the ninety per cent points. Crank-case dilution, which indicates the tendency for gasoline to dilute the crank-case lubricating oil, is shown by the temperature of the ninety per cent point. The higher the ninety per cent point temperature is, the greater will be the crank-case dilution. Starting temperature was the primary consideration in this work, but in a complete study of a gasoline the other three characteristics as well as the matter of economy must be considered.

RESULTS

In a gasoline there are a number of compounds, the most volatile of which affect the starting characteristics. This study of the Grand Forks gasoline showed that any particular brand varied in its characteristics not only from summer to winter but from week to week and from regular to premium.

It was found that all four gasolines tested showed definite changes in their distillation curves as the weather became warmer. This change consisted of a decrease in the lighter ends in the gasoline which were needed during winter to promote better starting and warm-up. This change occurred about the middle of March for gasoline A and a few weeks later for the other gasolines.

To obtain relative starting temperatures the ten percent points on the distillation curves were compared. Gasoline C was the best for starting with the more expensive gasolines, A and B, comparing closely. The least effective for winter starting was D.

Relative warm-up characteristics were obtained by comparing the areas between the twenty per cent and the seventy per cent points. Gasolines A and C compared very closely with B and D following in that order.

Acceleration characteristics were found by comparing the areas

under the 158°F and the ninety per cent points. Gasoline A was by far the best with B and C comparing closely and D being the least effective.

Crank-case dilution was determined by comparing the ninety per cent temperatures. Gasoline A was again superior with C and D comparing closely and B having the greatest tendency toward crank-case dilution.

Such qualities as starting and warm-up become less important as the weather becomes warmer. Therefore, in summer gasolines the qualities of acceleration and crank-case dilution become more important. Of the four gasolines tested, A proved to be better for overall summer and winter driving. The cheaper gasoline C compared very favorably in regard to all the characteristics, and since it was less expensive, would seem to have a slight advantage over A. The acceleration and crank-case dilution of the gasolines B and D proved to be poorer for both winter and summer driving. This factor is not too important in winter, because driving in town is limited to short distances and slow speeds. In both B and D the curve is lower for starting which shows adequate light ends, but there is a larger percentage of the heavy ends and less of the middle which are needed for warm-up acceleration.

ADDITIVES

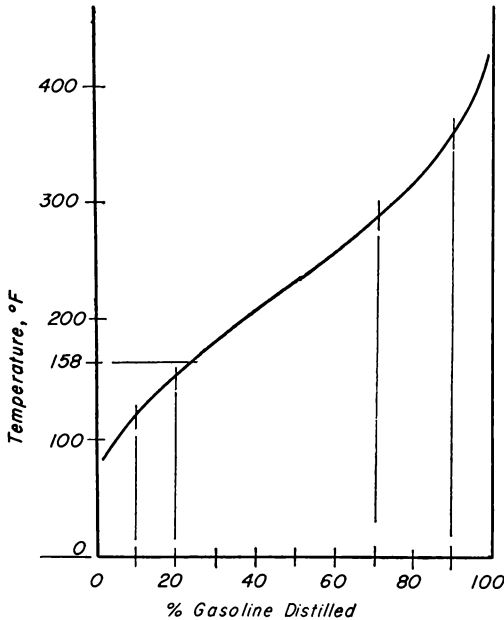
In northern areas there has been an increasing tendency in winter toward the use of additives with their various attributes. It was the aim of these tests to determine only whether the additives actually lowered the starting temperatures of the gasolines. It can be seen by the graph (figure 1) that in order to lower the starting temperature it is necessary to add to the gasoline some light ends which will evaporate at lower temperatures and form a combustible mixture in the engine.

Tests were run with the approximate per cent of additive obtained by the addition of twelve ounces to ten gallons of gasoline. This amounted to about one per cent. The cheaper additives which contain, as far as could be obtained, only alcohol, serve to absorb moisture in the fuel tank. They produced no effect in lowering the starting temperature. The two most expensive additives were the most effective and actually lowered the starting temperature by about 4.5°F.

In addition to the commercial additives, an acetone-ether mixture was tested. Acetone itself is not volatile enough to lower the starting temperature of a gasoline, but it has the ability to absorb moisture which collects due to condensation. The temperature may be lowered by including such volatile matter as ether. A one per cent additional of equal parts ether and acetone proved as effective as any of the commercial additives in lowering the starting temperature.

The main disadvantage to all the additives tested is that in the

FIGURE 1
 Typical
 Gasoline Distillation Curve



process of absorbing water they separate from the gasoline and are then less effective as fuels.

The effectiveness of these additives could be increased by increasing the concentration of the additive, but this practice is limited by the high cost.

A disadvantage of the additive to that of separation is that of volatilizing in the fuel tank. In winter this is reduced because of lower temperatures. Even then over a period of time the lighter ends will evaporate when not under pressure. A test on a gasoline kept at approximately 70°F and about the same conditions as that of an automobile fuel tank showed a rise in the starting temperature of 2°F after two weeks. A gasoline left standing outside in an automobile fuel tank for the winter months of January, February, and March of 1956 showed approximately the same rise in starting temperature. A fuel which was left in a vented underground storage tank from September, 1955 to April 1956 showed a rise in starting temperature of approximately 25°F. Gasoline kept in stoppered bottles at 50°F for two months was found to have a negligible rise in starting temperature due to evaporation.

SUMMARY

In summing up the results of the tests performed it could be said

that the better gasolines are not necessarily the higher priced. Although there are cheaper gasolines which show good characteristics, it would probably be best to rely on a nationally known brand for general overall driving. For winter starting there are a number of good additives which could be added to any gasoline to improve its starting characteristics, but it would be advisable to avoid the cheaper additives. The effectiveness of additives in reducing temperature is almost proportional to the price.

The evaporation of gasoline and additive depends on both temperature and pressure, but in actual winter driving there is not enough evaporation to affect starting temperature.

Although additives could possibly be made more effective and economical, it has been shown that their present use is definitely an aid to winter starting.

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ACKNOWLEDGEMENTS

The writer wishes to express his gratitude to Professor Edward C. Lawson, who gave permission for this project, and to Mr. Charles M. Harman for his assistance during this study and in the preparation of this paper.

A NEW DIGLUCOSIDE FROM FLAXSEED 1,2

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INTRODUCTION

The isolation of a new carbohydrate from flaxseed was reported before this group in 1954 (1). When linseed meal previously freed from fat is extracted with a mixture of alcohol and dioxane, a tan polymeric powder (I) (See Fig. 1) is obtained in about 3% yield. This substance is carbohydrate in nature and upon acid hydrolysis yields glucose and much resinous material.

The polymer (I) is readily degraded through the use of sodium or barium methoxide in methanol. This reagent cleaves the polymer into a series of simpler substances which may be studied individually.

-
1. Progress report on project Purnell 155, "The Structure of Certain Carbohydrates in Flaxseed Hull."
 2. Published with the approval of the Director, North Dakota Agricultural Experiment Station.

(10 m.e.) was stirred at room temperature for 14 hrs. The resulting mixture was treated with sulfuric acid to precipitate the barium. The yellow supernatant liquid was concentrated under reduced pressure to near dryness and the resulting syrup chromatogrammed on a cellulose column using butanol, ethanol, 3% aqueous ammonia (30:10:10) as the irrigating liquid. The diglucoside (II) (1 g.) was recovered by evaporation of the solvent.

The diglucoside (II) was very soluble in water and alcohol. It was never obtained in crystalline form.

The methods used in proving the structure of the diglucoside (II) were adaptations of published methods. Only the results of the studies are reported in the interests of conserving space.

RESULTS AND DISCUSSION

The formula of II is based upon the following experimental evidence. Compound II had free phenolic groups and upon acid hydrolysis (1N, 100°, 6 hrs.) yielded a crystalline, optically active, phenolic substance (V) and glucose in approximately equal quantities. Elemental analysis of V indicated a formula of $C_{20}H_{12}O_5$. This suggested two glucose residues per aglucon. Methoxyl determination indicated two per $C_{20}H_{12}O_5$ unit. There were no methyl groups attached to carbon. Methylation of V by diazomethane yielded a tetramethoxy compound VI.

When the diglucoside (II) was methylated by the Haworth method and acid hydrolyzed, compound VI was again obtained along with two moles of tetramethyl glucose. This disclosed that the phenolic hydroxyls of V were also free in the diglucoside (II). Since all the glucose was converted to tetramethyl glucose, both glucose residues were attached directly to the aglucon. It was concluded that the two hydroxyl functions which should have been liberated by the acid cleavage of the glucoside linkages had been lost through a subsequent reaction.

A further insight into the structure of VI was obtained when it was found that oxidation of VI yielded 3,4-dimethoxybenzoic acid (veratric acid). No other product could be isolated.

The diglucoside and its aglucon (III) showed absorption in the ultraviolet which is characteristic of lignans. It was found that homoguaiacol (B) showed absorption maxima at the same wave lengths as V and, furthermore, the specific extinction coefficients of homoguaiacol and V were nearly equal. This information combined with the formation of veratric acid from VI suggested that V contained two identically substituted benzene rings.

The infrared spectra of V and its dimethyl ether VI were complex and failed to disclose much that was not already known. The presence of a pyran or furan ring was suggested. The absence of terminal methyl groups was also confirmed.

The nature of the aglucon became quite evident when it was learned that very mild hydrolysis of the diglucoside (0.1N H_2SO_4 , 80°)

yielded a new compound (III) $C_{20}H_{26}O_6$. This compound was found to have four active hydrogens and upon prolonged treatment with acid (1N, 100°) III was converted to V. The more drastic conditions employed earlier for the hydrolysis of the diglucoside had resulted in the conversion of III to V. The elements of water were lost from the diol (III) during the formation of a furanoid ring to give the tetrahydrofuran derivative (V).

DISCUSSION

Haworth and his associates (6) in England have devoted much time to the synthesis of a number of compounds in the lignan series. Among these were several compounds which had the same melting points as compounds III, V, and VI. These synthetic compounds showed the same specific rotations as III, V, and VI, but opposite in sign. Their compounds were levorotatory, whereas III, V and VI were dextrorotatory. It appeared that their compounds were the enantiomorphs of our compounds.

To test this, racemic-VI was synthesized by the Stobbe condensation (7). Its infrared spectrum was similar to natural VI, but different in many respects. The methods of Haworth (6) were then applied to the preparation of the levorotatory diol. When equal weights of the levorotatory synthetic product and the natural dextrorotatory compound VI were dissolved and allowed to crystallize together, racemic-VI was obtained. Furthermore, the infrared spectrum of the levorotatory synthetic product was identical in every respect with the natural dextrorotatory compound, VI.

The exact formula for the diglucoside (II) has not yet been proved. In all probability the glucose residues are linked to the aglucon through a **B**-linkage. This is general for natural glucosides. The position of the free hydroxyls on the rings has not been proved. However, in natural products having an aromatic ring substituted by both hydroxyl and methoxyl, the hydroxyl is usually **para** to the side chain.

Studies are now under way which should lead to the synthesis of the diglucoside.

SUMMARY

1. A new diglucoside has been isolated from flaxseed.
2. The aglucon portion of the diglucoside is believed to be **d**-2,3-di(3-methoxy-4-hydroxybenzyl)butane-1, 4-diol.
3. The glucose residues are linked to the 1,4-diol positions.
4. The infrared spectrum of **l**- or **d**-3,4-di(3,4-dimethoxy-benzyl) tetrahydrofuran is different and distinguishable from the spectrum of the corresponding **dl**-form.

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A LANDSLIDE NEAR OSLO, MINNESOTA

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INTRODUCTION

According to Sharpe (1938, p. 3),* "Recognition of the importance of mass-movements in the shaping of the lands has lagged far behind our knowledge of the action of running water, glaciers, winds, and waves." Since there has been much geologic phenomena related to landslides already established by the excellent work of Sharpe and others, and since there is a need for more specific observations, this report may serve as an example of some of these phenomena.

The site of the landslide is located on the bank of the Red River two and a half miles north of Oslo, Marshall County, Minnesota. A mass-movement occurred which was largely horizontal, producing a "graben" at the head of the slip. At the same time a large mud bar was pushed up in the river reducing the channel to about half its normal size.

Previous Investigations. To the author's knowledge, there have been no previous studies made specifically of the geology of this particular landslide, however, much work has been done by the Minnesota Geological Survey on the geologic formations of the area.

Acknowledgements. This investigation was made under the general supervision of Dr. Gordon Bell, Assistant Professor of Geology, University of North Dakota.

Location of the Area. The area covered by this report is about 45,000 square feet along the river bank in the SW $\frac{1}{4}$ /SW $\frac{1}{4}$, Sec. 19, T.155., R.50W., Marshall County, Minnesota.

DESCRIPTION OF THE SLIDE

During the night of the 19th of September 1954, a landslide, or more appropriately slump, took place on the Minnesota side of the

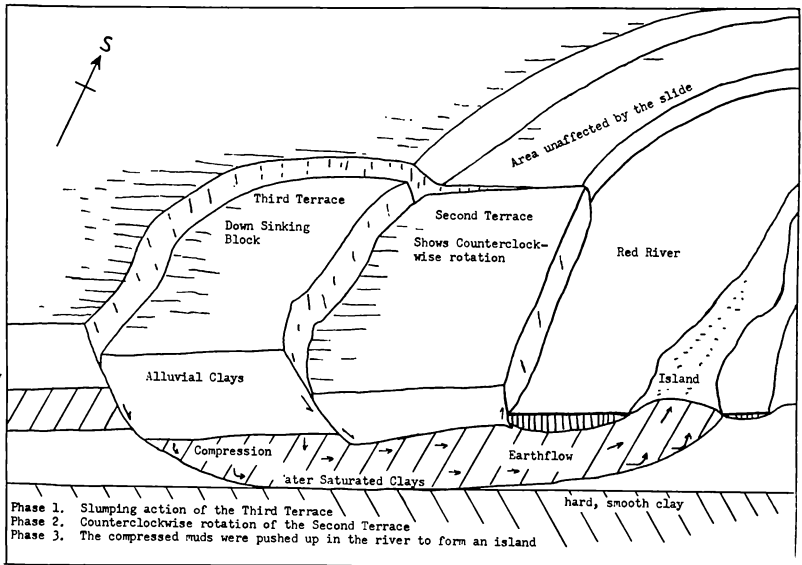


Figure 1. Panoramic view of the landslide area.

Red River. The distance from one end of the break to the other is about 400 feet. The sunken area is full of deep cracks many of them large enough to hold the average man. The sunken area dropped as much as 8 feet in places. The crescent-shaped crack runs north and south along the river with the concave portion of the crescent toward the river. Throughout most of the length of the slip the whole slope was very much unaffected by the slide, and the north and south ends of the upper edge of the slipped area tapered downward until finally the break in the slope died out. Also during the same night and apparently resulting from the slumping action of the bank, a crescent-shaped island was formed in the river. This island is about 35 feet longer than the 400 foot fracture on the bank.

A Mrs. Quern, whose home is on the upland just north of the slip about 115 feet from the river, explained that when she looked out in the morning, there was the sound of rushing waters which was very unusual. Not long after, she went to the slope and noticed the mud bar in the river which caused rapids and she also noticed the large crack along the top of the bank and then she made a quick look to see if there was any fracturing near her home. She stated that she did not hear any rumbling or noise accompanying the movement and that the slip was still moving slowly.

Section of the Area

1. Black soil	1 foot
2. Yellowish to gray alluvial clay	10 feet

3. Yellowish to gray stratified silty sand 15 feet
 4. Hard, blue, plastic, smooth clay Depth unknown

Just within the blue clay and just below the stratified silt is the horizon in which the slide probably took place.

Climatic. According to the farmers in the area, the weather at the time of the slip was dry, windy, and cool. In the vicinity of Grand Forks, however, 22 miles south, a total of 1.49 inches of rain fell from Sept. 10 to Sept. 19. The exact amount of rain in the area of the slide is not known, however, with regard to the cause of the land-slip, it is somewhat remarkable that the fall should have occurred during a spell of rather moderate weather, and not after a heavy rain. The data so far seem to point to some other cause than rain.

Ground-Water. It is known that the ground-water in this county increases toward the west, and that there are especially heavy flows along the Red River, (Allison, 1932, p. 126). This indicates possible saturation of the clays in the landslide area, probably enough to be one of the main causes of the slip. Subterranean waters sometimes produce disastrous results by adding their weight to loose or porous deposits and so giving rise to landslides.

DESCRIPTION OF SEDIMENTS IN THE AREA

According to Grout and Soper (1914, p. 54), "Very thick beds of stratified clay, however, occur in the central portion of the Red River Valley, and their position shows that they were not deposited by the waters of the lake . . . At the present time much of the area of the stratified clay is covered by the higher flood of the Red River, and probably no portion of these stratified clays is more than 10 feet above the high water line of the Red River or its tributaries. Since the river may have been much larger about the close of the glacial epoch, it seems clear that the clays were deposited as alluvium, in part of glacial time, and in part recent . . . Their depth and the width they cover increase northward . . . The clay is rather silty and contains considerable carbonaceous material. Near the surface the clay is colored yellow. The yellow is caused by oxidation near the surface, and is highly calcareous . . . The clays here have been leached to depths of from 1 to 10 feet. Overlying the clay is a thin layer of black loam. The leached portion of the clay usually is quite free from the limestone pebbles and is less plastic and dries more safely than the lower clays. The lower clay is spoken of as joint clay because of the tendency to crack when drying . . . This clay extends to depths of almost 100 feet."

POSTULATED MODE OF ORIGIN

The slide took place at a sharp bend in the river. Deposition of sediments near the bank opposite the slide area narrowed the channel and resulted in downcutting and removal of sediments near the bank where the slide occurred. Eventually the bank slumped into the river and in so doing displaced some of the saturated sandy silt of the river bottom, shoving it toward the opposite bank and above the river level, forming a bar.

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**BUCK HILL BURNING LIGNITE BED
THEODORE ROOSEVELT MEMORIAL NATIONAL PARK
NORTH DAKOTA**

by

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ABSTRACT

The burning lignite bed is situated in the South Unit of the Park, in Billings County, Township 140 North, Range 101 West, sections 22 and 23. The area may be reached by driving five miles north from the East entrance to the Park.

The lignite coal bed is at an altitude of 2500 feet on Paddock Creek, near the base of Buck Hill. The bed of lignite underlies about 11 acres and is approximately 12 feet thick, as shown in a pit near the east end, and a natural exposure at the south end. Except for three hills that rise 20 to 30 feet along the south and east margins of the area, the coal is covered by soil and clay that average five feet thick.

At present the lignite is burning near the center of the east end of the bed, and progressing westward. The area burning is 200 feet long and 100 feet wide, and distinguished by considerable slumping of the partly fused and baked soil. It is estimated that the burning may continue for 50 years, provided the present rate is maintained.

The lignite bed is merely a remnant of an extensive coal bed that burned in past geologic time. The remnant is completely surrounded by scoria that is prominent on Terrace No. 4, the uppermost, broad Pliocene floodplain of the Little Missouri River. The Buck Hill burning lignite bed, like the larger Amidon burning coal bed, 25 miles south, may be viewed as a continuation of a cyclic geologic process that started in Eocene time and culminated in Pliocene-Pleistocene time. As a result of the formation of the scoria during burning, certain areas were protected by the more resistant scoria, while others were deeply eroded to develop a diversity of landforms. The formation of the scoria has not only influenced the development of the landforms but it has also added color to the Badlands of North Dakota.

THE SYNTHESIS OF N-BENZYL-2-AMINOMETHYL-1,4-BENZODIOXANE

G. A. Sweeney, F. M. Young and R. E. Dunbar

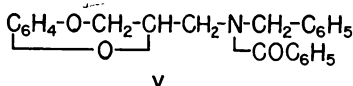
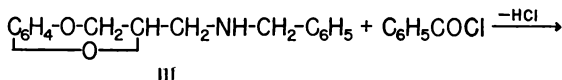
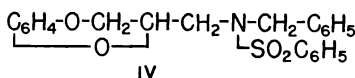
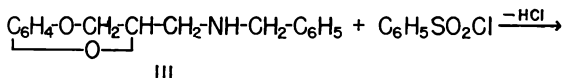
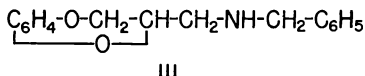
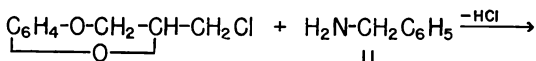
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Benzodioxane and phenyl alkylamine ethers are among the classes of compounds which have been shown to have adrenergic blocking activity (1,2). In the search for a more nearly perfect sympatholytic drug, investigation is pending on a series of compounds which link 1,4-benzodioxane with phenyl alkylamine ether (3). N-Benzyl-2-aminomethyl-1,4-benzodioxane (III) was prepared as an intermediate for the synthesis of a series of N-(alkyl aryl ether) substituted tertiary amines.

The secondary amine (III) was prepared by a method analogous to that which Wheeler and Wilson used for the synthesis of N-phenylbenzylamine (4). The reaction involved a dehydrohalogenation between 2-chloromethyl-1,4-benzodioxane (I), prepared by the method of Foltz and Data (5), and benzylamine (II). An excess of II was used to combine with the liberated hydrogen chloride and to inhibit the formation of a tertiary amine.

The Hinsberg and Schotten-Baumann reactions were used to



prepare the corresponding sulfonamide (IV) and benzamide (V) of III. Compound III reacted with bromophenotole producing the hydrogen bromide salt of III and an extremely viscous ether soluble residue. The structure of the latter, however, has not been elucidated.

EXPERIMENTAL

A 36.8g. (0.2 mole) portion of I was added dropwise over a period of 2½ hours to 85.6g (0.8 mole) of II in a 300 ml. flask equipped with a dropping funnel, reflux condenser and an electric stirrer. After I had been added, the solution was refluxed for an additional 1½ hours and then allowed to cool to room temperature. Upon the addition of 200g. of 6N hydrochloric acid, a precipitate of amine hydrochlorides was obtained. This precipitate was collected, washed with water and ether to remove the benzylamine hydrochloride and impurities. The crude material was then recrystallized from hot water. The free amine was obtained as a viscous oil by neutralization of the hydrochloride salt with sodium bicarbonate. The oil was extracted with ether, the ether removed by evaporation and the residue vacuum distilled in a Hickmann molecular still. The yield was 36g. (70.5 percent of theoretical) of a clear viscous liquid. Upon prolonged cooling, III solidified to a white crystalline solid melting at 41°C.

Properties of compound III:

$$n_{25}^D = 1.5778 \text{ density } (25^\circ\text{C} = 1.145)$$

Anal. Calc. for $\text{C}_{16}\text{H}_{17}\text{O}_2\text{N}$: C, 75.3; H, 6.67; MR, 74.7; mol. wt., 255.

Found: C, 75.6; H, 6.98; MR, 73.6; mel. wt.

(cryoscopic in benzene), 253

SUMMARY

1. N-Benzyl-2-aminomethyl-1,4-benzodioxane has been prepared and identified for the first time. Identification was based on molecular weight, molecular refraction, carbon-hydrogen content, and formation of characteristic derivatives.

2. A plausible method for the preparation of other substituted benzylamines has been developed.

ACKNOWLEDGEMENT

The authors wish to express their appreciation to Dr. R. F. Banziger of the School of Pharmacy, North Dakota Agricultural College, for furnishing valuable information pertaining to this work.

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STUDIES ON SUCKLING PIG ANEMIA*

*Carleton L. Lohse**Department of Veterinary Science**North Dakota Agricultural College, Fargo, North Dakota***INTRODUCTION**

Hog producers have been plagued by a disease that cuts the gains and livability of their suckling pigs. The disease, an anemia, is characterized by pale skin and mucous membranes, lack of vigor, failure to grow properly and labored breathing (thumps) on the slightest exertion. Craig¹ concluded these symptoms denoted a definite disease.

In contrast to many diseases, anemia in suckling pigs is more prevalent when the conditions for hog production are considered ideal. Such advantages as closed, clean pens with concrete or wooden floors contribute to the occurrence of anemic conditions in the newly farrowed piglet. The period of greatest danger from anemia is from one to six weeks of age while the sole food is milk from the sow.

Buchanan *et al.* (2) found hemoglobin levels of both the sow and the newborn pig to be higher after supplementing the sows ration with one-half ounce of ferrous sulfate per day, during the gestation period. This program resulted in a greater number of pigs weaned per litter; however, a drop in hemoglobin of the baby pigs blood occurred after parturition.

Investigation have been made to find a method for supplementing the necessary constituents for hemoglobin formation after birth, and to correct the characteristic drop in hemoglobin that occurs before weaning.

Materials and Methods

Two Duroc and two Chesterwhite sows, in advanced stages of pregnancy, were individually placed in wooden quonset houses. A wooden trough for feed and water was included in each house. All sows received equal amounts of feed and bedding. On the seventh day after farrowing each litter was ear tagged, weighed and hemoglobin values were taken by the acid hematin method.(3)

Five of the nine offspring farrowed in litter I received individual, oral treatment with 5 ml. of a 0.3N aqueous solution composed of 50 percent ferrous and 50 percent cupric sulfate.

Litter II consisted of ten suckling pigs. A 0.3N aqueous solution of (50 percent) ferrous and (50 percent) cupric sulfate plus 12.5 gms. each of cobalt and zinc sulfate added to 2.5 liters of the 0.3N solution was sprayed in 50 ml. quantities on the sow's udder.

Three of the six suckling pigs in litter III each received orally

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5 ml. of the same solution that was sprayed on the udder of the sow in litter II.

An aqueous solution of terramycin (0.3 gm/100 ml.) was given orally in 5 ml. doses to six of the eleven piglets in litter IV.

All of the pigs were weighed weekly and hemoglobin values taken. Treated animals received their respective doses weekly with the untreated animals remaining as controls.

RESULTS AND DISCUSSION

Average hemoglobin in grams per 100 ml. of blood are presented in table 1. The mean values for weights in pounds are depicted in table 2.

Four untreated controls died during the course of this experiment. Previous to their death these animals were listless, lacked vigor and were anemic. Definite differences were noted when compared to treated piglets. Lack of skin color, thickening of the skin and a loss of weight were observed.

Post mortem examination of all pigs that died revealed edema in the pleural, peritoneal and pericardial cavities; enlarged hearts; pale skin and mucous membranes; and light colored lungs and liver.

None of the treated animals died during the experiment except those of litter II.

Experimental data shows that treated animals possessed higher average hemoglobin values and made higher weight gains. Differences in final mean weights between treated and controls varied from 2.2 lbs. per animal in litter I (Fe, Cu) to 4.3 lbs. per animal in litter IV (teerramycin). Studies on litter II were concluded at seven weeks, I, III and IV being concluded after the eighth week.

By the eighth week all of the suckling pigs of litter II were dead. There were no controls in this litter because of the nature of treatment. All symptoms pointed to chronic anemia. This may have been caused by the fact that very little of the sprayed solution remained on the udder of the sow, thus the piglets received only scanty amounts of the minerals.

CONCLUSIONS

Three of the four litters in which the pigs received orally administered solutions of (1) Fe, Cu, (2) Fe, Cu, Co, Zn, (3) and terramycin showed the treated animals to have higher blood hemoglobins than possessed by the controls.

The complete loss of the suckling pigs in litter II demonstrated failure of this type of sprayed solution to correct anemia. Oral administration of the same solution in litter III showed the fault was not in the solution but in the method of application. With oral administration of Fe, Cu in litter IV there was 100 percent greater livability than in litter II.

The characteristic drop in hemoglobin during the first few weeks

TABLE I

Average Hemoglobin Values (gms. percent) and Livability in Treated and Untreated Suckling Pigs

Litter No.	Treatment	Original		Survivors	Average Hemoglobin Values (gms. percent)							
		No.			1 Wk.	2 Wks.	3 Wks.	4 Wks.	5 Wks.	6 Wks.	7 Wks.	8 Wks.
I	Fe, Cu	5		5	7	6	5.2	4.5	4.0	4.8	6.6	10.3
	Controls	4		3	8.5	5	4.6	4	3.2	3.4	6.5	8.0
II	Fe, Cu, Co, Zn, (Sprayed)	10		0	6.8	4.8	3.7	3.5	2.6	2.2	2.0	
	Controls	0		0	—	—	—	—	—	—	—	—
III	Fe, Cu, Co, Zn, (Oral)	3		3	10.3	5.6	5.2	4.4	4.7	5.4	8.8	10.4
	Controls	3		1	9.2	5	4.2	3.5	3.2	3.0	4.8	9.6
IV	Terramycin	5		5	10.0	8.1	4.5	3.8	4.7	7.3	9.4	10.5
	Controls	6		5	9.9	6.1	4.3	3.5	3.8	5.7	7.2	11.3

TABLE II

Average Weight Values (lbs./animal) in Treated and Untreated Suckling Pigs

Litter No.	Treatments	Average Weight Values (lbs./animal)							
		1 Wk.	2 Wks.	3 Wks.	4 Wks.	5 Wks.	6 Wks.	7 Wks.	8 Wks.
I	Fe, Cu	6.0	8.9	11.1	13.7	15.1	17.5	18.5	19.8
	Controls	6.0	8.2	10.5	12.8	13.4	14.0	16.6	17.8
II	Fe, Cu, Co, Zn (Sprayed)	4.5	7.9	12.2	14.2	15.3	13.1	13.0	
	Controls	—	—	—	—	—	—	—	—
III	Fe, Cu, Co, Zn (Oral)	5.6	9.1	11.8	15.5	19.2	23.2	24.1	25
	Controls	6.8	11.5	13.0	14.6	14.0	14.4	13.0	22.7
IV	Terramycin	3.6	7.0	11.8	11.9	15.4	15.9	17.6	18.9
	Controls	3.7	6.7	11.3	13.1	17.4	19.4	22.0	10.5

of life after farrowing was not completely corrected in the treated animals; however, it was not as severe as it was in corresponding non treated animals.

SUMMARY

Oral treatment with solutions containing ferrous and cupric sulfate, ferrous and cupric sulfate plus cobalt and zinc sulfate, and terramycin produced greater livability, hemoglobin and weight values when compared to the controls.

Spraying the udder of the sow with a aqueous solution of ferrous and cupric sulfate plus cobalt and zinc sulfate did not protect the suckling pigs from anemia.

Further studies involving hemoglobin, weight, hematocrit values, red and white blood cell counts, corpuscular morphology and hereditary effects need to be made to evaluate treatment and this disease.

ACKNOWLEDGEMENTS

The author wishes to express his appreciation to Dr. I. A. Schipper who gave valuable suggestions and guidance throughout this study. Acknowledgement is gratefully made to Drs. D. F. Eveleth and F. M. Bolin for assistance during the completion of this paper.

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DETERMINATION OF THE AMINO ACID SEQUENCE IN A DURUM WHEAT PEPTIDE

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North Dakota Agricultural Experiment Station.

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Grain rust is a problem to the people of North Dakota and production of wheat has been maintained only by breeding varieties resistant to the prevalent rusts. Very little is known as to why one variety of grain is susceptible to rust and another variety is resistant to the same rust.

The literature contains several references which lend credence to the concept that the development of rust in hosts is controlled

to a large extent by the availability of some specific nutrient required by the rust parasite. Mains (1) in 1917 showed that interference with the photo-synthetic mechanism either by withholding carbon dioxide or light inhibited the development of the rust parasite. When sucrose was fed to the isolated leaves in the absence of photosynthesis rust growth again occurred. Newton and Broun (2) made the interesting observation that in very young, rapidly growing tissue, oats and rye will support a limited amount of wheat stem rust. Johnson and Johnson (3,4) studied soluble sugars and total nitrogen in the varieties and found no appreciable quantitative differences.

An investigation has been undertaken to determine some of the biochemical differences such as organic acids, peptides and extractable proteins in the various durum wheats. No information is available in the literature on the composition of the protein fragments or peptides found in the growing wheat plant.

This paper is a description of the methods used in the elucidation of the amino acid sequence in a peptide isolated from Carlton variety of durum wheat.

MATERIALS AND METHODS

Isolation of the Peptide:

Wheat plants of the desired variety were grown to the three leaf stage, harvested by clipping at the soil line, and subjected to an 80% alcohol-20% water extraction by grinding in a Waring Blender. The fibrous material was removed by filtration through a coarse wire screen prior to further grinding in an Eppenbach colloid mill. The finely dispersed solids were removed by centrifugation and the supernatant evaporated to dryness at reduced pressure over a water bath at 30-50° C. The residue was dissolved in water and extracted with chloroform to remove chlorophyll, carotenoids and other lipid components.

The water solution was passed over an ion exchange column (IR-120) which absorbed the free amino acids, peptides and inorganic cations. After thorough washing with water, cationic components were eluted with 2N HCl. The eluate was neutralized with 2N NaOH prior to evaporation to prevent hydrolysis of the peptide bonds.

The neutral solution was evaporated to dryness at low temperature and reduced pressure; the peptides and amino acids were removed from the accompanying inorganic salts by solution in 90% alcohol.

Preparation and separation of the dinitrophenylated peptides:

The solution of the mixed amino acids and peptides was converted to the 2,4-dinitrophenyl derivatives using the method of Schroeder and LeGette (5). Separation of the dinitrophenylated derivatives was accomplished by means of chromatography using the method

described by Perrone (6). The material was placed on a phosphate buffered cellite 545 column, (pH 4.0) using acetone-chloroform (6:4) saturated with water as the solvent and developed with the same solvent. A number of distinct yellow bands separated. The three fast moving bands were recovered by elution; the slower bands were obtained as entities by acetone extraction of cut portions of the extruded column. The amino acid or peptide nature of each individual band was determined by hydrolysis of small portions of the band, followed by chromatography and color development with ninhydrin. The first dinitro-phenylated fraction to be eluted, a peptide, appeared to be a major constituent and was selected for further study.

Differential Hydrolysis: Peptide bonds vary in their resistance to acid hydrolysis. By subjecting small amounts of the dinitrophenylated peptide to hydrochloric acid hydrolysis in a sealed tube at 110° C. fragmentation of the peptide was accomplished. The degree of hydrolysis was controlled by varying the time of heating from five minutes to 16 hours and the strength of hydrochloric acid from one to six normal.

Determination of the N-terminal amino acid: The N-terminal amino acid which carried the DNP radical was identified by the application of a modification of the method of Blackburn and Lowther (7). A strip of filter paper is wetted in buffer, dried, then spotted and developed in the normal manner using a water saturated solution of t-amyl alcohol-ethyl alcohol (10:1). We found that by substituting 0.5 M. citrate buffer (pH 5) for the potassium phthalate of the published method the DNP derivatives of glutamic acid and aspartic acid could be separated very satisfactorily.

Determination of the amino acid sequence: The method of Isherwood and Crookshank (8) was used for the dinitrophenylation of the chromatogrammed partial hydrolysates on paper. The hydrolyzed material was applied as a band across the top of a six-inch strip of filter paper and developed in the usual manner using phenol-formic acid-water (80:1:19). After removing the irrigating solvent at room temperature a $\frac{3}{4}$ inch strip was removed from one side and the color developed with ninhydrin in order to detect the location of the hydrolytic products. The remaining paper was dinitrophenylated, the derivatives removed from the paper strips by acetone extraction and examined after further hydrolysis.

RESULTS

Total hydrolysis of the peptide I followed by paper partition chromatography and color development with ninhydrin indicated the following composition: Alanine glutamic acid, aspartic acid, threonine and leucine. The N-terminal amino acid was identified as aspartic acid. A five minute hydrolysis of I with 6N hydrochloric acid followed by dinitrophenylation on paper yielded a peptide having threonine as the N-terminal amino acid. The remaining acids in this fraction were identified chromatographically as alanine,

leucine and glutamic acid. The hydrolyzed mixture also contained dinitrophenylated aspartic acid indicating an aspartic acid-threonine linkage in peptide I.

Fifteen minute hydrolysis with six normal hydrochloric acid followed by separation in the manner described above yielded a peptide III containing a dinitrophenylated amino acid plus alanine and glutamic acid.

In other hydrolyses of peptide I with 1N hydrochloric acid for periods of one to two hours glutamic acid was the only free amino acid liberated in appreciable quantity. Dinitrophenylated aspartic acid and a peptide IV containing N-terminal threonine were found, in addition to the glutamic acid. Therefore, glutamic acid must have been located in the C-terminal position. Hydrolysis under the same conditions for a three hour period released glutamic acid and alanine as free amino acids. Alanine must therefore be linked to the glutamic acid.

DISCUSSION

The evidence for the aspartyl threonyl portion of the peptide chain is quite conclusive. The remaining portion of the chain contains leucine, alanine and glutamic acid with a C-terminal glutamic acid. Alanine is coupled to the glutamic acid in peptide linkage. If alanine and glutamic acid are present in one to one ratios with the remaining amino acids, the structure aspartyl threonyl leucyl alanyl glutamic acid can be assigned to peptide I. However, the color value of the glutamic acid spot indicates higher concentration for that acid than for the remaining amino acids. The N-terminal amino acid of peptide III was not identified with certainty so a number of possibilities exist. Structures such as glutamyl leucyl alanyl glutamic acid or leucyl alanyl glutamyl glutamic acid would be compatible with the data on hand. Further study is in progress to determine with certainty the arrangement of the central units of peptide I.

SUMMARY

A peptide I containing leucine, alanine, aspartic acid, glutamic acid and threonine was isolated and partially characterized.

The N-terminal portion consists of aspartyl threonyl and the C-terminal acid is glutamic.

An alanyl glutamyl linkage has also been detected.

Further work will be required to elucidate the position of the leucine and the glutamic residues in peptide I.

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FLOWERING DATES OF NORTH DAKOTA PLANTS

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ABSTRACT

Since 1905 the writer has kept records of the first flowers of as many plants as possible. The summaries for 1905-1909 in north-eastern Kansas were published (*Amer. Midl. Nat.* 1917) and for 1910-1920 in North Dakota (*ibid* 1921). Trees are predominantly early flowering: aspen, cottonwood, boxelder, elm, cedar, willows, ash, birch, hackberry, oak. A few exceptions are pine (June 1) and basswood (July 15). Late bloomers are well represented by asters and goldenrods. The largest number of species begin to bloom about June 1 and more than half of the total number come into bloom between May 20 and June 30.

Preliminary study has been made of the variations from year to year with weather conditions. A report on weeds (*Bimonthly Bulletin, N. D. Agr. Sta.*, July-Aug. 1956) shows as much as a month difference in first dates. Marked plants of perennials are best for such comparisons. Annuals show more variation due to germination conditions, soil disturbance and competition.

URANIUM ORE DEPOSITS IN WESTERN NORTH DAKOTA AND EASTERN MONTANA

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ABSTRACT

Commercial grade uranium ore in lignite was first discovered in North Dakota in Billings county in September 1954. Since then exploration and evaluation work has covered an area in western North Dakota from the South Dakota line northward to McKenzie county.

Two major areas of uranium ore occurrence are now known, one in the southern and one in the northern part of Billings county.

All the ore found to date in North Dakota has been found in lignite beds near the top of the Fort Union group. The type and grade of deposit is dependent on local sedimentary features and coal stratigraphy. Some evidence of structural localization of ore bodies has been developed, but due to lack of information no definite statements can now be made.

Two types of uranium ore-bodies have been found. One type is a blanket deposit of medium grade ore that may have large tonnage. A more common type of deposit is in the form of pods and lenses of higher grade ore. Reserves in these are likely to be lower than in blanket deposits.

The bulk of the ore mineral is a uranium-organic complex in the lignite material. On weathering and oxidizing ground-water action, some secondary autunite-like minerals are formed.

Ore grade mineralization is controlled by modern and paleo-ground-water conditions and by varying permeability in overlying and containing beds.

In western Golden Valley county and in eastern Fallon county, Montana, the first sandstone ore in the district is being developed. Drilling has shown the ore mineral meta-tyuyamunite associated with carbonaceous streaks in channel sandstone bodies in the upper part of the Fort Union formation. The deposits may be controlled by minor structures on the east flank of the Cedar Creek anticline.

Exploration in the district has progressed from airborne reconnaissance and outcrop sampling to deep drilling for stratigraphic information and ore reserve determinations.

More than 200,000 tons of ore-grade material is indicated from drilling to date in the area.

EFFECTS OF SEX AND PREVIOUS SALT DIET ON IN VITRO AORTAE

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ABSTRACT

Male and female Sprague-Dawley white rats of 80-100 grams at the beginning of the experiment were maintained for 10 weeks or more on food containing two percent salt and isotonic saline water. The same numbers of similar male and female rats on the identical diet, except for the omission of salt, kept for the same length of time in the same environment supplied the control aortae.

Identical dosages of 1. epinephrine invariably constricted blood-vessels from salt fed rats more strongly than those from the controls. Aortae from female salt fed and control rats in general were decidedly less responsive to 1. epinephrine than those from both groups of males. Aortae from female salt fed rats increased somewhat less in percentage of contractile response than those from males on the same diet.

(This investigation was supported in part by a research grant from the American Heart Association)

*United States Public Health Service Research Fellow.

INTERSPECIFIC HYBRIDIZATION BETWEEN YELLOW (*M. OFFICINALIS*) AND WHITE (*M. ALBA*) SWEETCLOVER USING EMBRYO CULTURE

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Commonly grown sweetclovers are relatively high in coumarin content. Coumarin gives sweetclover a bitter taste, and in spoiled forage its decomposition to dicoumarin causes non-clotting of the blood and hemorrhaging when fed to animals. Low-coumarin lines of white sweetclover are available; however, selection for low-coumarin lines of yellow sweetclover has not been successful. Yellow and white sweetclover will cross, but developing seed abort when 2 to 3 weeks old. Since hybrid embryos do not fully develop under normal conditions, artificial culturing of embryos into seedlings and subsequent transfer to soil may form the bridge to flowering hybrid plants and subsequent selection of low-coumarin yellow lines from their progenies.

Approximately 24,000 flowers were crossed using a series of yellow sweet-clover plants as female parents pollinated from a wide source of low-coumarin white sweetclover plants. Over 900 two-week old hybrid embryos were transferred to a sterile agar-plant food-sugar growth medium in two ounce bottles. One-third of the embryos made some satisfactory growth. A number of hybrid embryos have developed through the seedling stage and were established in soil.

The methods and materials used in crossing and culturing embryos are discussed. Research will continue to determine if plants surviving are true inter-specific hybrids, and through subsequent appropriate breeding procedures transfer genes for low-coumarin content to yellow sweetclover lines.

TWO NEW RESERVOIRS OF ERYSIPELOTHRIX RHUSIOPATHIAE

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ABSTRACT

The disease produced by *E. rhusiopathiae* invading tissue, often spoken of as swine erysipelas in animals or erysipeloid in man, is not uncommon in mammals, birds and fishes. In North Dakota this organism has been reported as being isolated from diseased tissues of swine, turkeys, sheep, calves and human beings. The disease is of serious economic importance in swine, turkeys and sheep. The same disease has been found on rare occasions in chickens in North Dakota.

Two new host species of natural occurring infections in the skunk, *Mephitis mephitis* and in the house cat, *Felix domesticus* have been encountered in North Dakota. In both instances the animals were submitted for laboratory diagnosis as rabies suspects because of the symptoms of encephalitis shown during the terminal stages of the disease; in both instances, the organisms were isolated from the brain.

(Published with the approval of the director, North Dakota Agricultural Experiment Station, Fargo, North Dakota.)

ABSCISSION OF LEAVES IN PICEA GLAUCA (MOENCH) VOSS AND ABIES BALSAMEA L.

Very Facey

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Abscission of plant structures has occupied the attention of investigators since the middle of the last century when intensive anatomical investigations were begun. Primary attention has been given to deciduous dicotyledons leading to a voluminous literature on the subject amply reviewed by Pfeiffer (5) whereas lower plant groups, gymnosperms, and monocotyledons have received comparatively little attention. Abscission of the needles of gymnosperms has been investigated by Neger and Fuchs (4) and by Campbell and Vines (1) in a study on the effect of *Lophodermellina macrospora* (Hartig) Tehon *Picea excelsa*.

In deciduous dicotyledons a protective layer is formed at the base of the leaf prior to or after leaf-fall. The layer of cells through which abscission takes place undergoes a change in insoluble pectates to the soluble form with a consequent rupturing of cell walls

and fall of the leaf. The present investigation is an attempt to determine the changes, if any, in the cell walls of the abscission zone and the mechanism of abscission in **Picea** and **Abies**. The two species were chosen because of the relative speed of abscission and availability of material.

METHODS

Leaf bases of **Picea glauca** and **Abies balsamea** were obtained from trees growing in their natural habitat in Minnesota. Immediately after removal from the tree, the leaf bases with included abscission zone were placed in 70% ethyl alcohol for fixation and storage. Microchemical tests were made on freehand sections from fresh material and on the material in 70% alcohol. No differences in reactions were observed. Permanent mounts were prepared by the celloidin technique and by the n-butyl alcohol paraffin method. In adapting these techniques to the material no solutions were used which were judged to alter chemically the composition of the cell walls under investigation. Longitudinal sections were cut at 10 microns from the celloidin and paraffin infiltrated material.

ANATOMY

When the leaves of **Picea** are shed a short portion remains on the twig (Fig. I, d), whereas in **Abies** the leaf breaks off at the point of attachment (Fig. I g). In each case a layer of tissue composed of ligno-suberized cells protects the living parenchyma cells underneath. This layer is designated the protective layer of the abscission zone in deciduous species where it forms either before or after leaf-fall in the species investigated by Lee (3) and others. The protective layer in **Abies** is composed of a tissue similar to that in **Picea** except that in the latter the walls possess more numerous simple pits, the cells contain considerable resinous material and the area itself is much more extensive as shown by Fig. 1, and 3.

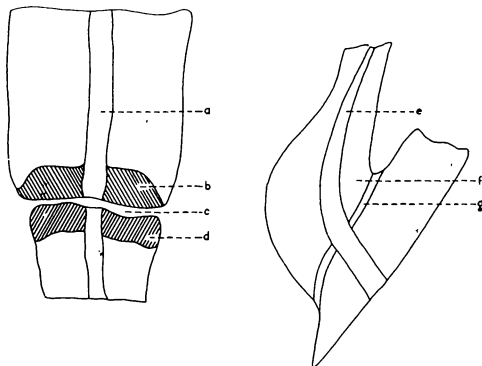
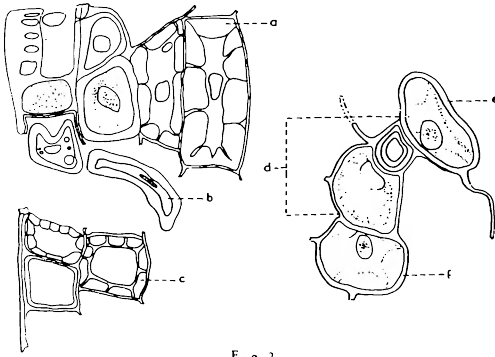
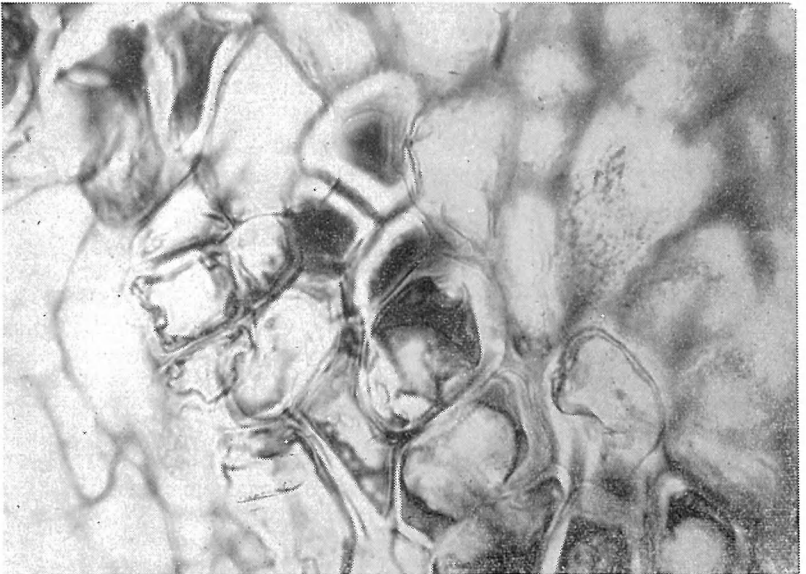


Fig. 1



F. g. 2

Immediately above the protective layer in *Picea* there is a layer one cell in thickness which is the abscission layer (Fig. 1, 2.). The cells of this layer possess a thin primary wall and a thick secondary wall with lamellations parallel to the protective layer. This secondary wall separates readily from the primary wall during all handling of material. *Abies* lacks an anatomically differentiated abscission layer as well as a layer of elongated thick-walled cells above the abscission layer (Fig. 1, 2.). The lamellations in these cells of the so-called hyaline layer of Campbell and Vines (1), lie at right angles to those of the secondary walls of the abscission layer. The lack of a definite abscission layer in *Abies* conforms to the situation in many deciduous dicotyledons.



The vascular strand in both species passes as an intact cylinder through the abscission zone into the leaf blade. As is typical of gymnosperms there is an outer endodermal sheath of ligno-suberized cells.

MICROCHEMICAL TESTS

An effort was made to determine the composition of the cell walls of the tissues of the abscission zone in both species. The majority of the tests were made on freehand sections one cell or less in thickness. The presence of lignin was determined by treatment with 1% phloroglucinol followed by 25% hydrochloric acid. A red coloration in the walls after this treatment was indicative of the presence of lignin in the walls. All primary and secondary walls of the abscission zone with the exception of the secondary wall of the abscission layer cells in *Picea* contain lignin. In *Abies* the secondary walls of the protective layer, as well as the primary walls, reacted positively to the lignin test. The cells through which abscission takes place were negative in their reaction.

Tests for suberin and cutin were carried out on both species. Both substances reacted to Sudan IV by an orange to red color which remained in the sections when mounted in glycerin. It was found impossible to differentiate these two substances satisfactorily following the usual procedure, thus confirming the conclusions of Scott (6). However, it was observed that the substance reacting to Sudan IV and composing the secondary walls of the abscission layer of *Picea glauca* was dissolved by heating the section on a slide in concentrated potassium hydroxide, whereas the similarly reacting substance in the cuticle was comparatively unaffected. All cells of the abscission zone in *Picea* and the protective layer in *Abies* contained a thin layer of suberized material lining the cells, a condition which has been found to be prevalent in plants of many different families. (Scott, 1948).

Cellulose tests were performed using both solubility and color reactions. Due to the impregnation of the walls with a fatty material it was found impossible to dissolve out cellulose without preliminary treatment with potassium hydroxide. After this procedure was carried out the secondary walls of all layers in *Picea* were found to have lamellations which dissolved in freshly prepared cupra ammonium hydroxide. Similar treatment of *Abies* gave comparable results with the exception that the abscission "layer" reacted without previous potassium hydroxide treatment. Immediate localization of the cellulose components of the walls was determined by treatment with chlor-zinc iodide or by iodine in potassium iodide followed by 75% sulphuric acid. The use of the polarizing microscope confirmed the presence of anisotropic dichroic substances in these walls, which is further support for the presence of cellulose materials.

Pectic materials as evidenced by a red coloration with aureous ruthenium red were found to be present in all primary walls. Solu-

bility tests suggested that pectic materials in the middle lamellae of the cells in both **Picea** and **Abies** were pectic acid and not calcium pectate as in **Fraxinus** (Facey, 1950). The treatment consisted in placing the sections in a 2% ammonium hydroxide solution in a water bath set at 80°C. The middle lamellae dissolved in these portions of the walls not reacting to tests for suberin and for lignin.

Similar tests to the preceding were performed on: (a) abscised ends and bases of leaves previously placed in a desiccator over calcium chloride. (b) abscised ends and bases of leaves from naturally abscised material collected in the field. No apparent differences from those obtained above were noted. All ends of cell walls reacted similarly to the entire wall in the complete longitudinal section of the leaf.

MECHANISM OF ABSCISSION

Freehand sections of **Abies** and **Picea** were mounted in glycerin and observed over a period of time. Abscission invariably occurred in length by actual measurement, leading to a widening of the leaf first in **Picea** through the abscission layer. The hyaline cells decreased and the breakage of the thin primary walls of the abscission layer. The vascular strand was torn across the region of the abscission layer. **Abies** reacted erratically; thin sections failing to abscise, thicker sections breaking off through the parenchyma above the protective layer which remained approximately the same width, whereas the non-ligno-suberized parenchyma tissue above contracted and broke away from the layer below. Thus it would seem that abscission is a mechanical process in **Abies** and **Picea** without previous chemical breakdown in cell walls as is evident in deciduous forms.

ILLUSTRATIONS

All figures represent longitudinal sections through the abscission zone. The lower part of the figure is toward the point of attachment to the twig.

Fig. 1 Diagrams through the abscission zone in **Picea glauca** (left) x40, and **Abies balsamea** (right) x50. a: leaf trace, b: hyaline layer, c: gap through which abscission occurs, d: protective layer of ligno-suberized cells, e: leaf trace, f: region where abscission occurs, g: protective layer of ligno-suberized cells.

Fig. 2 Semi-diagrammatic drawings through the abscission zone. **Picea glauca** (left) x250, **Abies balsamea** (right) x500. a: hyaline layer cell, b: secondary wall only of abscission layer cell, c: protective layer cell, d: protective layer cells, e: cell through which abscission occurs, f: parenchyma cell of twig.

Fig. 3 Photograph x500. **Abies balsamea**. indicating ligno-suberized protective layer cells containing resinous deposits. The parenchyma cells through which abscission occurs are to the right.

The drawings for Fig. 1 and 2 were reproduced for publication by Mathias Lanz, University of North Dakota, Grand Forks.

SUMMARY

The abscission process was studied in *Picea glauca* (Moench) Voss and *Abies balsamea* L. In both species the actual abscission under drying conditions was due to a mechanical breaking of cell walls in a region above a protective ligno-suberized layer which remained on the twig after abscission. No chemical changes in the cell walls of the abscission layer were found to occur prior to abscission as in deciduous species.

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ACKNOWLEDGEMENT

Grateful acknowledgement is made to the American Association for the advancement of Science for a grant which purchased equipment used in the above research.

INTESTINAL ABSORPTION OF GLYCINE FROM ISOOSMOLAR SOLUTIONS*

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ABSTRACT

The absorption of glycine by the upper small intestine of the rat has been studied by a continuous flow perfusion technique designed and developed in our laboratory. Our *in situ* procedures enable us to determine the continuous uptake pattern using a single animal in the steady state.

We carried out absorption studies using glycine over a range of 0.02, 0.04, and 0.08 Molar concentrations in Krebs's-Ringer-Phosphate buffer. Upon comparing the percentage uptake per given intestinal length, there was agreement in the uptake pattern for the first half-

*This study was aided by The North Dakota Cancer Society.

hour but a slight spread developed during the later part of the one-hour perfusion period.

A series of aqueous solutions was used to carry glycine at a 0.02 Molar concentration: in water, in isoosmolar glucose, xylose, sodium chloride and K-R-PO₄.

The uptake of glycine at low concentrations by the mucosa of the upper small intestine of the rat is essentially the same when carried in the above mentioned isoosmolar solutions, but in a simple water solution the uptake of water is a complicating factor in the amino acid uptake.

SALT MEASURES OF THE TIOGA AREA, NORTH DAKOTA

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The field work upon which this paper is based was carried out in the summer of 1955 under auspices of the North Dakota Research Foundation. The purpose of the investigation was to evaluate characteristics and extent of salt deposits and possibilities of exploitation of such a natural resource.

Occurrence of Salt

Salt deposits were discovered and outlined within the Williston Basin in the course of drilling for oil. In the State they cover an area of approximately 12,000 square miles, extending from the Canadian border to south Fryberg and from the Montana border to a few miles east of Stanley.

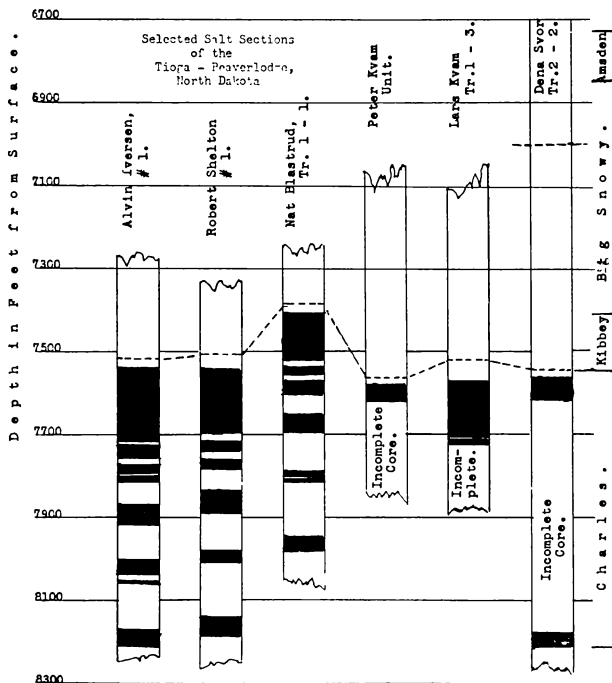
Salt occurs in the following formations:

Spearfish (Triassic),
Permo-Pennsylvanian,
Charles (Mississippian),
Devonian.

Nowhere in the area does salt occur closer to the surface than 6,300 feet. The salt beds of Charles lie in Tioga at between 7400 and 8200 feet below the surface. It is not known just where the salt deposits bottom, and it is possible that salt beds occur in Silurian strata as well.

Charles salt unit was selected for the detailed study because it is well developed in Tioga and could be readily accessible for exploitation through the use of already existing perforations.

As may be seen from the accompanying geologic section, Charles salt is not a solid body. Five major lenses were distinguished in Tioga with as many minor laminae. The whole assembly of salt len-



ses of high purity is enclosed in and is intercalated with anhydrite, red carbonate rock and limestone. These enclosing rocks are themselves impregnated with chlorides of sodium, calcium and magnesium. Because of such an impregnation these rocks are salty to taste and deliquescent in moist air.

Attempts to separate various salt lenses into salt horizons and to correlate the latter over large distances were not too successful. In part this may be due to difficulties in recognizing thin salt beds on well logs, but should be largely due to the structure of the salt unit. It is believed by the writer that various salt lenses are irregularly situated, overlapping each other both vertically and laterally. Thus, while for purposes of exploitation they might be divided into horizons actually they do not represent any definite stratigraphic horizons.

Various salt lenses show fluctuations in thickness. Some of the thickness fluctuations are due to the pre-existing structural control, others are due to posterior injection of saline liquors.

It is of considerable interest and of possible economical significance that various salt units show an echelon-like, successive thickening along the line which connects Fryberg and Tioga localities, striking N 11°30'E. Along this line, the topmost Spearfish salt unit is best developed at Fryberg and thins out northward. The next unit, Permo-Pennsylvanian is easily recognizable just south of Tioga but is lost on the Tioga logs. At Tioga, Charles salt is very well de-

veloped. Toward the Canadian border the Devonian salt becomes prominent. In Canada Silurian salt is important. The strike of this echelon is coincident with the strike of the Nesson anticline.

As was already stated, individual salt lenses vary considerably in dimensions but their purity remains very much the same. The similarity is so great that hand samples of salt from pure salt lenses of Charles, Spearfish and even Devonian cannot be distinguished unless the depths at which samples were taken are known.

The average of 32 samples taken and analyzed by the Great Northern Railway Company yielded the following results:

NaCl.	96.50%
SO ₃40%
Water solubles, other than NaCl.	1.60%
Water insolubles.	1.50%
	100.00%

The so-called water solubles other than NaCl consisted of chlorides of magnesium, calcium, potassium with traces of bromine and iodine.

Because of insufficient data for computation of tonnages, the salt content in lenses of pure salt in the Charles unit was calculated as 2,240 short tons per acre-foot.

Taking the Charles unit as a whole, i. e. including salt impregnated intervening material, the salt content is estimated to fluctuate up to one million tons per acre of area in the Tioga region.

Petrology of Salt Units

Detailed petrographic studies were made only on the Charles and Spearfish salt units in the Tioga area. In addition a hand sample of Devonian salt was also studied.

The material for this study was furnished by the Amerada Petroleum Co., whose engineering staff gave the writer hearty cooperation. Sixty one samples were cut from three diamond drill cores to represent all possible mineral relationships.

These samples were analyzed by the writer by the Spot Test, semi-quantitative techniques. Eighteen thin sections were prepared and studied under a polarizing microscope.

All this served to establish the character of mineralization and the exact genetic relationship of various minerals. Since such studies have rarely appeared in geologic literature a full account is given at the continuation.

Salt deposition at Tioga has transpired in the following sequence:

Stage 1. Halite I, the oldest is characterized by deliquescence and anomalous birefringence. Precipitation of chlorides of Na, Mg, Ca, and K was simultaneous and resulted in formation of a fine grained mass which shows practically no crystalline faces. It is differentially stained due to mechanical

dragging of colloidal ferric hydroxide but contains no identifiable inclusions of other minerals.

Stage 2. **Halite II**, is somewhat coarser, displays crystalline faces and usually one prominent cleavage. Individual crystals show strain in polarized light, which is due to crystallization in a crowded environment. Exposed to humid air, cleavage planes accumulated moisture. This indicates that deliquescent chlorides of Ca and Mg became concentrated on cleavage planes only.

Contemporaneous with Halite II is **Chlorocalcite**, $\text{CaCl}_2 \cdot \text{KCl}$, which is occasionally present as subcubic grains of milky white to very pale violet color in association with Halite II in the red carbonate material.

Bischoffite, $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$, is another contemporaneous mineral occurring in elongated crystals.

Carnallite, $\text{MgCl}_2 \cdot \text{KCl} \cdot 6\text{H}_2\text{O}$, had a greater range of deposition than Halite II. It is certainly younger than Halite I but some grains may be younger, contemporaneous or older than Halite II. It frequently shows corrosion, and is therefore, difficult of identification. Its decomposition might have contributed to formation of both chlorocalcite and bischoffite.

Ankerite, $\text{Ca}(\text{Fe}^{2+}, \text{Mg})(\text{CO}_3)_2$, is the chief constituent of the red carbonate material which intercalates in between salt lenses and is sparingly contained in these. Usually fine granular and deliquescent (from presence of chlorides) it occasionally occurs in large rhombohedra which are not deliquescent, are gray due to subtraction of iron (Ankerite II).

Stage 3. **Anhydrite**, CaSO_4 , may in part be contemporaneous with Ankerite II. Its deposition continued well into the stage IV. The age of the oldest anhydrite is unknown.

Hydration of anhydrite to **Gypsum**, $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$, had also a wide range. Gypsum crystals are twinned, contain unidentified inclusions. Some are contemporaneous with Halite II.

Hanksite, $11\text{Na}_2\text{O} \cdot 950_3 \cdot 2\text{CO}_3 \cdot \text{KCl}$ is tentatively assigned to stage III. It occurs in Ankerite I and is apparently contemporaneous with Ankerite II and with some gypsum. It is occasionally found in well formed crystals which may be mistaken for quartz crystals.

Iron Hydroxides and **Silica** increase in stage III due to separation of chemical constituents. These are finely colloidal and were identified microchemically.

Stage 4. Halite III is coarsely crystalline with individual crystals up to two inches in length. May contain milky inclusions, but is not deliquescent. Usually fragile due to several well developed cleavages. Most isotropic of all three halites. Frequently faults ankerite which then is less deliquescent than ankerite I but is more ferruginous.

These four stages were found in all salt lenses of both Spearfish and Charles. The hand specimen of the Devonian salt showed a very advanced development of stage IV.

Using the same criteria for estimating ages of individual lenses, it was concluded that thin lenses are in general younger than thick ones, regardless of their position in the stratigraphic column. Thus, some of the thinner pure salt laminae near the bottom of Charles

were found to be younger than the topmost thick Charles "Horizon I". Some of the salt lenses of Charles and of Spearfish appear to have formed contemporaneously.

This constitutes strong evidence in favor of the view that salt measures have been re-worked and even perhaps enlarged after the consolidation and compaction of enclosing rocks. The fact that enclosing and intercalating strata are impregnated with Chlorides of Na, Ca, Mg, and K indicates similar deductions.

Origin of Salt at Tioga

Many sedimentary geologists hold to a hypothesis that salt was deposited in Williston Basin when the latter was cut off from the sea and became an evaporate basin.

While this hypothesis is elegant in its simplicity, its use meets with many practical difficulties.

It has been shown experimentally by Vanthoff that precipitation of sodium chloride from evaporating marine waters does not begin until the water has evaporated to about 1/10 of its volume. In other words the concentration of NaCl should be first raised by evaporation from about 3.5% (Average marine waters) to about 36% (saturated solution at standard conditions). At the present time this happens only when saline lakes have become converted into marshes: saline marsh of Coipaza in Bolivia, for instance. Deep evaporate basins of today, such as Great Salt Lake of Utah, Kara-Bugaz Bay of Caspian sea or the Dead Sea of Palestine fluctuate from 13% to 25% NaCl, depending on the annual atmospheric precipitation. Although these three bodies are considered to be prototypes of salt depositing basins, solid sodium chloride does not exist in equilibrium with its brines.

It is therefore, difficult to believe that several hundred feet of salt lenses and salt impregnated intercalations were precipitated in a deep evaporate basin such as Williston in any of the five mentioned geological periods.

The hypothesis is sometimes modified by assuming a deposition of salt in shallow water and a continuous or rhythmically recurrent sinking of the basin's bottom under the weight of accumulating salts. If this were the case then the shores enclosing the basin should have risen as the basin's bottom was being depressed in accordance with the views on Isostasy. It is difficult to visualize just how the weight of salt (Specific Gravity of 2.17) would depress or displace heavier rocks (average Specific Gravity of 2.7).

Furthermore, salt deposition continued steadily or periodically and under remarkably identical conditions during 150 million to 250 million years. Such a persistency is just incompatible with drastic changes that were taking place in the world.

In substitution for that hypothesis of precipitation in a drying out basin, a view is advanced here which is better substantiated.

The bulk of salt deposited in Williston Basin appears to have

occurred in association with oil at some time after consolidation of sediments which now enclose both salt and oil. Percolating ground waters were responsible for the occurrence.

On analogy with some reactions in metalliferous ore deposits, it is believed that sodium chloride was a component of some colloidal complex which also contained either oil as such or some carbon compounds.

A large number of similar colloidal complexes, which Copeaux has termed "aquates" has been described in Russian literature (1). Several such complexes were identified by the writer in tungsten, tin and copper deposits of Bolivia.

Breaking down of some such colloidal complex has resulted in deposition of sodium chloride, some anhydrite, while the carbon containing portions were polymerized to oil.

The feasibility of polymerization to hydrocarbons is definite. The writer has collected thio-elaterite, or naturally formed sponge rubber in tin-silver veins of Bolivia which were apparently formed at temperatures not higher than those prevailing in Tioga (22° F. at 8200 ft. depth). Thioelaterite of Bolivia could have formed only at the expense of organic carbon in Devonian carbonaceous shales. Similar reactions are believed to have taken place in salt-oil horizons at Tioga, except that liquid hydrocarbons were formed there.

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SOME ASPECTS OF FEEDING LIGHTWEIGHT BARLEY AND OATS TO SWINE

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ABSTRACT

The problem of finding improved methods of getting maximum utility from lightweight thin kernalled barley and oats as swine feed has been studied at the North Dakota Agricultural Experiment Station. Lightweight barley and oats have higher fiber content and therefore have a proportionately decreased nutritional value for swine since this monogastric animal is not a roughage consumer.

In order to gather more information on this problem, 120 pigs, weighing about 33 pounds, were put on experiment using balanced rations containing barley of different weights per bushel and using various combinations of oat hulls and barley in both the pelleted and non-pelleted forms. The pigs were divided equally as to breed, weight, sex and allotted at random to twenty individual pens, six pigs per pen. Each treatment was replicated once. The pigs were fed ad

libitum from self-feeders with water available at all times. Lots were marketed as the average liveweight of the pigs reached 200 pounds.

The basal ration consisted of the following:

Barley	95.1
Meat Scraps	1.5
Blood meal	1.5
Limestone4
Trace mineral salt5
Steamed bone meal	1.0

100 lbs.

Also added to each ton of the ration were the following:

Merck's No. 259 Vitamin Mixture	1.0 lb.
Nagel's Trace Mineral Concentrate	0.5 lb.
Zinc Sulfate	0.2 lb.
Vitamin A	1 million units

The calculated crude protein level of the basal ration was 12.8% and this was held uniform except in the oat hull rations where the protein level was calculated at 14.0%.

Using the basal ration, thin barley weighing 39 pounds per bushel was compared with regular feed barley weighing 43 pounds and was compared with plump barley weighing 46 pounds per bushel. To study the effect of light-weight oats on the rate of gain, the basal ration was modified using 15 pound oat hulls in one ration and 30 pound oat hulls in another ration. In the rations containing oat hulls, the deficiency in protein was restored by the addition of enough soybean oil meal to maintain the protein level at 14.0%. All of the rations used were fed in both the pelleted and in the meal forms except the ration containing 30% oat hulls which was fed only in the pelleted form. All rations were mixed commercially by a local feed processor.

In summarizing the results it was found that the pelleted rations gave gains which were better than the comparable meal rations. Statistically the gains on the pelleted as compared to the meal rations were significantly better (1% level). There were no significant differences in the rate of gain between rations whether thin, regular or plump barley was used or whether oat hulls were included. Rates of gain in these tests were not significantly different even at the 5% level. The feed required per pound of gain was greater for the thin kernalled barley as well as with the oat hull additions indicating that the pigs consumed feed on the basis of total digestible nutrients and that pelleting increased the density permitting them to do so whereas the ground rations were too bulky and unpalatable to permit this compensation. It would therefore appear that the depressing effect of excess fiber on the rate of gain of swine can be minimized by pulverizing and pelleting the ration. Throughout the trial it was noted that some of the ground feed was rooted out and wasted,

whereas there was no appreciable waste of the pelleted feed. The result was that more feed was required per hundred pounds of gain with the ground than with the pelleted ration.

THE GEOLOGY OF THE GRASSY BUTTE AREA, MCKENZIE COUNTY, NORTH DAKOTA

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ABSTRACT

The Grassy Butte area is situated mainly in Townships 148 and 149 North, and Ranges 98 to 103 West. It lies in southern McKenzie County on the western flank of the Williston Basin, and is bordered on the north by the North Unit of the Theodore Roosevelt National Memorial Park.

The purpose of this investigation was: (1) to prepare a geological map of the area; (2) to map the geologic structure of the area; (3) to measure and describe detailed stratigraphic sections which would aid in correlating rock units in this area; (4) to indicate lignite beds of possible economic value.

The western three-fourths of the Grassy Butte area is thoroughly dissected badlands topography, but the eastern one-fourth is an upland plain, in places carved into badlands by the tributaries of the Little Missouri River and Missouri River. Five levels are discernible in this area, showing the various stages of dissection of the bedrock. The number one terrace is the present flood plain of the Little Missouri River, while the fifth level is the highest upland plain.

The Tongue River formation, including the Sentinel Butte member, and the lower part of the Golden Valley formation are exposed at the surface. The Tongue River formation is Paleocene in age. The Golden Valley formation, of Eocene age, was determined to be more extensive in this area than was previously supposed, and the writer used as the base of the formation an horizon approximately 15 feet lower than the orange stained marker bed which had usually been used before. The bed the present writer used as the base of the Golden Valley formation is not definitely of Eocene age, but it does grade imperceptibly into sediments that are, and it does not have the typical appearance of the Sentinel Butte beds below. It has a fairly definite contact with the underlying sediments and is quite easily traced in the vicinity of Grassy Butte.

Several small anticlines were found in the Grassy Butte area, trending either north-south or north west-south east, as do most other structures found in the Williston Basin. The structure contours also outline several plunging troughs and noses which seem

to exert directional control on the Little Missouri River. The out-crop pattern also seems to be controlled to some extent by the structure in this area

GRASSLAND RESOURCES OF NORTH DAKOTA¹

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Extent and Value of Grassland

The data of Table 1, taken from the 1954 census of agriculture, show that there are about 16¼ million acres in grassland and grassland crops in North Dakota at the present time. This is approximately 37 percent of the total land area in the State. Obviously grass is the largest single crop grown in North Dakota in any one year. As a comparison, wheat, the next largest single crop was grown on 9,961,000 acres last year. The two crops, grass and wheat, of course are not of equal cash value. The wheat crop in 1955 was worth \$245,197,000, whereas the grass crop had very little actual value until it had been consumed by animals capable of producing meat or milk from it in the course of the operation of their normal digestive functions. Thus the actual value of the grass crop is extremely difficult to estimate with any degree of accuracy. Nonetheless the grassland and the grasslands crops of North Dakota provide probably 70 percent or more of the total yearly feed consumed by cattle and sheep in the State.

At the present time cattle numbers in the State are at an all time high. The total number of cattle and calves last year was 2,066,805. The sheep population is down from previous highs of over 1,000,000 head, to 688,236 sheep and lambs. Figured as 70 percent of the feed for the adult animals in these two classes, and valuing such feed at a conservative price of \$10.00 per ton, we have in our total grass production a crop which is worth about \$45,000,000.

To this sum we could add the returns from sales of grass and legume seed and from such hay as is marketed commercially in areas outside of North Dakota and add about \$5,000,000 to this figure, bringing the total value of the crop to \$50,000,000. This very conservative estimate makes our grass crop the fourth most valuable crop produced in the State, being exceeded by wheat, as previously mentioned, at about \$245,000,000, barley at \$72,216,000, and flaxseed at \$66,828,000.

There are, of course, other ways of figuring the value of grassland, especially those ways which are tied to the value of market-

¹Published with the approval of the Director, North Dakota Agricultural Experiment Station.

able livestock products produced from a unit area of grassland. Such systems generally picture the grassland as having appreciably greater value than has been indicated by the system used here.

Types of Grassland

Reconstruction of the probable original vegetation of North Dakota shows that there were three general types of native grassland vegetation in the State; the tall grass, essentially limited to the Red River Valley area; a transitional type which occupied the remainder of the eastern third of the State, and a mixed grass type which was generally distributed over the remaining more westerly portion of the State. The types were associated essentially with differences in moisture and soil conditions as previously explained, the tall grass type being located in the extreme eastern part of the state where precipitation and soil moisture conditions were and are most favorable. The transitional type lay to the west of the Red River Valley and gradually blended into the mixed grass type as precipitation and soil moisture conditions became less favorable. Based on the evidence that we have today, the transitional type is closely related to the mixed grass type and is not essentially different from it except in terms of a greater proportion of taller grasses than is normally found in the mixed grass and a gradually increasing productivity, progressing from west to east.

The bulk of the remaining 14½ million acres of native grass in this State is of the mixed grass and transitional type. Since the two are essentially the same in regard to speciation, appearance, and general reaction to grazing, they will be considered as one type here, namely, the mixed grass. This is the type which is economically the most important in the State, which supplies the bulk of our pasture and hay feed for livestock, and constitutes the basic material of our grassland resource.

TABLE 1
Grassland in North Dakota

Total Pasture (Not improved)	- - - - -	12,723,223 acres
Improved Pasture	- - - - -	109,605 acres
Hayland (Not improved)	- - - - -	1,965,7744 acres
Improved Hayland (Alfalfa not included)	- -	355,557 acres
Alfalfa and Alfalfa—Grass Mixtures	- - - - -	1,080,909 acres
Total	- - - - -	16,235,038 acres

Source: 1954 Census of Agriculture

The Mixed Grass Type

Because of its economic importance the mixed grass type should be considered in some detail. This type has been studied over a period of years in the vicinity of the Dickinson Experiment Station at Dickinson, North Dakota. Table 2 gives the composition and yield

of this type of grassland as determined from 16 different samples of the type over the last six years. The data of this table show that about 60 percent of the yield of the type has been produced by two grasses, western wheatgrass and needle-and-thread. These two grasses together make up only about 16 percent of the basal area of the cover. Western wheatgrass and needle-and-thread are what are called mid-grasses, meaning that they are neither tall grasses or short grasses but are somewhere near midway between these two extremes. Actually they average in general somewhere between 20 and 30 inches in height.

TABLE 2
Mixed Grass — Composition and Yield
(Near Dickinson)

Species	Yield Lbs. Per Acre	Percentage Composition of Yield	Percentage Composition Basal Area
Western wheatgrass	440	39.7	7.7
Needle-and-thread	220	19.9	8.0
Upland sedges	129	11.6	18.6
Blue grama grass	120	10.8	48.9
Green needlegrass	27	2.4	2.0
Prairie Junegrass	21	1.9	0.2
All other grasses	75	6.8	8.9
Forbs	776	6.9	5.7
Totals	1108	100.0	100.0

The upland sedges, of which there are three common species, and blue grama grass make up the bulk of the short grass element of the mixed prairie. These two groups compose about 68 percent of the basal cover but provide together only about 22 percent of the yield. The remaining grasses make up only about 10 percent of the cover and provide about 12 percent of the yield. The forbs, those broad-leaved herbaceous plants common to grassland, make up about 6 percent of the cover and provide about 7 percent of the yield.

The ground cover relations between species and groups do not normally vary much from year to year, but of course the productivity relations do vary considerably depending primarily on moisture and temperature relations. The production of the type as a whole is extremely variable from year to year with the largest annual yield during the period of observation being over three times greater than the smallest annual yield. The average yield for the six-year period has been 1108 pounds of dry material per acre.

Most of the grasses in the type are cool-season species, that make their growth relatively early in the season. Blue grama grass is an exception to this rule, since it starts its growth later in the

season and also matures later than most of the other species. The net result of the combination of growth habits of the grasses and normal distribution of precipitation is that by the end of July the prairie has usually produced over 90 percent of its total growth, most species have reached or passed physiological maturity, available soil moisture is nearly exhausted, and the grasses are beginning to dry. During August and September the grasses continue to dry and turn brown. The maturity and drying of the prairie is usually distinctly noticeable by mid-August, when the brown color of mature, dry forage becomes the dominant aspect of the grassland cover.

Table 3, which summarizes some of the results of a long time grazing trial at the Northern Great Plains Field Station at Mandan, shows the type of livestock performance which can be expected on native mixed grass. It also shows how the gains of beef animals are correlated with quantity and quality of feed obtainable throughout the season on this type of grassland. In May insufficient forage is available to permit maximum gains to be made. In June the vegetation is making its maximum growth and also is at its peak of quality. Livestock grazing on the forage make their maximum gains during this period. During July the forage begins to mature and gains fall off. As the vegetation further matures and extensive drying takes place the animals make successively lower gains, until by October they begin to lose weight. In general this seasonal trend in livestock gains takes place even though an adequate quantity of forage may be available at the end of the seasonal grazing period.

The normal practical grazing season on mixed grass is about five months, roughly from May 15 to October 15. The generally rigorous nature of our winters puts a limit on how long the native grass may be used as a source of pasture feed. However, winters in the southwestern part of the State are more open and generally less rigorous than in the other sections. Here the grazing season may be as much as 10 months or even yearlong, if plenty of pasturage is available. Usually winter grazing requires some use of supplemental feeds, such as hay or cottonseed cake, if weight losses in the grazing animals are to be kept at a minimum.

Nature of Deterioration of Mixed Grass

The mixed grass, as it occurs in the Northern Plains, is probably the most resistant to grazing of any native grassland type in existence today. This is because under the influence of grazing misuse it is first converted to a short grass type of high total density, and this short grass cover can only be destroyed by the most abusive type of grazing. Furthermore it is at least partially protected by a relatively long period of winter dormancy, and frequently it is protected by a snow cover of sufficient depth to prevent its grazing use.

Long before the mixed grass has been converted to a short

grass type by grazing the overall production of forage has been considerably reduced and the grazing season has been shortened. The data of Table 2 showed that almost 60 percent of the yield from the mixed grass type is produced by the taller grasses. As these grasses are reduced in vigor and decline in importance in the cover, the overall production of the type declines. The data of Table 4 illustrate the nature and extent of this decline. Thus a type which has as much as 53 percent of taller grasses in the cover could be expected to yield somewhere in the vicinity of twice as much forage as a type in which the taller grasses had been reduced to about 23 percent of the total cover.

TABLE 3
Production of Beef at Mandan

May	-	-	-	-	-	-	-	-	-	53 lbs.
June	-	-	-	-	-	-	-	-	-	107 lbs.
July	-	-	-	-	-	-	-	-	-	69 lbs.
August	-	-	-	-	-	-	-	-	-	55 lbs.
September	-	-	-	-	-	-	-	-	-	38 lbs.
October	-	-	-	-	-	-	-	-	-	Loss
20 year seasonal ave.	-	-	-	-	-	-	-	-	-	308 lbs.
Seasonal gain per acre	-	-	-	-	-	-	-	-	-	44 lbs.

Stocking rate — 1 animal per 7 acres.

TABLE 4
Forage Production and Degree of Utilization
On Native Grass Pastures

(Near Dickinson, N. Dak.)

Pasture No.	% of Taller Grasses in Cover	4-year Avg.		% Utilization (Estimated)
		Yield — Lbs. Per Acre (Dry weight)	Yield as % of Type 1	
1	52.5	1937	100.0	40
2	47.1	1448	74.7	45
3	37.1	1143	59.0	55
4	25.2	1073	55.4	60
5	22.9	912	47.1	65

The grazing season is shortened both by the factor of the general decline in productivity and by the fact that the cool-season grasses are the ones that have been most seriously affected. These grasses provide the bulk of the forage available in the early part of the grazing season before blue grama grass has begun to make its major growth. In years of favorable moisture conditions these grasses also provide some fall growth for grazing. Thus the converted short grass type can be expected to have an appreciably shorter grazing season than a comparable mixed grass type, with the shortening of the season taking place in both spring and fall.

Maintaining Productivity of Mixed Grass

The most important tool now available for maintaining or increasing productivity of native mixed grass pastures in this area is grazing management. In the grazing management of this type of grassland two factors are especially important. The first factor is the prevention of excessive use of these pastures in the spring, and the second factor is the proper utilization of the forage produced during the season.

During the spring period the taller grasses are especially susceptible to injury as the result of heavy grazing use. Continued over-use during the spring period is almost certain to result in a decline in vigor and abundance of the relatively high-yielding taller grasses, and the conversion of the mixed grass type to a short grass cover is hastened by this type of misuse.

The factor of proper utilization of the forage crop is less well understood and is considerably more complex than the matter of proper spring use. However, experience and experiment have shown that all of the grass produced in the growing season cannot be grazed off year after year without inducing a decline in plant vigor, forage production, and undesirable shifts in plant composition of the vegetation cover.

The data of Table 4 illustrate how the percentage of taller grasses and the total forage yield are related to the degree of forage removed during the season by the grazing animals. Experimental evidence from many parts of the Northern Great Plains indicates that if mixed grass pastures are to be maintained in productive condition only about one-half by weight of the total production can be removed in any one grazing season. This principle of grazing management has become known as the 50-50 rule, and simply stated means that one-half of the forage crop can be grazed off, and one-half should be left on the ground at the end of the grazing season.

When this rule is applied, the grasses do not suffer unduly from loss of photosynthetic tissue during the growing season, and adequate food reserves can be maintained in the underground, perennial parts of the plants. Furthermore the material left on the ground promotes the maintenance of proper conditions for the entry of water into the soil, and seems in itself to have an influence on the maintenance of overall vigor in the grassland cover.

The objective of proper grazing management for this type of grassland should thus be to regulate grazing pressures, so that a good mixed grass cover with a relatively high proportion of the mid-grasses in the cover is maintained. The grazing practices which will best accomplish this objective are the reduction or elimination of grazing pressure in the spring and the application of the 50-50 rule to the overall utilization of the yearly forage crop.

To put these two practices into effect it would be logical to provide a substitute pasture for at least part of the season. For-

tunately, we can provide high-yielding tame grass pastures for the spring period and then utilize the native grass pastures in the latter part of the season. Through the use of tame grass pastures in the spring, followed by the use of native pastures later in the season, not only can our management objectives be attained, but overall pasture grazing capacity can be increased by at least 30 to 35 percent.

Tame Grass Pastures Used With Native Pastures

Crested wheatgrass is a tame grass that has been in use in North Dakota for some 30 years now. It is especially well adapted for use as spring pasture in the western two-third of the State. Bromegrass has been in use in North Dakota for over 70 years. It is well adapted for spring pasture in the eastern portion of our grassland area where moisture conditions are relatively favorable. Crested wheatgrass does better than brome in the drier areas.

Table 5 shows the production of these grasses alone, in combination with alfalfa, and with the addition of 100 pounds of nitrogen. The yields for the grasses alone and in combination with alfalfa are pasture yields. The yields with nitrogen are hay yields. More important than the total yields as shown, is the fact that both grasses produce a high proportion of their yield early in the season. This is especially true of crested wheatgrass, which is the earliest of all tame grasses in use in this area, and generally is ready for grazing 10 days to two weeks before native grass. Both grasses will commonly have produced at least 1000 lbs., dry weight, of grazing forage per acre by June 5, while native grass will have produced only about 300 lbs. per acre by the same date.

Thus these grasses will have about three times the grazing capacity of native grass in the early part of the season. Beef production on these grasses will average from about 80 to 120 lbs. per acre, whereas native grass in good condition will produce about 44 lbs. per acre (Table 3). At Dickinson last year a crested wheat-alfalfa pasture produced 96 lbs. of beef per acre in a 51 day grazing period from May 4 to June 23.

There is general agreement that native grass and tame grass should be used in a ratio of about four acres of native grass to one of tame grass. Thus, when the two are used in this simple pasture rotation of tame grass in the spring followed by native grass in the summer and fall, a total of five pasture acres will do the same job that formerly required seven acres of native grass. Not only is the acreage required to provide seasonal pasture for an animal reduced, but the native grass resource will be improved and increased in productivity as the result of the elimination of spring grazing and a more conservative utilization of the forage crop produced by the native grass.

According to the statistical reports there are only about 100,000 acres of improved pasture in North Dakota. The provision of an

adequate tame grass pasture base for use in conjunction with native grass pasture, considered on a statewide basis, would require about 3,000,000 additional acres of land to be converted to tame grass. The logical source for this land to be converted to tame grass is the crop land presently scheduled to be retired from cultivation under the Government crop control and price support plans. If such a large scale conversion should take place we could provide pasture for a five months summer season for about 3,000,000 animal units on a total pasture base of about 15,000,000 acres. We are now providing grazing for about 1,750,000 animal units on a pasture base of slightly less than 13,000,000 acres.

Only an extreme optimist would picture us as converting 3,000,000 acres of cropland to tame grass right away. but this is as good a time as any, in fact quite a favorable time, to make a substantial beginning on this project. The principles governing the advantageous use of this grass are well known, the plant materials necessary are at hand, and there is every hope for adequate financial assistance to aid in getting the grass seeded. Perhaps as significant as anything is the fact that this is a project that does not require completion before it begins to provide benefits. Every bit of tame grass pasture that is established and used wisely in conjunction with our existing native grass resource contributes directly to the economic benefits derivable from that resource, and at the same time promotes the improvement of the resource itself.

TABLE 5
Tame Grass Production
Eastern North Dakota

Bromegrass	-	-	-	-	-	-	2,322 lbs. per acre
Brome and alfalfa	-	-	-	-	-	-	4,090 lbs. per acre
Brome plus 100 lbs. nitrogen	-	-	-	-	-	-	4,600 lbs. per acre
Western North Dakota							
Crested wheatgrass	-	-	-	-	-	-	1,153 lbs. per acre
Crested wheatgrass and alfalfa	-	-	-	-	-	-	1,716 lbs. per acre
Crested wheatgrass plus 100 lbs. nitrogen	-	-	-	-	-	-	2,390 lbs. per acre

HEAT OF WETTING OF SOME PIGMENT-LIQUID SYSTEMS

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When a solid is brought into contact with a liquid, a thermal effect is noted, as in cases where no chemical reaction occurs. When a pigment comes in contact with a paint vehicle it is wetted to some degree by the vehicle. Pigment-air interface is replaced

by a pigment-vehicle phase boundary. What takes place at the pigment-vehicle interface influences the grinding efficiency and many properties of the finished paint, for example consistency, flow, leveling, and gloss.

If after wetting the newly formed solid-liquid interfaces have a lower energy than the previously existing interfaces the excess energy will be liberated as heat of wetting. In our research the liquids and solids were introduced separately into a Dewar flask, the temperature was allowed to become constant, then the solid was introduced into the liquid and the amount of heat liberated was measured. After a constant temperature was again attained a known quantity of heat was liberated from an electrical coil, so that it was not necessary to determine the thermal equivalent of the system.

The heat of wetting was determined on carbon black, chrome green and titanium dioxide in linseed oil and mineral spirits. The values obtained for carbon black were greater than those for chrome green. In the experiments with titanium dioxide the results fell within the limits of the sensitivity of the instrument.

It was found that the addition of wetting agents such as fatty acids and soya lecithin markedly influenced the heat quantities liberated in the cases of carbon black and chrome green. However, the influence of these additions was nil in the experiments with titanium dioxide.

In a second series of tests the heat of solution of linseed oil in mineral spirits and of mineral spirits in linseed oil was measured. Determinations were made also on the influence of the addition of either oil or solvent after a pigment dispersion had been made.

The heat of solution of mineral spirits in linseed oil was found to be greater than that of linseed oil in mineral spirits in dilute solutions. The heat of wetting of carbon black by linseed oil was found to be greater than the values measured on phthalocyanine green. In experiments with titanium dioxide, Spanish Oxide, and jet-milled Van Dyke Brown, the results again fell beyond the limits of the sensitivity of the instrument.

It was found that the addition of mineral spirits to a pigment-oil mixture caused the value for the heat of wetting to be higher. The opposite was tried also; in the case where oil was added to a pigment-mineral spirits dispersion a higher value for the heat of wetting was measured.

The additional heat evolved when mineral spirits was added to a carbon black-linseed oil mixture was greater than that measured when linseed oil was added to a carbon black-solvent mixture.

PROBLEMS ENCOUNTERED WHEN BRIDGING THE MISSOURI RIVER

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In the early days of the white race in North Dakota there was very little need for human beings to cross the wide expanses of the Missouri River. When it was necessary to cross to the other side, man needed only to carry the limited possessions that he carried on his back. The crossing made in those days was by small boats, by swimming the stream, or by use of the widely spaced and less dependable ferry boats.

In the latter part of the nineteenth century the Northern Pacific Railroad reached the banks of the Missouri River at Bismarck. The wide expanse of the Missouri River delayed the rapid westward movement of dependable regular railroad service for several years. Irregular service was handled by the use of ferries and by laying tracks on the ice during the winter. Not until late fall of 1882 was dependable service opened by the completion of a bridge across this barrier to transcontinental transportation.

The opening for traffic of this Northern Pacific Railroad bridge at Bismarck in October of 1882 was the first time that the Missouri River had been bridged in the State of North Dakota. Another forty years of time was to pass before additional bridges would span this stream. The public accepted, for many years, the slow and time consuming method of crossing the River by ferries.

The development of the automobile, and with greater speed in the movement of transportation, created a demand for a quicker method of crossing this barrier. The rapidly growing towns of Bismarck and Mandan indicated to the State that a highway bridge between these two towns would be economically feasible. Thus in 1922 the bridge across the Missouri River between Bismarck and Mandan was completed and uncontrolled traffic between the two towns became a reality.

During the next ten years three more bridges were built across the Missouri, first at Williston, then Sanish and lastly in 1932 the construction of a bridge on the Elbowoods Indian Reservation was started.

With the beginning of construction of the Garrison Dam, it was evident that the bridge at Elbowoods would no longer be practicable and the bridge at Sanish would have to be replaced with a longer, higher structure over the wide expanse of water that would be impounded behind the Dam. The structural steel in the Elbowoods bridge was removed, transported by truck to the new location and then incorporated in the new bridge at Newtown across the reser-

voir. The completion of Garrison Dam has provided another crossing of the Missouri River.

The depth and width of the river varies somewhat at the locations of these crossings. The following table lists the criteria of the bridges which have been constructed over the Missouri River up to the present time.

Bridge	Year Built	Overall Length	River Spans		Clearance Above		Original Cost
			No.	Clear Length	Low Water	High Water	
Northern Pacific	1882	2940'*	3	388'			
Bismarck	1922	2550'	3	465'	43'	53'	1,341,000
Williston	1927	1438'	4	308'	37'	58'	572,000
Sanish	1927	1160'	4	266'	42'	56'	426,000
Elbowoods	1934	1622'	3	463'	38'	53'	323,000
Newtown	1952	4482'	3	463'	41'	116'	4,141,000

* This structure was constructed with a long timber approach trestle on the west end which was subsequently removed.

There has been considerable agitation at various times within the past twenty years for bridges at other locations along the river. At the present time an extensive study is being made to determine the feasibility of the construction of an additional highway bridge in the Bismarck-Mandan area to handle the increased intensity of traffic. Undoubtedly, in the not too distant future, one or more additional bridges will be built across the Missouri River in North Dakota.

There are a number of features which contribute to the practicability of constructing any structure. The features which perhaps have the greatest effect on the construction of a bridge across the Missouri River in North Dakota are:

- a. Foundation conditions
- b. Ice conditions
- c. Scour conditions
- d. Navigation requirements
- e. Economics

Foundation Conditions

It is common knowledge that all structures of any size must have an adequate foundation resting on a type of material which will carry the super-imposed loads. The ideal soil material for carrying loads of an intensity such as those produced by a large bridge is a good grade of rock.

All soils data taken along the Missouri River in North Dakota reveal one important fact, that is the total absence of any type of rock capable of carrying these large concentrated loads. The absence of rock makes it necessary to use a less desirable material to support the structure.

A heavy layer of dense clay underlies the greater part of the

western half of North Dakota. This heavy clay is geologically known as the "Fort Union Formation". This clay formation is usually found to be very hard and is capable to safely withstand bearing loads up to six or eight tons per square foot. It has been found to contain a sand in varying quantities from none to nearly all sand.

This bearing material is found at varying depths below low water. In the Fort Yates and Cannonball area borings have been made to as low as 150 feet below low water without reaching this clay. At other locations in the State, this material has been found within thirty feet of the low water elevation. Obviously, it would be extremely expensive to sink foundations to as much as 150 feet below the river bottom. In fact it is economically impossible to do so until the demand and use for the bridge has increased many fold.

Ice Conditions

During the long winter months in North Dakota, the low temperatures and the lack of an insulation blanket of snow, creates a condition favorable to extreme thicknesses of ice on the Missouri River. The thickness of this ice has been known to reach 41 inches and at times has probably exceeded this thickness.

The Yellowstone River, which is a major tributary of the Missouri River, flows from an area in Montana where, as a rule, the atmospheric temperatures are considerably higher than in North Dakota. As a result the Yellowstone River generally breaks up earlier in the spring than does the Missouri River. This sudden rush of large volumes of water from the Yellowstone River starts the movement of large fields of ice in the Missouri. This ice is still very thick and extremely solid. The many bends in the river and large areas of timbered flood plains are ideal conditions for the creation of large ice jams. The continual piling up of this ice creates a high water condition not found in the warmer states.

In the majority of cases these large ice gorges move out after the river has reached a high stage. When this happens the ice will move down the river in accumulations of many feet in thickness. The impact of these large flows of ice on a span or pier creates an extreme load on the bridge structure that must be considered in the design of the bridge.

Scour Conditions

The bed of the Missouri River consists of many feet of fine sand and silt. A nominal rise in the level of the water creates a force which starts this sand moving downstream. At periods of high water these beds of sand have almost fluid characteristics. In fact the writer has seen evidence that, with a nominal rise, the bed of the stream has been scoured down to almost thirty feet below the low water level. Undoubtedly in periods of extreme flood and ice flow, this scour has reached a considerable depth.

It is imperative that pier footings be placed below any possible

scour. This extreme depth of scour makes it necessary to sink pier foundations to considerable depths below the river bed. These deep piers are very expensive and constitute a very important factor in determining the practicability of building a bridge at any given location.

Navigation Requirements

A number of years ago a considerable number of commercial boats operated on the Missouri River in this area, carrying goods for hundreds of miles up and down stream from Bismarck. When the Northern Pacific Railroad reached the Missouri River, Bismarck became an important cog in this field of navigation.

Shortly after the bridge over the Missouri River was completed by the railroad, the amount of navigation on the river began to decline. This decline was largely due to the faster service that the railroad could give to the smaller communities. This decline continued until about 1935 when commercial navigation had practically disappeared from the Missouri River in North Dakota.

The characteristics of these river boats made it necessary to leave large vertical clearances between the water level and the low point of the spans. The vertical clearance requirement on the Missouri River in North Dakota has been maintained at 38 feet above navigation high water for many years.

The characteristics of these river boats have also contributed to the control of locations of piers and the lengths of the river spans for these bridges. For many years, navigation interests have contended that span lengths of less than 300 feet were undesirable due to the uncertainties of river navigation.

The requirements as set up for navigation have contributed to a high cost for bridges over the Missouri River. However, since the construction of the major dams and reservoirs on the Missouri River a new phase of thinking has started. It is now believed to be economically impractical to set up any amount of commercial traffic on the river. All interested parties are now considering lowering the requirements for vertical navigation clearances, span lengths and control of pier locations.

Economics

The foregoing items, namely, Foundation conditions, Ice conditions, Scour conditions, and Navigation Requirements contribute to the economics of bridge construction over the river. These items play a large part in determining the cost of the structure.

Another item, however, that enters into the picture is the ability of the user to pay. Needless to say, it would not be feasible to construct a bridge costing a million dollars for the use of two or three men. Assuming that the proposed bridge near Bismarck would cost something over five million dollars, it is obvious that to be economically feasible, it should be constructed in a location that would enable thousands of vehicles to use it every day.

CONTROL OF VARIABLES AS ILLUSTRATED IN THREE EXPERIMENTS (PSYCHOLOGY)

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In this report an attempt is made to describe the variables, and the methods used in controlling those variables, which would have rendered suspect the findings in three psychological experiments. Controls vary in type or pattern according to the specific problems under study; naturally, the actual findings are usually of considerable interest, but in this report they are to be regarded as incidental to the main purpose which, as stated, is to illustrate differing types of controls as needed and used in the three projects.

Control Method: Equivalent Groups

In an experiment dealing with retroactive inhibition, the purpose was to determine the effect of new learning-activity upon the retention of old learning where the new (or interpolated) activity was **similar** in nature as against **dissimilar** new activity. At least three dependent variables were involved: the material to be learned; the time for learning; and the learners themselves. Nonsense syllables were used to eliminate the factor of previous learning; the timing was held constant by giving ten 2-second exposures of each syllable. Then, following computation of first-round results, the 155 subjects were divided into equivalent groups, after which the experimental group learned a second list of nonsense syllables (representing similar activity), while the control group engaged in a letter-deletion contest (dissimilar activity). Following the second-round activities, the retention scores of both groups were computed. Incidentally, the results appear in Table I.

TABLE I. Mean Scores of 155 Ss in Retroactive Inhibition

Syllables Retained	Syllables Retained
Control Group: 77 Ss	Experi. Group: 78 Ss
Mean 8.2	Mean 8.2
After Dissimilar Activity	After Similar Activity
Mean 8.4	Mean 6.0
Difference 0.2	Loss 2.2 (27%)

Control Method: Rotation

In an experiment dealing with retention as a function of self-recitation, the question, simply put, was: Which is the more efficient method in learning—the “reading method” or the “recitation method”? The material to be learned consisted of two selections of poetry (72 words in each), unfamiliar to all 161 Ss of course, to offset the factor of previous learning. But to offset the immediate

practice-effect gained from memorizing Stanza I, which conceivably might facilitate learning Stanza II, the following procedure was used: Two groups were organized (odds vs. evens, since only a reasonable equivalence was deemed necessary); one group to use the reading method in memorizing Stanza I, while the other group employed the recitation method, after which the groups reversed methods in memorizing Stanza II. By this alternation, the practice factor was offset. With all 161 Ss having used both methods, the resulting scores would measure, not the superiority of one group over the other (although this may have been a motivating factor), but the superiority of one **method** over the other.

As previously, although incidental, the results are presented in Table II.

TABLE II. Mean Scores 161 Ss In Recitation Experiment

Words Recalled		Words Recalled	
By Reading Method		By Recitation Method	
Possible	72	Possible	72
Mean	47.9	Mean	52.7
S. D.	15.8	S. D.	14.3

While the difference in the means seems small, the overall time limit was only six minutes. The data were checked by appropriate statistical formulas to determine significance, the Table of Probabilities indicating that the difference would be reliable to the extent of 997 out of a thousand chances. An interesting sidelight: Women excelled men 108.4 to 93.9 in recall words; but the men profited more in the use of the recitation method of learning.

Control Method—ABBA-Counter Balance

The third experiment dealt with the effect of distraction upon attention where 132 Ss engaged in simple addition exercises consisting of ten computations performed under normal study conditions as compared with ten additions done under conditions of intermittent noise, with the time-in-seconds recorded for each. The use of simple additions offset any variable arising from new or difficult learning processes. But the problem remained as to what constituted normal (that is, without noise)? Five additions were done under quiet conditions (Round I); Rounds II and III were accompanied by intermittent noise, covering ten computations; and Round IV returned to the quiet or normal conditions. The practice effect in going from one round to the next was held under control by summing the scores for Rounds I-IV as against the sum of scores for Rounds II-III (with noise). The control score (normal) revealed a mean of 302.8 seconds; the experimental (noise), 324.2 seconds.

The data are presented in Table III.

Common sense would suggest that noise is a distraction, but the findings revealed that approximately one-fourth of the Ss actually

gained under noise; one-fourth showed no difference (arbitrarily reckoned at plus-minus ten second from normal); while one-half showed definite losses under noise conditions.

TABLE III. Effect of Noise Upon Attention of 132 Ss

Control (Normal)	Experimental (Noise)
Time-in-Seconds	Time-in-Seconds
Mean 302.8	Mean 324.2

The attempt to apply scientific methods in holding numerous variables under control is sometimes difficult and even treacherous, and cautious conclusions are advised as applicable only to the particular participants under the given situations.

In summary, it can be said that two equivalent groups operated separately in the first experiment; in the second, rotation of Ss was used; and in the last, the materials themselves were rotated in order to establish controlled and experimental conditions.

FURTHER STUDIES ON CHICK GROWTH INHIBITION WITH LINSEED MEAL^{1,2}

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INTRODUCTION

Reports of the depressing effect of unheated linseed meal on chick growth have appeared periodically since 1928. The pertinent literature was reviewed recently by Schlamb, et al (1). The growth depressing factor was found to be concentrated to a greater extent in the cotyledon than in the hull fraction, eliminating mucilage as a major factor. In these experiments the cotyledon fraction approached but never equaled the growth depressing effect of the extracted unheated whole meal when fed on the basis of the cotyledon equivalent to the raw meal. In the flaxseed fractionation process a middling fraction accounting for about 20% of the meal is obtained. Feeding experiments were conducted to determine the relative inhibitory power of this fraction. Kratzer (2) had reported the beneficial effect of pyridoxine in suppressing the inhibitory factor in the whole unheated meal. In the feeding trials reported in this paper pyridoxine was added to rations containing the unheated

1. Progress report on Project Bankhead-Jones 9.33 Linseed Inhibition of Chick Growth.
2. Published with the approval of the Director, Agricultural Experiment Station.

meal and the fractions to furnish evidence that the same factor described by Kratzer was under consideration, and to obtain some quantitative data on the amounts of pyridoxine required to overcome the linseed meal inhibition.

EXPERIMENTAL

Lots of ten chicks on standard ration for one week were used in the experiments. Breed and sex varied with the experiments and will be identified with the individual case. The standard ration consisted of ground yellow corn 61.5, soybean meal 26.5, alfalfa leaf meal 2.5, trace mineral salts 0.5, vitamin mix 1.0, dried butter milk 2.5, steamed bone meal 3.5, meat and bone scraps 2.5. The composition of the vitamin mix was reported by Schlamb and coworkers (1). When linseed meal or fraction was substituted for a portion of the soybean meal the corn meal was adjusted to maintain a uniform protein level. Chicks were fed ad libitum.

RESULTS

Comparison of Inhibition With Middlings Compared With Whole Raw Meal

In previous experiments the cotyledon fraction was shown to be more inhibitory than the hull but never quite equaled the inhibition of the whole meal (1). The middling fraction was tested along with heated and unheated whole meal, and raw meal containing 9 mg. of pyridoxin per pound of feed. Chicks used were cockerels of broiler strain (Indian River). Table I shows the results of the feeding trials.

TABLE I
The Inhibitory Effect of the Middling Fraction
Compared With the Whole Meal

	Gain in Weight		
	1st Week	2nd Week	3rd Week
Control	83	115	127+
Heated Meal	69	100	116+
Raw Meal	35	68	118+
Raw Meal w B ₆	67	88	101+
Middlings	25	45	127+

+ Pyridoxine added at the end of the second week.

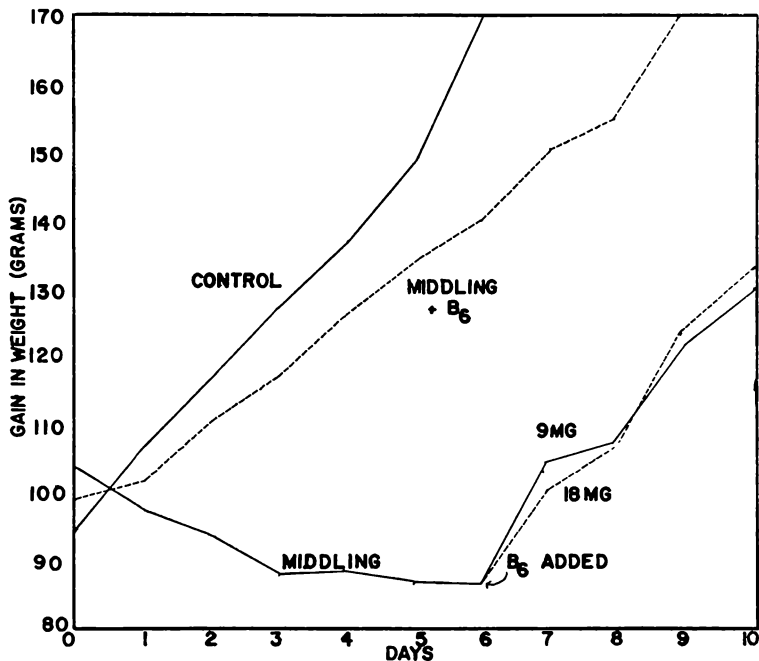
The fractions were added to the extent of 15% of the ration with the corn and soybean modified to adjust for the different levels of protein. Although the middling fraction was only slightly higher in protein (45%) than the whole meal (43%), the inhibitory effect was definitely greater than in the raw meal when fed on an equal weight basis.

Another feeding trial was conducted to determine the upper limits of the inclusion of the middling fraction of linseed meal in

the ration with the retention of some growth. The birds were fed the normal ration in which soybean meal was replaced with middlings so that the latter accounted for 21% of the ration. The chicks used were straight run 10 day old New Hampshire Reds. The results are shown in Figure 1.

Figure 1.

Effect of 21% linseed middling fraction in ration on chick growth; average of 10 chicks; on the 6th day pyridoxine was added to the ration at the rate of 9 and 18 mg per pound of feed.



The feed consumption in the case of the 21% middling ration was low and the rate of growth negative. The addition of 9 mg. per pound of pyridoxine to the 21% middling fraction increased the feed consumption to normal. At the end of the sixth day the chicks on the 21% middling fraction without added pyridoxine were divided into two lots of five chicks each and the rations were supplemented with 9 mg. and 18 mg. of pyridoxine, respectively. Both additions of pyridoxine had essentially the same growth effect. In other words, 9 mg. of pyridoxine per pound is optimum or above optimum for this particular fraction.

D. W. Bolin (3) found that the addition of the essential amino acids in quantities sufficient to bring the amino acid level of un-

heated meal up to whole dried egg content produced an inhibition in growth similar to that observed on the inclusion of 21% middlings in the ration, further more this inhibition was counteracted by the inclusion of 9 mg. of pyridoxine per pound of ration. This evidence would appear to eliminate the possibility of an amino acid deficiency as the chief causative factor. The reasons for a negative rate of growth on the addition of the "essential amino acids" is not apparent at present.

In previous experiments (1) we had never observed the inhibition of mucilage encountered by Mani and coworkers (4). The Canadian workers had used the equivalent of 30% linseed meal in the ration. A feeding trial was conducted using the isolated hull in the ration at the 15% level, along with various hulls, middling and cotyledon ratios. The hull fraction was used in place of a part of the corn and soybean content so that the protein content was essentially constant. Results of the trial are shown in Table II.

TABLE II

The Inhibitory Effect of the Hull Fraction Compared With Various Percentage Ratios of Middling and Cotyledon Fractions

	Gain in Weight		
	1st Week	2nd Week	3rd Week
Control	83	115	127+
Hull 15%	40	58	95+
Hull 7.5%, middling 7.5%	36	46.5	104+
Hull 5%, middling 5%, cot. 5%	18	37	111+
Raw Meal	35	68	118+

+ Pyridoxine added at the rate of 9 mg. per pound of feed at the end of the 2nd week.

The hull fed at the 15% level exerted a definite inhibitory effect. The beak necrosis reported by other workers was observed. There appeared to be some beneficial effect from the addition of pyridoxine to the ration, however the stimulation is not as great as in the raw meal or embryo fractions. We feel that the growth inhibition of the hull is a combination of mucilage interference with digestive and pyridoxine inhibition. The growth depression observed on the inclusion of hulls, middlings, and cotyledon fractions, each at the 5% level, is rather difficult to explain. Further work is being done in an attempt to evaluate this observation.

DISCUSSION

The inhibition of chick growth with linseed meal appears to be the summation of a number of factors. Pyridoxine at the rate of 9 mg. per pound of feed counteracts a part of the inhibition. When pyridoxine was added in excess of 9 mg. per pound to a ration containing sufficient linseed middlings to entirely suppress growth in the absence of pyridoxine, no additional stimulation was observed.

Work is now in progress to determine the lower limits of pyridoxine for maximum growth on linseed meal. The pyridoxine corrected chick growth inhibition of the middling fraction is greater than cotyledon which is greater than hull when calculated on a protein nitrogen basis.

The mucilage inhibition appears only when the hull fraction is added in excess of 7.5% of the ration. Rations containing the higher percentages of hull produced growth responses similar to those reported by Mani (4). The reason for poorer growth with linseed meal supplemented with B₆ than with soybean meal is not apparent. We feel that amino acid composition is not the controlling factor as supplementation either was without effect or actually produced negative growth in the absence of added pyridoxine.

Some preliminary studies have been made on fractionation of the cotyledon into alkali dispersible, isoelectric precipitable protein, nondispersible residue and non-isoelectric precipitable supernatants. Feeding trials have shown that the globulin fraction and nondispersible residue do not contain the pyridoxine counteracted inhibitor. Details of these studies will be published elsewhere. At present we have no information on the chemical nature of the inhibitor.

SUMMARY

Comparative chick growth studies with various percentage rations of linseed middlings, hulls, and cotyledon fractions indicate that the inhibitor is contained in the three fractions but is concentrated in the middling portion.

Hulls at high concentrations (15%) exert an inhibiting effect which is only partially compensated by pyridoxine. Presumably at these high levels mucilage content becomes one important factor.

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AERIAL PHOTOGRAPHY AND PHOTOGRAMMETRY AS APPLIED TO HIGHWAY ENGINEERING IN NORTH DAKOTA

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In discussing this subject I wish to leave to the photogrammetric specialists, matters pertaining particularly to that science and to

present from the point of view of the highway engineer our experience and progress in the State Highway Department.

Aerial photography and photogrammetry have been used extensively by the North Dakota State Highway Department since 1953. We have in our files complete stereophotographic coverage of the entire State. These photographs were purchased from the Production and Marketing Administration, U. S. Department of Agriculture. The scale of this photography is 1 to 20,000.

A. Reconnaissance

Aerial photographs are very useful in working out the solutions to highway location problems. Previous to the use of aerial photography, such a job would have required considerable tedious reconnaissance on the ground. In the first stage of highway location, a wide area is examined thoroughly from terminal point to terminal point. The width of this area may range from 40 to 60 percent of the length. It results in the determination of all feasible alternate routes for a highway between the terminal points after all of the controls of topography and land use have been ascertained and broadly considered. The reconnaissance is accomplished by a stereoscopic examination of the aerial photographs. Stereoscopic examination permits the engineer to view the area in the third dimension. Now a location engineer can accomplish much of his reconnaissance during the winter months thus increasing his annual mileage output.

B. Drainage Areas

Another very useful aspect of aerial methods is the determination of the size and character of drainage areas.

1. By stereoscopic examination it is simple to determine the type of terrain for the purpose of determining the speed of concentration of the run off water.

2. Because of the three dimensional effect obtained in stereoscopic examination, ridges and draws can be determined and drainage areas can be traced out on the photograph. The actual size of the drainage area can be accurately obtained through the use of a planimeter.

C. Provides Additional Information for Designer

Aerial photographs can be very useful to the designer for the examination of physical characteristics, topography, and general terrain outside the limits of a standard field survey. In many cases, additional information which normally would require a special effect on the part of a field party can be obtained speedily and accurately by stereoscopic examination.

D. Use in Compilation of County Maps

The Highway Planning Survey is presently involved in the improvement of county maps by the use of aerial methods which results in the production of more complete county maps in a shorter

period of time than by the conventional method of ground survey. A brief description of the methods employed follows:

1. Construction of Control Grid and Projection:

The entire county map is constructed on a scale of 1 inch to the mile. A system of straight lines every 50,000 feet in both horizontal and vertical directions is drawn on this base map. These lines are numbered according to the State Grid System established by the United States Coast and Geodetic Survey. Then through a series of computations, all triangulation stations are plotted and section corners located with respect to triangulation stations as reported by field parties. Section lines are then plotted in accordance with the original government land surveys.

2. Preparation of Aerial Photographs for Mapping and Field Inventory:

All principal points are plotted on each photograph by the intersection of fine lines through points of opposite collimating marks. These points are numbered with the same number as the photograph and are then transferred to all overlapping photos and numbered respectively. The principal point and transferred principal points then establish the flight line. All sections appearing on the photo are numbered and the township and range are written respectively on the edge of the photograph.

The county which is to be inventoried is then divided into zone maps, each zone being approximately two townships square. These zone maps are then loaded from Aerial Photographs, Quadrangle Maps and previous Planning Survey Maps as to roads, cultural and other identifiable features. These zone maps along with Aerial Photographs and other reference maps are taken out by the field crews for air inventory.

3. Obtaining Planimetric Detail:

By use of the Stereocomparagraph with a Pantagraph attachment, reduction in the scale of the photographs to the final map scale is made and planimetric details are traced from the photographs onto the map in one operation.

4. Final Map Compilation:

All of the aforementioned data is then compiled and the final outcome is a county map with all local roads, Secondary Highways and cultural features in Black; Primary Highways in Red and Drainage in Blue. Thus through the useage of aerial photographs a county map showing all pertinent data and printed in colors for good legibility. is the result.

E. Determining Locations of Aggregate Deposits Originating From Glacial Action

1. The conventional method of aggregate prospecting is done in the field with no advance information as to location of aggregate deposits. Considerable success has been realized in locating gravel deposits resulting from stereoscopic examination of aerial photo-

graphs. Third dimensional viewing brings out glacial land forms such as moraines, eskers, and kames which likely contain gravel deposits.

2. Steps used in this method of search for gravel are as follows:

(a) From County Mosaics general Geological features of various parts of the county are determined such as:

1. Locations of known gravel deposits.
2. Correlation of data with known productive areas.
3. By a detailed stereoscopic examination of the photographs of the area, predictions of likely productive areas are determined for field investigation.
4. Field party makes a record of the actual findings encountered at these selected areas.

3. It is believed that as work progresses, and areas covered become more extensive, more accurate results will be attained.

F. Large Scale Mosaics for Urban Areas

Complete mosaics and contact prints on a scale of 1 in = 400 feet covering the areas within and immediately surrounding all of the major cities within the State have been contracted for by the department and are used to advantage such as:

1. Determination of route locations in Urban Areas:

By a study of these mosaics together with stereoscopic examination of individual photographs, route locations can be made taking into consideration such features as intersecting streets, street widths, the type of developments, etc. This is extremely helpful not only to the location and design engineer, but also to the engineer who must keep in mind future development.

2. Economic feasibility studies:

Due to steadily increasing traffic and congestion resulting in urban areas, it is oftentimes necessary to make route changes. To justify these changes, a complete economic study must be made of the area taking into consideration construction costs and benefits to the users. A road user benefit analysis study will determine the justification of the relocation and reconstruction of a route. In making a study of this type, the aerial mosaic and stereoscopic examination is invaluable in the determination of types of terrain and the physical and cultural characteristics.

3. Assessing right of way damages.

On large scale photographs it is relatively simple to determine right of way costs and damages resulting from construction of a new route. Cultural developments such as buildings, utilities, parks and playgrounds are readily identifiable on aerial photographs.

4. Detailed layouts of interchanges, separations and construction details can be readily transposed onto aerial photographs.

Because the areas around the major cities of the State may be termed as critical, the use of these mosaics is invaluable for lay-

outs. A proposed improvement can be accurately laid out on the aerial mosaic to include many of the details.

5. To obtain for the designer information not covered in the conventional ground survey:

A conventional ground survey in urban areas is restricted to the limits of the survey. Through the use of an aerial mosaic, the designer has a complete and accurate map of the entire city which is a valuable aid in not only the initial design but also in the advance planning of future developments.

G. Use of Photogrammetry

Complete aerial surveys of selected projects to include topographic maps on a scale of 1 inch = 50 feet and having a contour interval of two feet are also contracted for by the department and are used to supplant conventional ground surveys, the advantages of which are as follows:

1. The cost of aerial surveys in rough terrain is less than by conventional ground methods. An aerial survey was made on a section of U. S. Highway No. 85 in an extremely rugged type of terrain. Before letting this project, the costs were estimated and it was determined that the aerial cost would be less than half of the cost of a conventional ground survey. Also, a ground survey of this project would have consumed an entire summer for a field party to complete. This factor alone is important in maintaining a survey schedule.

2. An aerial survey can be made to any width from a predetermined survey centerline. In the case of the project mentioned, the width was 1000 feet on each side of the survey centerline for a total survey width of 2000 feet. This extra width gives the designer room to shift the line because of the rugged terrain or to establish more favorable gradients. The aerial contractor does all of the ground control work which consists of permanent points set at intervals which are intervisible, co-ordinated and for which elevations are established. When the designer has established his final centerline all points can be tied to these control points by triangulation. The location of any centerline point can therefore be accomplished in the field by setting a transit on a control point, sighting to another, turning a computed angle and chaining a computed distance to the desired point.

Having established the centerline, a profile is taken by accurately scaling distances and reading elevations from the contour maps. The profile is used for the purpose of establishing gradients.

The project is then cross-sectioned from the contour maps by using an accurate scale and reading elevations. It is believed that this method is more accurate in rugged terrain than conventional field survey cross-sections due to the fact that a right angle with the centerline is always maintained. A right angle oftentimes is difficult to maintain in field cross sections when the terrain is ex-

tremely rugged. After the cross sections are determined and plotted it is a routine matter to compute and balance excavation quantities.

Conclusion:

Aerial photography, although relatively new in our highway program, has become an increasingly valuable tool in all phases of highway work from its initial stages to the final completion. We find that through its use we are planning and building highways which are more efficient, are more adaptable to their location and are more economical to the user. The aerial photograph has now made it possible to establish a proposed highway system with a final and fully approved location with less engineering effort than could have been done by conventional ground methods.

SPECULATION ON THE EFFECTIVENESS OF PIPERAZINE CITRATE IN ANIMAL HELMINTHOLOGY*

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ABSTRACT

Piperazine compounds have been highly successful as anthelmintics against large roundworms and pin worms in man and have exhibited excellent results in removing large roundworms from poultry and large roundworms and nodular worms from swine. In investigations involving helminths of ruminants, however, erratic results have been obtained.

In critical studies with parasites of sheep, no uniform criterion for effectiveness of piperazine citrate has been established. Speculative arguments as to species specificity, position in the host, feeding habits, permeability of cuticle, metabolic differences and resistance are discussed.

* Published with the approval of the Director, North Dakota Agricultural Experiment Station, Fargo, North Dakota.

PRELIMINARY REPORT ON EXPERIMENTS OF PASSING URANIUM ACETATE THRU LIGNITE COLUMNS

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ABSTRACT

Uranium acetate solution containing 2 g. of Uranium per liter

was passed thru 20 mesh and mixtures of 20, 14 and 28 mesh Kincaid-Truax-Traer lignite from Minot. Aliquots of the solution which passed thru the lignite were made 2.4 N with Con HCl and passed thru a Jones reductor, first made of lead and later made of amalgamated zinc. Uranium was extracted from sections of the lignite column with 3 N HOCl, 2 N H₂SO₄, 3 N HOCl, 9 N H₂SO₄; and 12 N HCl: Those extractions were made up to 1 L. and aliquots were analyzed for Uranium. Sulfato Ceric acid was used to oxidize Uranium plus 4 to plus 6 and from the volume of that acid used, the amount of Uranium present was determined.

From curves it is seen the amount of Uranium removed by lignite from a Uranium solution is dependent upon the time of contact. The difficulty of removing the Uranium from the lignite would indicate more than an adsorption phenomenon.

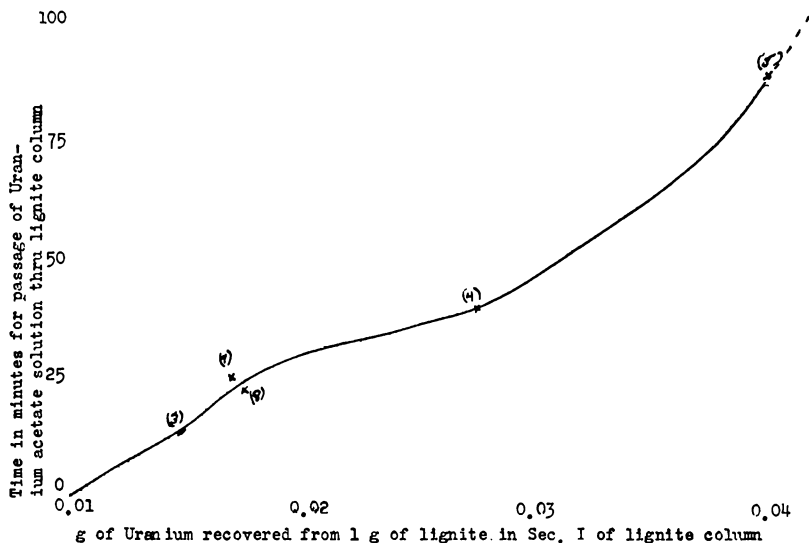
EXPERIMENTAL

Uranium acetate solutions containing 2 g. of Uranium per liter were passed thru 2.5 mm x 64 cm columns of Kincaid-Truax-Traer lignite from Minot. In the first experiments, mesh 20 lignite was used but the columns were not washed to remove the fines. Two millimeter bore stopcocks with a tapered end were used to control the flow of solution. Hence the flow of solution thru the columns was slow and there were interruptions due to the plugging of the stopcocks with fines. Therefore the first pair of experiments in which eight liters of Uranium acetate solution were used are not included in the graphs. In all other experiments, the lignite columns were thoroughly washed to remove the fines before the solution was passed thru them.

A 4 mm bore stopcock with both ends open was used in the later experiments. A mixture of equal parts of mesh 14, 20 and 28 lignite was used in Exp. III, IV, and V. The mixture was chiefly mesh 28 in Exp. VI, VII, VIII, and IX. In Exp. IX, it required all day to wash the column free from fines. At the beginning of the following day, the Uranium acetate solution was started to pass thru the column. Two hours were required to pass thru the first liter. Hence this data is not placed on the graphs.

Upon analysis of the sections in the lignite columns of the last four experiments, it was suspected that some reducing agent other than Uranium was being extracted. The results showed recovery of excess Uranium. Hence a control on a 20 g. sample of the lignite was made. This sample was washed thoroughly to remove fines and extracted with four 50 ml. portions of 12 N HCl, then washed just as the sections containing Uranium had been treated. This solution yielded a yellow solution comparable to the color of Uranium acetate solution. However this solution gave a red color with KSCN. Uranium acetate solution does not give this test but shows fluorescence under Ultra Violet light. The yellow solution extracted from the control lignite sample did not fluoresce. This 20 g. sample of

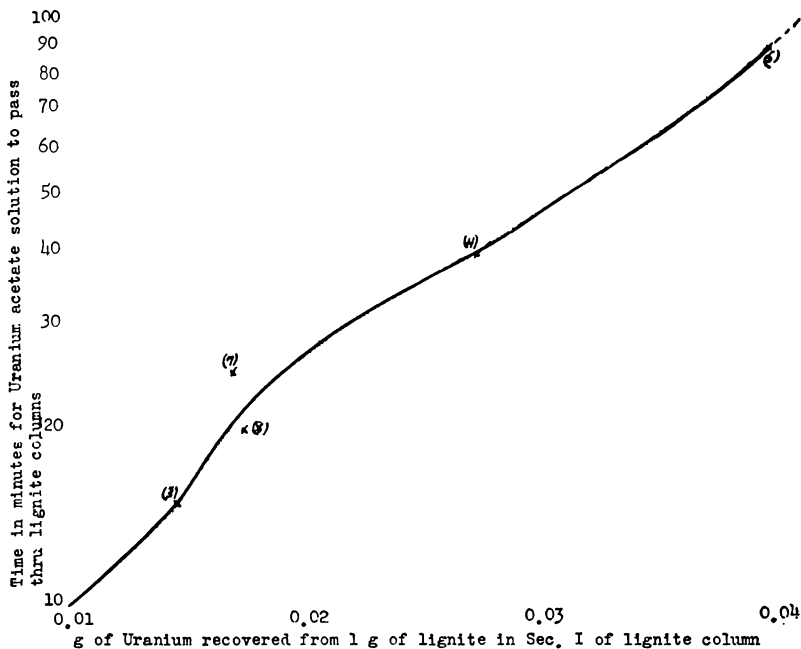
lignite yielded a reducing agent equivalent to 0.1049 g. of Uranium. In the columns of seven sections, this value was multiplied by 7 to give 0.7343 g. of reducing agent to be subtracted from the total calculated Uranium present in the column. This will be a source of error since the lignite is of variable composition and the amount of fines in a section washed out would not be constant. Examination of data on coal samples shows there is more ash in fine particles of coal (3). This fact was learned after mesh 28 lignite was used.



In the first two experiments, the columns were finally washed with 200 ml. of water and 1-2 mg. of Uranium were recovered. The columns showed no fluorescence under Ultra Violet light. Those columns were divided into 5 sections and each one extracted with 3 N HCl. Too much Uranium was unaccounted for and those sections were re-extracted with 2 N H₂SO₄. 3.7 and 2.8% of Uranium were still unaccounted for after the sulfuric acid extraction.

In the next three experiments, the sections lignite were extracted with four 50 ml. portions of 12 N HCl and diluted before filtering, then with four 25 ml. portions of 9 N H₂SO₄ and diluted before filtering. The solutions were made up to 1 liter and aliquots were analyzed for Uranium. In the last four experiments, the sections of lignite were extracted with four 50 ml. portions of 12 N HCl, then washed with water and made up to 1 liter.

A lead reductor was used in the first experiments. This reductor was difficult to keep in usable condition. Hence an amalgamated zinc reductor was used in the later experiments. 3.7 g. of mercuric chloride for every 100 g of zinc were used to prepare



the amalgamated zinc. This is three times the amount of mercuric chloride used by Sill and Peterson (2) who changed to the use of the lead reductor and recommended the use of a lead reductor over that of the amalgamated zinc. To prevent excess Hydrogen formation the amount of mercuric chloride should be about 14 g. for every 100 g. of zinc (4).

The amalgamated zinc reduces Uranium plus 6 to plus 3 and plus 4. Aeration for five minutes changes the plus 3 to plus 4. Sulfato Ceric acid was used to oxidize Uranium plus 4 to plus 6. The amount of Uranium was determined from the volume of sulfato ceric acid necessary for this oxidation.

Since the solution which passed thru the column had no acid, the aliquot samples used for analysis were made 3 N with con HCl. Acid is necessary both for reduction of Uranium plus 6 and also for oxidation of Uranium plus 4 to plus 6 with the sulfato ceric to prevent precipitation of ceric hydroxide. One normal acid will prevent precipitation of ceric hydroxide. The sections of lignite were extracted with 200 ml. of 12 N HCl and made up to 1 liter. Hence those solutions were 2.4 N acid.

Summary of Exp. VII

7 Sections (140g. of lignite)

1 liter of Uranium acetate solution containing 2 g. of Uranium

Section

I	0.3319 g. of Uranium plus other reducing agent
II	0.2909 g. of Uranium plus other reducing agent
III	0.2769 g. of Uranium plus other reducing agent
IV	0.2420 g. of Uranium plus other reducing agent
V	0.2322 g. of Uranium plus other reducing agent
VI	0.2275 g. of Uranium plus other reducing agent
VII	0.2220 g. of Uranium plus other reducing agent
Total	1.8234 g. of Uranium plus other reducing agent
	1.8234—0.7343 = 1.0891 g. of Uranium

Fraction passed thru column

	1 L	0.7762 g. of U
Uranium in		2.0000 g.
Uranium out		0.7762

Uranium removed		1.2238
Uranium recovered		1.0891

Uranium unaccounted	0.1347	
Uranium recovered =	(1.0891) 100	
from sections	-----	= 88.9%
of column	1.2238	
Uranium unaccounted for =	(0.1347) 100	
	-----	= 6.5%
	2.0000	

Basis: 1 L of original solution

Uranium removed	= (1.2238) 100	
	-----	= 61%
	2.0000	
Uranium in filtrate	= (0.7762) 100	
	-----	= 39%
	2.0000	
Uranium unaccounted	= (0.1347) 100	
	-----	= 6.5%
	2.0000	

Total 100%

The first 2-300 ml. of solution which passed thru the lignite columns was colorless indicating rapid removal of Uranium by the lignite. Upon standing, the solution of Uranium which passed thru the lignite precipitated, while a pure solution of Uranium acetate of the same concentration did not precipitate. This might indicate precipitation of an organic Uranium compound from a water solution.

DISCUSSION

The passing of solution thru a lignite column is a very difficult process at first, even under suction. This observation has been made before (1) and the explanation offered was that the difficulty of wetting the capillary surface is due to adsorbed films of air after the lignite is dehydrated. Lignite becomes dehydrated

upon standing. Uranium is removed from Uranium acetate solution at a rate dependent upon the time of contact with lignite. This is shown in the following curves

TABLE I

Uranium removed per g. of lignite in 1st. section (20 g.) vs time

Exp.	g. of U	Time
	g. of lignite	
III	0.0144	15 min.
IV	0.0274	40 min.
V	0.0402	90 min.
VI	0.0139	35 min.
VII	0.0166	25 min.
VIII	0.0173	20 min.

CONCLUSION

Time of contact of lignite and Uranium solution is a determining factor in the amount of Uranium removed from a solution of Uranium. Uranium is removed rapidly by lignite from a soluble solution of Uranium, approaching 0.05 g. of Uranium per gram of lignite. This is not an adsorption phenomenon since there is no fluorescence. Strong acid is necessary to recover the Uranium from the lignite. Upon standing for twenty-four hours, this acid extraction solution yields a yellow precipitate which is perhaps an organic compound of Uranium.

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